

Dear colleagues, friends and readers

On behalf of the Organizing Committee, I would like to welcome you to the XXX Bárány Society Meeting in Uppsala 2018.

We are happy to announce a record number of 547 abstracts that have been submitted, and more than 700 researchers and clinicians are registered to the meeting. The organizing committee's goal is to arrange a well-balanced and attractive program. The program includes 31 oral presentation sessions and two poster sessions.

The abstracts all have a robust scientific structure and offer a wide and interesting reading. Especially for those of you who have not the opportunity to join the meeting, here you find the conference abstracts on-line. The abstracts will also be available to the attendees on the conference app. We are grateful to the Journal of Vestibular Research, the official journal of the Bárány Society, that makes it possible for the abstracts to reach a wider scientific community

I would like to thank Måns Magnusson, Mikael Karlberg, Fredrik Tjernström and Niklas Danckwardt-Lillieström for their most valuable contribution to the conference organization.

The Bárány Society is a vibrant society and has a proud history of creating and advancing knowledge in oto-neurology. We are sure that you will find the meeting in Uppsala to be stimulating and productive.

Göran Laurell
President of the Bárány Society

Guide to abstract numbers

Abstracts for oral presentations are designated by the alphanumeric OPxx-n where xx indicates the topic of the presentation and n indicates the number of the presentation within that topic. The oral presentation topics are listed below. Abstracts for poster presentations are designated by the alphanumeric PPx-n where x indicates the poster session (1 or 2) and n represents the poster number.

- OP01: Clinical vestibular testing VEMP (I)
- OP02: Superior Canal Dehiscence Syndrome
- OP03: Spatial orientation
- OP04: Traumatic Brain Injury
- OP05: Acute vertigo
- OP06: Vestibular Prosthesis
- OP07: International classification of vestibular disorders (no abstracts available)
- OP08: Rehabilitation of vestibular disorders (I)
- OP09: BPPV (I)
- OP10: Functional and Psychiatric Vestibular Disorders
- OP11: Cochlear implantation
- OP12: Clinical vestibular testing VEMP (II)
- OP13: Ménière's disease (I)
- OP14: Clinical vestibular testing HIT I
- OP15: Imaging
- OP16: Miscellaneous
- OP17: Labyrinthine fistula/Vestibular schwannoma
- OP18: Central Vestibular Disorders
- OP19: Postural control
- OP20: Basic vestibular science/Animal models I
- OP21: Rehabilitation of vestibular disorders (II)
- OP22: Gait, Posture and locomotion
- OP23: Perception and Central Vestibular function
- OP24: Vestibular migraine
- OP25: Clinical Vestibular testing HIT II
- OP26: Epidemiology of vestibular disorders
- OP27: Ménière's disease (II)
- OP28: BPPV (II)
- OP29: Basic vestibular science/Animal models II
- OP30: Nystagmus and visual stabilization
- OP31: Bilateral Vestibulopathy

Contents

Oral presentations	1
OP01: Clinical vestibular testing VEMP (I)	2
OP01-1 - Role of oVEMP and cVEMP tests in relation to oscillopsia	2
OP01-2 - Ocular and cervical VEMPs to air conducted sound and bone conducted vibration in Meniere's Disease	2
OP01-3 - Eliciting ocular VEMPs by first order bone vibration and second order resonance effect	3
OP01-4 - Temporal Dynamics of Eye Movements Elicited by Combined Otolith and Semicircular Canal Stimulation	3
OP01-5 - Altered soleus VEMP may be a prognostic marker of progressive spinal cord damage	4
OP01-6 - The clinical significance of waveform morphology in OVEMP testing	4
OP01-7 - The effects of different sound stimuli when performing OVEMPs	5
OP02: Superior Canal Dehiscence Syndrome	5
OP02-1 - Cervical and ocular VEMPs to 4000Hz show Superior Semicircular Canal Dehiscence	5
OP02-2 - Efficacy of vestibular function tests post-canal plugging for superior canal dehiscence syndrome	6
OP02-3 - Heterogeneity in Reported Outcome Measures after Surgery in Superior Canal Dehiscence Syndrome	6
OP02-4 - Management of hearing and balance problems in SCDS	7
OP02-5 - Skull vibration induced nystagmus in patients with unilateral semicircular canal dehiscence	7
OP02-6 - Spontaneous plugging of superior canal: two possible natural evolutions of an unstable dehiscence	8
OP02-7 - The diagnostic value of vestibular evoked myogenic potentials in superior canal dehiscence syndrome	9
OP03: Spatial orientation	9
OP03-1 - Hearing & postural control: what is the impact of hearing loss and what role can hearing aids play?	9
OP03-2 - Towards a clinically useful test for vestibular perception	10
OP03-3 - The role ofvection and velocity storage in visually induced motion sickness	10
OP03-4 - The role of temporo-parietal cortex in upright perception and the link with torsional eye position	11
OP03-5 - Spatial navigation, sense of direction, and vestibular function in young deaf individuals	11
OP03-6 - Functional and mechanistic link between sensory cue integration and self-motion perception	12
OP03-7 - A Computational Model of Self-Motion Perception and Vestibular Cognition	12
OP04: Traumatic Brain Injury	13
OP04-1 - Benign Paroxysmal Positional Vertigo in acute traumatic brain injury	13
OP04-2 - Concussion Balance Test: Assessment and Treatment Effectiveness After Sports Related Concussion	13
OP04-3 - Does the Vestibular/Ocular Motor Screening (VOMS) Tool Predict Recovery in Collegiate Athletes?	14
OP04-4 - Is it clinically feasible to run a multi-modal battery of tests in a virtual reality goggle?	14
OP04-5 - Linking traumatic brain injury (TBI) severity, vestibular agnosia, and vestibular symptom load	15
OP04-6 - VEMP latency predict precision of subjective visual vertical in acute traumatic brain injury (TBI)	15

OP05: Acute vertigo.	16
OP05-1 - Acute Dizziness without Nystagmus: Incidence and Predictors of Stroke	16
OP05-2 - False negative stroke in acute dizziness.	16
OP05-3 - Prospective evaluation of cerebral lesion localization in acute vestibular and ocular motor stroke	17
OP05-4 - Spontaneous nystagmus characteristics in posterior circulation stroke.	18
OP05-5 - Truncal Ataxia in the Differential Diagnosis of Acute Vestibular Syndrome	18
OP05-6 - VOG vs MRI-All for Stroke Diagnosis of Vertigo in Emergency Departments: Cost Effectiveness Analysis	19
OP06: Vestibular Prosthesis.	19
OP06-1 - First-in-human Safety and Preliminary Efficacy Results for the MVI Multichannel Vestibular Implant	19
OP06-2 - Multichannel Vestibular Implant Early Feasibility Study: Gait and Posture Outcomes	20
OP06-3 - Multichannel Vestibular Implant Early Feasibility Study: Safety and Audiometric Outcomes	20
OP06-4 - Multichannel Vestibular Implant: Continuous Restoration of the Human Vestibulo-Ocular Reflex.	21
OP06-5 - The vestibular implant input interacts with residual natural function	22
OP06-6 - Combined stimulation of multiple canals to map a vestibular prosthesis.	22
OP06-7 - Electrically Evoked Compound Action Potentials in Patients with a Hybrid Cochlear-Vestibular Implant	23
OP08: Rehabilitation of vestibular disorders (I)	24
OP08-1 - The effect of darkness on human head impulse catch-up saccades	24
OP08-2 - Sensory Substitution quantified via the Oculus Rift in Patients with Vestibular Dysfunction.	24
OP08-3 - Accel. and velocity vHIT gains after unilateral vestibular loss: Insights into neural compensation	25
OP08-4 - Assessment of vestibulo-ocular reflex gain and catch-up saccades during Vestibular Rehabilitation	25
OP08-5 - Behavioral Evidence for Independently Modifiable Neural Circuits Mediating Concurrent VOR Adaptation	26
OP08-6 - Effects of saccular function on recovery of subjective dizziness after vestibular rehabilitation	26
OP08-7 - Efficacy of Gaze Stabilisation Exercises in Vestibular Dysfunction: A Systematic Review.	27
OP09: BPPV (I)	27
OP09-1 - A new numerical model : speed of migration of otonia under gravity action depending of their size.	27
OP09-2 - Association between serum vitamin D levels and BPPV in elderly patients.	28
OP09-3 - Clinical investigation and analysis of the risk factors of benign paroxysmal positional vertigo	28
OP09-4 - Correlations between scores of Eysenck Personality questionnaire and DHI in patients with BPPV	29
OP09-5 - Establishment of clinical diagnosis procedure in patients with benign paroxysmal positional vertigo	29
OP09-6 - Horizontal canal benign paroxysmal positional vertigo: Lempert vs Gufoni	30
OP10: Functional and Psychiatric Vestibular Disorders	30
OP10-1 - Altered functional brain connectivity in patients with visually induced dizziness	30

OP10-2 - Alternatives to Treat Associated Symptoms of Mal de Debarquement Syndromes (MdDS)	31
OP10-3 - Decreased Spontaneous Functional Activity of left PIVC in Persistent Postural-Perceptual Dizziness	31
OP10-4 - Integrating mental and physical health assessment in neuro-otology	32
OP10-5 - Interaction of Time Pressure and Anxiety upon Spatial orientation judgments.	32
OP10-6 - The cognitive-behavioural correlates of dizziness related interference.	33
OP10-7 - Vestibulo-cortical Hemispheric Dominance: the link between Anxiety and the Vestibular System?	33
OP11: Cochlear implantation.	34
OP11-1 - CI and vestibular assessment: controversies, measurement bias and ostensible clinical impact	34
OP11-2 - Intralabyrinthine schwannomas: vestibular function after surgery with/without cochlear implantation.	34
OP11-3 - Music May Improve Gait Pattern in Cochlear Implant Patients with Bilateral Caloric Areflexia.	35
OP11-4 - Preservation of vestibular function after cochlear implantation with round window approach.	35
OP11-5 - Vestibular and Balance Function is Impaired in Children with Unilateral Sensorineural Hearing Loss	36
OP11-6 - Vestibular function after cochlear implantation in partial deafness treatment.	36
OP11-7 - Vestibular function pre and post Cochlear implant in 71 patients	37
OP12: Clinical vestibular testing VEMP (II)	37
OP12-1 - Spatial Selectivity of Eye Movements Elicited by Combined Otolith and Semicircular Canal Stimulation	37
OP12-2 - Clinical evaluation of a new bone conduction transducer for VEMP	38
OP12-3 - oVEMP: A novel tool for non-invasive intracranial pressure monitoring	38
OP12-4 - Repetitive oVEMP stimulation for myasthenia gravis: optimization of stimulus parameters	39
OP12-5 - What kind of information can be provided using chirp sound in VEMP?	39
OP12-6 - VEMP a simple, portable and affordable vestibular evoked myogenic potential test device.	40
OP12-7 - VEMP triggered by galvanic stimulation may reveal a subclinical myelopathy	41
OP12-8 - Simultaneous recording of bilateral cervical/ocular vestibular-evoked myogenic potentials	41
OP13: Ménière's disease (I).	42
OP13-1 - Low-frequency vibration induced vestibular reactions and benefits in Meniere's disease patients	42
OP13-2 - Intratympanic Steroid is an Economic and Effective Treatment for Intractable Meniere's Disease	42
OP13-3 - Follow-up of a randomised, double-blind, trial of methylprednisolone vs gentamicin in unilateral MD	43
OP13-4 - Exploring Fluctuating Sensorineural Hearing Loss In Meniere's Disease Using iPad-Based Audiometry.	43
OP13-5 - Endolymphatic hydrops diagnosis at 3T MRI: Reproducibility and correlation with Meniere's disease.	44
OP13-6 - Endogenous Ouabain in Meniere's Disease.	44
OP13-7 - Acoustic absorbance in wideband tympanometry of Meniere's Disease is greater in affected side	45

OP14: Clinical vestibular testing HIT (II)	45
OP14-1 - Video-Head-Impulse testing in infants younger than 24 months	45
OP14-2 - Video head impulse test data in subjects with and without vascular risk factors and vertigo	46
OP14-3 - Viewing-target distance influences the VOR gain when assessed using the vHIT	46
OP14-4 - Dissociation between caloric test and video head impulse test: device factor vs stimulus factor	47
OP14-5 - Changes in vestibulo-ocular reflex during video Head Impulse Test in patients with cerebellar ataxia	47
OP14-6 - vHIT VOR-gain is not yet a reliable measure for bilateral vestibulopathy	48
OP14-7 - Problems with vertical Video Head Impulse Test (vHIT)	48
OP15: Imaging	49
OP15-1 - Meniere's disease affected inner ears are distinct from healthy controls with MRI and Radiomics	49
OP15-2 - MRI in Meniere patients: reliability of standard and additional diagnostic imaging criteria	49
OP15-3 - The human vestibular cortex	50
OP15-4 - Head tap stimulus to image the vestibular cortex on fMRI-- a pilot study	50
OP15-5 - MR volumetric measurement of endolymphatic space in patients without vertigo or hearing loss	51
OP15-6 - PET visualized stimulation of the vestibular organ	52
OP15-7 - The Ups and Downs of Endolymphatic Hydrops Imaging	52
OP15-8 - Neuroinflammation along the vestibular nerve and nucleus in acute unilateral vestibulopathy	53
OP16: Miscellaneous	53
OP16-1 - DIZZYNET - a European network initiative for vertigo and balance research: visions and aims	53
OP16-2 - Cochlear cooling for neuroprotection: The Cool-cochlea Project	54
OP16-3 - Vestibular dysfunction in mitochondrial disease: a common, treatable cause of dizziness or imbalance	55
OP16-4 - Otoconial loss a new important diagnosis - explanation for residual dizziness and chronic imbalance	55
OP16-5 - Amelioration of hyperacusis impacts vestibular symptoms and binocular vision dysfunction symptoms	56
OP16-6 - Correlations with hearing recovery and vestibular testing in sudden sensorineural hearing loss	56
OP16-7 - A reappraisal supported by functional and morphological assessments of delayed endolymphatic hydrops	57
OP17: Labyrinthine fistula/Vestibular schwannoma	58
OP17-1 - Detecting Perilymphatic Fistula by Variation of 3D Reconstruction Thresholds on CT scan	58
OP17-2 - Postoperative recurrence of perilymphatic fistula	58
OP17-3 - The change of hearing and positional nystagmus after surgery in barotraumatic perilymph fistula(PLF)	59
OP17-4 - The results of a nationwide study of PLF using a novel ELISA for human CTP detection test	59
OP17-5 - What are the serious symptoms of chronic perilymph fistula (PLF)?	60
OP17-6 - Specificity and sensitivity of two video Head Impulse Test systems in Vestibular Schwannoma patients	60
OP17-7 - Preoperative determination of nerve of origin in patients with vestibular schwannoma	61

OP18: Central Vestibular Disorders	61
OP18-1 - Apogeotropic Central Positional Nystagmus: Characteristics and Mechanism	61
OP18-2 - Combined Central & Peripheral Vestibular Disorders: CANVAS, iCABV & Other Differential Diagnoses	62
OP18-3 - Mal de Debarquement Syndrome: motion-triggered versus spontaneous/other onsets.	62
OP18-4 - The mystery of conversion of upbeat to downbeat nystagmus in thiamine deficiency	63
OP18-5 - Uncommon causes of episodic vertigo and imbalance: Ictal characteristics	64
OP18-6 - Vestibular Paroxysmia: Not Always As Simple As It Seems	64
OP18-7 - How to diagnose ataxia	65
OP19: Postural control	65
OP19-1 - Can Sensory Condition affect the Modified CTSIB relative to the SOT?	65
OP19-2 - Visual priming inducing expectational mismatch distorts sense of instability during postural control	66
OP19-3 - Sensitivity and specificity of 3 Hz tremor in patients with cerebellar ataxia	66
OP19-4 - Validity & kinematic outcomes of New Balance Test	67
OP19-5 - DHI score variation in vestibular rehabilitation patients, regardless of pathology	67
OP19-6 - Balanci: Improving balance in children with bilateral cochleovestibular loss using cochlear implants	68
OP19-7 - Balance, Gait and Dizziness in Adult Patients post Cochlear Implant	68
OP20: Basic vestibular science/Animal models (I)	69
OP20-1 - Endolymphatic fluid absorption in the developing inner ear	69
OP20-2 - Application of Gene Therapy to a Mouse Model of Vestibular Dysfunction	70
OP20-3 - Assessment of D-methionine Protecting Gentamicin-induced Otolith Toxicity	70
OP20-4 - What is the insulin signaling system doing in the inner ear?- implications for diabetes	71
OP20-5 - Biocompatibility and therapeutic effect of three intra-tympanic drug-delivery vehicles	71
OP20-6 - The effects of electrical vestibular stimulation on neurochemical release in the rat striatum	72
OP20-7 - Is it time for optical coherence tomography to be part of our vestibular workup?	72
OP21: Rehabilitation of vestibular disorders (II)	73
OP21-1 - Pain a common finding in patients with persistent dizziness	73
OP21-2 - Individualized vibrotactile neurofeedback training in bilateral vestibular loss patients	73
OP21-3 - Multi-sensory training and wrist fractures. A randomized controlled trial	74
OP21-4 - Vestibular rehabilitation exercises as a form of neural priming to regain motor control of the arm	74
OP21-5 - The reliability and validity of the Life Space Assessment in persons with vestibular disorders	75
OP21-6 - Histamine H1 receptor contributes to vestibular compensation	75
OP22: Gait, Posture and locomotion	76
OP22-1 - Balance control impairments in Fabry disease	76
OP22-2 - Body sway is mediated by vestibular cortical dominance	77
OP22-3 - Changes in Cortical Activity during Dual-task Walking in Individuals with and without Visual Vertigo	77
OP22-4 - Influence of hearing on postural control and stability in healthy subjects	78
OP22-5 - The auditory influence on postural control in stance and gait conditions	78
OP22-6 - Vestibular loss effects on standing balance during postural threat	79
OP22-7 - Virtual Reality for Vestibular and Balance Rehabilitation A Preliminary report	79
OP23: Perception and Central Vestibular function	80
OP23-1 - Exposure to an extreme environment comes at a sensorimotor cost	80
OP23-2 - Sensation and functional balance in elderly - low efficacy using the 256 Hz tuning fork	80

OP23-3 - Paroxysmal positional ocular flutter associated with middle cerebellar peduncle demyelination.	81
OP23-4 - Main sequence of torsional saccade under videooculography recordings.	81
OP23-5 - Structural connectome of the human vestibular cortex	82
OP24: Vestibular migraine.	83
OP24-1 - Abnormal Visuo-vestibular Interactions in Vestibular Migraine	83
OP24-2 - Errors of Upright Perception in Patients with Vestibular Migraine.	83
OP24-3 - Living with Vestibular Migraine; A qualitative investigation of patients perspectives	84
OP24-4 - Severe motion sickness - a possible rare presentation of vestibular migraine.	84
OP24-5 - Vertigo in Pediatric population. Migraine prevalence	85
OP24-6 - Vestibular migraine: reference to International Classification of Headache Disorders 3rd edition.. . . .	85
OP24-7 - Benign Recurrent Spontaneous Vertigo with Interictal Head-Shaking Nystagmus.	86
OP25: Clinical Vestibular testing HIT (II).	86
OP25-1 - Video-head impulse test results in Meniere's disease related to duration and stage of disease	86
OP25-2 - Acute video-oculography for vertigo in emergency rooms for rapid triage (avert) Trial: pilot results	87
OP25-3 - Different vHIT results of sudden deafness with vertigo and vestibular neuritis	87
OP25-4 - Enhanced VOR suppression in dancers during passive high velocity head impulses	88
OP25-5 - Investigating Mechanisms of Overt and Covert Saccades Using a Computer Model of Head Impulse Test	88
OP25-6 - Bedside examinations distinguish central from peripheral causes of vertigo	89
OP25-7 - Oral glycerol reduces the enhanced eye velocity in vHIT testing of patients with probable hydrops	89
OP26: Epidemiology of vestibular disorders.	90
OP26-1 - A retrospective cross-sectional study in an emergency department of a tertiary referral centre.	90
OP26-2 - Health Burden of Balance Problems and Falling: 2016 United States Health Survey of 33,028 Adults.	90
OP26-3 - Prevalence of Dizziness and Balance Problems and Significant Head Injuries in United States Children.	91
OP26-4 - Sensory impairments and wrist fractures. A case-control study.	92
OP26-5 - Stroke Risk after Diagnosis of Benign Vertigo is Lower in Specialty Care than General Practice.	92
OP27: Ménière's disease (II).	93
OP27-1 - Symptom severity and fluctuations in 192 patients with Hydropic Ear Disease	93
OP27-2 - Outcomes after Surgical Treatment of Meniere's Disease: Experience from Shanghai Xinhua Hospital.	94
OP27-3 - Prediction of unilateral Meniere's disease attack using inner ear test battery	94
OP27-4 - Shift of the frequency tuning on Ocular Vestibular-Evoked Myogenic Potentials in Meniere's disease.	95
OP27-5 - Simultaneous triple semicircular canal plugging and cochlear implantation in Meniere's disease.	95
OP27-6 - Slow-phase velocity of thermally-induced nystagmus is early reduced in Meniere's Disease	96
OP28: BPPV (II)	96
OP28-1 - Isolated positional vertigo of vascular origin.	96
OP28-2 - Positional Downbeating Nystagmus due to BPPV variants: our experience.	97

OP28-3 - Probable benign paroxysmal positional vertigo, spontaneously resolved: incidence and natural course.....	97
OP28-4 - Significance of repeated positional maneuver in the diagnosis of benign positional vertigo.....	98
OP28-5 - Supplementation of Vitamin D and Calcium May Prevent Recurrences of BPPV.....	98
OP28-6 - Upright Head Pitch Test to diagnose Posterior Canal Benign Paroxysmal Positional Vertigo.....	99
OP28-7 - Vestibular evoked myogenic potentials in posterior canal benign paroxysmal positional vertigo.....	100
OP29: Basic vestibular science/Animal models (II).....	100
OP29-1 - Effects of Selective Electrical Vestibular Stimulation on the Rat Hippocampus.....	100
OP29-2 - Biomechanical Origins of Tullio Phenomena.....	101
OP29-3 - How does 500Hz sound or vibration cause VEMPs.....	101
OP29-4 - Development of a non-human primate model for the cervical vestibular evoked myogenic potential.....	102
OP29-5 - Probing the role of the efferent vestibular system using direct monosynaptic viral tracing.....	102
OP29-6 - Visual Suppression has Minimal Effect on Adaptation to Magnetic Vestibular Stimulation.....	103
OP29-7 - Sound-evoked vestibular projections to the trapezius muscles in humans.....	104
OP30: Nystagmus and visual stabilization.....	104
OP30-1 - Discussion on the significance of nystagmus detection for continuous variable positional nystagmus.....	104
OP30-2 - Gaze Stability in Elite Athletes.....	105
OP30-3 - Comorbid inner ear disorders in patients with congenital nystagmus.....	105
OP30-4 - Utility Of Positional Testing In Acute Vestibular Syndrome: A Transversal And Longitudinal Study.....	106
OP30-5 - Video ocular counter-roll (vOCR): A new clinical test of otolith-ocular function.....	106
OP30-6 - The clinical utility of vibration-induced nystagmus and its role in the vestibular examination.....	107
OP30-7 - Accuracy of Automated Nystagmus Velocity Calculation by Video-oculographyImplications for Eye ECG.....	107
OP31: Bilateral Vestibulopathy.....	108
OP31-1 - Impaired spatial orientation in 30 patients with bilateral vestibulopathy.....	108
OP31-2 - Etiology and hearing status of 129 patients with bilateral vestibulopathy.....	108
OP31-3 - Cognitive impairment in patients with bilateral vestibulopathy with and without hearing loss.....	109
OP31-4 - Extensive exploration of symptoms of bilateral vestibulopathy.....	110
OP31-5 - Hierarchical cluster analysis of semicircular canal and otolith deficits in bilateral vestibulopathy.....	110
OP31-6 - On the effect of noisy galvanic vestibular stimulation on dynamic visual acuity.....	111
OP31-7 - Vestibular perception in patients with bilateral vestibulopathy.....	111
Poster presentations.....	113
Exhibition and poster viewing (poster session 1).....	114
PP1-1 - 3D Visualization and Position of Human Inner Ear Graviceptors A Synchrotron Imaging Study.....	114
PP1-2 - A multifaceted tailored randomised-controlled trial to reduce the burden of dizziness in middle aged and older people.....	114
PP1-3 - Developing a Model for Quantification of Heat Transfer to the Vestibular System.....	115

PP1-4 - Distribution of extracellular matrix in vestibular nuclei of developing mouse brain stem . . .	115
PP1-5 - Ion Transport Proteins and Claudin 11 Barrier in the Lateral Wall of the Human Cochlea . . .	116
PP1-6 - Is there a Neuroimmunoaxis in the Human Inner Ear - Role in Disease and Repair?	116
PP1-7 - Microcomputed Tomography Analysis of the the Fundus of the Human Internal Acoustic Canal	117
PP1-8 - A new procedure of labyrinthectomy in mice by means of transtympanic injection of p-arsanilic acid	117
PP1-9 - Altered circadian locomotor activity after acute otovestibular failure in rodents	118
PP1-10 - Effect of thioperamide on vestibular compensation in rats with immunohistochemistry . . .	119
PP1-11 - Evaluating an kinase inhibitor library for effects on hair cells using the zebrafish lateral line	119
PP1-12 - Extracellular matrix in vestibular compensation	120
PP1-13 - Locomotor hyperactivity in bilateral vestibulopathic rats: a consequence of spatial disorientation?	120
PP1-14 - Macrophages in the Human Endolymphatic Sac - Molecular Expression and Interaction . . .	121
PP1-15 - Neural Correlates of Galvanic Vestibular Stimulation in the Alert and Behaving Macaque .	121
PP1-16 - Photobiomodulation for peripheral vestibular dysfunction induced by aminoglycoside in animal model	122
PP1-17 - Tissue optical clearing of the mouse temporal bone for downstream applications	122
PP1-18 - Selective otolith organ dysfunction in patients with non-spinning vertigo	123
PP1-19 - The effect of distraction on motion sickness	123
PP1-20 - Efficacy of the Gufoni maneuver for treating the horizontal canal BPPV	124
PP1-21 - 25 (OH) D3 levels, incidence and recurrence of different clinical forms of BPPV	124
PP1-22 - Accuracy of Questionnaire-Based Diagnosis of Benign Paroxysmal Positional Vertigo . . .	125
PP1-23 - Apogeotropic variant of posterior semicircular canal benign paroxysmal positional vertigo	125
PP1-24 - Asking about dizziness when turning in bed predicts benign paroxysmal positional vertigo	126
PP1-25 - Canalith jam of the horizontal canal masquerading as acute vestibular loss: role of the video-HIT	126
PP1-26 - Characteristics of the Recurrence of Idiopathic Benign Paroxysmal Positional Vertigo . . .	127
PP1-27 - Characteristics and recurrent risks of Benign Paroxysmal Positional Vertigo in young and elder group	127
PP1-28 - Characteristics of Benign Positional Vertigo Tested on the Epley Omniax Chair	128
PP1-29 - Clinical analysis of benign paroxysmal positional vertigo with multiple canal involvement	128
PP1-30 - Clinical characteristic and risk factor of canal conversion in benign paroxysmal positional vertigo	129
PP1-31 - Demographics of patients with BPPV and treatment efficacy in the Singapore population	129
PP1-32 - Diagnosis and Treatment of Anterior Canal Benign Paroxysmal Positional Vertigo	130
PP1-33 - Effect of Intratympanic Steroid Injection in Light Cupula	130
PP1-34 - Efficacy of Gufoni maneuver and head-shaking for treating apogeotropic horizontal BPPV	131
PP1-35 - Frequency tuning of ocular vestibular evoked myogenic potential in BPPV	131
PP1-36 - Idiopathic benign paroxysmal positional vertigo in the elderly: A long-term follow-up study	132
PP1-37 - Immediate efficacy of Gufoni maneuver for HC-BPPV:a meta-analysis	132
PP1-38 - Objective Characteristics of Nystagmus in Posterior Semicircular Canal BPPV	133

PP1-39 - Optimal reassessment timing after treatment in posterior canal benign paroxysmal positional vertigo 133

PP1-40 - Positional downbeat nystagmus in posterior canal benign paroxysmal positional vertigo 134

PP1-41 - Relationship between clinical features and therapeutic approach in benign BPPV outcomes 134

PP1-42 - Residual dizziness after repositioning in BPPV with preexisting central neurologic disorders. 135

PP1-43 - The discussing between premier solution of Roll Test and Dix-Hallpike Test inBPPV. 135

PP1-44 - Trial of a two-item questionnaire for identifying patients with Benign Paroxysmal Positional Vertigo. 136

PP1-45 - TRV Chair For Diagnosis and Treatment of BPPV 136

PP1-46 - Use of the Brny Society criteria to diagnose benign paroxysmal positional vertigo 137

PP1-47 - Utility of Bow and Lean Test in Predicting Subtype of Benign Paroxysmal Positional Vertigo. 137

PP1-48 - Vitamin D deficiency and Benign Paroxysmal Positional Vertigo recurrence.. . . . 138

PP1-49 - Cogans syndrome: An autoimmune inner ear disease 138

PP1-50 - Etiology analysis and vestibular assessment of bilateral vestibulopathy 138

PP1-51 - Frequency properties of postural sway in bilateral vestibulopathy and somatosensory disorder. 139

PP1-52 - Impact of Bilateral Vestibulopathy on Spatial and non-Spatial Cognition: a Systematic Review 139

PP1-53 - Progressive central and peripheral vestibulopathy in superficial siderosis. 140

PP1-54 - Are gonadal hormones involved in the pathophysiology of Mal de Debarquement Syndrome? 141

PP1-55 - Central Positional Vertigo. 141

PP1-56 - Dissociation between semicircular canals and saccular function in Machado-Joseph Disease. 142

PP1-57 - Evaluation of gravitational recognition in patients with spinocerebellar degeneration 143

PP1-58 - Long term observation of slow saccades and caloric response in a SCA2 patient. 143

PP1-59 - Metabolic and Visuospatial Memory Function Changes in Transient Mal de Debarquement Syndrome 144

PP1-60 - Nystgamus and vestibular loss in autoimmune and paraneoplastic ataxia syndromes. 144

PP1-61 - Positional tests under Videonistagmography for Central Positional Vertigo Diagnosis. . . . 145

PP1-62 - Subjective visual vertical in typical Alzheimer’s disease and posterior cortical atrophy. . . . 145

PP1-63 - The Semicircular Canal Coordinate System and Its Relation to Neural Circuits for Saccades 146

PP1-64 - Tumor size of vestibular schwannoma impair vestibular function and compensation. 146

PP1-65 - Use of proprioception differentiates postural control in peripheral and central vestibular patients 147

PP1-66 - Vestibular dysfunction in Wernickes encephalopathy: selective impairment of the horizontal canals 147

PP1-67 - Visual fixation suppression of caloric nystagmus in progressive supranuclear palsy 148

PP1-68 - 3D analysis of VOR and spatial orientation during eccentric rotation while right ear downwards. 148

PP1-69 - A normative study of the Dynamic Visual Acuity test, with comparison of two vertical test methods 149

PP1-70 - Analysis of the result of normal youth sinusoidal harmonic acceleration test by NKI rotation chair 149

PP1-71 - Anxiety, depression, and visual dependence assessment in neuro-vestibular physical therapy	150
PP1-72 - Balance and Eye Movement Responses to Electrical Vestibular stimulation in Vestibular Schwannoma.	150
PP1-73 - Can HIT and oVEMP evaluate the superior vestibular nerve function in substitution for caloric test?	151
PP1-74 - Cervico-Ocular Reflex Induced by Manual stimulus of the Sternocleidomastoid Muscle: The First Report	151
PP1-75 - Clinical features of otolith organ-specific vestibular dysfunction	152
PP1-76 - Clinical study of the new three dimensional rotating equipment in vestibular function detection.	152
PP1-77 - Clinical usefulness of dizziness diagnosis in the foam posturography analysis system.	153
PP1-78 - Comparing the video Head Impulse to the Suppression Head Impulse as target distance is varied	153
PP1-79 - Comparison of video Head Impulse Test with Head Impulse Test and calorics: a retrospective study	154
PP1-80 - Comparison of video-head impulse, rotatory chair and bithermal caloric test in vestibular disease.	154
PP1-81 - Development of real-time video-oculography using high quality infrared video Frenzel.	155
PP1-82 - Differences of VOR gain in the conventional head impulse test and the suppression head impulse test	155
PP1-83 - Effect of gaze direction on vertical VOR gain during the video head impulse test	156
PP1-84 - Effect of intratympanic gentamicin injection on lateral and vertical canals using HIMPs and SHIMPs.	156
PP1-85 - Eliciting cVEMPs and oVEMPs from newborns through the elderly-a review	157
PP1-86 - Eye tracking during caloric nystagmus: a sensitive test to identify central vestibular disorder	157
PP1-87 - Functional Measure of Gaze Shifting in Healthy and Unilateral Vestibular Hypofunction Individuals	158
PP1-88 - Head Movement During Functional Gait Assessment Predicts Clinical Measures in Vestibular Patients	158
PP1-89 - High-frequency VOR in certain Hydropic Ear Disease	159
PP1-90 - Horizontal ocular deviation on brain MRI in acute vertigo patients	159
PP1-91 - How many sweeps are needed for Clinical OVEMP testing	160
PP1-92 - How well does clinical history correlate with results of vestibular assessment?	160
PP1-93 - Isolated posterior canal hypofunction on video-HIT: association with additional inner ear deficits.	161
PP1-94 - New protocol to optimize ocular-VEMP stimulation and recording with High-Force Level Bone Conductors	161
PP1-95 - Non compensation in the vestibular patient	162
PP1-96 - Normal values of video-head impulse test for healthy people in different age	162
PP1-97 - Outcome prediction of sudden sensorineural hearing loss using neurotological tests	163
PP1-98 - Postural control, vestibular restoration and disability perception in vestibular neuritis.	163
PP1-99 - Posturographic pattern of patients with peripheral vestibular dysfunction at vertigo interval period	164
PP1-100 - Preliminary results of video Head Impulse Testing (vHIT) in children with dizziness or vertigo	164

PP1-101 - Quantitative analysis of smooth pursuit eye movement by video-oculography (VOG)	165
PP1-102 - Relationship of Vestibulo Ocular Reflex and Gait in Patients with Vestibular Schwannoma.	165
PP1-103 - Reliability of the Suppression Head Impulse Test and Role of Test Predictability	166
PP1-104 - Simultaneous recording of cervical and ocular vestibular-evoked myogenic potentials	166
PP1-105 - Splenius capitis: Target for the cVEMP in older and neurodegenerative patients	167
PP1-106 - Suppression head impulse paradigm in normal adults: values and parameters	167
PP1-107 - Systemic Aminoglycosides-Induced Vestibulotoxicity in Humans	168
PP1-108 - The analysis of the value of spontaneous nystagmus in peripheral vestibular hypofunction.	168
PP1-109 - The diagnostic value of the bone-conduction cervical vestibular evoked myogenic potentials (cVEMP).	169
PP1-110 - The Role of Predictability in the Suppression Head Impulse Test	169
PP1-111 - The use of virtual reality in the assessment BPPV-related otolithic dysfunction a pilot study.	170
PP1-112 - Updated screening tests of balance for vestibular disorders.	170
PP1-113 - Variacin del dhi en pacientes de rehabilitacion vestibular, independientemente de la patologia.	171
PP1-114 - Variation of v-hit in patients with vestibular neuritis pre and post treatment.	171
PP1-115 - VEMP characteristics of vestibular paroxysm	172
PP1-116 - VEMP using a new low frequency bone conduction transducer	172
PP1-117 - Vestibular function in children with congenital cytomegalovirus infection: A two-year follow-up.	173
PP1-118 - Vestibular Infant Screening-Flanders (VIS-Flanders): the start of an exciting project.	173
PP1-119 - Vestibular testing results in a world-famous extreme tightrope walker	174
PP1-120 - VHIT and the influence of daily use of spectacles to correct a refractive error	175
PP1-121 - vHIT using a smart phone.	175
PP1-122 - VVOR and VORS tests as a tool in the diagnosis of unilateral and bilateral vestibular hypofunction	175
PP1-123 - Assessment of horizontal semicircular canal after cochlear implantation by vHIT and caloric test.	176
PP1-124 - Assessment of the otolith function of the cochlear implant surgery using eccentric rotation test.	176
PP1-125 - Correlation between hearing and vestibular function preservation after cochlear implantation.	177
PP1-126 - Effects of Cochlear Implantation on Visual, Postural and Haptic Verticality Perceptions	177
PP1-127 - Intra-cochlear Figuration of Implant Electrodes using Synchrotron Phase Contrast Imaging	178
PP1-128 - Long term effects of cochlear implantation on vestibular evoked myogenic potentials.	179
PP1-129 - Long-term evaluation of the vestibular function after cochlear implantation(CI) in children	179
PP1-130 - The Effect of Cochlear Implant on Postural Control	179
PP1-131 - A questionnaire for the patient with benign paroxysmal positional vertigo: a pilot study	180
PP1-132 - Epidemiology of acute isolated vertigo in an italian emergency department: a retrospective study	180
PP1-133 - Multicenter databanking in management of dizzy patients first results from the DizzyNet registry	181

PP1-134 - The prevalence of persistent tinnitus and dizziness in an elderly population in southern Taiwan	182
PP1-135 - Cognitive impairment in persistent postural-perceptual dizziness: working vs. non-working patients	182
PP1-136 - Dr	183
PP1-137 - Influence of Visual and Vestibular Hypersensitivity on Depersonalization/Derealization in Dizziness	183
PP1-138 - Persistent Postural-Perceptual Dizziness in the Light of New Diagnostic Criteria	184
PP1-139 - Selective serotonin reuptake inhibitor (SSRI) and vestibular function	184
PP1-140 - Sensory Organization Test Profile for Patients with Persistent Postural-Perceptual Dizziness	185
PP1-141 - Structure Changes of Superior longitudinal fasciculus in Persistent Postural-Perceptual Dizziness	185
PP1-142 - A study on auto-scoring algorithm for balance assessment	186
PP1-143 - Assessment of vestibular compensation in static posturography tests.	186
PP1-144 - Balance disorder of patients with Mnire's disease: assessing with posturography and gait analysis.	187
PP1-145 - Correlations between multiplane vHIT and balance control after acute unilateral vestibular deficit	187
PP1-146 - Disordered gait pattern after craniocervical trauma a case study	188
PP1-147 - Dissociated objective and subjective stability in the elderly due to postural anxiety.	188
PP1-148 - Does the sensory organization test discriminate between athletes and non-athletes?	189
PP1-149 - Effects of visuo-ocular state on vestibular-evoked behaviors during standing balance	189
PP1-150 - Evaluation of balance performance in vestibular loss patients using virtual reality system	190
PP1-151 - Influence of arteriosclerosis on balance function Data from Iwaki health promotion project.	191
PP1-152 - Postural control instability caused by virtual reality	191
PP1-153 - Postural instability according to the Virtual Reality program	192
PP1-154 - Relationship between cognitive function and balance in a community-dwelling population in Japan.	192
PP1-155 - Spatiotemporal parameters and variability with changes in gait velocity in bilateral vestibulopathy	193
PP1-156 - Stabilogram of patients with otolithic vertigo	193
PP1-157 - The characteristics of balance sensory weight of sudden hearing loss with vertigo	194
PP1-158 - Episodic ataxia type 2 characterized by recurrent dizziness/vertigo: a report of four cases	194
PP1-159 - Genome-wide association study in downbeat nystagmus.	195
PP1-160 - Molecular genetic studies of Familial Menieres disease: a systematic review.	195
PP1-161 - Regenerative medicine for vestibular disorders	196
PP1-162 - Voltage-gated Ion Channels in the Developing Human Inner Ear	196
Exhibition and poster viewing (poster session 2)	197
PP2-1 - Auditory-Vestibular Integration at the Posterior Superior Temporal Gyrus and Posterior Insula Gyrus.	197
PP2-2 - Imaging analysis of patients with Menieres disease treated with endolymphatic sac shunt surgery	197
PP2-3 - Multiplanar visualization of vestibular endolymphatic hydrops	198
PP2-4 - New strategy for diagnosis of Menieres disease using three dimensional MRI.	198

PP2-5 - Progression of Hydrops in Meniere's disease continues over time though the symptoms are relieved	199
PP2-6 - The Feasibility of MRI in the Differential Diagnosis of a patient with Acute Audiovestibular Loss	199
PP2-7 - Usefulness of intravital multi-photon microscopy in visualizing study of the scala media	200
PP2-8 - Antigen in the Endolymphatic Duct results in Chronic Hydrops and an Enlarged Endolymphatic Duct.	200
PP2-9 - Bilateral Meniere's disease or autoimmune inner ear disease presenting to the Emergency Department	201
PP2-10 - Cervical and Ocular Vestibular-evoked Myogenic Potentials in Patients with Menieres Disease	201
PP2-11 - Clinical application of glycerol test with endolymphatic sac decompression in Meniere 's disease	202
PP2-12 - Clinical features of symptom and audiovestibular test for Menieres disease and vestibular migraine	202
PP2-13 - Delayed contrast 3-dimensional MRI and regional hydrops in Meniere's disease and variants..	203
PP2-14 - Delayed effect and gain restoration after intratympanic gentamicin for Menieres Disease..	203
PP2-15 - Detecting endolymphatic hydrops with posterior tympanic medial wall Gd-DTPA delivery and 8 min-MRI.	204
PP2-16 - Diagnostic Diversity of Acute Vestibular Syndrome with Negative Video Head Impulse Test	205
PP2-17 - Diagnostic Value of the Multifrequency Tympanometry in the Patients with Menieres Disease	205
PP2-18 - Discrepancies between vHIT and caloric tests in congenital and acquired endolymphatic hydrops	206
PP2-19 - Discrepancy between results of vHIT and those of caloric test in the cases with Menieres disease	206
PP2-20 - Dissociated vestibular tests result in patients with Menieres is not due to central dysfunction.	207
PP2-21 - Eye Movement Response Patterns during vHIT in Menieres Disease or Migraine Related Vertigo.	207
PP2-22 - Fn14 and NF-B underlying inflammation in peripheral blood mononuclear cells in Meniere disease.	208
PP2-23 - Incidence of progression Into Mnires Disease from idiopathic sudden sensorineural hearing loss	209
PP2-24 - Intratympanic latanoprost for Menieres - A randomized, double-blind, placebo-controlled study	209
PP2-25 - Low- & high-frequency VOR disparity may differentiate Menieres disease from vestibular migraine	210
PP2-26 - Menire and friends: Classification of Hydropic Ear Disease	210
PP2-27 - Menieres disease: combined pharmacotherapy with betahistine and the MAO B inhibitor selegiline.	211
PP2-28 - P.M34T variant on GJB2 gene associated to familial deafness and Ménière's disease.	211
PP2-29 - Pressure therapy of intractable Menieres disease using transtympanic membrane massage device.	212
PP2-30 - Prognostic value of glycerol test of ECochG in patients undergoing sac decompression surgery.	212

PP2-31 - Pure-tone follow-up study of Meniere's disease.	213
PP2-32 - Revision surgery after triple semicircular canal plugging	214
PP2-33 - The Detection of Endolymph Hydrops in the Patients using a Multifrequency Tymanometry	214
PP2-34 - The Effect of Intratympanic Dexamethasone for Sudden Sensorineural Hearing Loss	215
PP2-35 - The effect of transtympanic ventilation tube insertion in people with intractable	215
PP2-36 - The effect of transtympanic ventilation tube insertion in people with intractable Meniere's disease.	215
PP2-37 - The importance of temporal 3T MRI in the diagnostics of menieres disease in Lithuania	216
PP2-38 - Treatment for intractable delayed endolymphatic hydropstriple semicircular canal plugging	216
PP2-39 - Unilateral Menieres disease with downbeat nystagmus in 2 cases.	217
PP2-40 - Vertical nystagmus during attacks of menieres disease or delayed endolymphatic hydrops..	217
PP2-41 - Vertigo and istamine: atopic reactions and histamin intolerance (HIT)	217
PP2-42 - Vestibular findings in patients with persistent apogeotropic nystagmus	218
PP2-43 - A Case of Pendular Nystagmus: Delayed onset congenital nystagmus or acquired form by head trauma.	218
PP2-44 - An Algorithm as a Diagnostic Tool for Central Ocular Motor Disorders.	219
PP2-45 - Living in the dark: self-induced visual deprivation leading to pendular nystagmus.	219
PP2-46 - Long-term course of progression of clinical ocular motor signs in progressive supranuclear palsy	220
PP2-47 - Rebound nystagmus, a window to the oculomotor integrator	221
PP2-48 - Vertical Component of Horizontal Nystagmus due to Impairment of Vertical Semicircular Canals	221
PP2-49 - Two case reports of perilymphatic fistula after nose blowing with review of possible mechanisms	222
PP2-50 - A prospective study of Cochlin-tomoprotein detection test in sudden sensorineural hearing loss cases.	222
PP2-51 - Proposal of the diagnostic criteria for barotraumatic perilymph fistula (PLF).	223
PP2-52 - Oxidative stress in leukoaraiosis dizziness patients, effect of a polyphenol supplementation.	223
PP2-53 - Acute topographical disorientation due to right-sided hippocampal haemorrhage	224
PP2-54 - Astronauts Gaze Behavior during Visual Target Acquisition during and after Space Shuttle Flights	224
PP2-55 - Body-based spatial reasoning selectively disrupted by vertigo after a decelerating velocity step	225
PP2-56 - Changes in Heart Rate Variability due to Continuous Stimulation in the Head with a mini-Vibrator.	225
PP2-57 - Comparison of Haptic and Visual Perception of Upright and the Effect of Handedness	226
PP2-58 - Cortical integration of vestibular and visual inputs during forward self-motion	226
PP2-59 - Effects of space perception on unilateral vestibular loss mice	227
PP2-60 - Effects of vestibular disorders on vestibular reflex and imagery	227
PP2-61 - Impact of alcohol on self-motion perception and reflexive eye movements: the role of the cerebellum	228
PP2-62 - Subjective cognitive dysfunction in patients with dizziness and vertigo	228
PP2-63 - Treatment of Mal de Debarquement Syndrome (MdDS) by readaptation of the vestibuloocular reflex (VOR)	229
PP2-64 - Vestibular Function and Hippocampal Volume in the Baltimore Longitudinal Study of Aging.	229

PP2-65 - Visual dependency in spatial orientation: The effect of body tilt and hemispheric lateralization	230
PP2-66 - Visual gravitational motions affect estimation of subjective visual vertical (SVV).	230
PP2-67 - A diagnostic dilemma: beyond high resolution computed tomography (CT) scan, thinning versus fistula.	231
PP2-68 - Aggregating the symptoms of superior semicircular canal dehiscence syndrome.	231
PP2-69 - Correlation of neuroradiological and post-mortem autopsy findings in SCDS	232
PP2-70 - Fremitus Nystagmus - a simple and objective clinical sign for SCDS.	232
PP2-71 - Hearing eyeball and/or eyelid movements on the side of a unilateral superior canal dehiscence	233
PP2-72 - Improving the Specificity of VEMP testing in Superior Canal Dehiscence: Trial by oVEMP.	233
PP2-73 - Management of Dehiscences Involving Superior Canal and Tegmen	234
PP2-74 - New issues within the third windows spectrum abnormalities impacting diagnosis and treatment.	234
PP2-75 - Ocular Vestibular Evoked Myogenic Potential Waveform Morphology: Signs of Superior Canal Dehiscence	235
PP2-76 - Outcome of surgical plugging in superior canal dehiscence syndrome	236
PP2-77 - Vestibular suppression of normal bodily sounds	236
PP2-78 - VOG and VEMPs in Superior Semicircular Canal Dehiscence and Perilymphatic Fistula	237
PP2-79 - Mild blast wave leads intensity-dependent sequential changes in MMP2 expression in rat brains	237
PP2-80 - Temporal bone fracture in acute traumatic brain injury: Vestibular consequences	238
PP2-81 - The utility of the Sports Concussion Assessment Tool in hospitalized traumatic brain injury patients	238
PP2-82 - Vestibular and optokinetic responses in post-concussive syndrome.	239
PP2-83 - Why is routine vestibular screening not undertaken by trauma ward staff? A qualitative study	239
PP2-84 - Acute dizziness/vertigo in the telestroke network TEMPiS: frequency and telemedical decision making.	240
PP2-85 - Canal and otolith test characteristics in vestibular neuritis and posterior circulation stroke	240
PP2-86 - Diagnosing dizziness of vascular origin: are there safer options than arteriography?	241
PP2-87 - Eye movements and vestibular function in patients with posterior circulation infarction	241
PP2-88 - HINTS vs ABCD2 to predict cerebrovascular cause in acute vestibular syndrome patients at the ED	242
PP2-89 - Transient vertigo preceding vestibular neuritis.	242
PP2-90 - A novel study on the relationship between dizziness or vertigo symptoms and nystagmus intensity.	243
PP2-91 - Efficiency of non-invasive cooling of the vestibular system	243
PP2-92 - Impact of visual stimuli on cervical vestibular evoked myogenic potentials (cVEMPs).	244
PP2-93 - Is there any difference between clockwise and counter clockwise dynamic subjective visual vertical?	244
PP2-94 - Pulsed infrared vestibular stimulation: evoked eye movement and cardiovascular responses.	245
PP2-95 - The Activity of Vestibular Pukinje Cells is Attenuated During Self-Generated Head Movements.	245
PP2-96 - Case study: benefits of integrated vestibular rehabilitation in neurosarcoidosis	246
PP2-97 - Case study: Reduction of intercranial hypertension-induced vestibular symptoms.	246

PP2-98 - Case study: Resolution of centrally maintained vestibular symptoms secondary to BBPV	247
PP2-99 - Do sinusoidal gaze stabilising exercises result in adaptation of the transient (head impulse) VOR?	247
PP2-100 - Efficacy of vestibular rehabilitation exercises in acute unilateral peripheral vestibulopathy	248
PP2-101 - HTC Vive to improve balance and dizziness in unilateral peripheral hypofunction: 2 case reports	248
PP2-102 - Impact of Vestibular Rehabilitation on Patients with Chronic Vestibular Hypofunction	249
PP2-103 - Is Static Acuity Pre-requisite for Dynamic Visual Acuity: Case Series Failed Vestibular Rehab	249
PP2-104 - Manifestation and Prognostic Factors of Dizziness due to Long-Term Use of Vestibular Suppressant	250
PP2-105 - Noisy galvanic stimulation improves vestibular perception	250
PP2-106 - PEDIATRIC VESTIBULAR REHABILITATION: A CASE STUDY	251
PP2-107 - Prognosis after Acute Unilateral Vestibulopathy: the importance of video Head Impulse Test	251
PP2-108 - Smartphone-based Virtual Reality Vestibular Therapy App for Motion Sickness	252
PP2-109 - Subsensory Neuromodulation Improves Vestibular Function in Bilateral or Unilateral Hypofunction	252
PP2-110 - The effect of consolidation on human vestibulo-ocular reflex adaptation and retention	253
PP2-111 - The role of physiotherapy in managing vestibular migraine: A critical literature review	253
PP2-112 - Therapy of impaired upright body orientation using a 3D device	254
PP2-113 - Training time affects human vestibulo-ocular reflex adaptation	254
PP2-114 - Changes CGRP serological parameters in patients with vestibular migraine	255
PP2-115 - Clinical characteristics of vestibular migraine based on Barany diagnostic criteria	255
PP2-116 - Differences between patients who have vestibular migraine and those who migraine only	256
PP2-117 - Do the inflammatory factors contribute to the pathogenesis of vestibular migraine?	256
PP2-118 - Is it possible to differentiate vestibular migraine from Meniere's disease neurophysiologically?	257
PP2-119 - Postural instability evoked by visual motion stimuli in patients with vestibular migraine	257
PP2-120 - The differences of clinical characteristics between Vestibular migraine and Meniere's Disease	258
PP2-121 - The Research of Cognitive Change and Imaging Features in patients with (vestibular) migraine	258
PP2-122 - Unique findings of video head impulse test during the ictal period of vestibular migraine	259
PP2-123 - Vestibular Migraineurs journey from symptom to diagnosis; long frustrating and often disappointing	259
PP2-124 - VHIT in Vestibular migraine - Overt and covert saccades with increased gain	260
PP2-125 - Diagnosing peripheral vestibular dysfunction by assessing 3D body tracking via Kinect v2	260
PP2-126 - Diplopia from skew deviation in peripheral vestibulopathy	261
PP2-127 - Disability and neuritis, prognostic factors	261
PP2-128 - Functional MR Spectroscopy of the Primary vestibular Cortex in Patients with vestibular neuritis	261

PP2-129 - Genome-wide Association Study in Vestibular Neuritis.	262
PP2-130 - Steroids for acute vestibular neuronitis - the earlier the treatment, the better the outcome?	262
PP2-131 - The clinical efficacy of vestibular function tests in patients with acute peripheral vestibulopathy.	263
PP2-132 - Vestibular function features and prognosis of vestibular neuritis in children.	263
PP2-133 - Video Head Impulse Test and Cervical Vestibular Evoked Myogenic Potential in Vestibular Neuritis	264
PP2-134 - Controlled postural responses upon electrical stimulation with a vestibular implant in humans	264
PP2-135 - Effects of long-term noisy vestibular stimulation on body balance in bilateral vestibulopathy	265
PP2-136 - Immediate efficacy of Gufoni maneuver for HC-BPPV: a meta-analysis	265
PP2-137 - A Novel Tele-Dizzy Consultation Program in the Emergency Department using Portable Video-oculography.	266
PP2-138 - A Retrospective Study of a Multidisciplinary Chronic Dizziness Clinic and an Acute Dizziness Clinic	267
PP2-139 - Brain tissue volume changes in astronauts after six months of exposure to microgravity.	267
PP2-140 - Central Vestibular Sensitivity affects Motion Sick Susceptibility through the Velocity Storage.	268
PP2-141 - Challenge and Limitation of the Emergent Care of Dizziness in a Hospital without Specialists	268
PP2-142 - Clinical characteristics of 26 cases with recurrent low frequency sensorineural hearing loss	269
PP2-143 - Cobalt-induced ototoxicity from metal-on-metal hip prostheses: preliminary results	269
PP2-144 - Description of otoneurological findings in peripuberal females.	270
PP2-145 - Direct Observational Procedural Skills in Otolaryngology Training	271
PP2-146 - Distorted own-body representations and out-of-body experience in 350 patients with dizziness.	271
PP2-147 - Dizziness related to patulous eustachian tube.	272
PP2-148 - EEG Correlates of Postural Control and Balance.	272
PP2-149 - Etiologic evaluation and risk factor profile of childhood hearing loss.	273
PP2-150 - Influence of vestibular stimulation on executive functions	273
PP2-151 - Influence of vestibular stimulation on phantom limb pain after supracondylar amputation	274
PP2-152 - Interaction between Vestibulo Ocular Reflex and Optokinetic Nystagmus in virtual reality worlds	274
PP2-153 - Mastoid Obliteration with Middle Temporal Artery and Inferior Musculoperiosteal Flaps	275
PP2-154 - Metabolic syndrome among patients with different type of peripheral vestibular vertigo	275
PP2-155 - Predictive capability of an iPad based medical device for the diagnosis of vertigo and dizziness	276
PP2-156 - Prevalence of and factors related to mild and substantial dizziness in older adults.	276
PP2-157 - Recovery of Ocular and Cervical Vestibular Evoked Myogenic Potentials after Vertigo Attacks.	277
PP2-158 - Sub-clinical symptoms of postural-perceptual dizziness are associated with general sensory avoidance	277

PP2-159 - The central nervous system complications accompanied by Ramsay-Hunt syndrome	278
PP2-160 - The ototoxic effect of cisplatin on vestibular hair cells in vitro	278
PP2-161 - Vestibular Neuropathy in Auditory Neuropathy: Detected by Vestibular Evoked Myogenic Potentials	279
PP2-162 - Vestibular Symptoms and Function in Veterans with Post Traumatic Stress Disorder.	279
PP2-163 - Voluntary eye closure disrupts the vestibulo-ocular response to head rotation in man and monkey	280
PP2-164 - Walking to the Toilet in Impatient with Vertigo (5th report)-An Evaluation Using the DHI	280
PP2-165 - When on earth a patient with congenital nystagmus experiences oscillopsia? -A case report-	281

Oral presentations

OP01: Clinical vestibular testing VEMP (I)

OP01-1 - Role of oVEMP and cVEMP tests in relation to oscillopsia

7. Clinical Testing for Vestibular Function

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Purpose: The term oscillopsia means a symptom of jumbling eye movements, manifested as blurred vision when walking or running. It occurs primarily from loss of vestibulo-ocular reflex (VOR) or ocular oscillations. This study investigated whether ocular and cervical vestibular-evoked myogenic potential (oVEMP and cVEMP) tests related to the occurrence of oscillopsia.

Methods: From 2012 to 2017, 26 patients with caloric areflexia on both ears underwent dynamic visual acuity (DVA) test subsequently. Half of them who had oscillopsia and failed to pass the DVA test were assigned to Group A, including 9 males and 4 females, with mean age of 67 years. The remaining 13 patients without oscillopsia and passed the DVA test were assigned to Group B, consisting of 5 men and 8 women, with mean age of 64 years.

Results: Groups A and B did not significantly differ in the abnormality rates of pursuit, saccade, optokinetic nystagmus, and caloric tests. Likewise, Romberg quotients of sway area on foam posturography were 1.96 and 2.36 in Groups A and B, respectively, exhibiting non-significant difference. For the oVEMP test, 81% vs. 85% abnormalities, no significant difference was identified between the two groups. However, Group A (96%) had significantly higher cVEMP abnormality than Group B (65%).

Conclusions: In patients with VOR loss, oscillopsia may occur depending on whether compensatory eye movements arise or not. In such condition, presence of cVEMP, but not oVEMP, may help compensate VOR loss via cervico-ocular reflex.

OP01-2 - Ocular and cervical VEMPs to air conducted sound and bone conducted vibration in Meniere's Disease

7. Clinical Testing for Vestibular Function

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Purpose: In definite Meniere's Disease, to investigate Air Conducted Sound and Bone Conducted Vibration results in cervical evoked myogenic potentials recorded over contracted SCM and ocular evoked myogenic potentials recorded beneath both eyes while the subjects is looking up

Methods: 50 definite Meniere's Disease were tested at MSA ENT clinic in Cassino (Italy) using a handheld Bruel & Kjaer 4810 minishaker for BCV stimulation. Surface EMG electrodes beneath both eyes were used, to record oVEMP n10 and over SCM, to record cVEMP p13-n23. The stimulus BCV at Fz of the skull were tone bursts at 500 Hz, the stimulus ACS were tone bursts at 500 – 750 and 1000 Hz. 40 healthy subjects were tested in the same paradigm.

Results: In 50 patients with Meniere's Disease, the n10 responses to ACS and Fz BCV showed results that appear to show dissociation between ACS and BCV stimulation. In response to ACS stimuli MD patients showed aberrant results; i.e. in some patients there was no detectable oVEMP n10 to 500Hz ACS, although oVEMP n10 was clearly present to 500Hz Fz BCV stimulation. ACS p13 – 23 to 500 Hz – 750 Hz – 1000 Hz are absent or reduced over the ipsilateral SCM. This may reflect a change in frequency tuning to ACS stimuli since the n10 to ACS stimulation was absent to 500Hz but present to 750Hz (mainly) or 1000 Hz.

Conclusions: The dissociation between the results to BCV as opposed to ACS stimulation may be due to changes in the endolymph volume. **These results are due also to different route of stimulation.**

OP01-3 - Eliciting ocular VEMPs by first order bone vibration and second order resonance effect

7. Clinical Testing for Vestibular Function

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Purpose: This study investigated ocular vestibular-evoked myogenic potential (oVEMP) tests via Fpz and Fz taps to assess the role of the frontal sinus in mediating oVEMP elicitation.

Methods: Forty healthy subjects and 80 patients with Meniere's disease (MD) underwent a series of oVEMP tests via a minishaker tapping at the Fpz and Fz sites in a randomized order. Response rates of oVEMP test via various tapping sites were compared. Dimensions of the frontal sinus were measured via CT scan.

Results: A significantly negative correlation between the age and height of the frontal sinus was noted, and the cutoff age for discriminating present and absent Fpz oVEMPs in MD patients was 52 years. Additionally, oVEMPs by Fpz tapping were more efficiently presented in males than females, likely because of greater resonance by the larger height of the frontal sinus in males (3.88 ± 0.68 cm) than females (3.42 ± 0.67 cm).

Conclusions: The height of the frontal sinus acts in mediating the elicitation of oVEMPs. The oVEMPs could be easily elicited by the first order bone vibration (Fpz/Fz tapping) coupled with the second order resonance effect (a high extent of frontal sinus). Thus, initial tapping at the Fpz site is suggested. If it fails, try the Fz site for screening the oVEMPs.

OP01-4 - Temporal Dynamics of Eye Movements Elicited by Combined Otolith and Semicircular Canal Stimulation

26. Vestibular Prosthesis

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Purpose: Efforts to develop a vestibular prosthesis have primarily focused on stimulation of the SCCs; however, the otolith end organs encode head movements with different kinematics and different temporal dynamics. We examined the temporal dynamics of eye movements evoked by individual and combined stimulation of electrodes in SCCs and otolith end organs.

Methods: We fit three chinchillas with head posts and binocular scleral coils for tracking 3D eye movements. We implanted a polyimide vestibular electrode array with 26 otolith and 24 SCC contacts into the left ear. Bipolar current pulses were delivered while the animals were kept still in dark, driving electrically evoked eye movements. Eye movements were recorded during a constant pulse train (encoding a virtual static tilt) delivered via multiple electrode configurations.

Results: The temporal dynamics to reach the final ocular counter-roll position during a virtual static tilt depended on location of the stimulating/reference electrodes. Stimulation with a otolith/distant reference combination resulted in quick onset of eye movement (consistent with the SCCs' high pass characteristic). Otolith/near reference stimulation resulted in a slower rise-time to final ocular counter-roll position (consistent with the otolith's low pass characteristic). Combining SCC and otolith stimulation resulted in an eye response like that of a mechanical static head tilt in a normal animal.

Conclusions: Responses differed in temporal dynamics for SCC and otolith stimulation. These results indicate that semi-selective prosthetic stimulation of the otolith end organs is possible and

that it may be necessary to restore sensation of low frequency head motion and static tilts.

OP01-5 - Altered soleus VEMP may be a prognostic marker of progressive spinal cord damage

7. Clinical Testing for Vestibular Function

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Purpose: Human T-cell leukemia virus type 1 (HTLV-1) infection causes a spastic paraparesis in around 5% of the HTLV-1-asymptomatic carriers. The purpose was to prospectively investigate the postural reflex of HTLV-1-infected individuals.

Methods: VEMP recorded from the soleus muscle (Soleus-VEMP) triggered by galvanic stimulation (duration: 400ms; intensity: 2mA) was annually applied for three consecutive years in 16 patients with definite HTLV-1-associated myelopathy (HAM), 22 with non-definite (oligosymptomatic) HAM and 20 HTLV-1-asymptomatic carriers. Galvanic stimulation was used to trigger the postural reflex through the vestibulospinal tract. The stimulus was applied in the mastoid processes and VEMP was recorded in the soleus muscle. The outcome analyzed was a changing in Soleus-VEMP from normal to altered.

Results: At baseline, 30% of the HTLV-1-asymptomatic carriers showed altered soleus-VEMP comparing to 55% in non-definite HAM and 75% in definite HAM ($p=0.03$). After a follow-up of three years, altered soleus-VEMP was 80% in the HTLV-1-asymptomatic carriers, 95% in the oligosymptomatic and 100% in HAM ($p=0.26$). The comparison of Kaplan-Meier survival curves between groups showed no statistical difference ($p=0.13$).

Conclusions: High prevalence and incidence of postural reflex alteration were found not only in patients with HAM, as expected, but more importantly, in HTLV-1-asymptomatic carriers, indicating sub-clinical impairment of spinal cord function. These results indicated a considerable portion of HTLV-1-asymptomatic carriers that are classified as normal despite of a subclinical impairment of neurological function. The follow-up will clarify the risk of the asymptomatic carriers with altered soleus-VEMP to progress to definite HAM. The subclinical diagnosis of the myelopathy has therapeutic implications.

OP01-6 - The clinical significance of waveform morphology in OVEMP testing

7. Clinical Testing for Vestibular Function

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Purpose: The OVEMP is a very delicate low amplitude reflex. Normal subjects have normal OVEMP amplitudes and latencies, but also very well-defined wave morphology. Some patients have “normal” OVEMP parameters but poor waveform morphology, where OVEMPs have an identifiable peak and trough but these are not well defined. We wondered what the meaning was of poor waveform morphology and wondered if it is clinically relevant. We hypothesize that the utricle (i.e. a loosely fixed vibration sensor) may be susceptible to decelerative trauma or other insult. Since the OVEMP is generated by a properly functioning utricle, it follows that a dysfunctional utricle may be able to produce a waveform, but poor morphology due to insult and normal latency. One difficulty with reporting OVEMP amplitudes is that there is a floor effect; there is no such thing as a “low amplitude”. We wondered if trauma to the otolith might prevent proper generation of the waveform. It follows that poor waveform morphology might be a significant observation (regardless of other measured parameters).

Methods: We compared OVEMP results in three groups; patients who had suffered trauma, “regular” vestibular patients, and normal controls. We defined what we called “poor morphology” of OVEMPs,

and we looked at the rate of poor morphological waveforms in each group.

Results: It appears that (as is the case with caloric testing) poor morphology does not infer any difference in clinical disease

Conclusions: poor waveform morphology may represent a clinically significant finding but this significance is as yet not understood.

OP01-7 - The effects of different sound stimuli when performing OVEMPs

7. Clinical Testing for Vestibular Function

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Purpose: We hypothesized that OVEMP reflexes generated by a sound stimulus represent an aphysiological supramaximal intermittent nonspecific response of the maculae of the inner ear to sound stimulation. Care in interpreting results from vibration and sound stimulation has to be undertaken, as the differing results means that with any particular type of stimulus, normative data must be established.

Methods: We used different sound stimuli when performing OVEMPs. Assuming that the supramaximal response is universal, use of sound stimuli at different frequencies, .25, .5, .75 and 1.0 KHz should produce identical responses.

Results: This hypothesis was tested and failed. There was variation in amplitude and latency with respect to the different frequency stimulations at the same decibel loudness.

Conclusions: The physical stimulus for vibration is much stronger than direct cochlear stimulation in terms of energy, and not surprisingly vibration VEMPs are frequently recorded while sound VEMPs are abnormal. The absence of sound VEMPs in a patient with symptoms probably is clinically significant, and caution in inferring that because vibration VEMPs are normal, abnormal sound VEMPs can be

ignored. As always, a pathological finding (more than two standard deviations from the normal by any technique) is significant, a normal response does not mean nothing wrong, and the diagnosis of disease depends on the history.

Variation of response indicates that the maculae responds to strong stimulus and is specific to the stimulus. The organ does not respond as a whole but vibrates variably depending on the stimulus and the neural responses are consistent and specific.

OP02: Superior Canal Dehiscence Syndrome

OP02-1 - Cervical and ocular VEMPs to 4000Hz show Superior Semicircular Canal Dehiscence

19. Superior Canal Dehiscence Syndrome

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Purpose: In patients with CT-verified SSCD and in patients with definite Meniere's Disease (MD) to investigate the effect of frequency on the n10 component of the ocular vestibular-evoked myogenic potential (oVEMP n10) and on the p13-n23 component of the cervical vestibular-evoked myogenic potential (cVEMP p13-n23) evoked by air conducted sound (ACS) and bone conducted vibration (BCV) at the midline forehead at the hairline (Fz).

Methods: A hand-held Bruel & Kjaer 4810 minishaker provided BCV stimulation and surface EMG electrodes beneath both eyes recorded oVEMP n10 and over SCM recorded cVEMP p13-n23. The stimulus ACS and BCV at either Fz or at the vertex of the skull (Cz) were tone bursts at 500Hz or 4000Hz with a short rise time (ramp). 27 healthy subjects were tested in the same paradigm.

Results: In response to ACS and Fz BCV at 500 Hz and 4000 Hz in 27 CT-verified SSCD patients the

oVEMP n10 beneath the contraSSCD eye was present and the cVEMP p13 – n23 over the ipsiSSCD sternocleidomastoid muscle was also present. In contrast in normals and Meniere's Disease patients neither oVEMPs or cVEMPs to 4000Hz are present with either ACS or Fz BCV.

Conclusions: Testing cVEMP and oVEMP with high frequency ACS or BCV allows very simple, very fast identification of a probable unilateral SSCD in a manner which is very easy even for junior and senior patients and testing only uses two frequencies, 500 Hz and 4000 Hz.

OP02-2 - Efficacy of vestibular function tests post-canal plugging for superior canal dehiscence syndrome

19. Superior Canal Dehiscence Syndrome

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Purpose: Dizziness and balance dysfunction is expected temporarily after surgically plugging the superior canal as a treatment for superior canal dehiscence syndrome (SCDS). However, some patients experience residual symptoms even months after surgery. Our aim was to assess the efficacy of vestibular function tests in evaluating surgery outcomes.

Methods: We retrospectively reviewed six patients with residual symptoms after canal plugging surgery. Subjects underwent audiometry, cVEMPs, oVEMPs, vHIT as well as MRI with reconstruction of the superior canal.

Results: MRI imaging demonstrated a persistent dehiscence post-operatively for all six patients. Five subjects with pre-operative air-bone gaps still had air-bone gaps post-operatively. Low threshold cVEMP present in all six ears pre-operatively normalized in four. VEMP asymmetry ratios could only be assessed in three patients with unilateral SCDS. For these three subjects, the cVEMP asymmetry ratio range dropped from 32-45% pre-operatively to

10-21% post-operatively. In the one subject with pre- and post-operative oVEMPs, the asymmetry ratio dropped from 41% to 1%. Four subjects had post-operative vHITs; two had normal gain (0.81 and 0.83) and two abnormal (0.41 and 0.46).

Conclusions: VEMP thresholds and asymmetry ratios often normalize even after incomplete canal plugging. The vHIT results are also not representative of surgery outcomes. The measure that was consistently abnormal after an incomplete plugging surgery was the air-bone gap on the audiogram; however, other studies have demonstrated that the air-bone gap often persists even with successful plugging surgery. Patient complaints and MRI appear to be the best way to assess the outcomes of SCD repair surgery.

OP02-3 - Heterogeneity in Reported Outcome Measures after Surgery in Superior Canal Dehiscence Syndrome

19. Superior Canal Dehiscence Syndrome

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Purpose: To assess available evidence on the comparative effectiveness and risks of different surgical treatments for superior canal dehiscence syndrome (SCDS), regarding: (1) symptom improvement; (2) objectively measurable auditory and vestibular function; (3) adverse effects; (4) length of hospitalization.

Methods: A systematic search according to PRISMA statement was conducted on Pubmed, Embase, and Cochrane library. Reference lists were searched. Retrospective and prospective cohort studies were included when they investigated the association

between a surgical treatment method and the relief of vestibular and/or auditory symptoms. Only studies including quantitative assessment of the pre- to postoperative success rate of a surgical treatment method were included. Case reports, reviews, meta-analysis, and studies not published in English, Dutch, or German were excluded.

Results: Seventeen studies (354 participants, 367 dehiscences) were grouped according to surgical approach. Seven combinations of surgical approaches were identified: plugging, resurfacing, or a combination of both through the middle fossa (middle fossa approach); plugging, resurfacing, or a combination of both through the mastoid (transmastoid approach); round window reinforcement through the ear canal (transcanal approach). Several studies showed high internal validity, but quality was often downgraded due to study design. Outcome measures and timing of postsurgical assessment varied among studies, making it unfeasible to pool data to perform a meta-analysis.

Conclusions: A standardized protocol including outcome measures and timeframes is needed to compare the effectiveness and safety of SCDS treatments. It should include symptom severity assessments and changes in vestibular and auditory function before and after treatment.

OP02-4 - Management of hearing and balance problems in SCDS

19. Superior Canal Dehiscence Syndrome

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Purpose: SCDS is a disorder with varying symptoms. The management is complicated by the need to offer the patient a realistic outcome with either conservative or surgical measures.

Methods: In our prospective, non-randomized series, 52 patients (31 female, 21 male, average age 48.8 yr) with radiologically confirmed SCDS were counselled, 41 agreed to undergo a surgical therapy. The surgical therapy consisted of canal occlusion via a

transmastoid approach. In addition, all patients were given a hearing implant (CI or VSB) for auditory rehab. The patients were followed up for 14 months (6 – 24 months) on average (DHI, neurotological testing- c/oVEMPs, excentric rotation, HIT and PTA).

Results: A positive outcome (n = 28, i.e. significant improvement in DHI, normalisation of cVEMP thresholds) was correlated to the severity of vertigo preoperatively, to the parallel implantation of a CI, to the age at implantation (younger than 45 yrs).

A negative outcome (n = 13; i.e., non-significant improvement in DHI, no normalization of cVEMP thresholds) was correlated to the co-morbidity of vestibular migraine and/or Menière's disease, the bilateral occurrence of SCDS, SCDS defect size (larger than 4 mm), old age (55 yrs). In those 13 patients, 5 were revised which significantly improved the DHI outcome and led to a normalization of cVEMP amplitudes.

The 10 patients who declined surgery were treated by antivertiginous drugs, which lead to a reduction of vertigo, but no significant improvement in DHI.

Conclusions: In essence, canal occlusion in SCDS can be highly effective when considering co-morbidity and adding hearing implants for auditory rehab.

OP02-5 - Skull vibration induced nystagmus in patients with unilateral semicircular canal dehiscence

19. Superior Canal Dehiscence Syndrome

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Purpose: bone conducted vibration applied to the mastoid in severe unilateral vestibular loss (SUVL) patients usually elicits a skull vibration induced nystagmus (SVIN) beating away from the affected side. In unilateral superior semicircular canal dehiscences (uSCD) SVIN beats *toward* the affected side. This study sought to establish the optimum stimulus frequency and location for these populations.

Methods: SUVL (n = 18); superior semicircular canal (SCD) patients (n= 40; 27 unilateral, 13 bilateral). The control group consisted of 11 cases.

Results: In SUVL, SVIN was always beating away from the lesion side and the optimal frequency was 100Hz for the horizontal and torsional components VIN-SPV. In uSCD SVIN beat toward the lesion side in 92%, a wider range of frequencies elicited SVIN (up to 800Hz) with optimal frequency being around 500Hz. In SUVL mastoid stimulation was significantly more efficient than vertex stimulation at 60 and 100Hz [$p<0.01$]. Conversely in uSCD SVIN SPV was significantly higher on vertex stimulation at 100 and 300Hz [$p=0.04$]. A VIN was significantly more often observed in uSCD than bSCD [$p=0.009$] and with a higher SPV [$p=0.008$]. In SUVL the optimal frequency is 100Hz and SVIN beats toward the intact side. In uSCD,

Conclusions: SVIN beats toward the lesion side with a greater sensitivity to higher frequencies. Vertex stimulations are more efficient in uSCD than in SUVL. SVINT reveals instantaneously a characteristic VIN and acts as a vestibular Weber test. It is more sensitive to reveal uSCD than bSCD. SVIN test should be considered as a useful indicator for uSCD diagnosis.

OP02-6 - Spontaneous plugging of superior canal: two possible natural evolutions of an unstable dehiscence

19. Superior Canal Dehiscence Syndrome

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Purpose: Besides third-mobile window symptoms/signs, superior canal dehiscence (SCD) can lead to unusual clinical pictures. As well as asymptomatic patients, Ménière-like attacks have been occasionally described though poorly explained. Moreover, while surgical occlusion of superior canal (SC) in symptomatic patients generally induces transient vestibulo-cochlear symptoms with a selective SC hypofunction, loss of SC function in patients with wide-sized dehiscence and poor symptomatology can be sporadically detected. A natural canal plugging by middle fossa dura (MFD) has been offered as possible interpretation for the latter scenario. We aimed to explain acquired spontaneous SC hypofunction with two possible theories.

Methods: Among patients who were followed-up for SCD, we reviewed clinical records of 3 cases who developed spontaneous impairment of SC function on video head impulse testing (vHIT) over time (mean follow-up 106 months). Audiometric, video-oculographic, vibratory, vHIT e VEMPs data were compared with post-operative (PO) findings of patients undergoing SC occlusion.

Results: While in 1 case progressive reduction of symptoms was reported, 2 patients developed recurrent vertigo spells (with auditory symptoms in 1 case) and spontaneous nystagmus similarly to surgical patients during the first PO days. Pure tone average impaired in 1 case. Unlike surgical patients, cervical- and ocular-VEMPs remained abnormal. In 2 cases vibratory nystagmus was mainly horizontal similarly to PO findings.

Conclusions: We hypothesized that, in particular cases with “unstable” wide-sized dehiscence, MFD may either slowly progressively occlude the dehiscence canal without causing symptoms or lead to partial and recurrent canal plugging. This event may induce a transient labyrinthine hydrops, similarly to PO findings.

OP02-7 - The diagnostic value of vestibular evoked myogenic potentials in superior canal dehiscence syndrome

19. Superior Canal Dehiscence Syndrome

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Purpose: Superior canal dehiscence syndrome (SCDS) shows several idiosyncrasies at vestibular evoked myogenic potentials (VEMP). Specific SCDS markers at VEMP testing have assumed a major role in the SCDS diagnostic work out. Here, we sum up the conclusions of different studies on the VEMP diagnostic accuracy for SCDS conducted at our department in the last decade.

Methods: SCDS markers at VEMP have been investigated in case-control and cohort studies in different conditions: cervical (cVEMP) and ocular VEMP (oVEMP) in response to stimuli at near and suprathreshold levels, with frequency specific or wide band configurations, and delivered with air (AC) or bone (BC) conducted modalities.

Results: VEMP amplitude in response to AC stimulation showed the best diagnostic properties as SCDS marker. At suprathreshold stimulations, oVEMP is superior to cVEMP and AC oVEMP is better than BC oVEMP, particularly in terms of SCDS sensitivity. A better diagnostic accuracy is however obtained with VEMP at near threshold stimulation levels, also here in terms of response amplitude and better for AC VEMP. Moreover, at threshold levels a specific SCDS showed a specific frequency tuning, which can further differentiate this syndrome from other conditions.

Conclusions: VEMP, especially in terms of response amplitude at near threshold AC stimulation, is a valid SCDS marker. This is of clinical relevance considering the variable presentation of other SCDS clinical key features and the suboptimal diagnostic accuracy of the radiological investigations.

OP03: Spatial orientation

OP03-1 - Hearing & postural control: what is the impact of hearing loss and what role can hearing aids play?

18. Spatial Orientation

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Purpose: This study determined the effect of spatial hearing/sound on the postural control of normally hearing, hearing-impaired and vestibular-impaired subjects. We also examined the role of hearing aids in the hearing-impaired subjects.

Methods: Centre of pressure analysis was used to measure the effect of sound on the postural sway of 50 normally hearing subjects, 28 hearing impaired subjects and 19 subjects with vestibular dysfunction. Subjects were asked to stand still for 60 seconds in various acoustic environments that utilised sound cues that were either present or absent. Hearing-impaired participants who were fitted with hearing aids were assessed with and without their hearing aids on.

Results: Sound cues facilitated postural control in normally hearing subjects. This ability was diminished in the hearing-impaired subjects, but appeared to be overcome with the use of a hearing aid. Patients with additional vestibular deficits exploited auditory cues to a greater degree, suggesting that a sensory re-weighting to enhance the use of auditory cues may be applied when there is diminished sensory redundancy.

Conclusions: People with balance problems are best to enrich their environments with sound cues and maximise their audible hearing to better maintain their balance. As the risk of falls and hearing impairment increase with age, the benefit of hearing aids in improving stability is appealing when considering the substantial disability, mortality and socio-economic burden of falls in the elderly.

OP03-2 - Towards a clinically useful test for vestibular perception

7. Clinical Testing for Vestibular Function

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Purpose: Clinical vestibular testing mainly consists of testing reflexes like the vestibulo-ocular reflex and the vestibulo-collic reflex. However, this type of testing does not always detect perceptual symptoms. Objective of this study was to propose a clinically useful test for vestibular perception, to investigate its age-related normative values and to compare these with the normative values of other known perceptual tests.

Methods: Fifty-five healthy subjects were included. Vestibular perceptual thresholds were measured using the MOTTEK platform in dark. The subject had to report the correct type and direction of movements. The platform delivered twelve different movements: six translations (forward, backward, right, left, up and down) and six rotations/tilt (yaw left, yaw right, pitch forward, pitch backward, roll left and roll right). A staircase paradigm was used for threshold detection. This test involved shorter testing times and continuous communication between subject and researcher, compared to perception tests performed in previous studies.

Results: Age significantly increased perceptual thresholds for all movements. Gender did not have a significant influence. Within the translations, significantly different thresholds were found between forward-backward translations and translations up-down. Within rotations, significantly different thresholds were found between yaw-rotations left-right and both pitches forward-backward and roll left-right.

Conclusions: The results of this faster and more patient friendly test for vestibular perception showed comparable results to more research oriented tests regarding age-related influences. This opens up new perspectives in examining vestibular perception in clinic.

OP03-3 - The role of vection and velocity storage in visually induced motion sickness

18. Spatial Orientation

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Purpose: Full-field visual rotation around the vertical axis induces a sense of self-motion (vection), optokinetic nystagmus (OKN), and, eventually, also motion sickness (MS). If the lights are suddenly switched off, optokinetic after-nystagmus (OKAN) occurs. This is due to the discharge of the velocity storage mechanism (VSM), a central integrative network that has been suggested to be involved in motion sickness. We previously showed that visually induced motion sickness (VIMS) following optokinetic stimulation is dependent on vection intensity. To shed light on this relationship, the current study investigates whether vection intensity affects VSM activity, and thus, the OKAN.

Methods: In repetitive trials (8 per condition), 15 participants were exposed to 120s of visual yaw rotation (60 deg/s), followed by 90s in darkness. The visual stimulus either induced strong vection (i.e., scene rotating normally) or weak vection (central and peripheral part moving in opposite directions). Eye movements and subjective vection intensity were continuously measured.

Results: OKAN occurred less frequent and with lower initial magnitude in the weak-vection condition as compared to the strong-vection condition. Decay time constants were not significantly different.

Conclusions: The results suggest that the occurrence of vection enhances the charging of the VSM. As VSM activity has been found to be a factor in

motion sickness, the enhanced VSM activity in our strong vection condition could explain why visual stimuli producing a strong sense of vection also elicit high levels of motion sickness.

OP03-4 - The role of temporo-parietal cortex in upright perception and the link with torsional eye position

18. Spatial Orientation

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Purpose: Upright perception is a key aspect of orientation constancy, as we maintain a stable perception of the world despite continuous movements of our eyes, head and body. Torsional position of the eyes can impact perception of upright by changing orientation of the images on the retina relative to gravity. Here we investigated the role of temporo-parietal cortex in upright perception with respect to ocular torsion, by means of the inhibitory effect of continuous theta burst transcranial magnetic stimulation (TMS).

Methods: We used a subjective visual vertical (SVV) paradigm to track changes in upright perception, and a custom video method to track ocular torsion simultaneously. Twelve participants were tested during lateral head tilt of 20° to the left.

Results: TMS at the posterior aspect of the supramarginal gyrus (SMGp) resulted in an average SVV shift in the opposite direction of the head tilt compared to sham stimulations (1.8°). Ocular torsion following TMS at SMGp showed no significant change compared to sham stimulations (-0.1°). Thus, changes in upright perception at SMGp was dissociated from ocular torsion.

Conclusions: This finding suggests that perception of upright at SMGp is primarily related to processing sensory inputs, as opposed to subcortical regions that have direct influence over ocular torsion.

OP03-5 - Spatial navigation, sense of direction, and vestibular function in young deaf individuals

18. Spatial Orientation

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Purpose: Literature suggests that vestibular impairment impacts visuo-spatial and cognitive functions, including spatial navigation and mental imagery. Hearing loss, and potentially acquired vestibular dysfunction, has been linked to cognitive decline in older adults, but spatial and cognitive abilities of young deaf adults, who are likely to have vestibular dysfunction, has not been studied. This study examines young deaf adults' navigational abilities and perceived sense of direction in relation to their vestibular and balance functions.

Methods: Young adults, ages 18-36 years, with hearing levels greater than 50dBHL in the better ear, and with normal middle ear function (Jerger Type A tympanogram), have been included. All reported either congenital or childhood onset of deafness. Navigational ability was assessed through an object-finding task in a virtual reality first-person avatar maze. Sense of direction was assessed with the Santa Barbara Sense of Direction Scale (SB-SOD). Hearing levels, vestibular function status (vHIT, VEMP, modified Clinical Test of Sensory Integration of Balance, Activities-specific Balance Confidence Scale [ABC]), and language use (spoken vs. sign) were obtained.

Results: Virtual reality maze completion time was negatively correlated with otolithic functions (VEMP thresholds) and with self-reported sense of direction (SBSOD). Self-reported confidence in balance (ABC) was correlated with SBSOD.

Conclusions: Results suggest a strong relationship between otolithic function, sense of direction, and the ability to efficiently locate objects in a VR maze, in a group of young deaf individuals. Otolithic impairment may hinder development of route-learning abilities in deaf individuals.

OP03-6 - Functional and mechanistic link between sensory cue integration and self-motion perception

18. Spatial Orientation

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Purpose: Navigating our environment successfully requires the ability to integrate multi-sensory cues, which in-turn facilitates appropriate self-motion perception. Despite advances in the macaque monkey, the neural mechanism underpinning multi-sensory cue integration in humans remains largely unknown. Considering the specific topic of how much we rely on visual as opposed to vestibular cues during sensory integration (i.e. visual dependence), two hypotheses can be constructed: it may reflect either the level of visual cortex excitability, or alternatively, reduced vestibulo-cortical dominance.

Methods: Accordingly, we explored the relationship between, (i) visual cortical excitability - assessed using transcranial magnetic stimulation (TMS)-induced phosphenes and, (ii) vestibulo-cortical dominance - assessed using a measure of vestibular-nystagmus suppression following transcranial direct current stimulation over the parietal cortex – with the degree of visual dependence during a sensory integration task.

Results: We observed that visual dependence was unrelated to either the early (V1/V2) or late (V5/MT) visual cortex excitability, however was related to the degree of vestibulo-cortical dominance. We proceeded to assess the functional significance of vestibulo-cortical dominance upon vestibular-behaviour by assessing the time taken to experience self-motion during opto-kinetic stimulation. We observed that the degree of visual dependence was correlated with the time taken to experience circular-vection.

Conclusions: Utilising a multi-method approach, we demonstrate that vestibulo-cortical dominance functionally and mechanistically link sensory integration and self-motion perception, two fundamental components that mediate human spatial orientation.

OP03-7 - A Computational Model of Self-Motion Perception and Vestibular Cognition

18. Spatial Orientation

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Purpose: Numerous studies in vestibular patients and healthy participants have demonstrated that sensory information provided by the vestibular system is involved in cognitive processes such as mental rotation, body representation, numerical tasks and affective control. Despite these interesting empirical findings, the underlying mechanisms are not well understood. The key to a better understanding of vestibular involvement in cognition is to consider the probabilistic computations performed by the vestibular system, rather than focus solely on the sensory signals.

Methods: We use a probabilistic model capable of processing sequential vestibular data. This model is a dynamic latent variable model, in which the latent variables represent the dynamics of the head. The same model can be applied when movement of the head is due to an external disturbance (passive), or when the movement is self-initiated (active). Besides information obtained via efference copy, our model can incorporate knowledge from multiple sources, including higher-level knowledge to predict the dynamics of the latent variables.

Results: Cognitive tasks (e.g., perceptual decision-making, meta-cognitive evaluation in self-motion perception, mental rotation of self-motion) use the probabilistic model with higher-level knowledge. For example, imagined self-motion is performed by running a Monte Carlo sampling algorithm; this amounts to sampling from the prior. Not only do the simulations serve to demonstrate that cognitive mechanisms are part of sensory inference, but they can also explain impaired self-motion perception in vestibular patients.

Conclusions: Mechanisms used for sensory inference are used in offline operations. By investigating interactions between online and offline usage we can better conceptualize the vestibulo-cognitive interplay.

OP04: Traumatic Brain Injury

OP04-1 - Benign Paroxysmal Positional Vertigo in acute traumatic brain injury

20. Traumatic Brain Injury

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Purpose: Benign paroxysmal positional vertigo (BPPV) is a common vestibular disorder following traumatic brain injury (TBI). Previous studies evaluating type and frequency of BPPV in TBI have been limited to the sub-acute population, or have employed dizziness screening tools prior to study inclusion. Currently there is no data pertaining to the frequency and type of BPPV in acute TBI. This prospective observational study aimed to provide such data.

Methods: Patients at a major trauma centre (St Mary's Hospital, London, UK) were screened for a prospective study evaluating markers of balance recovery in TBI. Patients meeting the inclusion criteria were assessed using a standardised neuro-otological examination. Details pertaining to BPPV frequency, type and treatment rates were recorded.

Results: 359 acute TBI patients were screened. Of those 359 patients, 42 were assessed for inclusion in the study. 52% of 42 patients (22) had a positive Dix-Hallpike test (Mean age 47±17 years; 68% Male). All patients had posterior canal BPPV, 86% had unilateral BPPV whilst 14% had bilateral BPPV. Critically, just over a third of patients did not complain of vertigo symptoms prior to the diagnosis, or during diagnostic or treatment manoeuvres.

Conclusions: Our data is the first to demonstrate the frequency and type of BPPV in acute TBI. Higher rates of BPPV were noted among our sample in comparison to previous data. Given that over 50% of patients were diagnosed with BPPV and a significant number did not complain of vertigo, we recommend a screening approach be utilised in all TBI patients.

OP04-2 - Concussion Balance Test: Assessment and Treatment Effectiveness After Sports Related Concussion

20. Traumatic Brain Injury

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Purpose: The Concussion Balance Test (COBALT) is an eight-condition postural control measure that assesses high-level balance skills necessary to successfully and safely return to play, with conditions 7 and 8 (C7 and C8) challenging these systems through a headshake (C7) and visual motion sensitivity (C8) task on a foam surface. The purpose of this study was to explore the utility of COBALT to assess treatment progress in a concussed athlete population

Methods: Subjects (age 10-25) were 84 concussed adolescent athletes (mean age = 15) referred for treatment of vestibular dysfunction at an outpatient concussion clinic, and 132 uninjured athletes (mean age = 14.8) who presented for baseline assessment. Postural control was assessed via COBALT at the initial visit (median = 13 days from time of injury) and at the conclusion of treatment for concussed athletes, and at one time point (pre-season screening) for uninjured athletes.

Results: Comparison of pre- to post-treatment data in concussed athletes revealed a positive effect for the most complex conditions (C7, C8). For C7, a significant improvement in sway scores was observed from initial to final assessment ($t=3.63$, $p<0.01$). Sway scores for C8 also improved substantially ($t=6.25$, $p<0.01$). Following treatment completion, the concussed group demonstrated significantly better sway scores than non-injured athletes for C7 ($t=3.63$, $p<0.001$), and demonstrated similar sway scores to the control sample in C8 ($p>0.05$).

Conclusions: COBALT is a useful measure to evaluate dysfunction and recovery of postural control in athletes following sports related concussion.

OP04-3 - Does the Vestibular/Ocular Motor Screening (VOMS) Tool Predict Recovery in Collegiate Athletes?

20. Traumatic Brain Injury

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Purpose: Following sport-related concussion (SRC), it is common for athletes to experience vestibular and/or oculomotor impairments and symptoms. The Vestibular/Ocular Motor Screening (VOMS) is a screening tool that evaluates vestibular and oculomotor symptom provocation and impairment following SRC. Research has yet to explore which components of the VOMS predict recovery time following SRC. The purpose was to determine if a total VOMS symptom score predicts recovery time, and determine if the individual VOMS component scores are better at predicting recovery time than the total score.

Methods: Division I and II collegiate student-athletes (n=68) with restricted participation post-injury completed self-reported demographic and medical history and the VOMS at preseason physical examinations. Variables reported to be significant univariate predictors of recovery were used to develop a Cox proportional hazards model with hazard ratio (HR) to identify the VOMS scores associated with recovery time. VOMS scores that optimally predicted recovery time for initial and multiple injuries were identified with Receiver Operating Characteristic (ROC) Area Under Curve (AUC) analysis.

Results: The likelihood of recovery after concussion at any time point was associated with VOMS vertical vestibular ocular reflex testing (VOR-V, HR = .94, P = .002) and total headache (HA) score (HR = 0.98, P = .006). Recovery at 7 and 14 days after injury was optimally predicted by VOR vertical

score (cut point < 3 points) and total HA score (cut point \leq 16 points).

Conclusions: Visual motion sensitivity, VOR-vertical and total headache symptom scores are key components of the VOMS for clinicians to consider in the prognosis of collegiate student-athletes following concussion.

OP04-4 - Is it clinically feasible to run a multi-modal battery of tests in a virtual reality goggle?

20. Traumatic Brain Injury

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Purpose: Comparison of oculomotor, vestibular, and reaction time (OVRT) test results using the clinical stationary Neuro Otologic Test Center (I-Portal® NOTC) vs. Portable Head Mounted Goggle with 3D Display and Integrated Eye Tracking System (I-PAS™).

Methods: A battery of OVRT tests were run using stationary and portable systems including: saccade horizontal and vertical; smooth pursuit horizontal and vertical; gaze horizontal and vertical; optokinetic; subjective visual vertical and horizontal. A total of 82 variables were evaluated using Bland-Altman and Deming regression methods. Participants consisted of 69 controls and four mTBI subjects. All subjects were tested on both systems. Test sequence order was randomized, with 49% tested on NOTC first, 51% tested on I-PAS first.

Results: The effect of gender, age, and sequence of tests and assessment of Slopes and Biases were evaluated. It was determined that gender, age, or sequence of tests had no effect. The Bland Altman and Deming regression results demonstrated significant

agreement between variables using the stationary NOTC system and the portable I-PAS device. No significantly different bias from zero and slope from 1 were observed for 78 variables.

Conclusions: Results and statistical analysis demonstrate that testing on the Portable Head-Mounted Goggle is equivalent to that of standard clinical stationary systems. I-PAS can successfully be used for accurate and efficient assessment of mTBI outside of the clinical environment. Note; FDA clearance for I-PAS has been obtained.

OP04-5 - Linking traumatic brain injury (TBI) severity, vestibular agnosia, and vestibular symptom load.

20. Traumatic Brain Injury

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Purpose: Dizziness and imbalance affect over 80% of TBI patients. We observed TBI patients with acute vestibular activation (e.g. BPPV) without complaint of vertigo. We hypothesised that acute TBI attenuates vertigo perception – i.e. vestibular agnosia – measured via laboratory tests of vestibular perception. This predicts (i) a non-linear change in vestibular symptom load over time; (ii) TBI severity is inversely related to vestibular symptom load acutely.

Methods: In this ongoing, prospective study, patients with a closed head injury were consented from an acute major trauma unit and were examined, completed questionnaires (vestibular symptoms, functional ability, cognition), neuro-imaging and laboratory testing.

Results: There was no significant linear relationship between symptoms and TBI severity. Vestibular perceptual thresholds (in yaw) were elevated initially

particularly in patients with low vestibular symptom scores. At three months, vestibular perception improved (lower) and symptoms increased.

Conclusions: These data support our predictions of a non-linear relationship between vestibular symptoms, TBI severity and vestibular perception. Important clinical implications include the masking of active vestibular diagnoses (e.g. BPPV) since patients may not report symptoms but still fall or manifest nausea and vomiting. This suggests that acute TBI patients should be screened routinely for vestibular dysfunction irrespective of symptoms. In conclusion, we show a non-linear, but predictable relationship between subjective vestibular symptoms and (i) TBI severity and (ii) degree of vestibular agnosia.

OP04-6 - VEMP latency predict precision of subjective visual vertical in acute traumatic brain injury (TBI).

20. Traumatic Brain Injury

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Purpose: Vestibular Evoked Myogenic Potentials (VEMPs) interrogate the integrity of otolith reflexes involving either the saccule (cervical VEMP) or the utricle (ocular VEMP). Traumatic brain injury (TBI) commonly impairs postural control and one element may be damage to the peripheral vestibular organ, or its brainstem connections controlling reflex functions. It is not known however, if the VEMP can provide a convenient marker of TBI or predict TBI-related imbalance.

Methods: In this ongoing, prospective study, patients with a closed head injury were consented from an acute major trauma unit. We assessed the subjective visual vertical (measured using a QUEST

algorithm) and VEMPs (ocular and cervical) at bedside of 6 patients so far.

Results: There was no significant difference in VEMP amplitudes or degree of asymmetry in patients versus controls and there was no link between VEMP amplitude, latency or symmetry and SVV bias. In contrast, we found a significant correlation between SVV precision and latencies for p1 (r.sq 0.41) and n1 (r.sq. 0.32) for cVEMP and also for n1 for the oVEMP (r.sq 0.79) but not for p1 oVEMP.

Conclusions: These data suggest that slowing of conduction in otolithic pathway may impair performance of the SVV (i.e. increased uncertainty of responses). Combining prospective behavioural and neuroimaging assessments may enable us to isolate the neural correlates of the observed behavioural measures. Whether these VEMP measures are associated with balance performance and tilt perception in acute TBI are as yet unknown.

OP05: Acute vertigo

OP05-1 - Acute Dizziness without Nystagmus: Incidence and Predictors of Stroke

21. Vascular Vertigo

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Purpose: The present study aimed to investigate the prevalence of stroke and clinical predictors for diagnosing stroke in acute dizziness without nystagmus where HINTS (Head Impulse, Nystagmus, Test of Skew) examination can be hardly applied.

Methods: We performed a prospective, single-center, observational study that had consecutively recruited patients presenting acute dizziness without

nystagmus who did not have an obvious causes. All patients received a constructed evaluation and brain MRIs, and patients without a definite cause further received perfusion-weighted imaging (PWI). Multi-variable logistic regression was used to determine clinical parameters to identify stroke in acute dizziness without nystagmus.

Results: The prevalence of stroke was approximately 60% in acute dizziness without nystagmus which mostly comprised posterior circulation infarctions involving the cerebellum and brainstem, and anterior circulation infarctions in some. A few patients showed hypoperfusion of the cerebellum, brainstem, or the territory of internal carotid artery on PWI without an infarction on diffusion-weighted image. The higher risk of stroke in acute dizziness without nystagmus was found in association with craniocervical pain and focal neurologic symptoms/signs.

Conclusions: Acute dizziness without nystagmus harbours higher incidence of stroke. However, bedside examination have a limitation in diagnosing strokes in acute dizziness without nystagmus. Perfusion imaging may help to identify strokes in case of unknown etiology. Associated craniocervical pain and focal neurological symptoms/signs are the useful clues for strokes in acute dizziness without stroke.

OP05-2 - False negative stroke in acute dizziness

21. Vascular Vertigo

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Purpose: To elucidate the characteristics of false negative stroke causing acute dizziness.

Methods: Among patients with acute stroke presenting with vestibular symptoms, we recruited 29 patients who showed initially negative diffusion weighted image (DWI). Patients received a constructive neurological examination including HINTS

“plus” (head impulse, nystagmus, test-of-skew plus hearing), perfusion-weighted image (PWI), and follow-up DWI. We analyzed the clinical features, anatomical location and perfusion status.

Results: Time from onset of symptoms to initial and follow-up DWI was 14.9 ± 13.2 and 79.4 ± 49.6 hours, respectively. The most frequently affected location was the lateral medulla (n=14, 48%), followed by the cerebellum (n=6, 21%), the pons (n=4, 14%), the lateral medulla and cerebellum (n=4, 14%), and the midbrain (n=1, 3%). Eleven patients showed a perfusion defect in unilateral cerebellum or lateral medulla which confirmed as acute stroke in follow-up DWI. About half of patients presented with isolated vestibular syndrome and 17 (59%) did not have any nystagmus. Although the HINTS “plus” battery identified false negative stroke with greater sensitivity (92%) than focal neurological signs (52%) or severe imbalance (48%), six patients missed by bedside examinations and three of them could be identified by only PWI.

Conclusions: Our study shows that false negative stroke in acute dizziness can occur commonly in the lateral medullary lesion. Some patients can present with isolated vestibular syndrome without nystagmus, resulting in the limited application of bedside examinations. PWI may help to identify false negative stroke in acute dizziness.

OP05-3 - Prospective evaluation of cerebral lesion localization in acute vestibular and ocular motor stroke

21. Vascular Vertigo

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Purpose: To prospectively investigate cerebral lesion localization in patients with acute isolated vertigo, dizziness or double vision due to acute stroke.

Methods: 342 adult patients submitted to the emergency room with acute vertigo, dizziness or double vision of unclear etiology were enrolled prospectively in the EMVERT trial and underwent a standardized protocol of clinical, video-oculographic and posturographic measurements as well as a MRI within 7d after symptom onset. The MRI protocol included DWI-/FLAIR-/T2-/T2*/-3D-T1-weighted sequences and a TOF-angiography. MRIs with acute DWI lesions were further processed using SPM-based algorithms for lesion mapping.

Results: In 47 of the patients the MRI indicated acute stroke (13.6%). The most frequent chief complaint was dizziness (44.7%), followed by vertigo (38.3%) and double vision (17.0%). In patients with dizziness the lesions were found mostly in the lateral PICA and SCA territories (involving the flocculus/superior vermis), and the pontomesencephalic brainstem tegmentum (involving the ocular motor centers for the pitch/role plane). Patients with vertigo frequently had lesions in the medial PICA territory (including the vermis/nodulus/uvula), the pontomedullary brainstem (involving the vestibular nuclei) and the parieto-insular vestibular cortex. Patients with double vision had pontomesencephalic and mesodiencephalic lesions. Lesion volume in patients with intratentorial strokes correlated with subjective estimation of symptoms on a visual analog scale.

Conclusions: Prospective evaluation of lesion localization in acute vertigo and dizziness showed that mostly the cerebellum was affected by strokes, with some preference towards the medial cerebellar structures associated with vertigo and lateral hemispherical structures associated with dizziness. In the brainstem pontomedullary lesions induced vertigo, pontomesencephalic rather dizziness.

OP05-4 - Spontaneous nystagmus characteristics in posterior circulation stroke

21. Vascular Vertigo

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Purpose: To characterize and compare spontaneous nystagmus (SN) characteristics in posterior circulation stroke (PCS) and acute unilateral peripheral vestibulopathy (AUPV).

Methods: Eye movement was recorded ≤ 7 days from vertigo onset with search coils in 41 PCS involving anterior inferior, posterior inferior and superior cerebellar artery (13 AICA, 17 PICA, 3 SCA, and lateral medulla (8 LM) confirmed by MRI and 20 AUPV. We determined the three-dimensional magnitude of SN velocity ($|SPV|$) with and without visual fixation in the neutral position, and on viewing ipsilesional and contralesional horizontal 20° targets.

Results: Following removal of visual fixation, $|SPV|$ increase was universal in AUPV (+4.7°/s), but variably present in AICA (+2.3°/s), PICA/SCA (+0.9°/s) and LM (+0.5°/s). On ipsilesional to contralesional horizontal gaze change, $|SPV|$ always increased in AUPV (+2.9°/s), but was inconsistent in PICA/SCA (+ 0.1°/s), AICA (-0.2°/s) and LM (-1.2°/s). Whilst no AUPV had direction changing nystagmus, this was present in AICA (15%), PICA/SCA (35%) and LM (13%). None of the AUPV had ipsilesional beating SN, though this was found in PICA/SCA (55%), AICA (15%) and LM (12.5%). SN, whether with or without visual fixation, was absent in 30% of PICA/SCA, 39% of AICA and 12.5% of LM.

Conclusions: Contrary to conventional view, removal of visual fixation can increase SN in PCS, albeit less strongly than in AUPV. SN changes variably on contralesional horizontal gaze shift, but always increases in AUPV. These findings have potential diagnostic implication and quantitative SN analysis should be further explored in future video-oculography study.

OP05-5 - Truncal Ataxia in the Differential Diagnosis of Acute Vestibular Syndrome

21. Vascular Vertigo

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Purpose: To demonstrate the utility of vestibulo-spinal signs to differentiate posterior fossa stroke from vestibular neuritis in Acute Vestibular Syndrome

Methods: HINTS protocol set a new paradigm to differentiate peripheral vestibular disease from stroke in patients with acute vestibular syndrome (AVS). The relationship between degree of truncal ataxia and stroke has not been systematically studied. We studied a group of 114 patients who were admitted to a General Hospital due to AVS, 72 of them with vestibular neuritis (based on positive head impulse, abnormal caloric tests, and negative MRI) and the rest with stroke: 32 in the posterior inferior cerebellar artery (PICA) territory (positive HINTS findings, positive MRI) and 10 in the anterior inferior cerebellar artery (AICA) territory (variable findings and grade 3 ataxia, positive MRI).

Results: Truncal ataxia was measured: grade 1, mild to moderate imbalance with walking independently; grade 2, severe imbalance with standing, but cannot walk without support; and grade 3, falling at upright posture. With HINTS protocol to our sample, we obtained 100% sensitivity and 94.4% specificity. Only those patients with stroke presented with grade 3 ataxia. With grade 2 ataxia (n = 38), 11 had cerebellar stroke and 28 had vestibular neuritis. Grade 2–3 ataxia was 92.9% sensitive and 61.1% specific to detect AICA/PICA stroke in patients with AVS, with 100% sensitivity to detect AICA stroke. In turn, two signs (nystagmus of central origin and grade 2–3 Ataxia) had 100% sensitivity and 61.1% specificity.

Conclusions: Ataxia is less sensitive than HINTS but much easier to evaluate.

OP05-6 - VOG vs MRI-All for Stroke Diagnosis of Vertigo in Emergency Departments: Cost Effectiveness Analysis

21. Vascular Vertigo

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Purpose: 4.4 million US emergency department (ED) visits occur annually for acute vertigo/dizziness (cost: 10 billion USD). Approximately 5% of these patients have strokes, yet one-third are misdiagnosed. Current care uses computerized tomography scans, despite low sensitivity. Magnetic resonance imaging (MRI) has a higher sensitivity but may increase costs. Eye movement-based bedside diagnosis accurately differentiates strokes from ear disease but requires clinical expertise. This abstract compares the cost effectiveness of VOG-guided vs. MRI-all diagnostic methods relative to current diagnostic care for ED patients presenting acute vertigo/dizziness.

Methods: One year, decision tree, cost-effectiveness analysis of diagnostic evaluation among ED patients presenting dizziness of a neuro-vestibular cause (stroke, vestibular neuritis, benign paroxysmal positional vertigo, and vestibular migraine/Menière's disease). Probability, utility, and cost parameters were determined through literature review supplemented by expert opinion. Outcomes were measured in units of cost (USD, 2016) and effectiveness (health utility ranging from 0 to 1 in quality-adjusted life years [QALYs]) to calculate incremental cost-effectiveness ratios (ICERs).

Results: Compared to current care (\$4183, 0.69), VOG-guided care incurred significantly lower cost and higher health utility (\$3683, 0.73), while the MRI-all pathway resulted in higher costs for the same health utility (\$4602, 0.69). VOG-guided care dominates both current care (ICER: -\$12,497) and MRI-all (ICER: -\$22,981) strategies, translating to 88,000 QALYs gained and >1 billion USD saved each year if routinely implemented in ED clinical practice nationwide.

Conclusions: VOG-guided diagnosis could save lives and reduce costs. Future research should focus on prospective validation of VOG-guided diagnosis and barriers to its dissemination.

OP06: Vestibular Prosthesis

OP06-1 - First-in-human Safety and Preliminary Efficacy Results for the MVI Multichannel Vestibular Implant

26. Vestibular Prosthesis

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Purpose: In rodents and nonhuman primates with bilateral vestibular hypofunction, we previously demonstrated that motion-modulated current pulses delivered via electrodes in the ampullae can partially restore the 3D angular vestibulo-ocular reflex (VOR) while partially preserving hearing. Based on those studies, we initiated a first-in-human clinical trial of continuous motion-modulated prosthetic stimulation using the MVI™ Multichannel Vestibular Implant system developed by Labyrinth Devices LLC and MedEl GmbH.

Methods: Four subjects underwent unilateral implantation; two were observed overnight and two were discharged the same day. VOR responses to 0.5-5 Hz passive head or whole-body rotation and prosthetic stimulation; pure tone and speech audiometry; and metrics of posture, gait, dynamic visual acuity and quality of life were assessed during 2-14 months of continuous MVI™ use.

Results: Electrically-evoked VOR responses typically ranged from 5-40°/s and aligned approximately with the stimulated canal for ≥ 1 electrode in each of 3 canals in each implanted ear. VOR responses were typically smaller than those for similar currents in animals, but significantly greater with motion-modulated stimulation than without. Motion perception thresholds are below VOR thresholds. Hearing sufficient for unaided communication was preserved in all subjects. At >6 mos postop, subjects 1-3 have preserved hearing except for high-frequency SNHL; at 8wks postop, subject 4 has a HFSNHL and 25dB speech reception threshold change.

Conclusions: The MVI™ system can be implanted in outpatient surgery, generates motion percepts and 3D binocular VOR responses consistent with selective stimulation of 3 implanted canals, and can be implanted with preservation of useful hearing.

OP06-2 - Multichannel Vestibular Implant Early Feasibility Study: Gait and Posture Outcomes

26. Vestibular Prosthesis

Margaret Chow¹

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Purpose: The Labyrinth Devices MVI™ Multichannel Vestibular Implant system is intended to treat severe-to-profound bilateral vestibular loss (BVL) in individuals who remain severely symptomatic despite vestibular rehabilitation by encoding head rotation information via pulsatile electrical stimulation to the vestibular afferent nerve. We investigated the efficacy of the MVI™ system on gait and balance of four study participants enrolled in the Multichannel Vestibular Implant Early Feasibility Study.

Methods: Devices were implanted in the left ears of the four participants. After onset of chronic, motion-modulated stimulation, subjects wore their MVI™ systems 24 hr/day and were evaluated at 10 time-points within 1-45 weeks after activation. We quantified performance using the Modified Romberg Test, Bruininks-Oseretsky Test Edition 2, Subtest 5 (BOT™), Timed Up and Go (TUG), Dynamic Gait Index (DGI) and gait metrics collected by a GAITRite™ system while the MVI™ system delivered either motion-modulated or constant-rate stimulation. We fit a linear mixed-effect model to quantify outcomes as functions of subject, condition (modulation vs. baseline) and time.

Results: All subjects reported improvement in activity level. BOT™ score improved compared to pre-implantation. Gait metrics did not exhibit consistent changes. DGI improved more than the clinical minimal detectable change (3.2 points) in three patients. One subject exhibited a clinically significant increase in time-to-failure during a modified Romberg test with eyes closed, standing on foam. TUG scores improved significantly ($p < 0.05$) for two of the four participants.

Conclusions: These data demonstrate that motion-modulated prosthetic input from the MVI™ system provides sensory input that may influence gait and balance in subjects with BVL.

OP06-3 - Multichannel Vestibular Implant Early Feasibility Study: Safety and Audiometric Outcomes

26. Vestibular Prosthesis

Desi Schoo¹

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Purpose: The Labyrinth Devices MVI™ Multichannel Vestibular Implant system is an investigational device which intends to continuously provide a motion-modulated electrical stimulus to unilateral afferent vestibular nerve branches driving the vestibulo-ocular reflex in patients with bilateral vestibular loss (BVL). This report aims to characterize safety outcomes, including measurements of cochlear function, in this first-in-human clinical trial.

Methods: Four participants with BVL confirmed by clinical history and caloric testing were consented and underwent implantation with the MVI™ device. We recorded safety outcomes including adverse events (AE), serious adverse events (SAE), pure-tone audiometry, and ear specific speech audiometry.

Results: Intralabyrinthine position of MVI™ electrodes near their target ampullae was confirmed in all 4 participants (MVI001-MVI004). We observed a favorable AE profile related primarily to stimulation errors. No SAE related to implantation or stimulation have been encountered.

Hearing in the implanted ear was mostly, but not completely, preserved and has remained stable up to 11 months postimplantation for MVI001-MVI003. Air conduction pure tone thresholds are within 10dBHL of pre-implantation (0.125-8kHz) in MVI001. MVI002-MVI003 retained hearing in the normal range for 125-2000Hz and exhibited a new 40-70dBHL high-frequency sensorineural hearing loss (SNHL) at 4-8kHz. At six weeks postimplantation, MVI004 demonstrated a new moderate low-frequency SNHL for range 125-2000Hz and a 75-85dBHL high-frequency SNHL from 4000-8000Hz.

Conclusions: While a larger sample size is needed for a statistically robust estimation of risk, this data demonstrates that implantation of MVI™ electrodes can be performed safely while preserving hearing to a degree sufficient to support unaided communication.

OP06-4 - Multichannel Vestibular Implant: Continuous Restoration of the Human Vestibulo-Ocular Reflex

26. Vestibular Prosthesis

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Purpose: Individuals with bilateral vestibular loss (BVL) suffer poor visual acuity during head motion, chronic disequilibrium and postural instability. Electrical stimulation of vestibular afferent neurons to partially restore the vestibulo-ocular reflex (VOR) has been effective in animal models of BVL. The Labyrinth Devices MVI™ Multichannel Vestibular Implant (manufactured by Med-El GmbH) was designed to sense 3D head motion and continuously provide artificial stimulation to the branches of the vestibular nerve to encode different components of head motion.

Methods: Four subjects with BVL were implanted in the left ear with MVI™ stimulators, with an array of electrodes inserted into each semicircular canal (SCC). An earth-vertical rotary chair provided *en bloc* sinusoidal rotations in darkness over 0.1–2Hz at 100°/s peak velocity. Additionally, head velocity waveforms were encoded via electrical stimulation with the subject's head stationary to directly observe the electrically-evoked VOR. 3D eye movements were recorded using 3DBinoc™ video-oculography goggles (Labyrinth Devices, LLC) pre-operatively, post-op/pre-activation and up to 8 weeks post-activation.

Results: Subjects activated with the MVI™ compensated to the prosthetic stimulation in ~35 min-

utes. Post-activation, all subjects reported improvements in visual and postural stability. Electrical stimulation of individual SCC branches produced conjugate 3D eye movements aligned with the intended SCC axis. Rotary chair testing produced greater VOR gains during motion-modulated stimulation than with placebo stimulation for all subjects.

Conclusions: Coupled with durable and significant subjective benefit, VOR responses measured in humans during whole-body rotation with and without motion-modulated MVI™ stimulation support the hypothesis that prosthetic vestibular nerve input effectively drives vestibulo-cerebellar VOR circuits.

OP06-5 - The vestibular implant input interacts with residual natural function

26. Vestibular Prosthesis

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Purpose: To investigate how “artificial” VI-input is integrated with residual “natural” input by the central vestibular system.

Methods: Five vestibular electrodes in 4 BV-patients implanted with a vestibular implant were available. This involved electrodes with a predominantly horizontal response and electrodes with a predominantly vertical response. Responses to predominantly horizontal residual “natural” input

and predominantly horizontal and vertical “artificial” VI-input were separately measured first. Then, inputs were combined in conditions where both would hypothetically collaborate or counteract. Each condition involved 60 cycles of 1Hz sinusoidal stimulation. Gain, asymmetry, phase and angle of eye responses were calculated.

Results: Combining residual “natural” input and “artificial” VI-input resulted in an interaction in which characteristics of the resulting eye movement responses could significantly differ from those observed when responses were measured for each input separately ($p \leq 0.0013$). In the total eye response, inputs with a stronger vector magnitude seemed to have stronger weights than inputs with a lower vector magnitude, in a non-linear combination. “Artificial” VI-input was able to significantly influence and counteract the response to residual “natural” input.

Conclusions: In the acute phase of VI-activation, residual “natural” input and “artificial” VI-input interact to generate eye movement responses in a non-linear fashion. This implies that different stimulation paradigms and more complex signal processing strategies will be required unless the brain is able to optimally combine both sources of information after adaptation during chronic use. Next to this, these findings could pave the way for using the VI as “vestibular pacemaker”.

OP06-6 - Combined stimulation of multiple canals to map a vestibular prosthesis.

26. Vestibular Prosthesis

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Purpose: Vestibular prosthesis technology is rapidly advancing, and techniques to optimize stimulation with such devices are being developed. Still, most controlled stimulation with such devices are performed by rotation in canal planes with observation of slow phase eye movement. Typically, this stimulation results in activation of single electrode arrays,

targeting the afferents of single canals. In these experiments, we performed systematic combinations of stimulations across multiple semicircular canals to see if there was a strict algebraic addition of the eye movement velocities associated with single canal stimulation.

Methods: Rhesus monkeys were unilaterally implanted with a vestibular prosthesis based on a cochlear implant. Eye movements were recorded with surgically implanted scleral coils during head restraint in complete darkness. 2s trains of fixed current amplitude and pulse frequency monopolar stimuli were used to drive slow phase eye movements. Pseudorandomly, combinations of such pulse trains were also performed to produce eye movements resulting from stimulation of 2 or more canals together.

Results: Consistent responses were evoked from either single or multiple canal stimulation. Single canal stimulation yielded eye movements that were predominately in the plane of the stimulated canal. However, combined stimulation of multiple canals did not result in the vector sum of the velocities elicited by single canal stimulation.

Conclusions: Multiple canal stimulation may produce temporal integration of activations resulting from current spread between electrodes in different canals, which are activated sequentially during combined stimulation. Programming strategies may need to take such interactions into account for optimal stimulation during natural behaviors.

OP06-7 - Electrically Evoked Compound Action Potentials in Patients with a Hybrid Cochlear-Vestibular Implant

26. Vestibular Prosthesis

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Purpose: To characterize electrically evoked compound action potentials (eCAPs) using electrodes implanted in the cochlea and in the peripheral vestibular system.

Methods: Patients with bilateral vestibular loss and severe hearing loss received a hybrid cochlear-vestibular implant (MED-EL, Austria). We recorded eCAPs in 4 implanted patients for three setups: i) a cochlear setup, where stimulation and recording electrode were in the cochlear array; ii) a mixed setup, where the stimulation electrode was in the cochlear array and the recording electrode in a vestibular branch or vice versa; and iii) a trans-canal setup, where the stimulation electrode was in one vestibular branch and the recording electrode in another vestibular branch. In one subject, we additionally measured eCAPs during continuous stimulation to investigate potential adaptation mechanisms.

Results: We successfully recorded eCAPs for all setups. Cochlear-vestibular and vestibular-vestibular eCAPs exhibited similar morphology as cochlear-cochlear eCAPs with two peaks. However, peak-to-peak voltages for cochlear-cochlear eCAPs were markedly larger than for the other setups. Amplitude growth functions for all setups displayed sigmoidal shape with distinct segments below and above threshold. Recovery functions for cochlear-cochlear eCAPs had a clearer exponential shape than the other setups. The investigation of eCAPs during continuous stimulation revealed very fast adaptation of the responses.

Conclusions: Our findings suggest that eCAP recordings with a vestibulo-cochlear implant could be used to reduce erroneous activation of non-target neurons by primarily guiding electrode placement during surgery. Post-operatively, the recordings

could be leveraged to aid implant programming and as supplemental information about neuronal activation during chronic use.

OP08: Rehabilitation of vestibular disorders (I)

OP08-1 - The effect of darkness on human head impulse catch-up saccades

23. Vestibular Compensation and Rehabilitation

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Purpose: In health, a rapid passive head-impulse generates an equal and opposite smooth eye-movement, driven by the vestibulo-ocular reflex (VOR). In vestibular loss, this smooth eye-movement is impaired and a compensatory 'catch-up' saccade maintains the eyes on target. We sought to determine the vestibular and visual contributions to catch-up saccades in health and disease.

Methods: We studied 18 normal controls, 22 subjects after total unilateral vestibular-deafferentation (UVD) and 10 subjects with bilateral vestibular loss (BVL). All subjects were tested in bright light and total darkness with the video head impulse test (vHIT, GN Otometrics), head and eye velocity data were processed offline (LabView, NI). Statistical analysis used GLM and GEE models and Fischer's exact test.

Results: In normals we detected a higher prevalence of small (0.6-1.3°, $p=0.01$) overt-saccades in the light (59%) compared with the dark (29%, $p<0.000$) while covert-saccades were very rare (0.5-1%, $p=0.04$). In UVD subjects, ipsilesional impulses conducted in light and dark generated covert-saccades of similar frequency (69 and 65%, $p=0.08$), magnitude (6.9 and 6.6°, $p=0.68$), and onset-latency

(123 and 117ms, $p=0.06$). In contrast, in BVL subjects, covert-saccades were more frequent (56 vs 30%, $p=0.00$) of larger magnitudes (7.8 vs 4.3°, $p=0.00$) in light compared with darkness, but occurred at similar onset-latencies (135 and 131ms, $p=0.51$). Saccade peak velocities greater than 100°/s were lower in darkness ($p<0.01$).

Conclusions: Our results indicate that ipsilesional covert-saccades in UVD are a conditioned response to contralateral vestibular input. Covert-saccades in BVL however are light-dependant. These multisensory catch-up saccades could prove useful in tracking vestibular-rehabilitation.

OP08-2 - Sensory Substitution quantified via the Oculus Rift in Patients with Vestibular Dysfunction

23. Vestibular Compensation and Rehabilitation

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Purpose: Patients with vestibular dysfunction typically employ a sensory substitution strategy by overly relying on visual or somatosensory cues. Our aims were: 1) assess the direct/inverse relationship of the sensory integration process, i.e., whether the weight of one sensory system decreases when the weight of another increases; 2) test whether these sensory substitution strategies are associated with self-reported disability via the Dizziness Handicap Inventory (DHI) and Activities-Specific Balance Confidence (ABC).

Methods: Twenty individuals with peripheral vestibular dysfunction and 16 age-matched controls (age range 24-81 and 24-79 respectively) were wearing the Oculus Rift and observed a 3-wall display of moving spheres in 2 scenes: (1) anterior-posterior movement (large 32mm amplitude, frequency 0.2Hz) and (2) medio-lateral movement (small 4.5mm amplitude, 0.48Hz). We quantified visual dependence via gains and postural sway directional-path in the anterior-posterior plane in scene (1), and

somatosensory dependence via differences in directional-path for scene (2) between compliant and stable surfaces.

Results: Both visual and somatosensory dependence increased with age and this effect was more pronounced in patients with vestibular dysfunction. Among the patients, 4 were more visually dependent, 3 more somatosensory dependent and the rest were high or low on both. Visual dependence was significantly and negatively correlated at -0.7 (gains) and -0.6 (directional-path) with ABC but not with DHI. Somatosensory dependence was not significantly correlated with ABC or DHI.

Conclusions: The sensory weighting process was not inversely dependent in all patients. Patients who were visually dependent displayed reduced balance confidence in their daily living but not increased dizziness-related disability.

OP08-3 - Accel. and velocity vHIT gains after unilateral vestibular loss: Insights into neural compensation

23. Vestibular Compensation and Rehabilitation

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Purpose: An acute unilateral peripheral vestibular deficit (aUPVD) causes deficient vestibular ocular reflex (VOR) control. The subsequent improvement of VOR deficit and contra-deficit side gains could be due to a greater increase in acceleration (phasic) than velocity (tonic) sensitive neural compensation (Minor and Lasker, JVR 2009). We examined this hypothesis using lateral video head impulse tests (vHIT).

Methods: 60 patients with vestibular neuritis were examined at aUPVD onset, 3 and 6 weeks later. Acceleration gain was computed as eye/head velocity over ± 12 ms around peak head acceleration. Velocity gain was calculated as eye/head velocity over ± 12 ms

around peak head velocity with eye velocity shifted 8ms because it lags head velocity.

Results: Deficit side acceleration gains increased ($p < 0.01$) from 0.46 at onset to 0.69 at both 3 and 6 weeks, and contra-deficit side acceleration gains from 0.88 to 0.96 respectively. Deficit side velocity gains increased ($p < 0.01$) from 0.28 to 0.55 at both 3 and 6 weeks, and contra-deficit side velocity gains ($p < 0.05$) from 0.82 to 0.90 respectively. Deficit side acceleration gain was significantly ($p < 0.01$) higher than velocity gain at onset and at 3 weeks. Contra-deficit side velocity gains were still < 1.0 at 6 weeks. Contra-deficit side acceleration gains were not different from 1.0 at 3 weeks. Improvement for both gains types post onset was similar.

Conclusions: These results indicate that greater acceleration rather than velocity sensitive compensatory neural mechanisms are active during the first 6 weeks of compensation for an aUPVD. The weaker velocity compensation is also apparent in contra-deficit side responses.

OP08-4 - Assessment of vestibulo-ocular reflex gain and catch-up saccades during Vestibular Rehabilitation

23. Vestibular Compensation and Rehabilitation

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Purpose: to assess, in patients referred to vestibular rehabilitation (VR) for persistence of disability after acute unilateral vestibulopathy (AUV), whether the video Head Impulse Test (vHIT) can be a useful technique in order to define patients' recovery.

Methods: 30 patients were prospectively evaluated; the main outcome measures included Dizziness Handicap Inventory score (DHI), high-velocity vestibulo-oculomotor reflex gain, asymmetry index, and catch-up saccade parameters. The tests were all performed at the beginning (4 and 8 weeks from the onset of the AUV), and after 10 weeks (end of the VR program).

Results: all patients reported a clear clinical improvement after VR, also demonstrated by better DHI scores ($p < .001$). A consistent increased gain

and decreased asymmetry index were also observed ($p < .001$ for both). Patients did not show any change in covert saccades, while a statistically significant reduction of the number and amplitude of the overt saccades was interestingly detected ($p = .009$ and $p = .030$, respectively).

Conclusions: VR is a valid approach for patient with residual disability after AUV. A reduction in number and amplitude of overt saccades seems to be related to clinical improvement.

OP08-5 - Behavioral Evidence for Independently Modifiable Neural Circuits Mediating Concurrent VOR Adaptation

23. Vestibular Compensation and Rehabilitation

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Purpose: Patients with unilateral damage to the Vestibulo-Ocular Reflex (VOR) typically also have a slightly reduced VOR gain (eye/head velocity) during contra-rotational head rotation due to loss of afference from the crossed inhibitory commissural vestibular pathway. Here, we conduct behavioral experiments to examine whether motor learning in the VOR is supported by separate and independently modifiable neural circuits. We sought to examine if the VOR could be driven simultaneously in opposite directions, i.e., increase for rotations to one side and decrease to the other.

Methods: Fourteen healthy subjects were each tested over three separate days to three randomly-applied paradigms of concurrent (right and left head rotation) VOR adaptation: 1) Up-gain bilaterally; 2) Down-gain bilaterally, or 3) Mixed (one side up, opposite side down). We used the unilateral incremental VOR adaptation technique with horizontal active head impulses as the vestibular stimulus. Active and passive VOR gains were measured before and after training.

Results: All three adaptation sessions caused significant Pre to Post VOR gain change ($p < 0.001$) for both active and passive head rotation. Significant correlation between post training gain values and training condition was found (Pearson's $r = 0.663$). Linear regression predicted 51% of our result. There was no difference in the magnitude of VOR gain change between Up-gain to Mixed-Up (side) and Down-gain to Mixed-Down (side) trainings.

Conclusions: The right and left VOR can be driven concurrently in opposite directions, suggesting mediation from at least two independently modifiable neural circuits. This may be useful for developing rehabilitation strategies that reduce the VOR asymmetry in vestibular hypofunction.

OP08-6 - Effects of saccular function on recovery of subjective dizziness after vestibular rehabilitation

23. Vestibular Compensation and Rehabilitation

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Purpose: We attempted to investigate whether the integrity of saccular function influences the severity of subjective dizziness after vestibular rehabilitation in vestibular neuritis.

Methods: Forty-six patients with acute unilateral vestibular neuritis were included and analyzed retrospectively. All patients completed vestibular rehabilitation therapy until their computerized dynamic posturography and rotary chair test results were significantly improved. The rehabilitation patients were classified into the normal to mild subjective dizziness and moderate to severe subjective dizziness groups according to the dizziness handicap inventory score (cut-off of 40). Differences between the two groups were analyzed.

Results: After rehabilitation, 32.6% of the patients still complained of moderate to severe dizziness. Age, gender distribution, the presence of comorbidities, caloric weakness, pre- and post-rehabilitation gain values in rotary chair test, post-rehabilitation composite scores in posturography, and the duration of rehabilitation were not significantly different between the two groups. However, initial DHI score and composite score in dynamic posturography were worse and the proportion of patients with absent cervical vestibular-evoked myogenic potential in the moderate to severe group was much higher (93.3% vs. 35.5%, $p < 0.001$). After multiple regression analysis of those factors, initial DHI score and absent cVEMP response were identified as being associated with higher post-rehabilitation DHI score.

Conclusions: Saccular dysfunction in acute vestibular neuritis can contribute to persistent subjective dizziness, even after the objective parameters of vestibular function tests have been improved by vestibular rehabilitation.

OP08-7 - Efficacy of Gaze Stabilisation Exercises in Vestibular Dysfunction: A Systematic Review

23. Vestibular Compensation and Rehabilitation

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Purpose: This systematic review examined evidence for efficacy of gaze stabilisation (GS) exercises as a stand-alone treatment or part of multimodal treatments for vestibular dysfunction. Comparators were sham/placebo, usual care or vestibular rehabilitation (VR) excluding GS exercises. Primary outcomes evaluated were dynamic visual acuity (DVA) and self-reported dizziness.

Methods: Electronic databases were searched from inception to January 1st 2017. Randomised controlled trials of adults with confirmed vestibular disease where VR (including or comprising solely of GS exercises) in comparison to sham/placebo, usual

care or VR excluding GS exercises were tested. Records were assessed by two independent reviewers.

Results: 22 studies, $n=765$ adults, were included with $n=9$ providing data for meta-analysis. When VR (including GS exercises) was compared with sham/no treatment, no DVA outcomes could be evaluated, but promising effects on Dizziness Handicap Inventory Scores (DHI) were noted from 2 studies with mixed and unspecified dysfunction ($n=65$ subjects; MD: -13.85; $p=0.008$ I^2 68%). When VR (including GS exercises) was compared with VR (excluding GS exercises), no effect and high heterogeneity was noted in $n=2$ peripheral dysfunction studies on DVA ($n=19$ subjects; SMD: 0.84; $p=0.14$; I^2 82%). Similarly, from $n=5$ studies, no effect on DHI total was observed ($n=114$ subjects; SMD: -0.13; $p=0.50$ I^2 47%).

Conclusions: When considered as a stand-alone intervention or in addition to VR, insufficient data exist to conclusively address by meta-analysis, the efficacy of GS exercises on DVA in vestibular disease. Individual small RCTs demonstrated efficacy but could not be included in the MA due to heterogeneous outcomes. Larger RCTs are required.

OP09: BPPV (I)

OP09-1 - A new numerical model : speed of migration of otonia under gravity action depending of their size.

4. Benign Paroxysmal Position Vertigo

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Purpose: Canaliths disorders are probably a larger group than the BPPVs, including these lasts but also a part of the dizziness with some symptoms that are not positional vertigo. We will present the results of the numerical model of the spontaneous migration of otoconia into a semi-circular canal under gravity action depending of their size. Secondary we will apply

some hypergravity environment to reproduce the effect of mechanical assisted manoeuvres with the TRV CHAIR® that is used to help to treat canaliths disorders, and to measure its effects on particles migration.

Methods: We built a mathematical model of a canal with the same size that a posterior canal, 20 millimeters long and 150 micrometers diameter. Various sizes of particles were reproduced. Only gravity, then 0,75; 1 and 1,5 G deceleration were tested.

Results: The smallest particles (3,5 micrometers) take 70 minutes to make the trip of 20 millimeters from the cupula to the exit when the biggest (30 micrometers) make it within 30 seconds and it takes 6 minutes for a middle sized one (10 micrometers). The application of one G deceleration vector to the 3,5 sized particle makes its instantaneous speed 500 time faster.

Conclusions: The size of the particles have a very important influence to the sensivity of these lasts to gravity. It leads to consider that the canaliths disorders should have some very various expression depending of the size of the particles, and their number. The use of some mechanical assistance could be interesting to improve the canaliths disorders management.

OP09-2 - Association between serum vitamin D levels and BPPV in elderly patients

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the association between serum vitamin D levels and benign paroxysmal positional vertigo in elderly patients.

Methods: 64 cases of elderly patients over 60 years old with BPPV as BPPV group and 100 cases of elderly people who got physical examination at the same period as the control group. The serum 25-hydroxyvitamin D₃ concentration of the two groups was analyzed.

Results: The 25-hydroxyvitaminD₃ was significant lower in BPPV group than in controlP0.01The serum

25-hydroxyvitamin D₃ concentration was no significant difference between male BPPV patients and female BPPV patients. There was higher prevalence of vitamin D deficiency and severe deficiency in BPPV group than in control groupP0.01.

Conclusions: Vitamin D deficiency may be a risk factor for the onset of BPPV in elderly patients.

OP09-3 - Clinical investigation and analysis of the risk factors of benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the risk factors of the recurrent reason of the benign paroxysmal positional vertigo.

Methods: A total of 175 elderly patients with primary BPPV confirmed our center who underwent repositioning therapy and were followed up for 12 months were retrospectively analyzed. The follow-up results were divided into 61 cases of recurrent BPPV patients and 141 cases of non-recurrent BPPV patients. During the same period, 73 young middle-aged patients were randomly selected as control group. The influencing factors of the recurrent BPPV was analyzed by Logistic regression method.

Results: There was no significant difference in age (68.03 / 66.71, P=0.107), sleep disturbance (48/127, P=0.129) and hypertension (96/79, P=0.065), but the difference was statistically significant in diabetes (40/135, P=0.003), migraine (61/114, P=0.004) and hyperlipidemia (104/71, P=0.025) between the recurrent BPPV elderly patients and the non-recurrent BPPV elderly patients. There was no significant difference between the middle-aged group recurrent and non-recurrent BPPV patients among gender (2.286/1.632, P=0.531), age (41.92/42.17, P=0.482), sleep disorders (32/41, P=0.29), diabetes(0), hypertension (10/63, P=0.715), hyperlipidemia (16/57, P=0.559), and cervical spondylosis (20/53, P=0.337), but the difference was statistically significant in tiredness (32/41, P=0.013), migraine(24/49,

$P < 0.001$). There was no significant difference in the recurrent rate of BPPV at 12 months (36.9%/31.5%, $P = 0.611$), the type of BPPV (55/23, $P = 0.99$), and the responsible semicircular canal (1.77/1.86, $P = 0.49$) and the times of recurrence (94.83%/97.26%, $P = 0.398$) also had no statistical significance.

Conclusions: Hyperlipidemia, diabetes mellitus and migraine are risk factors in the recurrent BPPV elderly patients, but fatigue, migraine are the risk factors of the recurrent BPPV young middle-aged patients.

OP09-4 - Correlations between scores of Eysenck Personality questionnaire and DHI in patients with BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: To evaluate whether there is a possible correlation between scores of Eysenck Personality Questionnaire (EPQ) and Dizziness Handicap Inventory (DHI) in patients with benign positional paroxysmal vertigo.

Methods: 35 cases of BPPV patients confirmed by manual reduction were included in our research. They were investigated with EPQ and DHI in the first visit, 1 week after manual rehabilitation.

Results: The mean values were 58.34 ± 12.14 , 47.97 ± 12.95 , 46 ± 6.52 ; 58.2 ± 6.71 for E, N, P, L, respectively. DHI scores were 50.85 ± 25.31 before treatment, and 35.76 ± 32.67 1 week after manual reduction. The mean courses of disease were 17.08 ± 10.74 days. Correlation analysis showed no significant correlations between E, N, P, L and DHI scores both before and after treatment and the improvement of DHI scores (all $p > 0.05$). There were also no significant correlations between scores of E, N, P, L and courses of disease (all $p > 0.05$).

Conclusions: There were no significant correlations between E, N, P, L and DHI scores both before and after treatment.

OP09-5 - Establishment of clinical diagnosis procedure in patients with benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: To establish a clinical diagnosis procedure of benign paroxysmal positional vertigo (BPPV).

Methods: 331 patients with BPPV were included. All patients underwent positional tests (PT), including Dix-Hallpike test, straight head hanging test and Roll test in the naked eye and videonystagmography examinations. Patient's hearing and vestibular function were also evaluated. Patients with an unclear diagnosis were followed-up until a definitive diagnosis was obtained.

Results: 407 patients were initially included because of transient dizziness/vertigo caused by changes in head position. 27 patients with orthostatic hypotension, 18 patients with vestibular migraine, and 12 patients with central paroxysmal positional vertigo were excluded, thus 331 patients with BPPV were included. Medical history: positional vertigo was observed in 221 (66.8%) patients, positional dizziness in 56 (16.9%) patients, stumbling in 36 (10.9%) patients, and blurred vision in 18 (5.4%) patients. Physical examinations: typical BPPV was confirmed in 209 (63.1%) patients in the naked eye examination, with single PT examination in 152 patients and twice PT in 57 patients. Atypical BPPV was confirmed in 122 (36.9%) patients, with twice PT in 28 patients in naked eye, videonystagmography examination in 57 patients, and experience-based repositioning and follow up in 37 patients. Hearing and vestibular evaluation: 81 (24.5%) patients had vestibular dysfunction and 87 (26.3%) patients had impaired hearing. Primary/secondary BPPV: 205 (61.9%) patients primary BPPV and 126 (38.1%) patients secondary BPPV.

Conclusions: Typical and primary BPPV is easy to diagnose, but atypical and secondary/concomitant BPPV often require further layered diagnosis based on medical history, physical examination, vestibular evaluation and dynamic follow-up.

OP09-6 - Horizontal canal benign paroxysmal positional vertigo: Lempert vs Gufoni

4. Benign Paroxysmal Position Vertigo

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Purpose: Benign paroxysmal positional vertigo (BPPV) is a frequent and disabling entity. Horizontal canal (HSC) is the second canal most affected. There is little evidence about compared effectiveness of Lempert (LM) vs Gufoni (GM) repositioning maneuvers. The aim of this study is to compare the different maneuvers and to expose our results.

Methods: We present an observational retrospective study over HSC-BPPV outpatients of a tertiary hospital with results between January 2015 and January 2017. Complete personal and vestibular history and clinical evaluation have been recorded. The exclusion criteria include: anterior, posterior or multicanal BPPV; atypical nystagmus; other vestibular or neurological disease.

Results: 50 (28%) outpatients were diagnosed of BPPV. 16 (32%) HSC-BPPV patients (2:1, women:men) of 61 years on average; 11 Canalolithiasis and 5 Cupulolithiasis. Among canalolithiasis, LM (n = 6) or GM (n = 5) were performed: it were observed a higher resolution percentage in Gufoni's group both in first (n=4, 80%; n=2, 33%; p=0.175) and second maneuver (n=1, 100%; n=1, 25%; p=0.4) without statistical significance. All cupulolithiasis were treated by GM, with a resolution percentage of 60% after the first maneuver and 50% after the second. Recurrence was higher in cupulolithiasis (n=1, 20%-n=2, 9%) and slightly higher for GM (n=1, 20%-17%).

Conclusions: Since Lempert and Gufoni maneuvers are effective in the treatment of HSC-BPPV, there is a clinically significant higher success percentage for Gufoni's one in our sample. It is possible that larger sample sizes studies could find statistical differences.

OP10: Functional and Psychiatric Vestibular Disorders

OP10-1 - Altered functional brain connectivity in patients with visually induced dizziness

10. Functional and Psychiatric Vestibular Disorders

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Purpose: Patients experiencing dizziness caused or aggravated by challenging visual stimuli have now been classified as visually induced dizziness (VID). The pathophysiology of this condition is poorly understood. Hereto, we conducted an explorative resting-state functional MRI study on 10 VID patients to investigate possible changes in functional connectivity in this patient group.

Methods: 10 VID patients and 10 age- and gender-matched healthy controls participated in the study. Data were acquired on a 3T MRI scanner and 280 volumes of functional resting-state data were acquired by a T2* weighted EPI sequence. Data analysis was divided in a hypothesis-free analysis using the intrinsic connectivity contrast (ICC) and a region

of interest (ROI) analysis with seeds in vestibular and visual brain areas.

Results: When considering the VID group versus controls, a decreased connectivity between the superior temporal gyrus/posterior insula (primary vestibular area) and the rest of the brain was noted. Increased connectivity was found between the primary visual cortex and the rest of the brain. ROI analysis revealed altered functional connectivity between the visual association area and higher-order brain regions involved in spatial orientation. Also the thalamus revealed altered connectivity with the cerebellum, basal ganglia and primary visual cortex.

Conclusions: This first neuroimaging perspective on VID revealed stronger connectivity within visual areas and weaker connectivity in the primary vestibular area. These findings are in line with the behavioural profile of VID patients, namely increased reliance on visual cues for spatial perception. These findings provided a first framework for future neuroimaging studies and treatment options for VID patients.

OP10-2 - Alternatives to Treat Associated Symptoms of Mal de Debarquement Syndromes (MdDS)

10. Functional and Psychiatric Vestibular Disorders

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Purpose: The Mal de Debarquement Syndrome (MdDS) is primarily characterized by a continuous feeling of swaying and rocking (primary symptoms), commonly follows water or air travels. The primary symptoms are also accompanied by many other associated symptoms, such as a static force pulling in a particular direction, floor undulating or bouncing when walking, circular motion of the body, general woozy feeling, head pressure, heaviness or floating of body, elevated visual sensitivity and agoraphobia. We recently demonstrate that primary symptoms could be treated by re-adaptation of the vestibulo-ocular reflex (VOR, Dai et al., 2014, standard treatment). Accompanied symptoms are also decreased after treatment (Dai et al., 2017). Sometimes, however, accompanied symptoms persist.

Methods: Over the last several years while treating more than 400 patients, we have developed and used alternative optokinetic (OKN) stimuli and visual vestibular interactions to treat specific symptoms.

Results: The results of these alternative treatments are promising. Interestingly, the alternative treatment sometimes alone effectively reduces both primary and companion symptoms.

Conclusions: Recently, we have had an increased rate of successful treatment. This may be due to the application of the alternative procedures. The background, hypotheses and outcomes will be presented and discussed.

OP10-3 - Decreased Spontaneous Functional Activity of left PIVC in Persistent Postural-Perceptual Dizziness

10. Functional and Psychiatric Vestibular Disorders

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Purpose: To investigate the changes of brain spontaneous functional activity in patients with persistent postural-perceptual dizziness (PPPD).

Methods: Seven patients (3 males and 4 females) with PPPD were enrolled. All patients underwent detailed medical history acquisition; cranial MRI, peripheral vestibular function evaluation, internal medicine and laboratory tests were performed to exclude other chronic dizziness lesions. SVDS, CVS, DHI score were performed to assess the patient's symptoms. The patients confirmed PPPD were further scanned by fMRI. Fractional Amplitude of Low Frequency Fluctuation (fALFF) was calculated to investigate the changes of brain spontaneous functional activity in patients with PPPD.

Results: In PPPD patients, the fALFF values of the left-sided PIVC region were significantly lower than healthy subjects ($P < 0.05$, FDR corrected). Further correlation analysis showed no significant correlations between SVDS, CVS, DHI score and this area. The length of history had a negative correlation

with the spontaneous activity of the brainstem and a positive correlation with inferior occipital gyrus and gray matter near the central sulcus. SVDS score was positively correlated with the occipital lobe, the right PIVC and Supp_motor_area ($P < 0.05$, FDR corrected).

Conclusions: (1) Spontaneous functional activity in the left PIVC of PPPD patients is often decreased. (2) The severity of subjective symptoms in patients was positively correlated with the spontaneous functional activity of occipital lobe, right PIVC area, and Supp_motor_area. The duration of the medical history was negatively correlated with the functional activity of the brain stem, and positively correlated with suboccipital gyrus and the gray matter near central sulcus.

OP10-4 - Integrating mental and physical health assessment in neuro-otology

10. Functional and Psychiatric Vestibular Disorders

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Purpose: To assess the feasibility and acceptability of a web-based informatics system for collection of patient-reported outcomes, with real-time feedback to guide clinical care in a specialist neuro-otology clinic, and to describe the prevalence of common psychological symptoms.

Methods: Nine hundred and fifty-four consecutive patients (69.6% female, M age 51, range 16-90) completed the web-based questionnaire comprising patient-reported outcome measures at their initial appointment. Data was analysed retrospectively. Condition specific questionnaires included the Dizziness Handicap Inventory, Headache Impact Test, Situational Vertigo Questionnaire and Disability Rating Scale. Psychological symptoms were screened using the Patient Health Questionnaire-9 and Generalised Anxiety Disorder Questionnaire-7. Feasibility was quantified as the proportion of patients who completed the questionnaire. Acceptability was quantified as the proportion of patients declining screening.

Results: The proportion of patients who successfully completed the screen was high (70%). The decline rate was low (7%). The most common reason to decline was lack of confidence in using IT. The prevalence of probable depression was 21% and for probable anxiety was 29%. Suicidal ideation was present in 5%. The proportion of patients who reported either recent or long term severe disability was 11%. The proportion of patients reporting high impact headache was 54%. Anxiety and depression were strongly correlated to dizziness handicap, disability and all other outcome measures ($p < 0.001$).

Conclusions: Patients attending a specialist neuro-otology service are at risk of common mental disorders. Web-based screening is feasible and acceptable to patients in this setting, helping to identify service needs, inform care and monitor outcomes.

OP10-5 - Interaction of Time Pressure and Anxiety upon Spatial orientation judgments

10. Functional and Psychiatric Vestibular Disorders

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Purpose: Spatial orientation is achieved via the integration of visual, vestibular and proprioceptive cues. The degree to which an individual relies on visual cues instead of the others is termed visual dependency. Perceptual judgements, such as spatial orientation, are affected by psychological factors, like anxiety and contextual influences like time pressure. However, the impact of time pressure and innate levels of anxiety upon visual dependency have not been investigated. Therefore, we assessed the impact of time pressure on visual dependency and how this relationship is modulated by anxiety.

Methods: In 44 healthy subjects, the effect of time pressure on visual dependency was measured using the rod-disk test, where participants align a rod to their perceived gravitational vertical during background visual motion, in the absence of any visual reference cues to vertical. The experimental procedure was split in two parts; a baseline condition (average completion time 7 seconds) and a time pressure condition where subjects were given a maximum of 3 seconds to complete the

task. Non-situational levels of anxiety i.e. trait anxiety and situational levels of anxiety i.e. state anxiety were quantified using the Spielberg State Trait Anxiety Inventory.

Results: Higher trait anxiety levels correlated with reduced visual dependency under time pressure compared to baseline conditions ($R^2 = 0.393$, $p = 5.31 \times 10^{-6}$). State anxiety did not influence the levels of visual dependency in either condition.

Conclusions: Levels of trait anxiety influenced the impact of time pressure on visual dependency. Counterintuitively, time pressure reduces inaccuracy in perceptual judgements for individuals with higher trait anxiety.

OP10-6 - The cognitive-behavioural correlates of dizziness related interference

10. Functional and Psychiatric Vestibular Disorders

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Purpose: To determine the contribution of cognitions, behaviours and emotions to explain the variance in dizziness related handicap (interference) over and above demographic and objective illness measures.

Methods: One-hundred and eighty-five consecutive patients who were on the waiting list to attend an initial diagnostic appointment for dizziness related symptoms completed a cross-sectional survey including valid and reliable psychometric questionnaires. Dizziness handicap was measured using the Dizziness Handicap Inventory and the psychological questionnaires included the Patient Health Questionnaire-9, Generalised Anxiety Disorders-7, Illness Perceptions Questionnaire – Revised, Cognitive and Behavioural Responses to Symptoms Questionnaire, Psychological Vulnerability Questionnaire and the

Beliefs About Emotions Scale. Correlations and hierarchical multiple regressions determined the relative contribution of illness severity, psychological distress, cognitions, and behaviours to the prediction of dizziness related handicap.

Results: All psychosocial factors including distress, negative beliefs about dizziness and its consequences, cognitive and behavioural responses to symptoms were related to dizziness outcomes. The total hierarchical regression model explained 70% of the variance in dizziness handicap. Only six percent was explained by demographic factors and a further 43% was explained by illness factors, which included visually triggered dizziness (Situational Vertigo Questionnaire). A further 23% was uniquely accounted for by the psychological factors, which was statistically significant.

Conclusions: The psychosocial factors identified as important in predicting dizziness handicap are potentially modifiable and thus may be useful to address within interventions in the future and highlight the importance of adopting a biopsychosocial approach in this setting.

OP10-7 - Vestibulo-cortical Hemispheric Dominance: the link between Anxiety and the Vestibular System?

10. Functional and Psychiatric Vestibular Disorders

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Purpose: Vestibular processing and anxiety networks are functionally intertwined, as demonstrated by reports of reciprocal influences upon each other. Previous findings have also highlighted the involvement of hemispheric lateralisation in processing of both anxiety and vestibular signals. Yet whether there is an underlying neural mechanism relating these two systems remains unknown.

Methods: Accordingly, we explored the interaction between vestibular cortical processing and anxiety by assessing the relationship between anxiety levels and the degree of hemispheric lateralisation of vestibulo-cortical processing in 64 right-handed, healthy individuals. Vestibulo-cortical hemispheric lateralisation was determined by gaging the degree

of caloric-induced nystagmus suppression following modulation of cortical excitability using trans-cranial direct current stimulation targeted over the posterior parietal cortex, an area implicated in the processing of vestibular signals. The degree of nystagmus suppression yields an objective biomarker, allowing the quantification of the degree of right vestibulo-cortical hemisphere dominance. Anxiety levels were quantified using the Trait component of the Spielberger State-Trait Anxiety Questionnaire.

Results: Our findings demonstrate that the degree of an individual's vestibulo-cortical hemispheric dominance correlates with their anxiety levels. That is, those individuals with greater right hemispheric vestibulo-cortical dominance exhibited lower levels of anxiety.

Conclusions: By extension, our results support the notion that hemispheric lateralisation determines an individual's emotional processing, and hereby we suggest a possible mechanistic link between cortical circuits involved in processing anxiety and vestibular signals respectively.

OP11: Cochlear implantation

OP11-1 - CI and vestibular assessment: controversies, measurement bias and ostensible clinical impact

8. Cochlear Implant and Vestibular Function

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Purpose: Investigating the apparent clinical need and value of semicircular canal assessment in CI candidates and users.

Methods: Pre- vs -postoperative hearing and vestibular function were analyzed in 626 patients. Subjects underwent pre-post caloric irrigational testing, rotary chair testing, vHIT and completed the Dizziness Handicap Inventory. Canal functionality was compared and in contrast to all previous studies, categorical analysis were applied and contralateral

(non-implanted) side was also taken into account. Possible deterioration (or complete loss) after CI was defined using a 4 category scale. Objective and subjective vestibular measures of previous studies are compared with recent data.

Results: Present group data show extremely small, although statistically significant, postop vestibular reduction: 3.1 %/s and 4.7 %/s (warm and cold irrigation, respectively). 37.4% of patients dropped 1 or more categories. Similarly, vHIT data also showed small, but significant VOR decrease of -0.057, -0.040 and -0.045 (anterior, lateral and posterior canal gains, respectively). Subjective symptoms (DHI) did not show any postop changes for composite total score, as well for scores on functional and emotional subdomains. The physical subdomain score however, showed small but significant increase. Behaviourally, 9.0% show a deterioration of 1 or more categories.

Conclusions: In contrast to many previous smaller studies (including our own), this study did not show any relevant clinical impact on group level for canal testing (calorics & vHIT) at all, taken into account contralateral ear and categorical deterioration. Nevertheless, on the individual level, CI can still lead to serious individual vestibular changes, still justifying pre- and postop behavioural and objective assessment.

OP11-2 - Intralabyrinthine schwannomas: vestibular function after surgery with/without cochlear implantation

8. Cochlear Implant and Vestibular Function

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Purpose: Intralabyrinthine schwannomas (ILS) are a rare differential diagnosis of sudden hearing loss and vertigo. We describe the outcome after surgical tumor removal through subtotal or partial cochlectomy and/or labyrinthectomy with or without cochlear implantation (CI).

Methods: In an own case series of 24 patients, 11 tumors showed an intracochlear, 3 an intravestibular, 3 an intravestibulocochlear, 3 a transmodiolar, 1 a transmodiolar with CPA, 1 a transotic with CPA and 2 a multilocular location. 16 patients received surgery for tumor removal, 4 patients are scheduled for surgery and 8 patients decided for a “wait-and-test-and-scan (W&T&S)”-strategy.

Results: The 3 intravestibular tumors were removed via labyrinthectomy and patients received a CI in a single stage procedure. Nine intracochlear tumors were surgically removed via an extended cochleostomy with single stage CI (x1), via partial or subtotal cochleoectomy and partial cochlear reconstruction with CI (x6) or implantation of an electrode dummy for follow up with MRI and possible later CI (x2), or via labyrinthectomy and partial cochleoectomy (x2). The transotic and the transmodiolar tumors were removed via a translabyrinthine approach. For the intracochlear tumors, vestibular function could be at least partially preserved after surgery. In all but one case, hearing rehabilitation with CI was successful.

Conclusions: Surgical removal of ILS is recommended before tumor growth leads to a complete filling of the cochlea or before a transmodiolar or transmacular growth complicates surgical removal and prevents cochlear implantation. If done early enough, CI after surgical removal of ILS is an option and an alternative to a “W&T&S” strategy.

OP11-3 - Music May Improve Gait Pattern in Cochlear Implant Patients with Bilateral Caloric Areflexia.

8. Cochlear Implant and Vestibular Function

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Purpose: Patients with bilateral caloric areflexia suffer from imbalance, resulting in an increased risk of falling. In case of simultaneous deafness, the lack of auditory feedback results in less auditory scene awareness. Our aim was to explore the relationship

between cochlear implant (CI) stimulation, auditory feedback and gait.

Methods: Adults (seven males, one female, mean age 61 ± 14 years), wearing a CI to treat profound sensorineural hearing loss and presenting with bilateral caloric areflexia walked barefoot, over ground, at self-selected speed in three different conditions: CI on, while listening to music and CI off. Spatio-temporal and kinematic parameters were calculated using the conventional gait model.

Results: Removing auditory feedback by turning off the CI decreased stride time (mean difference 0.03 ± 0.15 s) and slightly increased stride length (mean difference 0.5 ± 1.2 cm) compared to the control condition with the CI on. Walking while playing music positively affected gait compared to walking with the CI on but without auditory feedback. By increasing the motion of the pelvis (mean difference $1.3^\circ \pm 0.4^\circ$), the knee (mean difference $3.9^\circ \pm 0.8^\circ$) and the ankle (mean difference $2.2^\circ \pm 0.2^\circ$), stride length increased (7.8 ± 1.2 cm), while stride time decreased (0.059 ± 0.016 s).

Conclusions: This pilot study suggests that playing music while wearing an active CI may improve gait in patients with bilateral otovestibular loss. It remains unclear if the musical cues boost balance control or the CI might produce current spread and electrical stimulation to the vestibular afferents.

OP11-4 - Preservation of vestibular function after cochlear implantation with round window approach

8. Cochlear Implant and Vestibular Function

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Purpose: Nowadays, the preservation of cochlear function can be highly predicted after cochlear implantation (CI) by using round window approach (RWA) with a combination of systemic and local applications of steroid during the surgery. The preservation of vestibular function might also be possible and highly expected after CI surgery with RWA.

Methods: Caloric response, vHIT response, oVEMP, and cVEMP were recorded before and after CI surgery.

Results: The preservation of vestibular function after CI surgery was compared between two procedures: CI surgery with classic cochleostomy (n=5) and CI surgery with RWA (n=12). All the surgeries were done by a single senior oto-surgeon. Caloric response was preserved in 40% of CI surgery with cochleostomy (n=5), while it was preserved in 83% of CI surgery with RWA (n=12). vHIT response was preserved in 50% of CI surgery with cochleostomy (n=4), while it was preserved in 83% of CI surgery with RWA (n=12). oVEMP was preserved in 50% of CI surgery with cochleostomy (n=2), while it was preserved in 89% of CI surgery with RWA (n=9). cVEMP was preserved in 80% of CI surgery with cochleostomy (n=5), while it was preserved in 92% of CI surgery with RWA (n=12)

Conclusions: These results suggest that CI surgery with RWA should have an advantage over CI surgery with cochleostomy in the preservation of inner ear functions. Systemic and local applications of steroid during the surgery would be strongly recommended to reinforce it.

OP11-5 - Vestibular and Balance Function is Impaired in Children with Unilateral Sensorineural Hearing Loss

8. Cochlear Implant and Vestibular Function

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Purpose: Children with unilateral deafness could have concurrent vestibular dysfunction which would be associated with balance deficits and potentially impair overall development. The prevalence of vestibular and balance deficits remains to be defined in these children.

Methods: Twenty children with unilateral deafness underwent comprehensive vestibular and balance evaluation.

Results: More than half of the cohort demonstrated some abnormality of the vestibular end organs (otoliths and horizontal canal), with the prevalence of end organ specific dysfunction ranging from 17-48% depending on organ tested and method used. In most children, impairment occurred only on the deaf side. Children with unilateral deafness also displayed significantly poorer balance function than their normal hearing peers.

Conclusions: The prevalence of vestibular dysfunction in children with unilateral deafness is high and similar to that of children with bilateral deafness. Vestibular and balance evaluation should be routine and the functional impact of combined vestibulo-cochlear sensory deficits considered.

OP11-6 - Vestibular function after cochlear implantation in partial deafness treatment

8. Cochlear Implant and Vestibular Function

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Purpose: Nowadays, the indications for cochlear implantation have been broadened and include the patients with bilateral profound deafness, partial deafness and unilateral deafness. It requires to put the great emphasis to protect not only the cochlear but also the vestibular function. The aim of the study is to assess the postoperative vestibular function with the application of hearing preservation techniques and to determine whether the type and insertion depth of the electrode have the impact on vestibular status after cochlear implantation in partial deafness treatment.

Methods: The patients who underwent cochlear implantation procedure were divided into three groups according to the type of the electrode applied in cochlear implantation: perimodiolar, straight,

flexible electrode. Each patient was assessed with cVEMP, oVEMP, caloric tests, vHIT and fulfilled the questionnaire before and 6 months after the operation.

Results: The vestibular disorders are rare, transient and in early postoperative period. Despite applying hearing preservation techniques, the possibility of vestibular damage still exists. The rate of vestibular function loss was as follows: cVEMP response in 16,3%, oVEMP response in 13,6%, reduction in caloric response (change from normal response to unilateral weakness or unilateral weakness to areflexia) in 7,9% of the whole study population. The vestibular function was better preserved after insertion of flexible electrodes than perimodiolar or straight electrodes. No significant difference in postoperative vestibular function was observed between the various length of inserted electrodes.

Conclusions: Application of hearing preservation techniques in partial deafness treatment has significantly diminished the rate of vestibular disorders after cochlear implantation.

OP11-7 - Vestibular function pre and post Cochlear implant in 71 patients

8. Cochlear Implant and Vestibular Function

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Purpose: There is no doubt that cochlear implant has been the most important contribution made by otologic surgery to the disabilities caused by profound hearing loss, both in children and in adults, there is not information about the vestibular function.

Methods: 71 adult and pediatric patients with profound bilateral deafness of different etiologies, were studied. The possible cause of deafness was obtained and a Video Head Impulse Test was performed to all of them pre implant and a month late.

Results: The vestibular function previous to the implant was not significantly affected except in 9.72% of the cases. In most patients, the cochlear implant did not significantly modify the VOR function. In the group of patients who previously had a damaged or asymmetric vestibular function, if the best ear is implanted, this could cause a bilateral vestibular failure, so that the ear with the lowest gain should be chosen to be implanted

Conclusions: The implant, when performed by experienced professionals, does not affect vestibular function, except in those cases where it is already damaged or asymmetric

OP12: Clinical vestibular testing VEMP (II)

OP12-1 - Spatial Selectivity of Eye Movements Elicited by Combined Otolith and Semicircular Canal Stimulation

26. Vestibular Prosthesis

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Purpose: The semicircular canals (SCCs) and otolith end organs encode head movements with different kinematics and temporal dynamics. We examined the spatial selectivity and range of eye movements evoked by individual and combined stimulation of electrodes in SCCs and otolith end organs intended to encode head tilts about different Earth-horizontal axes.

Methods: We fit three chinchillas with head posts and binocular scleral coils for tracking 3D eye movements. We implanted a polyimide vestibular electrode array with 26 otolith and 24 SCC contacts into the left ear. Bipolar current pulses were delivered while the animals were kept still in dark, driving

electrically evoked eye movements. Eye movements were recorded during a constant pulse train (encoding a virtual static tilt) delivered via multiple electrode configurations.

Results: Providing a step change in pulse rate to different electrode pairs resulted in an ocular counter-roll for the duration of the virtual static tilt. A linear increase in pulse rate or pulse amplitude on the same pair of electrodes elicited a linear increase of the magnitude of the eye movement. The direction and magnitude of ocular counter-roll responses depended on the relative locations of the pairs of electrodes intended to stimulate different locations on the maculae.

Conclusions: Spatially selective stimulation of different regions within a utricular or saccular macula can repeatedly elicit eye movement responses consistent with those expected for static head tilts about different axes, indicating that stimulation of the utricle and saccule may serve as a useful complement to prosthetic SCC stimulation for encoding head tilt and translation.

OP12-2 - Clinical evaluation of a new bone conduction transducer for VEMP

7. Clinical Testing for Vestibular Function

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Purpose: The aim of this study is to in clinical vestibular evoked myogenic potential (VEMP) evaluate a prototype version of a new bone conduction (BC) transducer, called B250. Conventionally, VEMP responses has been evoked using air conduction (AC) ear-phones, which requires high sound levels and is limited to patients without conductive hearing loss. By using BC stimuli, the sound level can be decreased and conductive hearing losses by-passed. BC stimuli are today commonly applied with a Minishaker B&K4810 or audiometric transducers neither optimal nor intended for VEMP.

Methods: This study is ongoing and includes otologically normal hearing subjects, patients with conductive hearing loss and vestibular disorders between 18 and 65 years. Cervical (cVEMP) and ocular (oVEMP) responses are compared for AC ear-phones as well as the audiometric BC transducer Radioear B81 and the B250 prototype. Thresholds, peak values and latencies are determined for tonebursts and click-sound stimuli. Furthermore, the findings are compared with literature data.

Results: Based on three otologically normal test subjects, BC stimuli with B250 were up to 40 dB more efficient than AC-stimuli. Also, BC stimuli with B250 were superior at 250 Hz compared to 500 Hz. One patient with conductive hearing loss, who was unable to evoke a VEMP response for AC stimuli, was tested and found have clinically viable VEMP responses using B250.

Conclusions: Preliminary results suggest B250 as an alternative for clinical VEMP testing. Data from more subjects will be presented at the meeting.

OP12-3 - oVEMP: A novel tool for non-invasive intracranial pressure monitoring

22. Vestibular and Inner Ear Physiology

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Purpose: Ocular VEMP (oVEMP) are currently being established as a rapid and simple test for utricular function. Here, we present a novel application for VEMP.

Methods: OVEMP were recorded from controls and from patients with idiopathic intracranial hypertension (IIH). Tilt-table experiments with “body-up” inclination angles at 0-30 degrees were performed in controls. The influence of stimulus frequency

(500 or 1000 Hz) and type (ACS or BCV) were examined with respect to their sensitivity to intracranial pressure (ICP) changes. Repeated measurements before and after lumbar drainage were performed in patients with IIH. The correlations were examined and the diagnostic accuracy to detect ICP changes was calculated.

Results: Tilt table experiments in 20 controls revealed a highly significant linear correlation between tilt angle and ACS oVEMP amplitude ($R=0.999$; $p < 0.01$). This effect was restricted to the ACS stimulus ($p=0.001$ for ACS oVEMP) and it was restricted to the 500 Hz stimulus ($p < 0.001$ for 500 Hz ACS). Repeated ACS oVEMP measures before and after lumbar drainage in ten patients with IIH confirmed the correlation between the oVEMP amplitude reduction and the CSF pressure reduction. In each individual patient, the oVEMP amplitude was reduced by at least 30% after the lumbar drainage. BCV oVEMP remained unchanged. The diagnostic accuracy for the detection of a change in CSF pressure of 10 cm H₂O was 100%.

Conclusions: These data confirm with direct evidence the principal suitability of ACS oVEMP measurements for monitoring of intracranial pressure.

OP12-4 - Repetitive oVEMP stimulation for myasthenia gravis: optimization of stimulus parameters

15. Ocular Motility: Physiology and Pathology

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Purpose: Early diagnosis of myasthenia gravis (MG) is important for the course and outcome of the disease. Recently, repetitive ocular vestibular evoked myogenic potential (oVEMP) stimulation has been developed as a novel diagnostic tool for MG. Quantification of extraocular muscle response decrement after repetitive stimulation facilitates the diagnosis of MG at the predilection site of initial symptoms. We compared different stimulation paradigms to determine the optimal parameters for detecting the characteristic oVEMP decrement.

Methods: Repetitive bone-conducted oVEMPs were elicited in 18 MG patients and 17 healthy subjects. We compared four different repetition rates (20Hz, 30Hz, 40Hz, 50Hz) to determine the most sensitive and specific oVEMP parameters for decrement detection.

Results: Mean age of MG patients and healthy subjects was 62±18 and 30±6 years, respectively. The majority (89%) of MG patients had ocular symptoms at time of measurement, including ptosis (n=14) and diplopia (n=12). Eight patients (44%) had isolated ocular symptoms, 4 (22%) had additional bulbar weakness and 9 (50%) generalized muscle weakness. Repetitive stimulation at 30Hz yielded the best differentiation between MG patients and healthy subjects, with a sensitivity of 82% and a specificity of 83% (area under the curve (AUC) 0.84) when using an overall decrement of ≥9% as cutoff.

Conclusions: Preliminary data of our study suggest that 30Hz repetitive oVEMP stimulation is the most effective stimulus paradigm. Repetitive oVEMP stimulation with optimal parameters facilitates early and accurate diagnosis of ocular MG.

OP12-5 - What kind of information can be provided using chirp sound in VEMP?

7. Clinical Testing for Vestibular Function

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Purpose: For recording cervical vestibular evoked myogenic potentials (cVEMP), 500Hz and 1000Hz air-conducted short tone bursts (STB) or clicks have been used. Nowadays, 500Hz STBs are used most frequently because the otolith organs, especially the saccular sensory cells, best respond to STBs around 500Hz. Additionally, 1000Hz STBs are used to assess tuning property change of cVEMP due to endolymphatic hydrops (EH). Recently, chirp sound, which can be described as a sound in which frequency varies with time, has been applied in the field of audiology. However, its usefulness in VEMPs is not clear yet. We studied chirp-cVEMP to clarify its usefulness in the field of vestibular research.

Methods: Patients diagnosed with having Meniere's disease, vestibular migraine or their related disorders were enrolled. Subjects underwent cVEMP testing using STBs (500Hz, 1000Hz) and chirp sound. Myogenic potentials were recorded on the sternocleidomastoid muscle.

Results: The rates of present responses were not significantly different among the 3 types of stimulation. The normalized amplitude was the largest to 500Hz STB. The most interesting result was that the latency of P1 (p13) of chirp-cVEMP showed association with 500-1000Hz cVEMP slope, which is an index of tuning property change due to EH.

Conclusions: The latency of P1 of chirp-cVEMP might reflect tuning property because frequency in chirp sound varies with time. This finding suggests that the latency of P1 of chirp-cVEMP might be used as an index of EH.

OP12-6 - VEMP a simple, portable and affordable vestibular evoked myogenic potential test device.

7. Clinical Testing for Vestibular Function

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Purpose: In 2008, we developed the first useable vHIT (video head impulse test) goggles to simplify the assessment of the six semicircular canals. Testing the remaining four end-organs (otoliths) still requires complicated, bulky and expensive equipment. In this project we aimed to develop a simple portable and affordable VEMP test device which we call the μ VEMP.

Methods: Similar to the vHIT development strategy we tried to employ recent advances in electronic component performance and to simplify the VEMP device by implementing the minimum necessary features for effective testing. We used the traditional cVEMP (cervical) and oVEMP (ocular) electrode placements and the simplest bone-conducted tendon hammer taps and air-conducted clicks for stimuli.

The pocket-sized interface connects to phones, tablets, laptops etc. and a first prototype was evaluated in the lab and clinic. Six copies of a second prototype were distributed to colleagues for feedback on usability, durability, etc. A third design is easier to make and more likely to meet strict regulatory requirements (such as 5kV isolation).

Results: Validation data collected simultaneously from the same subject and electrodes using the mVEMP device and 'gold standard' research grade commercial equipment shows a strong similarity with an average concordance correlation coefficient of $r_c = 0.997 \pm 0.003$. Results recorded with the μ VEMP device on patients with audio-vestibular diseases are similar to those typically found in the literature.

Conclusions: It is now possible to assess the function of all ten vestibular end-organs in less than 20 minutes using simple, portable and affordable equipment including vHIT and μ VEMP.

OP12-7 - VEMP triggered by galvanic stimulation may reveal a subclinical myelopathy

7. Clinical Testing for Vestibular Function

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Purpose: VEMP triggered by galvanic vestibular stimulation (galvanic-VEMP) evaluates the vestibulo spinal tract and the purpose is to use the galvanic-VEMP to test the postural reflex aiming at a precocious diagnosis of the myelopathies that is associated with a vestibular central disorder.

Methods: Dizziness can be the first symptom of the human T lymphotropic virus type 1 (HTLV-1)-associated myelopathy (HAM). This cross-sectional study nested to a 20-years cohort included 25 individuals with HAM, 26 HTLV-1-asymptomatic carriers and 45 HTLV-1-seronegative individuals (controls). Galvanic stimuli (duration: 400ms; intensity: 2mA) were applied bilaterally to the mastoid processes and VEMP was recorded in the gastrocnemius muscle. The electromyographic parameters investigated were the latency and amplitude of the short-latency (SL) and medium-latency (ML) wave responses.

Results: While SL and ML amplitudes were similar, SL and ML latencies were delayed in HTLV-1 groups compared to control group ($p < 0.001$). Using neurological examination as the gold standard, Receiver Operating Characteristic (ROC) curve analysis showed an area under the curve of 0.83 ($p < 0.001$) for SL and 0.86 ($p < 0.001$) for ML to detect altered postural reflex. Sensibility and specificity were, respectively, 76% and 86% for SL and 79% and 85%

for ML. Galvanic-VEMP disclosed alterations that were progressive in HTLV-1-neurological disease, ranging from SL delayed latency in HTLV-1-asymptomatic carriers to absence of VEMP response in HAM group.

Conclusions: The worse the galvanic-VEMP response, the more severe the myelopathy. Galvanic-VEMP alteration may be a prognostic marker of progression from HTLV-1-asymptomatic carrier to HAM. The earlier the diagnosis of HAM, the better the therapeutics opportunities.

OP12-8 - Simultaneous recording of bilateral cervical/ocular vestibular-evoked myogenic potentials

7. Clinical Testing for Vestibular Function

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Purpose: We premised that cervical vestibular-evoked myogenic potential (cVEMP) and ocular VEMP (oVEMP) can be elicited simultaneously using bone-conducted vibration (BCV) stimuli. With the aid of novel four-channel surface electromyography (EMG) recording, the purpose of this study is to investigate the feasibility of performing bilateral cVEMP and oVEMP tests and getting four VEMP waveforms simultaneously.

Methods: Twenty subjects younger than 60 years without previous inner ear diseases were prospectively enrolled in this study. All subjects underwent individual unilateral cVEMP, unilateral oVEMP, and simultaneous bilateral cVEMPs and oVEMPs testing using BCV stimuli at forehead. The response rate and characteristic parameters of VEMP tests such as p13 latency, n23 latency, nI latency, pI latency, p13-n23 amplitude and nI-pI amplitude were further compared and analyzed.

Results: All of 40 ears had clear cVEMP and oVEMP responses, regardless of individual VEMP test or 4-channel simultaneous VEMP test. There were no significant differences between the individual and simultaneous VEMP tests in terms of all

VEMP parameters. Furthermore, Pearson's correlation analyses revealed significant positive correlations between the individual and simultaneous VEMP tests in terms of all VEMP parameters.

Conclusions: Bilateral cVEMP and oVEMP tests can be obtained simultaneously using BCV stimuli with the aid of four-channel surface EMG recordings.

OP13: Ménière's disease (I)

OP13-1 - Low-frequency vibration induced vestibular reactions and benefits in Meniere's disease patients

14. Meniere's Disease and Related Disorders

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Purpose: To explore the mechanism of low-frequency vibration on interfering vertigo and the efficacy of controlling vertigo in Meniere's disease (MD) patients using a novel device that generates the defined vibrations.

Methods: The frequency spectrum of vibrations induced by temporal bone drilling in cadavers and that of a rotatory vibrator were analyzed. 13 normal individuals and 14 MD patients were exposed to low-frequency vibrations for 30 min. The audiograms and cervical vestibular evoked myogenic potentials (cVEMPs) were measured at various time points. The complaints in MD patients were followed for 7-19 months.

Results: Drilling of the temporal bone induced vibrations ranging from 4 Hz to 3.2 kHz. The novel device generated vibrations ranging from 42-116 Hz depending on the voltage of power supply. Of the 13 volunteers, 3 experienced transient vestibular stimulating symptoms during exposure to the 68 Hz vibra-

tions. The cVEMP amplitudes were reduced at 30 min and 7 d post-exposure. 12 out of 14 patients felt comfortable within 24 h after exposure except that 2 patients did not show any benefit. The vertigo was significantly controlled after exposure ($p < 0.01$, Wilcoxon signed ranks test). The tinnitus and ear fullness were also significantly improved after exposure ($p < 0.05$, Wilcoxon signed ranks test).

Conclusions: The novel device delivered sufficient vibration to disrupt the vestibular activity by mimicking temporal bone drilling during the ear surgery, which is safe for the auditory system and effective in controlling vertigo, tinnitus, and ear fullness of MD patients. The study was supported by National Natural Science Foundation of China (contract 81771006).

OP13-2 - Intratympanic Steroid is an Economic and Effective Treatment for Intractable Meniere's Disease

14. Meniere's Disease and Related Disorders

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Purpose: The aim of this study was to investigate the cost-benefit of intratympanic dexamethasone injection (ITD) in patients with medically intractable Ménière's Disease (MD).

Methods: Fifty-five patients with MD receiving the ITD were reviewed. All participants were followed-up for 24 to 40 months. The vertigo control, functional level scale (FLS), visual analog scale (VAS), cost before and after ITD were recorded.

Results: For the Meniere's patients involved, vertigo was effectively controlled in 87.3% after one or repeated ITD courses. Our results showed that, compared with the healthcare cost before ITD, the cost after ITD (including the cost of related examinations and treatments) decreased, except for patients with bilateral MD. In addition, compared with results before ITD, the FLS decreased and self-assessed satisfaction, assessed by VAS, increased significantly.

Two parameters related to the cost-effectiveness, cost/(6-FLS) and cost/VAS, decreased significantly after ITD treatment.

Conclusions: For the patients with medically intractable MD, ITD is an economic and effective treatment for controlling vertigo. Various natural courses, delayed diagnoses and lacking objective diagnostic test may result in substantial healthcare burden for MD patients.

OP13-3 - Follow-up of a randomised, double-blind, trial of methylprednisolone vs gentamicin in unilateral MD

14. Meniere's Disease and Related Disorders

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Purpose: Our recent randomised, double-blind trial in The Lancet showed that the effectiveness of intratympanic methylprednisolone is comparable to gentamicin in managing refractory unilateral MD with 24 months follow-up. We now aim to assess the long-term outcome of the interventions as MD is a chronic relapsing disease.

Methods: A questionnaire package was sent to all participants of the original trial followed by a telephone follow-up if necessary. Of the 60 participants, one dropped out, one was lost to follow-up and two had died of unrelated causes. We had 46 responses (82%) of which 22 had methylprednisolone and 24 had gentamicin.

Results: All patients for both treatments had excellent vertigo control at an average of 70 months follow-up. In the gentamicin group the mean number of vertigo attacks in the previous 6 months were 1.0 (SD 2.4) and for the steroid group 0.8 (SD 2.6). Eight participants (five methylprednisolone and three gentamicin) had had further injection treatment

due to recurrent symptoms following the original study period.

Conclusions: Long-term outcomes for intratympanic methylprednisolone are comparable to gentamicin with satisfactory vertigo control at 70 months follow-up.

OP13-4 - Exploring Fluctuating Sensorineural Hearing Loss In Meniere's Disease Using iPad-Based Audiometry

14. Meniere's Disease and Related Disorders

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Purpose: Fluctuating sensorineural hearing loss (FSNHL) is a diagnostic symptom of Meniere's Disease (MD). Little is known about how hearing fluctuates, the relationship between FSNHL and vertigo, whether FSNHL should be targeted for treatment, or if treatments alter permanent hearing loss. Patients normally have infrequent audiologic testing. iPad-based audiometry is validated, portable, and extremely easy to use. We aim to explore FSNHL by having patients test their own hearing daily.

Methods: 5 patients were recruited with MD. Patients who had migraines or intratympanic injections within one year were excluded. Patients were trained to use the iPad-based audiometer. They kept a diary of attacks and performed daily and post-attack audiograms for 3 months. Patients had conventional audiometry monthly. Pure tone averages were plotted over time for both ears. Data analysis looked for trends and variability.

Results: All patients completed at least 50 audiograms. iPad-based audiometry was easy to use with no side effects or technical issues. 2 of 5 patients showed marked daily PTA variability in the diseased ear. All normal ears, and diseased ears where the patient experienced no attacks, showed limited PTA

variability. All patients felt that without testing sequence randomization, responses could be predicted.

Conclusions: This is proof of principle that iPad-based audiometry can be used to track FSNHL in MD. This technology allow improved understanding of the cochlear manifestations of MD, with the potential to fine-tune diagnostic criteria for FSNHL in MD and allow improved diagnosis and treatment of hearing loss. Future larger studies are planned.

OP13-5 - Endolymphatic hydrops diagnosis at 3T MRI: Reproducibility and correlation with Meniere's disease.

14. Meniere's Disease and Related Disorders

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Purpose: Evaluate the reproducibility of magnetic resonance imaging (MRI) for the diagnosis of endolymphatic hydrops in patients with Meniere's disease (MD) symptoms and assesse its correlation with clinical diagnosis of MD.

Methods: This retrospective analysis included 3T MRI examinations of 50 patients with MD symptoms (21 men, 29 women, mean age = 53+/-12). 3DT2 and 3D FLAIR were performed 4 hours after iv. injection of gadolinium and a « hydrops sequence » was obtained by subtracting the first two sequences. Two experienced readers assessed blindly and independently the presence and location of hydrops. Inter-observer agreement was evaluated per patient, per ear and whether the hydrops was vestibular, cochlear or vestibulo-cochlear. According to the 2013 Barany Society's criteria for MD, 16 patients had *definite* MD, 6 *probable* MD and 28 didn't match criteria. Correlation between clinical and MRI findings was based on the most experienced reader's findings.

Results: Inter-observer agreement was substantial for the MRI diagnosis of hydrops per patient (=0.82)

and moderate for hydrops diagnosis per ear (=0.76), moderate for vestibular hydrops per ear (=0.78) and fair for cochlear hydrops per ear (=0.40). MRI hydrops was found in 93% of *definite* MD, in 83% of *probable* MD and in 75% of non-MD patients. 76% of MRI hydrops were bilateral.

Conclusions: Although overall MRI diagnosis of hydrops is well reproducible, the diagnosis of cochlear hydrops should be made with caution due to substantial interobserver variability. Despite strong correlation between clinical MD and MRI-hydrops, MRI-hydrops is also found in many patients not matching the strict MD criteria.

OP13-6 - Endogenous Ouabain in Meniere's Disease

14. Meniere's Disease and Related Disorders

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Purpose: Endogenous Ouabain (EO) has been demonstrated to modulate the activity of ionic exchangers, and genetically determined activity of them has been studied as a predisposing factor to develop Meniere's Disease (MD). We recently published data on gene polymorphism of SLC8A1 and SIK1 in MD subjects. Our purpose was to assess EO plasma levels in MD subjects and assess a possible correlation with these gene polymorphism.

Methods: EO plasma levels have been assessed in 127 MD subjects and 129 normal Caucasian subjects; clinical history for migraine, hypertension, autoimmune disorders and SLC8A1 / SIK1 gene polymorphism have been saved.

Results: EO plasma levels in MD subjects was 195 pmol/L (range 59-540, median 194), while in controls was 137 pmol/L (range 39-341, median 124). A significance has been detected between groups by a non parametric analysis (p=0.005). No correlation has been found in MD subjects with hypertension (p=0.1), migraine (p=0.07) and autoimmune disorders (p=0.59). Moreover, no correlation has been found with SLC8A1 and SIK1 mutation (p=0.3 and 0.5 respectively)

Conclusions: Since EO has been demonstrated to be a regulator of ionic and water balance in the inner ear, we propose that altered plasma levels of EO may act as a predisposing level to develop MD. Our data support the hypothesis that EO and SLC8A1 / SIK1 gene polymorphism act as independent predisposing factors.

OP13-7 - Acoustic absorbance in wideband tympanometry of Meniere's Disease is greater in affected side

14. Meniere's Disease and Related Disorders

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Purpose: To compare acoustic absorbance of wideband tympanometry in patients with Meniere's disease with control group without inner ear and middle ear disorders.

Methods: Acoustic absorbance were detected using wideband tympanometry in 60 patients with unilateral Meniere's disease and 30 control subjects excluding inner ear and middle ear disease. All patients with Meniere's disease underwent electrocochleography and Sp/Ap was recorded. Meniere's disease was diagnosed and graded according to diagnostic criteria for Meniere's disease (published in Journal of Vestibular Research, 2015) and graded. The integral area formed by the absorbance curve on peak pressure and x-axis (frequency) was calculated. Student's t-test was used to compare integral areas difference of 2 ears in Meniere's disease patients and control group.

Results: The integral area of absorbance was greater in affected side than unaffected side in Meniere's disease patients. The average integral area difference in Meniere's disease patients was 5.69%±2.20%, in control group was 2.09%±1.25% (P<0.01). But there was no significant difference between Meniere's disease in different grade (P>0.05). Only 45% Meniere's disease patients showed Sp/Ap >0.4 in affected side.

Conclusions: Affected side in Meniere's disease showed higher absorbance than other side. Whereas, in control group, the difference between 2 ears is not significance. Wideband tympanometry is more sensitive than electrocochleography in Meniere's disease.

OP14: Clinical vestibular testing HIT (II)

OP14-1 - Video-Head-Impulse testing in infants younger than 24 months

7. Clinical Testing for Vestibular Function

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Purpose: Earlier work revealed that Video-Head-Impulse testing (vHIT) is often difficult to perform on infants younger than 24 months. In particular, calibration of the system can be challenging, as active cooperation of the child is required. The aim of our study was to evaluate horizontal semicircular vestibular function in infants using a newly developed software that simplifies vHIT examination.

Methods: 18 patients (10 boys, 8 girls) aged 4-24 months were included. The newly developed software enabled calibration of the eye position signal with the infants fixating on animated graphics projected on a screen. After calibration, a vHIT goggle (EyeSeeCam ©) was used to perform head impulses in the horizontal plane while the infant was watching a movie sitting on their parent's lap or in a baby chair. At least 15 impulses to each side were obtained and the occurrence of refixation saccades was analyzed.

Results: The new calibration method and modified test setup provided reproducible results in all infants tested (n=18). An increased incidence of artifacts was not observed. In 4 patients, more than one test was needed to obtain reproducible results. Median gain for impulses to the right side was 0.87 (+/-0.23) and 0.86 (+/-0.19) for impulses to the left. Refixation saccades could not be identified.

Conclusions: The study emphasizes that vHIT with an optimized calibration is an easy and sensitive screening tool to evaluate vestibular function in infants younger than 24 months and should be used as the gold standard in pediatric vestibular assessment.

OP14-2 - Video head impulse test data in subjects with and without vascular risk factors and vertigo

7. Clinical Testing for Vestibular Function

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Purpose: To compare video head impulse test (vHIT) vestibulo-ocular reflex (VOR) gain values and proportion of subjects with saccades among healthy subjects, subjects with cerebrovascular disease (CVD), and subjects with an acute vestibular syndrome (AVS).

Methods: We recruited at Umeå university hospital between 2016-06-14 and 2017-11-17:

- i) healthy adults without vascular risk factors, a history of neurological disease, vestibular disease or head injury, n=70, median age 43 (SD) 16.6;
- ii) subjects with anterior circulation TIA/stroke admitted to the stroke ward, n=51, median (IQR) age 74 (SD) 12.5; and
- iii) subjects presenting at the emergency department with an AVS, n=46, median (IQR) age 64 (SD) 17.

All subjects provided informed consent. The head impulse test battery was conducted using the Synapsys vHIT Ulmer II system. We used one-way ANOVA to compare means, and the chi-square test to compare proportions, across subject categories.

Results: The mean gain for all horizontal canal impulses were higher among healthy subjects vs subjects with CVD and subjects with an AVS (0.97 vs 0.92 vs 0.74, $p < 0.001$). All three categories of subjects displayed saccades on horizontal canal testing, however the proportion was lower among healthy subjects vs subjects with CVD and subjects with an AVS (11.6% vs 22.2% vs 29.1%, $p = 0.025$).

Conclusions: Low VOR gain and occurrence of saccades on vHIT testing among subjects without known vestibular dysfunction, especially among subjects with vascular risk factors, may affect the interpretation of the HINTS algorithm in acute vertigo presentations.

OP14-3 - Viewing-target distance influences the VOR gain when assessed using the vHIT

7. Clinical Testing for Vestibular Function

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Purpose: Gaze stabilisation during head movements is provided by the vestibular ocular reflex (VOR). Clinical assessment of this reflex is performed using the video head impulse test (vHIT). To-date the influence of different fixation distances in VOR gain using the vHIT remains unknown.

Methods: We assessed the horizontal VOR using the vHIT, in 18 healthy subjects. Firstly, we assessed the VOR gain with viewing targets at 150cm, 40 cm, 30 cm, 20 cm, and 10cm.

Results: The gain increased significantly as viewing target distance decreased. Pearson's correlation showed a significant relationship between VOR gain and target distance. We performed a second experiment in 10 subjects in complete darkness whilst subjects imagined targets at different distances. There was a significant negative correlation between gain

and distance. There was a statistically significant difference between light and dark 20 and 40cm distances, but not for 150cm.

Conclusions: Theoretical VOR gains at different target distances were calculated and compared with those found in light and dark. The gain increase observed was less than predicted by the formulae, implying a physiological ceiling-effect of the VOR. The VOR gain increase in the dark represents a convergence-mediated VOR gain enhancement. The physiological VOR modulation with distance/convergence can be replicated using vHIT.

OP14-4 - Dissociation between caloric test and video head impulse test: device factor vs stimulus factor

7. Clinical Testing for Vestibular Function

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Purpose: The caloric test and the video head impulse test (vHIT) can lateralize vestibulopathy by measuring vestibulo-ocular reflex (VOR) of each horizontal canal separately. However, they are frequently dissociated. The aim of study is to test if the discrepancy between vHIT and caloric test is related to the device-specific gain calculation algorithm (device factor) or different characteristics of vestibular stimuli (stimulus factor).

Methods: Among the patients who received caloric test and vHIT, 27 subjects (12 males, mean age=48) showed ipsilateral canal paresis (CP, >25%) and normal VOR gain on vHIT-device A (vHIT-A) (0.86-1.22). For those subjects, vHIT was subsequently repeated using vHIT device-B (vHIT-B). All the tests were performed on the same day. The gain of vHIT-A was compared with that of vHIT-B at 40, 60, and 80 msec.

Results: The average of CP was 50.8%. The average gain of vHIT-A was 1.0±0.08, and the gain of the vHIT-B was 1.07±0.32, 1.06±0.23, and 0.97±0.17.

The gain of vHIT-B did not show any correlation with CP (40, 60, 80ms; P=0.08, P=0.15, P=0.95). Twenty-four among 27 subjects showed normal gain in both vHIT-A and vHIT-B. In the remaining 3 patients, the gains with vHIT-A and vHIT-B at 60 ms were 0.95 and 0.75, 0.93 and 0.79, 0.95 and 1.47, respectively.

Conclusions: Device factors do not seem to be associated with dissociation between the caloric test and vHIT in dizzy patients. Considering the dissociation between two tests is mostly originated from stimulus factor, caloric test and vHIT should be complementary tools for the lateralization of vestibular dysfunction.

OP14-5 - Changes in vestibulo-ocular reflex during video Head Impulse Test in patients with cerebellar ataxia

7. Clinical Testing for Vestibular Function

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Purpose: Vestibulo-ocular reflex (VOR) is a reflex that stabilizes the visual image on the retina during brief head movements, information from semicircular canals. Head impulse test detects disorders of vestibulo-ocular reflex and thus peripheral vestibular dysfunction; however, cerebellar impairment can cause changes in corrective saccadic eye movements. The aim of the study was to analyze corrective saccades during head impulse test in patients with cerebellar ataxia and to compare these findings with a group of patients with peripheral vestibulopathy and with healthy controls.

Methods: 45 patients with cerebellar ataxia were examined (11 genetically determined, 34 idiopathic cerebellar ataxia), results were compared with 15 patients with peripheral vestibulopathy and 25 healthy persons. The video Head Impulse Test was administered in all subjects; we evaluated gain of VOR and distribution of the corrective saccades. Vestibular reactivity was examined by means of electronystagmography with rotational and caloric testing. Range of impairment in patients with cere-

bellar ataxia was assessed by the Scale for the assessment and rating of ataxia.

Results: The video Head Impulse Test, especially the distribution of the corrective saccades helps to distinguish patients with cerebellar impairment from the patients with vestibular impairment and healthy controls. Scattered corrective saccades prevail in patients with cerebellar ataxia (64%), gathered saccades in peripheral vestibulopathy.

Conclusions: The video Head Impulse Test allows to identify and quantify combined vestibular and cerebellar pathology. VOR gain and character of distribution of corrective saccades could serve as a neurophysiological biomarker of the disease and thus help in the diagnostic algorithm.

OP14-6 - vHIT VOR-gain is not yet a reliable measure for bilateral vestibulopathy

7. Clinical Testing for Vestibular Function

Tessa van Dooren¹

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Purpose: To evaluate the vestibulo-ocular reflex (VOR) gain of three different video head impulse test systems (vHIT).

Methods: vHITs were performed in 50 patients with bilateral vestibulopathy (BV) and a control group of 37 healthy volunteers. All BV patients had a reduced caloric response of summated slow phase mean peak velocity of less than 20°/s. In the BV patients, a lateral vHIT was performed with the EyeSeeCam, Otometrics and Synapsys systems and the vertical vHIT was performed with the Eyesecam and Otometrics systems. These results were compared with the

group of healthy volunteers. VOR-gains obtained by the different systems were compared. The order of the tests was randomized. All tests were performed under standardized circumstances.

Results: As expected, VOR-gain of the lateral vHIT was mainly reduced in BV patients. Most importantly, VOR-gains between systems differed significantly for BV patients as well as for healthy volunteers. When only relying on vHIT-results, some BV-patients did match the criteria for BV with one system, but not with the other.

Conclusions: VOR-gains remarkably differed between systems within the same subjects. This could lead to misdiagnoses regarding vestibular function. The differences could most likely be attributed to different types of gain calculation. It is therefore of utmost importance to have a uniform way of gain calculation for all vHIT-systems.

OP14-7 - Problems with vertical Video Head Impulse Test (vHIT)

7. Clinical Testing for Vestibular Function

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Purpose: To highlight some inherent problems with vertical HIT

Methods: Retrospective review on vertical HIT on patients deemed as having normal vestibular function a considerable number with both Otometrics and Interacoustics systems reveal large differences between the RALP and LARP plane. On 12 healthy volunteers vertical HIT was simultaneously recorded with the cameras over both eyes, with gaze directed straight ahead and 20 degrees to either side in the direction of the stimulated SCC.

Results: Statistical difference in gain values were obtained regardless of the examined SCC when comparing the recordings of left vs. right eye. Gain values increased when gazing in the direction of the stimulated SCC but there were still significant differences between gain-values between recordings of

the different eyes. We also demonstrate the movement of goggles in 3D and its implications of the obtained values.

Conclusions: The algorithms when calculating vertical HIT gain do not seem to be sufficient to reliably reflect actual vestibular function and the question is whether goggles (especially if the camera is fixed over one eye) will survive to the future vestibular test-battery. Transparency is urgently needed both for interpreting clinical findings as well as research.

OP15: Imaging

OP15-1 - Meniere's disease affected inner ears are distinct from healthy controls with MRI and Radiomics

13. Imaging of the Inner Ear & Vestibular System

M. Van Hoof¹

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Purpose: Ménière's disease (MD) is characterized by non-exclusive symptoms, relying on diagnostic criteria instead of imaging. Recently it has been shown (Aerts et al. 2014) that intensities in conventional medical imaging can be processed using data-characterization algorithms (radiomics) to enable feature quantification beyond the human eye. The purpose of this project was to investigate if conventional MRI scans of the inner ear contains radiomics

features that can specifically be attributed to MD and if machine learning would be able to discriminate subjects with and without definite MD.

Methods: A retrospective study was performed in Maastricht University Medical Center, VieCuri hospital, the Antwerp University Hospital and the Apeldoorn Dizziness center. Patients with definite MD according to the American Academy of Otolaryngology-Head and Neck Surgery criteria were included. The control group consisted of patients with idiopathic asymmetrical sensorineural hearing loss, i.e. the unaffected inner ear as control. The T2-weighted MRI scans were characterized by a set of primary and secondary radiomics features which were analyzed by the machine learning package of Wolfram Mathematica 11.2 (Wolfram Research Inc., USA).

Results: The prevalence of MD in the 288 included patients was 44%. The randomly mixed training set consisted of 213 scans. The separate randomly mixed validation set consisted of 50 scans in which a statistically significant accuracy of 80±6% was achieved (p = 0.005).

Conclusions: Machine learning can distinguish inner ears affected by definite MD accurately from healthy controls by using semiautomatic volumetric segmentation and radiomics features of conventional MRIs obtained in different centers.

OP15-2 - MRI in Meniere patients: reliability of standard and additional diagnostic imaging criteria.

13. Imaging of the Inner Ear & Vestibular System

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Purpose: In this retrospective study we determined: 1) intra- and interrater variability of our MRI technique, 2) sensitivity and specificity of hydrops

imaging in definite Ménière's disease (MD) patients, 3) value of additional diagnostic imaging criteria.

Methods: Patients were scanned (3T MRI, 3D-FLAIR) 4 hours after intravenous gadolinium (double dose). 148 patients (296 ears) were graded twice by 3 experienced radiologists: cochlear endolymphatic hydrops (CEH) was classified as either none, grade I or grade II. For vestibular endolymphatic hydrops (VEH), a third grade was added. Three additional diagnostic imaging criteria were evaluated: enhancement of: 1) cochlea, 2) vestibule and 3) vestibular aqueduct (VA). We determined the intraclass correlation coefficient (ICC) for inter-reader variability (inter-RV) and intra-reader variability (intra-RV).

Results: For all patients (296 ears), inter-RV values were: 0.90 (CEH); 0.93 (VEH); 0.84 (cochlear enhancement); 0.73 (vestibular enhancement) and 0.65 (enhancement VA). The intra-RV values were: 0.93 (CEH); 0.96 (VEH); 0.91 (cochlear enhancement); 0.80 (vestibular enhancement) and 0.80 (enhancement VA). The sensitivity, determined in 79 unilateral definite MD patients, was 84.8% when only the grading of CEH and VEH was taken into account and increased to 91.1% when making use of the additional diagnostic imaging criteria. The specificity, determined on 105 healthy ears of unilateral MD patients, was 90.4%.

Conclusions: Endolymphatic hydrops imaging is a robust and reliable MR technique, able to detect and grade hydrops with a very high sensitivity and specificity. Adding extra diagnostic imaging criteria might augment the sensitivity, but should be further investigated.

OP15-3 - The human vestibular cortex

13. Imaging of the Inner Ear & Vestibular System

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Purpose: A cortical vestibular network of at least seven regions has been established in non-human primates 20 years ago. The complete delineation of a human vestibular cortex has been impeded by several confounders and technical limitations so far. Aim was to localize all cortical vestibular regions in humans.

Methods: We examined 60 healthy subjects with galvanic vestibular stimulation (GVS) after local postauricular anaesthesia in 3T fMRI (64-channel coil). Data analysis was performed using SPM12. Results were considered significant at FDR $p < 0.01$.

Results: We were able to identify the cortical homologues to known non-human primate vestibular representations. Beside the cerebellar nodule and uvula, we found area OP2 in the parietal operculum to be the human core equivalent to PIVC. Monkey VPS could be mapped to area PFcm, whereas area 7 is probably located in area PF. Area VIP, areas 2v and 3aV were identified in the human IPS, and area 6 in the human lateral premotor region. Human area CSv was found to be the VC region. Strong vestibular responses were shown in area MST. Responses in monkey periarculate cortex may be homologous to activations in the human SMA. All findings could be replicated internally in an independent cohort.

Conclusions: We were able to robustly map the human vestibular cortex and to identify all established cortical vestibular regions. The confounder-minimised GVS response patterns show that the core of the cortical vestibular network in humans is represented by areas OP2 (PIVC), MST, PFcm (VPS), PF (area 7) and CSv (VC).

OP15-4 - Head tap stimulus to image the vestibular cortex on fMRI – a pilot study

13. Imaging of the Inner Ear & Vestibular System

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Purpose: Very different areas of the cerebral cortex have been labelled vestibular. More recently PET and fMRI scans have confirmed it is the parietoinsular cortex. Delivery of the vestibular stimulus (optokinetic, caloric for canals, tone bursts for otoliths) in the scanner has been challenging. Vestibular evoked myogenic responses (VEMPs) are an inhibitory response elicited from the saccule (cVEMP) detected in the neck and utricle (oVEMP) detected in the contralateral inferior oblique. oVEMPs can be elicited from a simple forehead tap. It was decided to investigate whether a head tap in the fMRI scanner could produce reliable vestibular responses.

Methods: Six “normal” adults were tested who had normal hearing for age, normal vHIT test, and present oVEMPS. There were three controls: (1) a woman who had had a right acoustic neuroma removed with no right hearing, reduced vHIT and absent oVEMP (2) a profoundly deaf male with absent vHIT and absent oVEMP (3) a profoundly deaf male with normal VOR and present oVEMP. In a 3Tesla fMRI scanner a series of forehead taps were delivered.

Results: In all the normal adults there was bilateral vestibular activity. A correlation with handedness could not be established. Controls: (1) There was absence of vestibular activity on the right side (2) There was no vestibular activity (3) Bilateral vestibular activity was present.

Conclusions: Simple head taps in the fMRI scanner elicit vestibular cortex activity. The two profoundly deaf controls imply that the stimulus is not activating a hearing response. The technique could easily be automated.

OP15-5 - MR volumetric measurement of endolymphatic space in patients without vertigo or hearing loss

13. Imaging of the Inner Ear & Vestibular System

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Purpose: The presence of endolymphatic hydrops (ELH) in patients with Meniere’s disease (MD) is generally accepted as a hallmark of this disease. The purpose of this study was to quantitatively measure the volume of inner ear endolymphatic space (ELS) in patients without vertiginous or cochlear symptoms and to determine the normal value for the ELS using three-dimensional inner ear MR imaging.

Methods: Forty-seven patients with chronic rhinosinusitis were enrolled. Inner ear fluid space images and positive perilymph/positive endolymph images were acquired using a 3.0-tesla unit. Three-dimensional (3-D) images were constructed semi-automatically using both anatomical and tissue information by fusing the 3-D images of the TFS and the ELS (KIIS technique).

Results: The ELS/the total fluid space (TFS) ratio in the cochlea was $10.2 \pm 1.7\%$ and that in the vestibule was $17.7 \pm 10.2\%$. Age-related differences were found in the TFS, ELS, and ELS/TFS ratio in the inner ear and the ELS and ELS/TFS ratio in the vestibule.

Conclusions: The existence of the ELS in patients without vertiginous or cochlear symptoms was shown. These findings could be useful as a standard reference for further research for the relationship between ELH and clinical and functional aspects of MD and other disease.

OP15-6 - PET visualized stimulation of the vestibular organ

13. Imaging of the Inner Ear & Vestibular System

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Purpose: Our knowledge of the vestibular cortical network in humans is variegated. The current knowledge of vestibular cortical processing in humans is mostly based on studies where PET or fMRI were performed during a non-physiological stimulation either with caloric testing, galvanic stimulation, or vestibular evoked myogenic potentials (VEMP). However, the use of non-physiological stimulation may always be discussed and interpreted carefully. For instance, a caloric test not only stimulates the vestibular organ but also vagal, thermal, nociceptive and tactile sensory receptors leading to a potential misleading cortical activation.

This study aims to visualize cortical activity during physiologic stimulation of the human vestibular organ.

Methods: 12 healthy right-handed healthy volunteers underwent three FDG-PET scans. In our self-propelled chair the volunteers were injected with an FDG-tracer. After the injection the chair was set in motion for 35 minutes. Subsequently a brain PET-scan was obtained. To obtain a comparable baseline, participants were injected with FDG while seated in the chair without movement.

Results: *Linear acceleration*

A significant increase in activity is seen in the left posterior insula. The increase is seen in all 12 participants. In addition a significant increase is seen in the right posterior insula and the thalamus.

Rotation

A significant increase is seen in the left posterior insula. A smaller but significant increase is seen in the right posterior insula and the thalamus.

Conclusions: The *left posterior insula* showed a significant increase in brain activity during both types of vestibular stimulation suggesting that this may represent a main part of the human vestibular cortex.

OP15-7 - The Ups and Downs of Endolymphatic Hydrops Imaging

13. Imaging of the Inner Ear & Vestibular System

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Purpose: In the last decade, MR imaging of the inner ear with the aim of visualizing endolymphatic hydrops has seen a fast and worldwide distribution. This method has an unprecedented diagnostic value since it can unequivocally confirm the presence of endolymphatic hydrops. Nevertheless, unawareness of some pitfalls can lead to frustrating results.

Methods: The complex and variable MRI anatomy of the inner ear is revisited, since its knowledge is essential for the interpretation of endolymphatic hydrops imaging data. The implications of the complex geometry of endolymph fluid spaces for the interpretation of the data are explained. The multitude of parameters that can influence the image quality are reviewed and examples are presented. The problems associated with a very weak endolymph/perilymph contrast and the advantages and disadvantages of intratympanic vs intravenous contrast application are discussed. Multiplanar reconstructions for the visualization of the inner ear structures including sacculus and utriculus are demonstrated.

Results: The clear visualization of endolymphatic hydrops is of great value for the diagnosis of Hydropic Ear Disease. However, especially early in the disease course, the hydrops may be too faint to be recognized with certainty on MRI. Utriculus distension may be overestimated if only axial images are analyzed. For the evaluation of vestibular hydrops, multiplanar reconstructions are helpful tools. For the evaluation of cochlear hydrops, a sufficiently strong signal intensity is necessary.

Conclusions: A detailed knowledge of the complex anatomy of the inner ear and recognition of many confounding technical parameters are necessary for a reliable interpretation of endolymphatic hydrops imaging.

OP15-8 - Neuroinflammation along the vestibular nerve and nucleus in acute unilateral vestibulopathy

13. Imaging of the Inner Ear & Vestibular System

Andreas Zwergal¹

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Purpose: The aetiology of acute unilateral vestibulopathy is unknown. Some histological findings suggest that it may originate from inflammation of the vestibular afferents. In the present study a novel PET-based approach was used to show neuroinflammation along the vestibular nerve and brainstem entry zone in patients with acute unilateral vestibulopathy in vivo.

Methods: Six patients with an acute unilateral vestibulopathy were included in the study. All patients

underwent detailed neuro-ophthalmological and vestibular testing to confirm the clinical diagnosis. MRI was done to exclude a central aetiology. Glial activation as a marker of neuroinflammation was visualized by [¹⁸F]GE180-PET within the first 7 days after symptom onset.

Results: All patients showed signs of an acute unilateral peripheral vestibulopathy including spontaneous nystagmus, pathological video-head impulse test and caloric asymmetry towards the affected side, ipsilesional SVV deviation and falling tendency. Central ocular motor and vestibular signs were absent. MRI was unremarkable in all patients. [¹⁸F]GE180-PET depicted glial activation in the ipsilesional vestibular nerve in 4 of 6 patients and in the ipsilesional vestibular nucleus in 5 of 6 patients at 3 to 7 days after symptom onset. The one patient without [¹⁸F]GE180 uptake developed additional clinical signs indicate for Menière's disease (i.e. hearing loss, tinnitus, recurrent vertigo attacks) in the longer-term follow-up, challenging the initial diagnosis of an acute unilateral vestibulopathy.

Conclusions: In patients with acute unilateral vestibulopathy the majority of cases show in vivo evidence for neuroinflammation in the ipsilesional vestibular nerve and nucleus during the acute and subacute stage of symptoms.

OP16: Miscellaneous

OP16-1 - DIZZYNET - a European network initiative for vertigo and balance research: visions and aims

27. Others

Andreas Zwergal¹

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Purpose: Patients with vertigo often receive inappropriate treatment. The most important reasons are insufficient interdisciplinary cooperation, nonexistent standards in diagnostics and therapy, missing translations of basic science findings to clinical applications, and the scarcity of prospective multicenter clinical trials.

Methods: To overcome these problems, 20 European expert centers started an initiative to establish a European Network for Vertigo and Balance Research called DIZZYNET. The central aim was to create a platform for collaboration and exchange among scientists, physicians, technicians, and physiotherapists in the fields of basic, translational, and clinical research.

Results: DIZZYNET members defined the following objectives as regards structure and content: to focus on multidisciplinary translational research in vertigo and balance disorders, to develop interdisciplinary networks for patient care, to increase methodological competence by implementing common SOPs, to internationalize the infrastructure for RCTs, to create a common database for patients with vertigo and balance disorders, to offer and promote attractive educational and career paths in a network of cooperating institutions. As first results of networking activity (1) a pilot databank was implemented, (2) a European UEMS initiative for a common curriculum in vestibular medicine was supported, (3) common fundraising activities were prompted, (4) a European guideline process for driving licence in vestibular patients was initiated and (5) annual joint teaching and training events were offered.

Conclusions: DIZZYNET will function as an additional structure that addresses some of the practical problems in vestibular and balance research and does not compete with the traditional national or international societies active in the field.

OP16-2 - Cochlear cooling for neuroprotection: The Cool-cochlea Project

17. Pharmacotherapy

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Purpose: Hypothermia is an effective neuroprotective strategy for a variety of injuries. Cooling the cochlea offers the capability to selectively protect inner ear neural structures. This study investigated the efficiency of inner ear cooling in a cadaveric head with thermocoupling electrodes providing real time temperature monitoring.

Methods: Two fresh cadaveric heads were imaged using a 192 slice computed tomography (CT) scanner to evaluate for standardized anatomy. Thermocoupling electrodes were placed in the ear canal, middle ear, lateral semicircular canal, and basal turn of the cochlea and electrode localization was verified with CT. System input temperature served as an independent variable. Air and water, at controlled temperature levels, were introduced into the ear canal and directly into the middle ear and the efficiency of thermal transfer was measured.

Results: Temperature curves were recorded and graphed as a continuous function of time. Results showed a brief response delay to each caloric modulation with a subsequent linear temperature response in the inner ear. Time to reach near steady state was

determined in each experiment. Temperature change effects were noted to be greater with liquid medium than air. Direct modulation of the middle ear temperature showed greater temperature changes in the cochlea; however, significant change was also noted with ear canal delivery.

Conclusions: Cochlear cooling via a caloric irrigation system can effectively lower the temperature of the inner ear. Applications of therapeutic hypothermia for inner ear neuroprotection range broadly and include treatment of labyrinthitis, sudden sensorineural hearing loss, hearing preservation cochlear implantation, among others.

OP16-3 - Vestibular dysfunction in mitochondrial disease: a common, treatable cause of dizziness or imbalance

12. Genetics, Development, and Regeneration

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Purpose: Mitochondrial diseases are a clinically heterogeneous group of genetic disorders with limited treatment options. Despite the known rehabilitation benefits for vestibular disorders, there is limited data concerning the incidence of vestibular dysfunction in mitochondrial disease. Thus, advancing understanding could potentially inform therapy and outcome development for those affected.

Methods: People attending a specialist mitochondrial disease clinic between May 2016 and August 2017 were included. They were asked about dizziness and imbalance using pre-determined criteria. Referral for neuro-otological investigation was

arranged when symptoms could not be explained by neuropathy or cerebellar ataxia.

Results: Forty-two people with a clinic pathological, biomechanical or genetic diagnosis of mitochondrial disease were included in the study; age range 24-84 years; females: male 2:1. Of the 34 (81%) individuals who reported dizziness, a neuro-otological diagnosis was confirmed in 91% (31/34; OR 3.69, CI 0.982 to 16.66, $p=0.08$). Eight people were not referred for neuro-otological investigations; six had cerebellar ataxia; one had biomechanical falls; and one with presyncope.

Peripheral (unilateral or bilateral) vestibulopathy was confirmed in 77% (24/31), vestibular migraine in 6% (2/31), central vestibular dysfunction in 10% (3/31) and BPPV in 6% (2/31). Seven people had dual neuro-otological diagnoses.

Of those with peripheral vestibulopathy, 88% (21/24) had coexistent hearing loss. Two individuals with previously documented unilateral vestibular deficit progressed to develop bilateral vestibulopathy.

Conclusions: This review demonstrates a high occurrence of vestibular dysfunction in people with mitochondrial disease reporting dizziness and/or imbalance. Neuro-otological investigation may help guide therapeutic intervention and may serve as a possible clinical biomarker of disease progression.

OP16-4 - Otoconial loss a new important diagnosis - explanation for residual dizziness and chronic imbalance

27. Others

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Purpose: We will again describe the new diagnosis of otoconial loss, first described on the Barany meeting in 2012 but with a different etiology. A patient slipped on ice, fell on the back of her head with consequent MTBI and massive bilateral BPPV in the

horizontal and posterior SCCs. After several canalith repositioning maneuvers, she was free of BPPV but is suffering since then (2010) from chronic imbalance, often described as “Residual Dizziness” (RD)

Methods: Case report: Audiogram, calorics, vHIT, cVEMP, oVEMP, subjective visual vertical during whole body tilt and eccentric rotation, linear VOR (search-coil)

Results: Traumatic hearing loss on the left, Normal calorics, HIT, c- and oVEMP, tested twice. Significantly increased variability of (SVV) during whole body tilt. Low IVOR gains horizontally and vertically. Pathologic SVV during eccentric rotation.

Conclusions: From normal oVEMP we conclude that her utricular haircells were intact, but because she had massive BPPV, we believe that she lost too many otoconia or maybe all of the left utricle. Since we know that animals with intact haircells but missing otoconia have lifelong balance problems. We believe that otoconial loss is a major factor to explain persisting dizziness after MTBI, RD after successful CRM and is also most likely involved in imbalance associated with aging, because we know that otoconia are progressively degenerating with age above at least 60 years. Otoconial loss has never been considered as an explanation for the symptom of imbalance although this seems quite logical for us, even if there is still missing absolute proof.

OP16-5 - Amelioration of hyperacusis impacts vestibular symptoms and binocular vision dysfunction symptoms

27. Others

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Purpose: Patients with binocular vision dysfunction (BVD) have vestibular symptoms (dizziness, nausea, gait abnormalities) as well as headache/head pressure, neck pain, anxiety and unclear vision. Treatment of BVD with micro-prism lenses usually

significantly reduces these symptoms. One cohort did not improve as expected, and all admitted to hyperacusis. This study’s purpose is to demonstrate reduction of residual symptoms with noise cancelling devices.

Methods: This retrospective study includes 23 patients presenting for annual vision examination previously diagnosed with BVD and treated with microprism lenses for ≥ 1 year who had residual vestibular and BVD symptoms and who admitted to hyperacusis. Baseline data included completion of the modified Khalfa questionnaire, and subjective 0-10 scoring of headache, neck pain, dizziness, unsteadiness walking, nausea, anxiety and light sensitivity. Bose QC 30 earbuds or QC 25 headphones were placed upon the patient and subjective symptom scoring was repeated. Then the vision examination was performed with the patient wearing the sound cancelling device. Post-examination, subjective symptom scoring was repeated with both the updated vision prescription and sound cancelling device in place.

Results: 65% of patients had moderate to severe hyperacusis. All subjective symptom scores decreased markedly including dizziness (58.4%), nausea (63.3%), and unsteady walking (76.6%). Over 90% of symptom reduction was due to sound cancellation, with $\leq 10\%$ due to micro-prism lenses.

Conclusions: In patients previously diagnosed with BVD and treated with micro-prism lenses, who had residual vestibular and BVD symptoms and who admitted to hyperacusis, amelioration of the hyperacusis using sound cancelling devices resulted in marked reduction of the residual symptoms.

OP16-6 - Correlations with hearing recovery and vestibular testing in sudden sensorineural hearing loss

3. Autonomic Function and Vestibular Disorders

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Purpose: The vestibular testing has been applied to the vertigo disease, but the relationship between vestibular testing and the hearing recovery has been

unclear in patients with sudden sensorineural hearing loss (SSNHL). We therefore conducted a retrospective study in order to identify parameters that influence hearing recovery.

Methods: The data base contains results of basic vestibular testing of 154 patients with SSHL, diagnosed and treated at the Anhui Provincial Hospital, China between 2016 and 2017. Hearing recovery was measured by pure tone audiometry.

Results: Multivariate linear and logistic regression analysis indicated that the chance of hearing recovery is lower for the patients with vertigo, age ≥ 60 years and abnormal vestibular testing, including vestibular evoked myogenic potentials (VEMP), caloric testing and horizontal semicircular canal (HC) of video head pulse Test (v-HIT). The risk factors of hearing recovery chance include vertigo, C-VEMP, HC of v-HIT, anterior semicircular canal (AC) of v-HIT. The magnitude of hearing recovery is lower for the patients with vertigo, age ≥ 60 years and abnormal vestibular testing, including VEMP caloric testing. The risk factors of hearing recovery magnitude include vertigo, C-VEMP, o-VEMP and HC of v-HIT.

Conclusions: We conclude that associated with disorders of the vestibular system represent special sub-entities of SSHL that may be caused by unique pathophysiological mechanisms and are associated with worse outcome. The vestibular testing is very important to the patients with SSHL. Vestibular rehabilitation and psychological intervention should be carried out as early as possible for patients with abnormal vestibular testing.

OP16-7 - A reappraisal supported by functional and morphological assessments of delayed endolymphatic hydrops

3. Autonomic Function and Vestibular Disorders

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Purpose: To investigate the morphological and functional characteristics in patients with delayed endolymphatic hydrops (DEH), by observing the involvements of endolymphatic hydrops imaging (EHI) and the impairments of vestibular function. Meanwhile, to speculate the feasible pathological process by analyzing the correlation between morphological and functional features.

Methods: 30 patients who visited Department of Otolaryngology and Skull Base Surgery of EENT Hospital of Fudan University were enrolled in this study. All were diagnosed with DEH and medical history was collected, including the onset age of precedent deafness, onset age of vertigo and the time delay. Work-up included caloric tests, cervical and ocular vestibular evoked myogenic potentials (c-VEMP and o-VEMP), and magnetic resonance imaging (MRI) of inner ear after intratympanic gadolinium injection.

Results: Vestibular hydrops could be definitely observed as its function declined, dysfunction of both saccule and utricle was not essential when vestibular hydrops were detected from imagings. In the LSCC, there was not necessarily morphological abnormality as its function decreased. However dysfunction was bound to exist as LSCC hydrops were observed from imagings. The results of hydrops localization consisted of three status: vestibular hydrops (13.04%), vestibular-cochlear co-hydrops (69.57%), vestibular-cochlear-LSCC co-hydrops (17.39%). There were no cochlear hydrops or canal hydrops alone.

Conclusions: In patients with DEH, the vestibule is most likely to be involved in hydrops, followed by cochlear, and the semicircular system tend to be the latest; functional and morphological changes in the vestibule was inconsistent with that in the canal system.

OP17: Labyrinthine fistula/ Vestibular schwannoma

OP17-1 - Detecting Perilymphatic Fistula by Variation of 3D Reconstruction Thresholds on CT scan

16. Perilymphatic Fistula

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Purpose: We hypothesized that a perilymphatic fistula (PLF) decreases the radiological density of the labyrinthine windows. Our objective was to evaluate this parameter by virtual endoscopy of the labyrinthine windows on CT scan combined to the variation of density threshold and its diagnostic performance.

Methods: This prospective study included 47 adult patients with a PLF and 98 control patients. Diagnosis of PLF was based on a composite radio clinical score > 7 (Portmann et al, 2005) and/or intra operative visualization of the fistula and/or resolution of the symptoms after surgery. Labyrinthine windows were examined by virtual endoscopy and the reconstruction threshold was gradually increased until a virtual opening appeared corresponding to the region with lowest density in the field (opening threshold, OT). The OT difference between the suspected and contra lateral side was calculated for each window in the same patient. The highest (maximal) OT difference among round and oval windows in the same patient was chosen as the diagnostic criteria. The side of the fistula was indicated by the lowest OT value.

Results: The maximal OT difference was higher in patients than in controls (60.2 ± 10.36 (SEM), $n=47$ versus 28.0 ± 2.29 Hounsfield units, $n=98$, $p<0.01$ unpaired t-test). A non parametric ROC analysis showed that at an OT difference of 31.5 UH had a sensitivity of 75 % and a specificity of 75% for the PLF diagnosis.

Conclusions: CT-scan virtual endoscopy and threshold variation provided high specificity and sensitivity in the PLF diagnosis.

OP17-2 - Postoperative recurrence of perilymphatic fistula

16. Perilymphatic Fistula

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Purpose: Patients with perilymphatic fistula (PLF) usually undergo operations if their symptoms persist after conservative therapy. If the operation is performed with appropriate timing, hearing loss and vertigo or dizziness can be eliminated. Many previous reports support the effect of the operation; however, few studies have addressed postoperative course or recurrence. In this retrospective study, the postoperative course in patients with PLF was investigated.

Methods: Between January 2010 and January 2017, 22 ears in 22 cases were operated on in our department. Four patients were excluded because they were diagnosed with other diseases postoperatively. The age of the 18 remaining cases ranged from 16 to 78 years old (median 48.5), and the patients included 15 males and 3 females. Diagnosis was based on the criteria of the Intractable Hearing Loss and Research Committee of the Ministry of Health and Welfare, Japan.

Results: The follow-up period was 3 to 73 months (mean 15 months). Ten cases were probable PLF and eight cases were definite PLF. Of the eight definite PLF cases, three had recurrence of vertigo and two of the three underwent re-operation. In probable PLF, two cases had recurrence of vertigo and one underwent re-operation. The recurrence rate was 28%. These cases are presented with the results of the Cochlin tomo-protein detection test, which detects a perilymph-specific protein.

Conclusions: In conclusion, long-term follow-up is necessary in PLF patients who undergo surgery because postoperative recurrence is not rare.

OP17-3 - The change of hearing and positional nystagmus after surgery in barotraumatic perilymph fistula(PLF)

16. Perilymphatic Fistula

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Purpose: The purpose of this study was to evaluate the changes in hearing and nystagmus after surgery of the PLF.

Methods: Twenty-seven patients who underwent the surgery on suspicion of barotraumatic PLF were enrolled. The change in hearing and nystagmus were analyzed preoperatively and at 1week and 1month postoperatively.

Results: Hearing was improved in 20 out of 27 when hearing improvement defined as postoperative 4-frequency PTA of bone conduction \leq 25dB or hearing gain \geq 15dB. Twenty-five out of 27 had nystagmus, of which 36% had spontaneous nystagmus(SN), and 100% had positional nystagmus(PN). Within a week after surgery, SN was persistent in four patients, and it was resolved in three of them at one month postoperatively. In addition, PN was observed in 10 patients one week after surgery and persisted in 7 patients one month later. Vertigo and nystagmus were completely improved in 22 patients. However, three subjects who had recurred dizziness with PN underwent revision surgery. The pattern of PN was multi-directional, and sustained longer in duration with slower velocity without reversibility. Also, there was a tendency of no improvement by the otolith repositioning maneuver.

Conclusions: Patients suspicious on barotraumatic PLF showed improvement in hearing and vertigo by surgical repair. However, the PN can continue for a while after surgical repair. It could also recur after complete remission. Therefore, it might conclude that the hearing loss was related directly to peri-

lymph leak, but the PN was probably related to positional effects of perilymph volume or other microstructure rather than simple perilymph leak.

OP17-4 - The results of a nationwide study of PLF using a novel ELISA for human CTP detection test.

16. Perilymphatic Fistula

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Purpose: The manifestations of perilymphatic fistula include a broad spectrum of neuro-otological symptoms such as hearing loss, vertigo/dizziness, disequilibrium, and tinnitus. The difficulty in making a definitive diagnosis due to the lack of an appropriate biomarker to detect perilymph leakage has caused a long-standing debate regarding its management. We have reported an ELISA-based human Cochlin-tomoprotein(CTP) detection test and its high diagnostic accuracy in clinical subjects (sensitivity and specificity were 86.4% and 100%) (1).

Methods: We have performed a multicenter investigator-initiated trial of the CTP detection test (2).

Results: We have tested 497 cases in total. Eight to 50% of patients in category 1 (trauma, middle and inner ear disease cases), and about 20% of those in categories 2, 3 and 4 (external origin antecedent events; internal origin antecedent events; without antecedent event, respectively) were positive for CTP. The characteristic clinical features of CTP positive cases will be presented.

Conclusions: The present study clarified that CTP detection test-positive patients exist at considerable rates among patients with inner ear-related manifestations. Appropriate recognition and treatment of perilymphatic fistula can improve a patient's condition and hence the quality of life.

1) Ikezono T et al., The diagnostic performance of a novel ELISA for human CTP (Cochlin-tomoprotein) to detect perilymph leakage. *PLOS ONE* 2018.

2) Matsuda H et al., A nationwide multicenter study of the Cochlin tomo-protein detection test: clinical characteristics of perilymphatic fistula cases. *Acta Otolaryngol* 2017.

OP17-5 - What are the serious symptoms of chronic perilymph fistula (PLF)?

16. Perilymphatic Fistula

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Purpose: Perilymph fistula is a leak of perilymph at the oval or round window, initially recognized after stapedectomy surgery. It easily comes to mind for a patient presenting with aural barotrauma or direct blow to the ear, but usually not considered in a patient presenting months or years after mild head trauma where mild brain injury is assumed. That various traumas could cause a PLF was recognized early but then claims of "spontaneous" PLF and two decades of unjustified ear explorations with misdiagnosis resulted its becoming a confused and emotional topic amongst Otolaryngologists and non-recognition by Neurologists. Early work by Grimm and Black in regards to the vestibular and cognitive symptoms and Robert Kohut's unique temporal bone studies for predisposing cause have been largely ignored.

Methods: Twenty-two patients (most with mild head trauma or whiplash months or years prior) presented with chronic unilateral postural instability, nausea, motion intolerance and mild cognitive symptoms. The postural instability is easily demonstrable.

All had total resolution of symptoms after PLF repair. These features are illustrated by a *video-documented* case history of a 53 year-old professional

rugby coach with disabling right postural instability and cognitive symptoms for months after hitting his head on a table.

Results: *Video-documented* PLF repair at the right oval window fissula antefenestram resulted in immediate cessation of all symptoms and an increasingly successful career.

Conclusions: Although chronic PLF symptoms have been assumed to be due to inner ear endolymphatic hydrops, they are almost certainly from fluctuating *otolith organ dysfunction*, first stated by Brandt in 2001.

OP17-6 - Specificity and sensitivity of two video Head Impulse Test systems in Vestibular Schwannoma patients

27. Others

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Purpose: To determine both the specificity and the sensitivity of two different video Head Impulse Test systems (v-HIT) in a Danish cohort of Vestibular Schwannoma patients. Secondary endpoint examined if inter examiner variability significantly affected the test results.

Methods: 46 patients diagnosed with a vestibular schwannoma all underwent audio-vestibular testing with standard tone- and speech audiometry. All patients also filled out the Dizziness Handicap Inventory (DHI). Complete v-HIT testing of all six semicircular canals (SCCs) with two separate v-HIT systems was carried out randomly by an experienced and an unexperienced examiner. A pathological test included *concomitant* low gain values (lateral<0.8, vertical<0.7) AND pathological saccades.

Results: Specificity of both v-HIT systems for five SCCs was close to 100%; only exemption was the left posterior SCC with around 90% for both v-HIT systems. Sensitivity in general was 44.4% with

system 1 and 48.9% with system 2. Sensitivities of the right SCCs, in general, were higher than the left SCCs with both v-HIT systems, and system 2 produced the highest sensitivities of all six SCCs independently. The experienced examiner had a sensitivity of 56.5% with both v-HIT systems whereas the unexperienced examiner had a sensitivity of 31.8% and 40.9% respectively with system 1 and system 2. Higher than normal gain values were seen with all six SCCs when testing patients with system 1.

Conclusions: Close to 100% specificity with both v-HIT systems regardless of examiners experience. The experienced examiner produced the highest sensitivities with both v-HIT systems. The sensitivity of system 2, in general, was the highest.

OP17-7 - Preoperative determination of nerve of origin in patients with vestibular schwannoma

27. Others

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Purpose: Most Vestibular schwannomas (VS) arise from one of two vestibular branches: the superior or inferior vestibular nerve. Determining the specific nerve of origin may improve patient management in terms of preoperative counseling, treatment selection, and operative decision-making and planning. The aim of this study was to introduce a novel scoring system that was designed to preoperatively determine the nerve of origin.

Methods: The nerve of origin was predicted based on video head-impulse assessments (vHIT) of all semicircular channels, together with cervical/ocular vestibular-evoked myogenic potential tests (cVEMPs, oVEMPs). The acquired data were entered into a scoring system developed to allocate the tumor origin. Finally, the nerve of origin was definitively determined intraoperatively. The blinded results were then compared.

Results: The novel scoring system was used in 30 consecutive patients undergoing surgery for VS treatment. Three decisions were indifferent. In 27 cases, the preoperatively predicted tumor origin was the same as the nerve origin determined during surgery.

Conclusions: The scoring system can predict the origin of schwannomas of the 8th cranial nerve with high accuracy. The scoring system is now applied in an ongoing larger cohort study.

OP18: Central Vestibular Disorders

OP18-1 - Apogeotropic Central Positional Nystagmus: Characteristics and Mechanism

6. Central Vestibular Disorders

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Purpose: To determine the underlying mechanism of apogeotropic type of central positional nystagmus (CPN), we analyzed the characteristics of nystagmus and responsible lesions, and simulated apogeotropic CPN using a velocity storage model that is involved in resolution of ambiguity between tilt and translation.

Methods: In twenty-seven patients with apogeotropic CPN and 20 patients with apogeotropic benign paroxysmal positional vertigo (BPPV), we recorded spontaneous nystagmus while sitting, supine, and ear-down positions. To identify the possible lesions of apogeotropic CPN, demarcated lesions of twenty-two patients with apogeotropic CPN were overlapped.

Results: The spontaneous nystagmus was similar between sitting and supine positions in apogeotropic CPN, but stronger while supine in apogeotropic BPPV. In CPN, the lesions mostly involved the nodulus, uvula, and tonsil. Persistent apogeotropic CPN was successfully generated by implementing the gain of lesion in the connection between the cerebellum and brainstem that conveys the information for estimated gravity.

Conclusions: Apogeotropic CPN shows positional modulation that is different from that observed in apogeotropic BPPV. Apogeotropic CPN can be explained by lesions involving the central graviceptive pathway involving the cerebellum and brainstem.

OP18-2 - Combined Central & Peripheral Vestibular Disorders: CANVAS, iCABV & Other Differential Diagnoses

6. Central Vestibular Disorders

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Purpose: The traditional dichotomy of central versus peripheral causes of imbalance may be viewed as an obstacle, rather than an aid to diagnosis. This paper aims to review the clinical assessment of conditions with combined central and peripheral vestibular impairment and the more common conditions which may manifest this joint pathology.

Methods: Detailed clinical, neuro-otological, neurophysiological, pathological and imaging data has been gathered on 182 patients with the Cerebellar Ataxia with Bilateral Vestibulopathy (CABV)

phenotype, in an effort to further our understanding of the pathophysiology as well as the nosology of these disorders.

Results: CABV was initially believed to be a distinct syndrome but has more recently been recognised as a phenotype which may be found in a number of disorders including CANVAS, Friedreich's ataxia, spinocerebellar ataxia types 3 and 6 and multiple system atrophy. Oculomotor assessment provides a valuable means of identifying such patients and centres around the identification of an abnormal visually enhanced vestibulo-ocular reflex.

Conclusions: The growing number of conditions which express the CABV phenotype raises important questions around the utility of conceptually separating central and peripheral vestibular pathology, and how this may hamper the progress of taxonomy within the field of balance disorders. In the clinical context, identification of the CABV phenotype limits the number of potential differential diagnoses and provides a directed investigation pathway in order to facilitate an accurate diagnosis.

OP18-3 - Mal de Debarquement Syndrome: motion-triggered versus spontaneous/other onsets.

6. Central Vestibular Disorders

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Purpose: Mal de Debarquement Syndrome (MdDS) is a neurological condition characterised by a sensation of motion. The most common form of MdDS is motion triggered (MT) and it occurs after disembarking from a vehicle. However, it has been acknowledged that some patients develop it spontaneously, those are here named as spontaneous or other onset (SO) MdDS subtype. Our studies aimed to address similarities and differences between the two MdDS subtypes involving diagnostic procedure and comorbidities. Secondly, we replicated for the first time a potential treatment for MdDS patients based on the previously proposed protocol of Dr. Dai involving optokinetic stimulation.

Methods: Part of the study was based on a retrospective online survey involving 370 MT and SO MdDS participants. Participants were required to respond to a set of comprehensive questions regarding epidemiological details, onset and diagnostic procedures. The second part of the study was a clinical trial involving 25 MdDS patients the same protocol of Dr. Dai was reproduced.

Results: MdDS is often misdiagnosed, more so for the SO subtype. In addition levels of stress, anxiety and depression were present in both subtypes. A higher percentage of MT MdDS better reacted to the VOR treatment protocol compared to the SO subtype.

Conclusions: It appears at present that both MdDS subtypes are still poorly recognised, thus we proposed new comprehensive diagnostic guidelines. In addition, we addressed that stress, anxiety, depression should be closely considered when treating patients. In our study, the optokinetic protocol previously proposed by Dai resulted to be a successful treatment for MT MdDS patients.

OP18-4 - The mystery of conversion of upbeat to downbeat nystagmus in thiamine deficiency

6. Central Vestibular Disorders

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Purpose: To study the mechanism of conversion of acute upbeat nystagmus (UBN), to chronic downbeat nystagmus DBN in patients with Wernicke's encephalopathy (WE)

Methods: Serial clinical oculomotor and vestibular examination in two WE patients; they presented with acute UBN, and converted to chronic DBN which is unchanged for the last six and seven years respectively.

Results: The initial evaluation revealed a primary gaze UBN in both patients, UBN suppression occurred with convergence in both cases, and vertex vibration in patient one and by head shaking in patient two. A low amplitude DBN developed during these suppressive stimuli. Treatment with thiamine and return to a normal diet improved the WE, Over-time, however an enduring DBN replaced UBN. The MRI in case one showed FLAIR MRI hyperintensity in periventricular areas of the midbrain, pons and medulla.

Conclusions: Here we develop a hypothesis to explain how this pattern of nystagmus in WE patients relates to the normal anatomical substrate for holding the eyes still; why there is UBN in the first place; in addition, why UBN disappears leaving DBN? Our overriding hypothesis is that there is a *selective vulnerability* and *selective recovery* from thiamine deficiency of neurons within the brainstem and cerebellar circuits that hold vertical gaze steady (nucleus of Staderini, superior vestibular nucleus, interstitial nucleus of Cajal and the paramedian tract neurons). Furthermore, since these structures are paraventricular, we suggest a local BBB *breakdown* in WE. We conclude that UBN to DBN transition

points to thiamine deficiency preceding a chronic, non-progressive DBN/truncal ataxia syndrome.

OP18-5 - Uncommon causes of episodic vertigo and imbalance: Ictal characteristics

6. Central Vestibular Disorders

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Purpose: Episodic vertigo is associated with ictal nystagmus, facilitating diagnosis of the underlying disorder. Ictal characteristics of common disorders such as Benign Positional Vertigo, Vestibular Migraine and Meniere's Disease have been described. Here we describe eye-movement characteristics arising from uncommon aetiologies.

Methods: Ictal-nystagmus was recorded from seven subjects with vertigo and imbalance.

Results: A patient with paroxysmia due to a large right petroclival meningioma demonstrated six-second flurries of spontaneous right-beating nystagmus with a slow-phase velocity (SPV) of 15 degrees/sec (°/s). Two patients with Episodic Ataxia Type-II presented with oscillopsia and imbalance, and demonstrated spontaneous vertical nystagmus; The first showed up-beating nystagmus with an SPV of 79.5°/s, and the second had down-beating nystagmus with an SPV of 34.5°/s. Of three patients diagnosed with Paraneoplastic syndrome, the first presented with cerebellar ataxia and oscillopsia with spontaneous right-beating nystagmus (46.3°/s SPV), the second presented with imbalance and bi-directional nystagmus flurries lasting four seconds each with an SPV of 10.9°/s, and the third presented with brainstem encephalitis with ocular flutter, each flurry lasting 3-11 seconds. The final patient was found to have a stable, calcified, medullary lesion and presented with spontaneous, torsional down-beating nystagmus with an SPV of 16.3°/s.

Conclusions: Vestibular event monitoring in the form of video-oculography, both in the outpatient

and home setting is a useful technique that contributes to the accurate diagnosis of common and uncommon causes of vertigo and imbalance.

OP18-6 - Vestibular Paroxysmia: Not Always As Simple As It Seems

6. Central Vestibular Disorders

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Purpose: Compression of a cranial nerve by a blood vessel has long been recognized as the cause of trigeminal neuralgia, glossopharyngeal neuralgia and hemifacial spasm. Acceptance that the same mechanism for the 8th cranial nerve can cause tinnitus, vertigo attacks and other symptoms has been extremely slow. Early evidence came from pioneering otoneurosurgeons in the pre-MRI era. The Barany Society has now recognized the phenomenon as vestibular paroxysmia with published diagnostic criteria which require that the vertigo attacks last only seconds or minutes. However, they can be much longer.

Methods: Three patients with vestibular paroxysmia treated by surgical 8th nerve IACA decompression are presented, with operative videos. (1) a 68 year-old female with as many as 12 attacks in a month lasting hours, occasionally twice a day, with no auditory symptoms. (2) a 51 year-old female who for 5 years experienced motion sickness, visual vertigo, and then vertigo attacks lasting at least 2 hours with a hissing and pulsating noise in her left ear, followed by an occipital headache. (3) a 70 year-old male with tinnitus and

Results: All had immediate cessation of vertigo and other symptoms, with long-term followup.

Conclusions: While many patients with vestibular paroxysmia experience only very brief vertigo attacks, in some cases the presence of a progressive hearing loss and tinnitus and headache accompanying the attacks can cause confusion with vestibular migraine in particular and with Meniere's disease.

OP18-7 - How to diagnose ataxia

6. Central Vestibular Disorders

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Purpose: One of the most common and medically concerning manifestations of ataxia is gait imbalance. In contrast to peripheral vestibular pathology, there are a lack of ‘tools’ for readily describing and measuring dysfunction in the central vestibular systems. This program of work aims to instrument key aspects of the clinical examination that are utilized in the assessment of the ataxic patient, with the aims of:

1. Being able to recommend which bedside components of the ataxia examination are most clinically valuable.
2. Creating a device to add objective, quantifiable, in-office assessment of ataxia for clinicians & researchers
3. Aiding accurate diagnosis based on objective metrics
4. Advancing the classification of the central and peripheral ataxias

Methods: Customized inertial measurement units, speech recognition and visual-kinematic systems have been applied to a set of functional clinical domains in 127 patients with diagnoses of combined central and peripheral vestibular conditions as well as pure central vestibular disorders.

Results: We have been able to instrument the bedside examination of ataxia, and thus quantify the relative utility of the various traditional clinical measurements. By employing these objective metrics, we are able to rank the clinical utility of clinical

tests within a functional domain. This has formed the foundations for the development of a portable device which is capable of both diagnostics and scalable measurements of ataxia severity, within each of the functional ataxia domains.

Conclusions: We envisage that this work will aid not only accurate diagnosis but also advances in the classification of central and peripheral vestibular disease.

OP19: Postural control

OP19-1 - Can Sensory Condition affect the Modified CTSIB relative to the SOT?

11. Gait, Posture, and Locomotion

Bo LIU¹

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Purpose: Aim of this study is to investigate the relationship between two balance test, modified clinical test of sensory interaction and balance (mCTSIB) and sensory organization test (SOT) of computerized dynamic posturography (CDP).

Methods: Seventy patients with unilateral vestibular hypofunction (vertigo group) and 37 healthy subjects (control group) were enrolled in tests of SOT and mCTSIB. The correlations of equilibrium scores (ES) between the SOT and mCTSIB were analyzed for both groups individually, and the sensitivity and specificity of mCTSIB for the vertigo group were evaluated.

Results: Our findings demonstrated that the strongest correlation between the sensory conditions on the mCTSIB and the equivalent condition on the SOTs existed between the mCTSIB4 versus the SOT5 in both groups respectively. Each 95% confidence interval of the correlation coefficient has a

coincidence part, and the differences of correlation coefficient were not statistically significant. Fifty-one patients had abnormal SOT results (72.9%) and 47 had abnormal mCTSIB results (67.1%). The sensitivity and specificity of mCTSIB versus SOT was 74.5% and 52.6% respectively.

Conclusions: The significant correlations between the mCTSIB and SOT are more likely occur in the conditions of visual and/or somatosensory cues interrupted. However, the levels of these correlations may not be affected by the degree of sensory conflicting.

OP19-2 - Visual priming inducing expectational mismatch distorts sense of instability during postural control

11. Gait, Posture, and Locomotion

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Purpose: Several studies have suggested a link between anxiety and postural control. Previously we have shown that subjective instability during a postural task is correlated with anxiety as well as the amount of sway in healthy individuals. Here, we investigated whether it is possible to modulate these correlations by changing expectations via visual priming.

Methods: 30 healthy participants (19-36yr) performed a postural task standing as steady as possible on a linearly oscillating sled for 30sec whilst blindfolded. Before performing the task, participants were split into two groups randomly and watched either a video of an actor being stable (Group 1) or

the same actor being unstable (Group 2) whilst performing the task. Task-related anxiety was assessed before and after the task using two different scales. Participants rated their subjective instability on a numerical scale. Upper trunk sway, angular hip velocity and steps were recorded as objective measures of instability.

Results: We observed a strong correlation ($r=.531$; $p=.042$) between upper trunk sway and subjective instability ratings in Group 1. This relationship was abolished in Group 2 ($r=.213$; $p=.447$). No significant between-group differences were found in measures of sway, subjective instability or anxiety. However, in Group 1 anxiety was significantly higher after the task ($p<.05$).

Conclusions: We showed that it is possible to distort the perception of instability, which usually correlates with objective instability measures, by changing expectations using visual priming. This finding highlights the prominent influence that expectation and anxiety can have on the perception of self-stability.

OP19-3 - Sensitivity and specificity of 3 Hz tremor in patients with cerebellar ataxia

7. Clinical Testing for Vestibular Function

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Purpose: 3 Hz postural tremor was described in patients with anterior cerebellar lobe atrophy, however sensitivity and specificity of this sign in degenerative cerebellar diseases has not yet been evaluated. The aim of the study was to analyze posturography findings – to assess sensitivity and specificity of 3

Hz postural tremor in patients with cerebellar ataxia and to compare these findings with a group of patients with balance problems of non-cerebellar etiology (peripheral vestibulopathy) and with healthy controls.

Methods: 30 patients with cerebellar ataxia were examined, results were compared with 30 patients with peripheral vestibulopathy and 30 healthy persons. Static posturography was performed in all subjects, 3 Hz tremor was assessed both qualitatively and quantitatively, its sensitivity and specificity was compared with other standard posturography parameters. Vestibular reactivity was examined by means of electronystagmography with rotational and caloric testing. Range of impairment in patients with cerebellar ataxia was assessed by the Scale of the assessment and rating of ataxia.

Results: Posturography is able to distinguish patients with cerebellar and vestibular impairment from healthy controls. Finding of 3 Hz postural tremor can differentiate patient groups among themselves. Prevalence of 3Hz tremor in patients with cerebellar ataxia was 90%, including those with mild impairment, with 100% specificity.

Conclusions: 3Hz tremor can serve as an objective correlative of cerebellar impairment. The evaluation of 3 Hz postural tremor should be a standard part of posturography examination when considering a cerebellar impairment.

OP19-4 - Validity & kinematic outcomes of New Balance Test

7. Clinical Testing for Vestibular Function

Oz Zur¹

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Purpose: Background: There are many balance tests, but all have significant disadvantages, including ceiling effects, long administration, or limited to people with mild-to-moderate balance disorders. In

addition, a balance test that can specifically examine the visual, vestibular and somatosensory systems in standing position is lacking.

Objective: 1) To assess the reliability of the Zur Balance Scale (ZBS) and to determine normal range scores for different age groups, and 2) To differentiate healthy vs. retrospective vestibular subjects (positive vHIT with low VOR gain) using the modified ZBS on the AMTI force plate.

Methods: In this cross-sectional, double-blind study, 88 subjects, ages 29-70 years old, recruited from a high-tech company in Petah-Tikva, were evaluated using the ZBS compared to the Modified Clinical Test Sensory Integration for Balance (mCTSIB). Inter-tester and intra-tester reliability were evaluated, and normal age results were checked. As well we added an additional 27 subjects with a diagnosis of vestibulopathy were compared to 44 of 88 healthy subjects to characterize four common kinematics parameters: Velocity Avg, ML sway, AP sway and Area95.

Results: ZBS had high inter-tester reliability (0.945 Cronbach Alpha, and 0.945 ICC), and high intra-tester reliability (0.938 Cronbach's Alpha). ZBS scores decreased with increasing age. T-tests for all four kinematic parameters were significant ($p < 0.05$) in both mCTSIB and mZBS.

Conclusions: ZBS is a sensitive test to detect balance disorders. It is reliable, simple and easy to administer. The kinematic parameters of the mZBS can differentiate vestibular subjects.

OP19-5 - DHI score variation in vestibular rehabilitation patients, regardless of pathology

7. Clinical Testing for Vestibular Function

Javier Martin Previgliano¹

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Purpose: The dizziness handicap inventory is a tool used to quantify the affect of herself-perceived disability in patients with vertigo, dizziness or instability in relation to its impact on daily life,

identifying among the imbalance problems that the patient presents the reasons for functional, physical and emotional character and as their self perception. Vestibular kinesthetic rehabilitation is a therapy that has shown its importance in the treatment of patients with vertigo, dizziness and balance disorders, significantly improving the quality of life of these.

Methods: Child cards were collected from 1057 patients, of both sexes with vestibular pathology, Argentineans, with ages between 5 and 98 years, possibility of understanding Spanish. These patients were approached through vestibular rehabilitation, performed at the beginning and end of the treatment of the questionnaire D.H.I, for the power of the changes produced in the automatic perception of disability after its first 10 sessions.

Results: The mean of the D.H.I at the time of pre-treatment measurement was 20.16 points, while the average of the subsequent treatment was 10.56 which is equivalent to a 47.6% general improvement. In this way, when we observed the articles separately, a functional level of 31.92% was obtained, emotionally 36.32% and physical level of 33.87% evidencing improvements in all aspects evaluated.

Conclusions: The data obtained in this study demonstrate the efficacy of the kinesthetic rehabilitation protocols applied in the private practice of Martin Prevgliano being able to observe a significant improvement in the same, in all the aspects evaluated after the treatment.

OP19-6 - Balanci: Improving balance in children with bilateral cochleovestibular loss using cochlear implants

8. Cochlear Implant and Vestibular Function

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Purpose: We set out to determine the impact of a head referenced cochlear implant stimulation system "Balanci" on balance in children with bilateral cochleovestibular loss (BCV²;/.2) as well as using the Wii Balance Board, a validated clinical measure of postural control.

Methods: This prospective, blinded case-control study of balance was performed in 2 settings: a quiet clinical and an immersive virtual environment at the Challenging Environmental Assessment Laboratory in the Toronto Rehabilitation Institute's iDAPT Centre. Balance was assessed in 16 patients with bilateral cochlear implants and total bilateral vestibular loss. Children wore the Balanci system which is a head mounted device to restore head-referenced spatial information. Postural control measured by center of pressure (COP) and balance measured by the BOT2.

Results: In the virtual environment, children demonstrated better balance when using Balanci as measured by an improvement in BOT-2 scores. Similarly, in a quiet clinical setting, the use of Balanci led to better postural control as demonstrated by a significant reduction in COP root mean square (RMS) and velocity. The number of falls was significantly reduced with the use of Balanci.

Conclusions: Balanci is a simple and effective means of improving postural control and balance in children with congenital bilateral vestibular loss and bilateral cochlear implants. This device could potentially improve the safety of these children and allow them to take part in more complex balance tasks where sensory information may be limited.

OP19-7 - Balance, Gait and Dizziness in Adult Patients post Cochlear Implant

8. Cochlear Implant and Vestibular Function

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Purpose: Cochlear implantation may affect the vestibular apparatus due to the proximity to the surgical site but this has not been comprehensively investigated. The aim of the study was to evaluate the prevalence and severity of dizziness, balance and walking problems in cochlear implant users.

Methods: An observational, cross-sectional, clinical study of a cohort of cochlear implant users. Outcomes included; subjective dizziness and balance confidence (Vestibular Rehabilitation Benefit Questionnaire (VRBQ) and Activities Specific Balance Questionnaire (ABC) respectively), gait (Functional Gait Assessment and 10m walk test), balance (Equitest Sensory Organisation Test: SOT), and computerised Dynamic Visual Acuity (DVA). The Dix Hallpike test was also performed.

Results: 20 participants (n=10F), mean age 59.3 years (SD15.8) were assessed. Mean time post implantation was 3.8 years (SD4.6). Mean VRBQ score was low at 6.4% (SD18.1) and mean ABC score was high at 83.5% (SD14.2). FGA scores were minimally below expected range (mean 25.1, SD 4.4) and gait speed was 1.8m/sec (SD 0.41). Dix Hallpike was positive in 3 (15%) participants. Mean DVA loss was -3.2 LogMAR (SD1.9). Mean SOT score was 59.5% (SD14.2), with 70% (n=14) of participants demonstrating vestibular dysfunction by falling on balance conditions 5 and 6.

Conclusions: Physical measures indicated vestibular dysfunction post cochlear implantation in this sample, with a high frequency of falls in SOT conditions 5 and 6. A higher than expected frequency of BPPV was found and DVA was often impaired. Further longitudinal studies are required but the findings suggest an unmet need for vestibular rehabilitation in this population.

OP20: Basic vestibular science/ Animal models (I)

OP20-1 - Endolymphatic fluid absorption in the developing inner ear

22. Vestibular and Inner Ear Physiology

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Purpose: Mutations of *SLC26A4* are a common cause of hearing loss associated with enlargement of the endolymphatic sac and duct and vestibular aqueduct (EVA). The purpose of our present study was to gain insight into the functional, molecular and cellular architecture of the developing endolymphatic sac and to identify the components of the physiologic-developmental pathway that is disrupted in EVA.

Methods: Endolymphatic sacs were isolated from E14.5 *Slc26a4*^{Δ/+} and *Slc26a4*^{Δ/Δ} 129S6 mice, filled with a solution containing a fluorescent dye, and maintained in organ culture in the absence and presence of inhibitors of channels and transporters. The rate of fluid absorption was quantified by volume measurements with 3D confocal microscopy. Gene array analysis was performed on embryonic endolymphatic sacs from E13.5, E14.5, E16.5, and E17.5 *Slc26a4*^{Δ/+} and *Slc26a4*^{Δ/Δ} mice to determine temporal gene expression profiles and differences between genotypes.

Results: Endolymphatic sacs from E14.5 *Slc26a4*^{+/-} mice engaged in fluid absorption. The rate of fluid absorption at E14.5 was higher in endolymphatic sacs from *Slc26a4*^{Δ/+} than from *Slc26a4*^{-/-} mice, sensitive to ouabain and gadolinium and insensitive to benzamil, bafilomycin and S3226. Microarray analysis demonstrates expressed genes encoding transporters, ion channels and pumps and four genes (*Slc26a4*, *Foxl1*, *Atp6v0a4*, *Atp6v1b1*) known to cause EVA, suggesting that MRCs mediate vectorial ion transport.

Conclusions: Based on functional and pharmacological data and expression profiles, we propose a molecular mechanism for fluid absorption in the endolymphatic sac during development based on the absorption of NaCl. We conclude that disruption of this mechanism is the root cause of endolymphatic hydrops.

OP20-2 - Application of Gene Therapy to a Mouse Model of Vestibular Dysfunction

2. Animal Models and Molecular Approach

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Purpose: Vestibular dysfunction is a common and debilitating medical condition. The whirler mouse, a model of Usher syndrome, has a mutation in the whirlin gene which results in short and abnormal stereocilia in cochlear and vestibular hair cells. Consequently, these mice are deaf and have significant vestibular dysfunction. In this study, we assess whether gene therapy with wild type whirlin cDNA can be used as a treatment for vestibular dysfunction in the whirler mouse.

Methods: Adeno-associated virus serotype 2/8 containing whirlin cDNA (AAV8-whirlin) was delivered to the inner ears of neonatal whirler mice (P0-P5) via the posterior semicircular canal approach *in vivo*. Vestibular function was assessed by behavioral testing (circling, swim test, rotarod), as well as vestibular evoked potential (VsEP) measurements. Stereocilia morphology and whirlin expression were examined using immunohistochemistry.

Results: Treatment with AAV8-whirlin gene therapy resulted in whirlin expression at the stereocilia tips of vestibular hair cells in whirler mutant mice. Infected whirler vestibular hair cells have normalized stereocilia lengths compared to non-injected

controls. Whirler mice treated with AAV8-whirlin gene therapy had improved vestibular function, as measured by circling behavior, swim test, rotarod, as well as VsEP peak latencies.

Conclusions: AAV8-whirlin gene therapy was effective at restoring whirlin expression and stereocilia lengths in vestibular hair cells of whirler mutant mice. In addition, AAV8-whirlin gene therapy was able to significantly improve vestibular function in whirler mutant mice. These results suggest inner ear gene therapy holds potential as a viable treatment for vestibular dysfunction.

OP20-3 - Assessment of D-methionine Protecting Gentamicin-induced Otolith Toxicity

2. Animal Models and Molecular Approach

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Purpose: to determine whether gentamicin would induce otolith toxicity and vestibular-evoked myogenic potentials (VEMPs) are practical electrophysiological methods of testing and to examine if D-methionine (D-met) pre-injection would protect the otolith organs against gentamicin-induced changes in enzyme activities and/or oxidative status.

Methods: Guinea pigs were intraperitoneally treated once daily with the following injections for 14 days: sterile 0.9% saline control, gentamicin (120 mg/kg) only, D-met (300 mg/kg) only, or a combination of D-met (300 mg/kg) and gentamicin (120 mg/kg). Each animal underwent the oVEMP and cVEMP tests before and after treatment. The changes in the biochemistry of the otolith organs, including membranous Na⁺, K⁺-ATPase and Ca²⁺-ATPase, lipid peroxidation (LPO) levels and nitric oxide (NO) levels, were also evaluated.

Results: In the gentamicin-only treated group, the mean amplitudes of the cVEMP and oVEMP tests were significantly ($p < 0.05$) decreased when

compared to the other three groups. In guinea pigs receiving both D-met and cisplatin, the amplitudes of their cVEMP and oVEMP tests were significantly larger ($p < 0.05$) than those of the gentamicin-only group, but smaller ($p < 0.05$) than those of the saline control or D-met-only group. In comparison with the other three groups, the gentamicin-only group had the lowest ($ps < 0.05$) mean Na^+ , K^+ -ATPase and Ca^{2+} -ATPase, and the highest ($ps < 0.05$) LPO and NO levels.

Conclusions: The VEMP tests were feasible for the evaluation of gentamicin-related otolith dysfunction. D-met attenuated the reduced ATPase activities and increased oxidative stress induced by gentamicin toxicity in the otolith organs.

OP20-4 - What is the insulin signaling system doing in the inner ear? implications for diabetes

2. Animal Models and Molecular Approach

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Purpose: A number of studies indicate that diabetes is associated with inner ear dysfunction, however, basically nothing is known about mechanisms involved. We have demonstrated that the insulin receptor and related signaling components are expressed in the human inner ear sensory epithelium, however, the functionality and targets of the signaling system remain to be established in vitro and in vivo.

Methods: To study the impact of insulin signaling and action in the inner ear, human saccules and HEI-OC1 cells, a cell-line originating from auditory sensory epithelium established by Dr. Kalinec, are used in combination with immunohistochemistry and cell signaling strategies. The impact of insulin resistance on inner ear fluid homeostasis is studied in mice us-

ing MR imaging. The Andis (All new Diabetes patients in Skåne) study will be expanded to include also an inner ear perspective initially using diagnosis codes.

Results: Preliminary results show that the HEI-OC1 cells are highly sensitive to insulin (protein kinase B phosphorylation) as well as the beta adrenergic agonist isoproterenol (PKA substrate phosphorylation). A PI3kinase inhibitor blocked the insulin effect and the isoproterenol effect was enhanced by a phosphodiesterase 4-inhibitor. Identification of targets for insulin and cAMP-signaling such as ion channels, aquaporins and metabolic enzymes and MR-imaging on mouse models are on-going.

Conclusions: The inner ear appears to be a target for insulin signaling and action with implications for insulin resistance and diabetes. It is tempting to speculate that the known association between diabetes and inner ear dysfunction could be related to insulin resistance in the inner ear.

OP20-5 - Biocompatibility and therapeutic effect of three intra-tympanic drug-delivery vehicles

17. Pharmacotherapy

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Purpose: We assessed the biocompatibility of several intra-tympanic (IT) drug-delivery vehicles and compared hearing outcomes.

Methods: After acute acoustic trauma, rats were treated with IT 5 mg/mL dexamethasone (D) and divided into the following groups for drug delivery: saline+D ($n = 15$), HA+D (hyaluronic acid, $n = 17$), and MP+D (methoxy polyethylene glycol ϵ -polycaprolactone block copolymer, $n = 24$).

Results: No inflammation was found in the saline+D or HA+D groups. The duration of vehicle/drug persistence in the bulla was significantly longer for the MP+D (47.5 d) and HA+D groups (1.8 d) than the saline+D group (< 1 day). The tympanic membrane was significantly thicker in the MP+D group than in

the saline+D and HA+D groups. The proportion of ears with good hearing outcome was significantly higher (63.6%) in the HA+D group than the MP+D group. The number of hair cells in the hearing loss (HL) control group was significantly fewer than in the MP+D group.

Conclusions: Thus, HA shows great potential as a biocompatible vehicle for dexamethasone delivery via the IT route, without an inflammatory reaction and with better hearing outcomes. Considering inflammation and hearing, MP may not be a good candidate for IT drug delivery.

OP20-6 - The effects of electrical vestibular stimulation on neurochemical release in the rat striatum.

1. Anatomy and Morphology

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Purpose: For over a century, it has been speculated that the vestibular system, as a result of its role in sensing angular and linear acceleration of the head, transmits information about self-motion to the basal ganglia, and the striatum in particular. Nonetheless, there are virtually no data available on the effects of stimulating the vestibular system on neurochemical release in the striatum.

Methods: In this study we used *in vivo* microdialysis to analyse changes in the levels of a number of amino acids and monoamines in the rat striatum, following electrical stimulation of the peripheral vestibular system.

Results: We found that only serine and threonine showed significant changes in the stimulated animals, compared to the sham controls ($P < 0.005$ and $P < 0.01$, respectively); these were decreases that were independent of side and/or current intensity. Dopamine (DA) also exhibited a small but significant decrease in release on the ipsilateral side of stimulated animals ($P < 0.05$); the ratio of DOPAC:DA, also decreased on the ipsilateral side ($P < 0.005$). Taurine levels exhibited a signifi-

cant treatment x side x intensity interaction ($P < 0.002$), which appeared to be due to a small but consistent decrease on the contralateral side in stimulated animals, which varied as a function of current.

Conclusions: These results are consistent with the view that activation of the vestibular system exerts effects on the function of the striatum.

OP20-7 - Is it time for optical coherence tomography to be part of our vestibular workup?

7. Clinical Testing for Vestibular Function

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Purpose: Complete lesions of the vestibular nerve (as in vestibular neurectomy) result in ipsiversive ocular cyclodeviation (torsion of the retinae towards the side of the lesion) that diminishes over months. Incomplete lesions (as in vestibular neuritis) cause less pronounced, but still detectable, ocular cyclodeviation. The torsional position of the retinae is partly influenced by utricular afferents, so one would expect for there to be some correlation between diminished ocular vestibular evoked myogenic potentials (oVEMPs) and ipsiversive ocular cyclodeviation. We report here a pilot study of patients diagnosed with superior division vestibular neuritis who were also assessed with oVEMPs and retinal imaging by optical coherence tomography (OCT).

Methods: We studied a series of patients with a clinical history compatible with vestibular neuritis, whose workup showed a unilateral superior division vestibular weakness (based on caloric testing and video head impulse testing), who also had oVEMPs and OCT performed.

Results: Patients with superior division vestibular neuritis studied within 6 months of symptom onset exhibited cyclodeviation ipsiversive to the side of reduced or absent oVEMPs. One patient studied at 11 months after symptom onset exhibited no cyclodeviation despite persistently reduced oVEMPs.

Conclusions: OCT may be a useful tool in the acute/subacute evaluation of patients with superior division vestibular neuritis. Since OCT is non-invasive, rapid, easy to perform and to interpret, it could play a more prominent role in vestibular workups, or be deployed in acute settings (such as emergency rooms) where more detailed vestibular testing is unavailable.

OP21: Rehabilitation of vestibular disorders (II)

OP21-1 - Pain a common finding in patients with persistent dizziness

23. Vestibular Compensation and Rehabilitation

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Purpose: Persisting dizziness causes suffering and interferes with daily activities. Impaired sensory processing with multi-sensory interference, such as vestibular and nociceptive inputs, has been suggested as a maintenance factor.

Methods: Patients referred to a tertiary center for balance disorders (n=49, 34, 15; 14 peripheral vestibular, 8 central vestibular and 27 with no vestibular diagnosis) were asked for the presence of pain and filled out Dizziness Handicap Inventory (DHI, 0-100 points) and intensity 'as most common' of perceived dizziness and pain (if applicable) on Visual Analog Scales (0=no, 10=worst possible). If pain was present its location was reported and any interference with daily activities was stated on a Visual Analog Scale. Duration of symptoms was estimated.

Results: Dizziness intensity was stated to 6.0±2.5 (mean±SD) and DHI to 42.0±23.2 (e 15.3±9.4,

f 14.5±9.6, p 11.6±6.7). 61% of the patients reported pain, most commonly in neck/shoulders, head and back. Pain intensity was reported to 3.4±3.2 with a pain interference of 3.0±3.5. 88% reported dizziness with a duration of more than 6 months and 85% of the patients with pain reported a pain duration of more than 6 months. 30% of the patients indicated that dizziness came first, 35 % that pain came first and 35% that dizziness and pain started simultaneously.

Conclusions: Patients with persistent dizziness often report concomitant pain. We suggest a multi-sensory interaction with possible interference with pain syndromes when dizziness persist. This might be important for the choice of therapy and rehabilitation.

OP21-2 - Individualized vibrotactile neurofeedback training in bilateral vestibular loss patients

23. Vestibular Compensation and Rehabilitation

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Purpose: Bilateral vestibular loss (BVL) patients suffer extremely from postural instability during daily life conditions which in turn lead to a high frequency of falls. Unfortunately, conservative vestibular rehabilitation techniques are successful in only 50 % of all patients. The individualized vibrotactile neurofeedback training (iVNT) with the Vertiguardsystem has a proven high efficacy for the vestibular rehabilitation in many different balance disorders. The present study investigates therefore the effect of this modern approach on the postural control in BVL-patients.

Methods: All patients without a bilateral caloric response (n=19) performed the iVNT in stance and

gait tasks daily for 10 days. Before and after the training period stance stability was tested by the Sensory Organisation Test (SOT). The risk to fall was estimated by the Standard Balance Deficit Test (SBDT) which contains stance and gait tasks under different sensory conditions. Subjective complaints in daily life performance were determined by the Dizziness Handicap Inventory (DHI).

Results: The iVNT reduced the DHI-score and the risk to fall (SBDT-score) significantly (39.7 % and 19.2 %, respectively). The stance stability (SOT-score) was significantly enhanced (22.9 %). In total, the rehabilitation was successful in approximately 90 % of all patients (DHI-score).

Conclusions: The hard to treat BVL-patients benefit significantly from an iVNT training. Nearly all treated patients showed and reported an improved postural stability. The long-term effect should be further investigated.

OP21-3 - Multi-sensory training and wrist fractures. A randomized controlled trial

23. Vestibular Compensation and Rehabilitation

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Purpose: To investigate whether multi-sensory balance training improves postural control, vestibular function, foot sensation and functional ability among people with fall-related wrist fractures compared to those receiving wrist stabilisation training.

Methods: Ninety-eight people (mean age: 61.9±7.1 yrs; range 50-75) who had sustained a fall-related wrist fracture participated in the study. They were randomized to either multi-sensory (MST) or wrist

stabilization training (WT). Measurements pre- and post-training included the Head-Shake test (HST), Video-head impulse test (vHIT), Semmes-Weinstein monofilaments (SWF), Biothesiometer (BT), Sensory Organization Test (SOT), 10-meter walk-test (10mw), and the Five-times sit-to-stand test (FTSTS).

Results: There was a 16% non-significant (p=0.058) reduction in asymmetric vestibular function (HST) in the MST group but no change in the WT group. According to linear models correcting for baseline values, age and gender, there were significant endpoint differences in the SOT (p=0.01) between the two groups, in favor of the MST group, but not in other outcome variables. Subgroup analysis using participants with below normal baseline SOT scores indicated that the MST was more effective in improving 10mw fast (p=0.04), FTSTS (p=0.04), SWF (p=0.04) and SOT scores (p=0.04) than the WT.

Conclusions: Multi-sensory training improves postural control among people who have sustained a fall-related wrist fracture. The results of the study further suggest that the program is more effective for those with balance scores below age related norms on the SOT. These findings need to be confirmed in subsequent studies.

OP21-4 - Vestibular rehabilitation exercises as a form of neural priming to regain motor control of the arm

23. Vestibular Compensation and Rehabilitation

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Purpose: To describe the effects of vestibular rehabilitation exercises to address idiopathic lost motor control of the right arm in a 56-year-old female. Motor control loss was complete for the right arm for 4 months duration and for which traditional rehabilitation was unsuccessful.

Methods: The hypothesis was to use vestibular and oculomotor exercises to prime the motor cortex to regain control over the right arm. Vestibular stimuli were induced by passive and active gaze stability exercises. These were combined with hemisphere

specific oculomotor exercises i.e. leftward pursuit combined with rightward saccades. When minor movements were feasible, therapy was extended to include mirror box therapy, timing and coordination training using Interactive Metronome®. Training was performed daily for 4 consecutive days.

Results: Within two hours of vestibular and oculomotor applications mild movement of the shoulder and elbow occurred. Coupling these mild movements with hemisphere specific eye exercises by simultaneously timing led to further progression after which functional aspects could be addressed. On the fourth day she was able to perform all regular daily activities e.g. typing, lifting a cup, using scissors, and using knife and fork whilst eating.

Conclusions: In this case, vestibular and hemisphere specific motor exercises were successful in priming the left motor cortex to regain control over the paralytic and dysfunctional right arm.

OP21-5 - The reliability and validity of the Life Space Assessment in persons with vestibular disorders

23. Vestibular Compensation and Rehabilitation

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Purpose: The objective of this study was to determine the reliability and external structure validity of the Life Space Assessment (LSA), a self-reported measure of mobility, in persons with balance and vestibular disorders.

Methods: This prospective cohort study conducted in a balance disorders clinic included a convenience sample of patients experiencing dizziness or imbalance. Subjects completed the LSA, Dizziness Handicap Inventory (DHI), and Short Form 12-Item Health Survey (SF-12) at the start of care and the LSA, Global Rating of Change (GROC), and disability questions at 3 months.

Results: Seventy-two subjects (mean age 53 ± 16 years) completed the outcome measures at baseline and 42 subjects at 3 months. Test-retest reliability of the total LSA ($n=37$) was excellent (ICC [3,1] = 0.92) and internal consistency was good (Cronbach's alpha=0.77) measured at the start of care. The LSA showed moderate correlations with the DHI ($r=-0.402$), with the SF-12 physical ($r=0.602$) and mental ($r=0.405$) component summary scores ($n=37$). Patients who reported improvement at 3 months ($n=19$) based on GROC ≥ 4 had significantly better LSA scores (88.3 ± 27) at 3 months than those who did not improve ($n=23$) (67.9 ± 30.2), $p=.023$. An improvement in LSA over 3 months was moderately correlated with less activity limitations at work, home, and in the community over 3 months ($n=42$) ($r=-.322, -.341, -.442$).

Conclusions: Measurements of mobility using the LSA appear to be valid and reliable in persons with vestibular disorders. The LSA may be a potential measure of mobility in vestibular rehabilitation clinics.

OP21-6 - Histamine H1 receptor contributes to vestibular compensation

23. Vestibular Compensation and Rehabilitation

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Purpose: Vestibular compensation is critical for facilitating recovery from vestibular disorders and is of great importance in understanding the post-lesion neural plasticity. However, the underlying neural mechanism is still far from clear. Intriguingly, beta-histidine, a widely used clinical drug for treatment of vestibular disorders, exerts not only antagonistic action on the presynaptic H3 receptor, but also agonistic effect on postsynaptic H1 receptor, indicating a possible involvement of H1 receptor in betahistidine's pharmacological effect. Therefore, we assess the exact role of postsynaptic H1 receptor in vestibular compensation.

Methods: Unilateral labyrinthectomy (UL) was performed on adult male Sprague-Dawley rats to establish a model for vestibular compensation. Behavioral assessment, western blotting, immunostaining, retrograde tracing, and whole-cell patch-clamp recording were combined to investigate the pathophysiological function of histamine H1 receptor in the medial vestibular nucleus (MVN) in vestibular compensation and the underlying mechanisms.

Results: Selective blockage of H1 receptor in the MVN retards the recovery of both static symptoms, including postural asymmetry and nystagmus, and dynamic dysfunction in locomotion and motor coordination following UL. The expression of H1 receptor is significantly and restrictedly increased in the ipsilesional rather than contralesional GABAergic MVN commissural neurons. Furthermore, the histamine-induced excitation mediated by postsynaptic H1 receptor is selectively increased in the ipsilesional MVN commissural inhibitory but not excitatory neurons.

Conclusions: Histamine H1 receptor mediates the asymmetric activation of MVN commissural inhibitory system and actively promotes vestibular compensation. The findings reveal a previously unknown functional role for H1 receptor in vestibular compensation and provide new insight into the post-lesion neural circuit plasticity.

OP22: Gait, Posture and locomotion

OP22-1 - Balance control impairments in Fabry disease

11. Gait, Posture, and Locomotion

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Purpose: Fabry disease (FD) is an X-linked recessive inborn error glycosphingolipid metabolism due to the deficient activity of the lysosomal enzyme alpha-galactosidase A. The deficiency of this enzyme leads to an accumulation of glycosphingolipids throughout the body. Impairments include renal, cardiac and neurological damages. FD may also have neurootological and visual impairments, which can generate postural control alterations, inner ear and vision being involved in this function. This study aimed to evaluate the impact of FD on postural control.

Methods: Fourteen adult patients (mean age = 37.62 +/- 11.43 years) and two children (mean age = 11.01 +/- 2.54 years) with FD and 19 healthy adults (mean age = 36.51 +/- 16.99 years) and two children (mean age = 10.49 +/- 0.79) took part in this study. Postural control was evaluated by a sensory organisation test combining three visual situations (eyes open, eyes closed, sway referenced visual surround motion) with two platform situations (stable platform, sway referenced platform motion), aiming to calculate a composite equilibrium score (CES). Somatosensory contribution to postural control (R-SOM), visual contribution (R-VIS) and vestibular contribution (R-VEST) were calculated.

Results: The CES was lower in patients with FD compared to healthy subjects ($p < 0.001$). R-VIS ($p = 0.001$) and R-VEST ($p = 0.003$) were lower in FD patients compared to the control group.

Conclusions: Inner ear and visual pathologies associated to central nervous system impairments are factors of a postural control impairments. Physical activities, which can also be rehabilitative, by maintaining or increasing the weight of proprioception, may help diminish dependency to altered sensorial inputs.

OP22-2 - Body sway is mediated by vestibular cortical dominance

11. Gait, Posture, and Locomotion

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Purpose: The posterior parietal cortex is heavily implicated in vestibulo-cortical processing. Recent behavioural data and meta-analysis of imaging data suggests a right-hemispheric dominance for vestibular processing. Functionally, the vestibular cortex is implicated for maintaining spatial orientation and postural control. However, to-date whether the degree of an individual's hemispheric dominance influences postural control remains unknown.

Methods: 24 right-handed healthy individuals underwent either cathodal or anodal transcranial Direct Current Stimulation (tDCS) for 15min over the left Posterior Parietal Cortex (PPC). Vestibulo-cortical hemispheric dominance was quantified using the, "nystagmus suppression index" calculated as the change (i.e. before/after tDCS) in the peak Slow Phase Velocity in response to cold-water caloric irrigations. To assess postural control, subjects performed a postural task before and after tDCS which required them to maintain balance whilst they stood on a linear sled and were exposed to random left-right perturbation. Objective measures of body sway were recorded.

Results: Increased right vestibulo-cortical dominance (i.e. larger nystagmus suppression index) was negatively correlated with the sway path change ($r:0.7$, $p<0.05$) in the cathodal group. Sway velocity was also positively correlated with the degree of nystagmus suppression index in the cathodal group ($r:0.65$ $p<0.05$). No relationship was observed following anodal stimulation (control group).

Conclusions: The degree of right hemispheric vestibulo-cortical dominance influences postural control.

OP22-3 - Changes in Cortical Activity during Dual-task Walking in Individuals with and without Visual Vertigo

11. Gait, Posture, and Locomotion

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Purpose: Under dual-task conditions, cognitive resources are divided between a cognitive task and a dynamic balance task. The aim of this study was to determine differences in cortical activity in the frontal cortex between individuals with and without visual vertigo (VV).

Methods: Fourteen individuals with VV and 14 age- and gender-matched healthy controls (mean 39 ± 11 years old) were monitored with functional near-infrared spectroscopy (fNIRS) over the frontal cortex. Subjects performed a cognitive task (every other letter of the alphabet) while walking over an even or uneven surface and fNIRS signals were compared to quiet standing.

Results: Individuals with VV had greater increases in deoxy-hemoglobin over the left frontal cortex while standing with a cognitive task ($T = 4.35$, $p < .001$), walking over an even surface with ($T = 4.34$, $p < .001$) and without ($T = 4.20$, $p < .001$) a cognitive task, and walking over an uneven surface ($T = 5.81$, $p < .001$) compared to quiet standing relative to healthy individuals. During dual-task walking over an uneven surface, individuals with VV had decreases in deoxy-hemoglobin over the left frontal cortex compared to quiet standing relative to healthy individuals ($T = -22.93$, $p < .001$).

Conclusions: During complex walking tasks, individuals with VV display greater activity in the frontal cortex, indicating that they may be devoting greater cognitive resources to performing dual-tasks

than healthy individuals. During the most challenging task, individuals with VV may have shifted attention away from the cognitive task or may have been utilizing regions of the brain other than the frontal cortex.

OP22-4 - Influence of hearing on postural control and stability in healthy subjects

11. Gait, Posture, and Locomotion

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Purpose: In postural control, auditory input seems to interact with vestibular, somatosensory and visual information. However, various, sometimes conflicting, assessments of this process have been reported during both static and mobile posturography experiments. We hypothesize a beneficial effect of sound, and that there are differences in audiovestibular regulation mechanisms depending on the type of experiment.

Methods: 30 normal hearing, healthy subjects were tested in a sound-insulated hypoechoic auditory booth in two conditions, with and without 0°-presentation of sound. Stability was measured using a force plate system (Interactive Balance System, IBS) with 8 standardized stance conditions. Postural control was measured with the Vertiguard trunk sway device using the Standard Balance Deficit Test (SBDT, 14 tasks).

Results: Trunk sway measurement showed a significant reduction of angular sway velocity with auditory input in two tasks of the SBDT: walking over four barriers (pitch plane, $p < 0.0001$) and standing on one leg with eyes closed (roll plane, $p = 0.0055$). In the condition with sound, IBS showed a

relevant decrease of the level of postural regulation in the frequency bands F1 ($\eta^2 = 0.122$) and F2-4 ($\eta^2 = 0.125$), representing the visual and the peripheral-vestibular system, as well as in the Weight Distribution Index ($\eta^2 = 0.159$).

Conclusions: We could show a significant benefit of auditory input on postural control. Force plate based stability analysis indicates a shift of multisensory regulation weighting due to auditory input. Audio-vestibular regulation mechanism seems to influence the postural performance, particularly visual and vestibular subsystems.

OP22-5 - The auditory influence on postural control in stance and gait conditions

11. Gait, Posture, and Locomotion

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Purpose: The influence of visual, vestibular and proprioceptive sensory information on postural control has already been well investigated. However, little is known about the impact of auditory information on balance in stance and gait conditions. In the present study, body sway was therefore evaluated in young, healthy volunteers under different auditory and motor condition.

Methods: All volunteers ($n=30$, age 16-40 y) showed normal hearing, normal visual acuity and normal peripheral vestibular receptor function.

Body sway was measured with the Vertiguard mobile posturography system at the hip close to the center of body mass in eleven stance and gait tasks under the following acoustic conditions:

- quiet (reference condition)
- continuous white noise (frontal)
- pulsed with noise (frontal)
- plugged ears
- amplified walking sound

Results: Continuous noise and ear plugging increased the body sway during most stance tasks,

while pulsed noise was able to enhance the postural control. The sway during walking was significantly decreased by all kind of applied noise if the head was not turned in rhythm. Amplified walking sound did not influence postural control during walking.

Conclusions: Postural control in stance tasks could be impaired by masking the auditory input with continuous noise or earplugs and enhanced with the application of additional, exactly timed acoustic reflections. The sway during walking could be reduced by the permanent localization of a sound source.

The results indicate that specific auditory information seem to have a significant influence on postural control during specific stance or gait tasks.

OP22-6 - Vestibular loss effects on standing balance during postural threat

11. Gait, Posture, and Locomotion

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Purpose: Vestibular deficit patients have an increased fall risk and presumably an increased fear of falling. Postural threat, known to increase balance-related fear and anxiety, has been shown to influence vestibular gains during quiet standing in young healthy adults. Threat-related balance changes were found to be unaffected by unilateral vestibular loss (Young et al., 2012). However, short duration standing trials, with a mild postural threat (standing on a 62cm high platform) limited previous work. The current study was designed to examine the relationship between vestibular loss and strong threat effects on standing balance control.

Methods: Eight patients with complete unilateral vestibular loss (UVL) due to operated vestibular nerve tumors and six healthy controls stood for two minutes on a force-plate mounted to a hydraulic lift

placed at two heights: low (0.8m, away from edge) and high (3.2m, at edge). Amplitude (root mean square, 90% range), mean power frequency, (MPF), and mean position were analyzed for center of pressure (COP; AMTI, USA) and trunk sway (Sway-Star, CH).

Results: UVL patients had larger COP amplitudes, larger 90% ranges for trunk sway and velocity, but smaller 90% ranges for COP velocity than controls. Independent of group, height significantly increased COP MPF and the 90% ranges for COP and trunk velocity, and lean away from the edge.

Conclusions: Independent of height, balance in UVL patients differs from controls, presumably due to reduced vestibular gain. However, increased sway velocity with height and the balance strategy used by UVL patients under fearful conditions is not different.

OP22-7 - Virtual Reality for Vestibular and Balance Rehabilitation A Preliminary report

11. Gait, Posture, and Locomotion

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Purpose: We report here five patients complaining for chronic dizziness and five healthy subjects (controls) who performed balance rehabilitation using Virtual Reality (VR).

Methods: We used a Wii Balance Board and our 'BalanceRite' App on an iPhone to assess balance on a stable surface and a compliant surface (Wii board+foam). Several visual conditions were used: eyes open, eyes closed, and using Virtual Reality goggles (Samsung Gear VR). The VR scene generated by our 'Tuscan Villa' App was an immersive garden that can be perturbed (by a sum-of-sines) at various amplitudes (unpredictable visual distractor). The rehabilitation was done with a VR optokinetic cloud of dots or a drum of black and white stripes. Baseline balance performance was assessed at an initial stage before any intervention. After subjects had been exposed to 8-10 mins of the rehabilitation

stimulus their balance was assessed again. This process was repeated once a week for four weeks.

Results: Patients showed an improvement of balance performance measures. Balance of healthy subjects was not affected by the VR stimulus. For those subjects tested again one month later, balance performance improvements were still maintained.

Conclusions: Balance rehabilitation using virtual reality could be a very efficient way to improve balance in patients.

OP23: Perception and Central Vestibular function

OP23-1 - Exposure to an extreme environment comes at a sensorimotor cost

27. Others

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Purpose: Long duration space flight disrupts sensorimotor function. In preparation for future exploration, NASA employs research analogs that mimic some of the physical, psychological, and emotional challenges that crewmembers will experience. NASA's Extreme Environment Mission Operations (NEEMO) is one such research analog; individuals live for up to three weeks at saturated atmospheric pressure (~2.5 ATM) in a habitat located 19 m under-sea in the Florida Keys National Marine Sanctuary.

Methods: We have developed the Portable Sensorimotor Assessment Platform (PSAP) to measure different aspects of sensorimotor function. PSAP uses a Microsoft Surface Pro 3 tablet computer (Microsoft Corporation, USA) and five small MTw inertial sensors with a sampling frequency of 100 Hz (Xsens

Technologies BV, Netherlands). Ten crewmembers (six from NEEMO 21 and four from NEEMO 22) were recruited to perform tandem walking in two conditions: eyes open (EO) and eyes closed (EC).

Results: We found significant changes in performance while tandem walking in both EO and EC conditions. During the EC tandem walk condition, significant correlations between the mission duration and gait regularity and trunk displacement worsened over the duration of the mission. Trunk displacement did not return to baseline upon return to land (1 ATM).

Conclusions: The results of our study reveal that the PSAP instrumented version of tandem walking test can be useful for identifying crewmembers with transient sensorimotor deficits. Our data suggest crewmembers exposed to the long duration NEEMO mission suffer a postural control cost. This cost may be avoidable, or treatable given the plasticity existent in sensorimotor function.

OP23-2 - Sensation and functional balance in elderly - low efficacy using the 256 Hz tuning fork

27. Others

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Purpose: In elderly, diminished foot somatosensation contributes to balance deficits and increased fall risk. However, it remains unclear how to adequately measure somatosensation in the outpatient clinical setting.

Methods: Discrimination between vibration sensation and pressure perception was tested bilaterally with a 256 Hz tuning fork at the base of the first metatarsal bone (MTP-I), the medial malleolus (Mall), and proximal Tibia in 36 relatively healthy elderly (mean 69.4±5.3 years). Subject were allocated into 4 different tuning fork sensation groups (TFSG) according to their ability to detect vibration from pressure on at least one leg: TFSG 3 (three sites), TFSG 2 (Mall, Tibia), TFSG 1 (Tibia) and TFSG 0 (no sites). Vibration perception thresholds (VPTs) were measured with a 120 Hz biothesiometer

and tactile pressure sensation thresholds (TPSTs) with a 20-piece monofilament kit. Balance was assessed with one-leg standing time (OLST) on firm and compliant surfaces with eyes open or closed, walking speed, Figure-8, Timed Up & Go (TUG), Berg Balance Scale (BBS), and posturography.

Results: Four subjects were included in TFSG 3, nine in TFSG 2, 14 in TFSG 1 and nine in TFSG 0. There were no significant differences in age, BMI, VPTs, or TPSTs between the four groups, nor in the outcome of OLST (any condition), walking speed, Figure-8, TUG, BBS, or posturography results.

Conclusions: Vibration perception measured with a 256 Hz tuning fork seems to be a very minor determinant for functional balance and thus a superfluous test when evaluating the importance of vibration perception for balance control in elderly.

OP23-3 - Paroxysmal positional ocular flutter associated with middle cerebellar peduncle demyelination

15. Ocular Motility: Physiology and Pathology

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Purpose: Positional ocular flutter is a rare disorder, with two cases described in the literature, both lacking an underlying focal lesion (ie, in one patient with degenerative ataxia and in another with Krabbe's disease). Given its strictly positional nature, a dysfunction of the cerebellar saccadic-otolithic network has been hypothesized. We describe a patient with a right middle cerebellar peduncle demyelinating lesion associated with symptomatic positional ocular flutter, in whom the use of dalfampridine (4-AP) was not effective.

Methods: History taking; Clinical exam; Video-oculography; Head MRI

Results: A 24 year-old woman presented with a 3-year history of paroxysmal oscillopsia and nausea when moving to supine position. Brain MRI revealed several lesions in the supratentorial region and one located at the anterior and medial aspect of the right middle cerebellar peduncle, consistent with demyelinating disease. Video-oculography in upright position showed occasional single saccadic pulses and square-wave jerks on fixation. When moving to head hanging position, a ~2 second positional ocular flutter followed by ~30 second square-wave oscillations was consistently precipitated, along with intense nausea. She was started on 4-AP, 10mg bid. 180 minutes after the first intake, positional ocular flutter was unchanged. Five days later, minor side effects led to 4-AP interruption.

Conclusions: Positional ocular flutter in our case may reflect transverse ephaptic spread of excitation from a lesion involving tracts that subservise otolithic input, to contiguous cerebellar tracts modulating saccadic burst neuron activity in the brainstem. Dalfampridine does not seem to be effective in positional ocular flutter.

OP23-4 - Main sequence of torsional saccade under videoculography recordings.

15. Ocular Motility: Physiology and Pathology

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Purpose: 3-dimensional eye movement description can recently be obtained using video-oculography. We've been quantifying video of eye movement into horizontal, vertical and torsional dimensions, and integrating them into rotational vector. During this procedure, pattern matching of subject's iris is employed to quantify torsional eye movement, which tends to cause the error and reduce the accuracy of recordings. We are seeking for a procedure to set the upper limit on the angular value per frame, to restrict the recordings of torsional movement under reason-

able numeric, which enables us to exclude false measurements. However, it may also exclude actual torsional saccade, and rather decrease the accuracy. To settle appropriate value of limitation, angular velocity characteristics of torsional saccade should be clarified.

Methods: Relationship between torsional amplitude and angular velocity (torsional “Main Sequence”) of healthy subjects’ saccade was evaluated under video-oculography recordings. Torsional saccade cannot be delivered intentionally. So, we employed intermittent saccade during torsional vestibulo-ocular reflex.

Results: Amplitude of torsional saccades distributed up to about 10 degrees, and did the velocity up to around 100 deg/sec. Angular velocity increases proportionately to the torsional amplitude, and its averaged coefficient was around 10.

Conclusions: Main sequence of torsional saccade demonstrates linear characteristics mimicking horizontal and vertical saccade. It can enable us to set upper limit of torsional angular change per each sampling frame under video-oculography recordings, to improve the accuracy of 3D eye movement analysis.

OP23-5 - Structural connectome of the human vestibular cortex

1. Anatomy and Morphology

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Purpose: The aim of this study is to characterize modules and hubs within the multimodal vestibular system and in particular to test centrality of posterior peri-sylvian regions.

Methods: Structural connectivity matrices from 100 unrelated healthy right-handed subjects from the Human Connectome Project (HCP) database were analyzed using multishell diffusion-weighted data, probabilistic tractography (constrained spherical-deconvolution informed filtering of tractograms) in combination with subject-specific grey matter parcellations. Network nodes included parcellated regions within posterior thalamus (Fan 2016 atlas), insula, opercula, superior temporal, parietal, frontal and cingulate cortex, hippocampus and parahippocampal cortex (Glasser 2016 atlas). A group matrix was then calculated by averaging weights across the most consistent tracks. Modularity calculation maximized the number of within-module links and minimized the number of between-module links. Hub-regions were identified according to aggregate ranking of multiple metrics (average range across node strength, nodal efficiency and betweenness centrality).

Results: Areas in both hemispheres were grouped in three modules: the first comprised the posterior thalamus, insula and opercula, superior parietal and peri-insular frontal regions; the second module was constituted by high order visual areas (MT, MST), inferior parietal and temporal peri-sylvian regions; the third module included the cingular, hippocampal, and parahippocampal areas. Hubs were mainly located in the parietal opercula and peri-sylvian inferior parietal cortex.

Conclusions: This analysis revealed three paths within the multi-modal vestibular system, seemingly related to vestibular / somaesthetic processing, vestibular / visual processing and spatial orientation / navigation. Posterior peri-sylvian regions may represent the main hubs of this modular network.

OP24: Vestibular migraine

OP24-1 - Abnormal Visuo-vestibular Interactions in Vestibular Migraine

24. Vestibular Migraine

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Purpose: Vestibular migraine (VM) is amongst the commonest causes of episodic vertigo. Chronically, VM patients develop both an abnormal responsivity to vestibular and visual stimuli, as characterised by heightened self-motion sensitivity and visually-induced dizziness. However, to-date the neural mechanism mediating such symptoms in VM remains unknown. We postulate that impaired visuo-vestibular cortical interactions in VM disrupt normal vestibular behaviour and in-turn mediate the evolution of symptoms.

Methods: To assess this, we investigated whether full-field, prolonged (5 minute) visual motion exposure, which has previously been shown to modulate visual cortical excitability, could modulate vestibular ocular reflex (VOR) and vestibular-perceptual thresholds of self-motion during horizontal yaw rotations in VM patients.

Results: Our findings reveal that VM patients exhibit abnormally elevated VOR and vestibular-perceptual self-motion detection thresholds at baseline. Following visual motion adaptation both reflex and perceptual vestibular thresholds were further increased in comparison to healthy controls and migraineurs without vestibular symptoms.

Conclusions: We provide a novel demonstration of abnormal baseline vestibular thresholds in VM. Additionally, we observed altered visuo-vestibular cortical interactions following visual motion adaptation, as reflected by modulation of vestibular thresholds, in VM patients only, thereby elucidating a potential neurophysiological bio-marker.

OP24-2 - Errors of Upright Perception in Patients with Vestibular Migraine

24. Vestibular Migraine

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Purpose: Patients with vestibular migraine (VM) suffer from disturbances in perception of spatial orientation with symptoms triggered or worsened by changes in the head or body positions. Here we studied the impact of static head tilt on spatial perception by measuring subjective visual vertical (SVV) at different lateral head tilt positions in 27 VM patients and 27 healthy volunteers matched for age and handedness.

Methods: SVV responses were collected using a forced choice SVV paradigm in three head tilt conditions (upright, +/- 20°) with the head immobilized using a bitebar in a dark room.

Results: In the upright head position, SVV accuracy was within the normal range for VM patients and healthy controls (two degrees from true vertical). During the static head tilts of 20° to the right, VM patients showed errors consistent with overestimation of the tilt magnitude (i.e. greater E-effect than controls) ($-3.21^\circ \pm 0.93$ vs. $0.52^\circ \pm 0.70$; $p=0.002$). During the head tilts to the left, SVV errors in VM patients did not differ significantly from controls ($0.77^\circ \pm 1.05$ vs. $-0.04^\circ \pm 0.68$; $p=0.52$). There was no significant difference in SVV precision between the VM patients and healthy controls for any head tilt position. Consistent with the SVV errors, the majority of VM patients reported symptoms toward the right side with daily activities.

Conclusions: The larger errors of upright perception during head tilt suggests abnormal sensory integration for spatial perception in vestibular migraine. This finding could be related to symptoms induced by changes in the head position in these patients.

OP24-3 - Living with Vestibular Migraine; A qualitative investigation of patients perspectives

24. Vestibular Migraine

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Purpose: This study investigated the patients' perspectives on living with Vestibular Migraine (VM) to help Healthcare Professionals (HCPs) gain a more comprehensive understanding of needs and wants of the patients. This information will be used to inform recommendations to help practitioners optimize their practice.

Methods: A qualitative descriptive method was implemented in this study. Eleven adults with a confirmed diagnosis of VM by their physicians were interviewed for an average of 35 minutes. Interviews were audio-recorded, transcribed and analyzed using thematic coding.

Results: Four major themes emerged through categorization and abstraction of the concepts; 1) VM resembles a restrictive wall, 2) Life within the wall is dramatically different than life outside, 3) Isolation and 4) Hopelessness. Within the theme two, six subthemes were identified where participants described variable impacts on their lifestyle, occupation, personal life, self-sufficiency, social network and self-image. This finding specifically highlights VM as a debilitating illness with pervasive functional restriction and extensive psychologically repercussions.

Conclusions: Disregarding the VM impacts on patients' quality of life downgrades the therapy outcome. To Optimize VM clinical management, practitioners must implement a holistic collaborative

approach comprising of not only the medical treatment but also the development of goal-oriented interventions that address the patients' unique functional/psychological restriction.

OP24-4 - Severe motion sickness - a possible rare presentation of vestibular migraine

24. Vestibular Migraine

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Purpose: To describe a rare presentation of severe motion sickness due to possible vestibular migraine.

Methods: A retrospective review of patients presenting with severe motion sickness who responded to migraine prophylaxis was conducted. These cases were collected over a 20 year period and were analysed according to the medications prescribed, duration of symptoms, history of migraine and presence of migrainous features during bouts of motion sickness.

Results: A total of 16 patients with severe motion sickness were identified who responded dramatically to the use of migraine prophylaxis, with a greater than 50% reduction in symptoms of motion sickness, though most had a substantial or near total improvement in their symptoms. Medications used included pizotifen, topiramate, amitriptyline and propranolol. This collection was from a total cohort which included over 600 patients with a diagnosis of suspected vestibular migraine. Of the 16 cases, 7 had a history of motion sickness dating back to early childhood. Only 5 cases (31%) had a history of migraine according to IHS criteria. Nine cases (56%) had a history of headache or photophobia during bouts of motion sickness. No cases fulfilled the IHS criteria for the diagnosis of vestibular migraine.

Conclusions: Severe motion sickness may be a presenting feature of vestibular migraine. These cases responded dramatically to trials of migraine prophylaxis and this treatment should be considered in patients presenting with severe motion sickness. A trial of therapy may be indicated even when there is no other history to suggest a diagnosis of migraine.

OP24-5 - Vertigo in Pediatric population. Migraine prevalence

24. Vestibular Migraine

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Purpose: To establish the prevalence of Vestibular Migraine (VM) in our series of pediatric patients.

Methods: A retrospective, observational, descriptive, and cross-sectional study was conducted.

Patients aged 1-18 years who consulted because of balance disorders at the Otolaryngology Department of a Pediatric Tertiary-Care Hospital between June 2014 - June 2017.

Results: 247 patients ages 1-18 were included in the study; 123/247 (49%) girls y 124/247 (51%) boys. The age median was 9 years.

Within this group of studied patients 76/247 (30%) referred vestibular symptoms and headaches. Fifteen of them (20% - 15/76) met the diagnostic criteria for defined VM and 6/76 (8%) met the criteria for probable VM, i.e. 21/76 (28%) patients are included in this condition. This represents 8.5% (21/247) of the total sample considered in this work. Fifty five patients 55/76 (76%) do not meet the VM criteria.

A family history of migraine is relevant data to be considered in this group of patients. 100% (15/15) of the patients with defined vestibular migraine had a family history of migraine.

BPVC is a migraine equivalent: 21/247 (8.5%) patients present this pathology in our series.

Thus, we have 21 patients with a VM diagnosis and 21 patients with BPVC. (total: 42/247-17%- patients)

Conclusions: It can be established that, out of all children who consult due to "headache" associated to balance disorders, only a percentage below 10% meet the criteria for VM. The simple association of both symptoms does not define this pathology.

OP24-6 - Vestibular migraine: reference to International Classification of Headache Disorders 3rd edition.

24. Vestibular Migraine

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Purpose: Clinical characteristics of vestibular migraine in reference to actual diagnostic criteria of International Classification of Headache Disorders -3: verification.

Methods: A cross-sectional historical cohort study was conducted. Clinical records of all patients attended to the tertiary referral neurootological outpatient clinic in the period from January 2014 to May 2017 and diagnosed as having vestibular migraine were evaluated. Diagnosis was based on criteria of International Classification of Headache Disorders 3: main points extended by the notes which are enclosed to the criteria, especially concerning the duration of attacks (not only attacks between 5min to 72h but also lasting seconds up to five minutes and longer than 72 hours).

Results: A total of 156 records of patients (141 female, 15 male, 47 ± 13.0 years old) were enrolled in the study. The mean age of onset of vertigo was 38,1±13,2 years. The duration of attacks less than 5 minutes or more than 72 hours was present in 24% of patients. Temporal relationship between headaches and vestibular symptoms occurred in 65% of patients, but the remaining part (35%) have never had headache during attacks of vertigo. 26% of patients did not reported any migrainous symptoms (photo and phonophobia) during vestibular migraine. Absence of concomitant occurrence of dizziness and headache and migrainous symptoms was observed in 15% of individuals.

Conclusions: Part of patients due to criterion of time attacks and the criterion of the presence of migraine symptoms do not fulfilled main points of ICHD-3 criteria for VM without concerning the notes added to main points.

OP24-7 - Benign Recurrent Spontaneous Vertigo with Interictal Head-Shaking Nystagmus

6. Central Vestibular Disorders

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Purpose: To define a disorder characterized by recurrent spontaneous vertigo and interictal head-shaking nystagmus (HSN).

Methods: We had recruited 35 patients with recurrent spontaneous vertigo of unknown causes (also known as benign recurrent vertigo; BRV) and interictal HSN. We characterized the HSN in comparison to that recorded in randomly selected patients with compensated vestibular neuritis (VN), vestibular migraine (VM), and Meniere's disease (MD).

Results: The estimated time constants (TCs) of the primary phase of HSN was 12 seconds (95% CI=12–13 seconds) in patients with BRV, which were larger than that from VN (5 seconds, 95% CI=4–5 seconds), VM (5 seconds, 95% CI=5–6 seconds) or MD (6 seconds, 95% CI=5–6 seconds). The TCs of the horizontal vestibulo-ocular reflex were also larger during rotatory chair test in patients with BRV. Among the 35 patients with BRV and HSN, seven showed vigorous long-lasting HSN with a peak slow phase velocity 50.0°/s. In five patients (5/7, 71%) with vigorous HSN, HSN could have been induced even with head shaking only for two to five seconds. Long-term prognosis was favorable with a resolution or improvement of the symptoms in more than half of the patients during the median follow-up of 12 years (range=2-58) from symptom onset. None developed VM or MD during the follow-up.

Conclusions: The clinical features and characteristics of HSN in our patients indicate hyperactive and asymmetric velocity-storage mechanism that gives rise to intermittent attacks of spontaneous vertigo

OP25: Clinical Vestibular testing HIT (II)

OP25-1 - Video-head impulse test results in Meniere's disease related to duration and stage of disease

14. Meniere's Disease and Related Disorders

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Purpose: The video-head impulse test employs the vestibulo-ocular reflex (VOR) to assess vestibular function. To this day, no consensus has been reached among scientists in terms of whether or not vHIT results change in MD patients as the disease progresses. To assess whether the vHIT is more often abnormal during later stages of MD compared to earlier stages.

Methods: We retrospectively analyzed patients with 'definite' MD who had undergone the vHIT and caloric test between 2012 and 2015. Patients were evaluated based on duration of disease in years (≤ 1 , $>1 \leq 5$, $>5 \leq 10$, >10) and stage of disease (stage I and II versus III and IV). For the vHIT, an abnormal vestibulo-ocular reflex was defined as a gain cut-off value of ≤ 0.8 and presence of correction saccades.

Results: In 89 definite MD patients (42 (47%) male, mean age 55 ± 5 (SD)), data on both the caloric test and the vHIT was available. The risk at an abnormal vHIT was 25% in patients with a duration of disease over 10 years compared to 22% in the patients with a disease duration of 10 years or less (risk difference 3%, 95% CI: -28% to 35%), $p=0.82$). The risk for an abnormal vHIT in the Stage I and Stage II was 17% compared to 26% in Stage III and IV (risk difference 9%, 95% CI: -30% to 11%).

Conclusions: Using the criteria of either duration or stage of disease, no relationship could be demonstrated between the proportion of abnormal vHIT test results in patients with MD.

OP25-2 - Acute video-oculography for vertigo in emergency rooms for rapid triage (avert) Trial: pilot results

7. Clinical Testing for Vestibular Function

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Purpose: Report preliminary results from a two-year logistical pilot phase of the AVERT trial. AVERT is a multicenter, patient-level randomized phase II trial comparing the impact of video-oculography (VOG)-guided rapid triage to standard Emergency Department (ED) diagnostic care (NCT02483429).

Methods: From November 2015 to November 2017, we screened 291 patients with acute vertigo at three EDs during the AVERT pilot trial. We performed a standardized screening battery of VOG tests using the ICS Impulse device (GNOMetrics, Taastrup, Denmark). Tests included Head Impulse, Nystagmus, and Test of Skew (HINTS) as well as gaze and positional testing. Of 131 VOG recordings, neuro-otology experts reviewed 101 to determine the presence of pathologic nystagmus (>10deg/sec), and, if present, render a final diagnosis, masked to the ED

diagnosis. Expert diagnoses were compared to recorded ED diagnoses. Barriers to automated VOG interpretation were identified and addressed.

Results: Among 101 patients, 31% (n=31) had pathologic nystagmus (15 BPPV, 7 vestibular neuritis, 6 central, 3 unknown). Of these, 26% (n=8) were diagnosed correctly by ED providers. The principal barrier to automated VOG interpretation was false positive software readings suggesting nystagmus slow phase velocity >10deg/sec when no nystagmus was present. Measurement issues were addressed by implementing software updates allowing real-time review of VOG results before randomization, and review of VOG results for patients randomized to the intervention arm by an on-call neuro-otology fellow.

Conclusions: ED diagnosis of vestibular patients is highly inaccurate. We will further evaluate accuracy, efficiency, and safety of VOG-guided rapid triage in the main AVERT trial.

OP25-3 - Different vHIT results of sudden deafness with vertigo and vestibular neuritis

7. Clinical Testing for Vestibular Function

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Purpose: The present study investigated whether sudden sensorineural hearing loss (SSHL) with vertigo (SHLV) and vestibular neuritis (VN) share the same etiology using the video head impulse test (vHIT).

Methods: The vHIT was conducted in 30 patients with SHLV and 22 patients with VN to quantitatively determine the vestibulo-ocular reflex (VOR) gains (vHIT-G). Next, vHIT-G and other parameters, including audiology variables and bedside examinations, were assessed and analyzed in the SHLV and VN patients.

Results: The SHLV and VN groups differed significantly in terms of vHIT-G in the anterior semicircular canal (AC) and horizontal semicircular canal

(HC, $P < 0.05$) but not in terms of vHIT-G in the posterior semicircular canal (PC). The severity and extent of change in the affected canals differed between the two groups, as did vestibular nerve and vascular involvement.

Conclusions: The different vHIT results of the two patient groups suggest that VN and SHLV have different etiologies.

OP25-4 - Enhanced VOR suppression in dancers during passive high velocity head impulses

7. Clinical Testing for Vestibular Function

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Purpose: The vestibulo-ocular reflex (VOR) is responsible for stabilizing images on the fovea during head movements. However, in some situations, one needs to suppress the VOR in order to be able to follow a target moving along with the head. This ability is either made possible by a central modulation of the sensitivity to head movements or by the generation of a signal counteracting the VOR. Evidence suggests that the visual mechanism underlying VOR suppression can be modulated by experience. Unfortunately, the non-visual mechanism underlying VOR suppression has never been examined in dancers and, consequently, it is still unsure whether dance training can enhance eye-head tracking accuracy. The goal of the present study was to look at the influence of dance training on the VOR suppression during passive head impulses.

Methods: Twenty-four individuals participated, 12 controls and 12 dancers. VOR and VOR suppression were assessed using a head impulse paradigm (HIMP) as well as a suppression head impulse test paradigm (SHIMP) with video head impulse test, respectively.

Results: The results suggest that dancers display a significantly reduced VOR gain during the SHIMP at 60ms in comparison to controls. Moreover,

dancers with more than 10 years of dance training exhibited a significantly reduced VOR gain during the SHIMP at 60 ms.

Conclusions: Overall, the results suggest that dance training not only improves VOR suppression, but also modulates VOR suppression abilities by increasing the efficiency of the vestibular efferent system.

OP25-5 - Investigating Mechanisms of Overt and Covert Saccades Using a Computer Model of Head Impulse Test

7. Clinical Testing for Vestibular Function

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Purpose: Overt and covert saccades during the head impulse test are cardinal signs of a peripheral vestibular lesion. The difference between the eye and target positions after the impulse is assumed to be the mechanism that triggers overt saccades. Yet very little is known about the possible mechanisms underlying covert saccades. The purpose of this study is to investigate the mechanisms for generating overt and covert saccades.

Methods: A fully-customizable model of the head impulse test was developed. The vestibulo-ocular reflex parameters include the cupula and velocity storage mechanism time constants as well as nonlinearities of the vestibular nerve. Two different mechanisms, one based on head and eye position differences and one based on velocity differences, were implemented for generating catch-up saccades. Either or both mechanisms could be activated or deactivated selectively.

Results: Simulation results match findings in normal subjects for both standard vHIT and SHIMP protocols. Simulation results also match findings in patients with varying degree of unilateral and bilateral vestibular loss. Simulations included various clinical conditions such as different levels of static compensation and cerebellar clamping. Activation and deactivation of different saccade mechanisms enabled selective initiation of overt or covert saccades.

Conclusions: A mechanism that triggers covert saccades based on the difference between head and eye velocities matches pattern of findings in normal subjects and patients with different levels of unilateral and bilateral loss. Knowledge of mechanisms underlying overt and covert saccades may assist in developing more effective therapy protocols as patients with covert saccades demonstrate improved functional impairment.

OP25-6 - Bedside examinations distinguish central from peripheral causes of vertigo

7. Clinical Testing for Vestibular Function

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Purpose: To explore the accuracy of bedside examinations used to distinguish central from peripheral causes of vertigo and to determine the best strategy for vertigo management in otorhinolaryngology practice.

Methods: We recruited 1,335 patients presenting with vertigo to our otorhinolaryngology department. All patients underwent bedside evaluation, including history-taking, eye movement examination, otological and neurological examinations. Based on these examinations, we decided whether to perform further evaluation or institute treatment. Patients with BPPV underwent canalith reposition maneuvers (CRPs) and were instructed to engage in self-treatment at home.

Results: Bedside examinations yielded clear diagnoses for 53.03% of patients (708/1,335). In detail, two older patients (0.15%) had cerebral infarctions, in which bilateral sudden sensorineural hearing loss presented before the infarctions. A total of 579 patients (43.37%) presented with BPPV, of whom 91 (6.82%) had atypical BPPV without nystagmus, but in whom vertigo was relieved after the first repositioning maneuver. Of the typical BPPV cases, 85.86% of patients had posterior semicircular canal BPPV and 67 (13.73%) horizontal semicircular

canal BPPV. The initial CRP was effective in 86.1% of patients, and 96.5% of patients reported relief after one further week of self-treatment. We used the bedside head-impulse test to evaluate vestibular function; this measure was associated with a sensitivity of 63.6% (95%CI=41.0%~86.3%) and a specificity of 95.5% (95%CI =91.4%~99.7%).

Conclusions: The bedside examinations provided a valuable contributor to differentiate central from peripheral vertigo. The combination of history-taking with bedside examination prior to further evaluation or treatment is the best strategy for vertigo management in the otorhinolaryngology department.

OP25-7 - Oral glycerol reduces the enhanced eye velocity in vHIT testing of patients with probable hydrops

14. Meniere's Disease and Related Disorders

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Purpose: The reduction in auditory thresholds after oral intake of glycerol is a subjective test for identifying hydrops. Our modelling has shown that hydrops can cause enhanced eye velocity in head impulse testing (Grieser et al., 2014). Here we report the effect of glycerol dehydration on objective measures of semicircular canal function using the video head impulse test (vHIT) (MacDougall et al., 2009). On vHIT some patients with probable hydrops show an enhanced eye velocity response, so that eye velocity exceeds head velocity and we tested if glycerol reduced that enhanced eye velocity in such patients.

Methods: All the subjects were given orally 86 % glycerol in 1.5 ml/kg of body weight, dissolved 1:1 in physiological saline. Horizontal vHIT testing was performed at the initial examination before glycerol intake (time 0), then at intervals of 1 (time 1), 2 (time 2) and 3 (time 3) hours after the oral glycerol intake. The testing was conducted with the patient's approval as part of the standard clinical assessment of their vestibular function. We used a new measure

of the enhanced eye velocity – peak VOR gain – defined as the peak eye velocity/ head velocity measured at peak eye velocity

Results: We found that glycerol caused a temporary but significant reduction in the enhanced eye velocity. Control testing over the same time intervals with water instead of glycerol had no effect on the eye velocity response.

Conclusions: This reduction appears to be an objective indicator of endolymphatic hydrops.

OP26: Epidemiology of vestibular disorders

OP26-1 - A retrospective cross-sectional study in an emergency department of a tertiary referral centre

9. Epidemiology

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Purpose: Vestibular symptoms are common complaints in the general population with prevalences of up to 60%. In emergency departments (ED) dizziness has been reported in 3.3% of all patients. We assessed frequency and aetiology of vestibular symptoms in a large interdisciplinary tertiary ED.

Methods: We screened all 23.608 patients admitted to the ED in 2013 and included patients with vestibular symptoms either as a chief or accompanying complaint. Clinical, radiological and laboratory findings as well as presumed aetiologies from ED medical records were manually extracted. Symp-

toms were classified according to the Classification of Vestibular Disorders of the Bárány Society.

Results: 2473 patients (11%; mean age/SD 51.9/20.2 years; 50.7% females) complained about any vestibular symptom with 64.5% as a chief complaint. Vestibular symptoms were classified as vertigo (44.8%), dizziness (55%), postural symptoms (15.8%) and unknown vestibular symptoms (0.6%). Most frequent aetiologies were strokes (12.4%), orthostatic (12.1%), infections (10.3%), cardiovascular (9.8%), other central vestibular disorders (9.3%), peripheral vestibular disorders (8.8%). All other causes including trauma and somatoform dizziness were <5% each. In 13.8%, no diagnosis was assigned. 23% of underlying causes were potentially life threatening.

Conclusions: Reported one-year prevalence of vestibular symptoms was 11% in a tertiary ED setting, which is higher than previously described. Every 4th patient with vestibular symptoms suffers from a stroke and/or any other potentially life threatening condition. Every 7th patient was sent home with a diagnosis of dizziness “not further specified”. Improvement of diagnostic accuracy should be pursued to reduce the risk of missing severe pathologies.

OP26-2 - Health Burden of Balance Problems and Falling: 2016 United States Health Survey of 33,028 Adults

9. Epidemiology

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Purpose: This study examined falling risk last 1 (and 5) years due to self-reported balance and dizziness problems (BDP) in a nationally-representative health survey. The objective was to estimate prevalence, risk factors, and sequelae.

Methods: Data from the 2016 National Health Interview Survey (NHIS) Balance and Dizziness Supplement were analyzed. NHIS was administered to 33,028 randomly-sampled adults aged 18+ years. BDP was classified based on questions about dizziness and unsteadiness. Follow-up questions about specific symptoms during the past 12 months included vertigo and blurred vision with head movement. Subjects were asked which symptoms were most bothersome. Outcome variables were falling, injuries, and resulting days of interrupted activities. Prevalence estimates and adjusted risk ratios (RR) were calculated using post-stratification national weights with 95% confidence intervals (CIs).

Results: Lifetime BDP prevalence for adults was 23.9% (58.5 million); during the past 12 months, BDP prevalence was 15.1% (37.1 million). The 12-month BDP prevalence was strongly associated with age, rising from 11.7% to 25.8% for adults aged 18-44 to 85+ years, respectively. Nearly 12 million adults (4.8%) could not perform their usual activities, more than 7 million (2.9%) were injured owing to falls, and 5.6 million (2.3%) missed work or school days because of BDP in the past 12 months. Approximately half, 49.6% (95%CI: 45.6%-53.6%), with BDP had seen a healthcare provider. More than 50% had fallen in the last 5 years while experiencing BDP.

Conclusions: BDP prevalence is substantial for young as well as older U.S. adults. Sequelae include increase risk of falls, injuries, and healthcare burden.

OP26-3 - Prevalence of Dizziness and Balance Problems and Significant Head Injuries in United States Children

9. Epidemiology

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Purpose: To study balance and dizziness problems (BDP) in children and examine the potential association with significant head injuries or concussions.

Methods: A multistage, nationally representative sample of children (n=9,247; aged 3-17 years) was selected for the 2016 National Health Interview Survey. Parents reported if during the past 12 months their child had BDP (i.e., vertigo/motion sensation, light-headedness/fainting, clumsiness/poor coordination, poor balance/unsteadiness when standing-up or walking, frequent falls, or other BDP) and if their

child ever had significant head injuries or concussions. Logistic regression was used to examine associations after adjusting for socio-demographic variables and accounting for the complex survey design.

Results: BDP prevalence was 5.5% (3.4 million U.S. children); females, 5.6%, males, 5.4%. Prevalence increased with age from 3.4% (3-5 years) to 9.1% (15-17 years), $p < 0.001$. Significant head injury/concussion prevalence was 7.0% (4.3 million); females, 5.8%, males, 8.1%, $p < 0.001$. Head injuries of non-Hispanic (NH) white (8.7%) were increased compared to Hispanic (5.9%) and NH black (4.5%) children, $p < 0.001$. Head injuries increased with age, from 4.0% (3-5 years) to 11.8% (15-17 years), $p < 0.001$. Among children with head injury, 13.7% had BDP, while among children with BDP, 17.5% had head injury. During the past year, 39.4% with BDP were seen by healthcare providers and 33.8% received treatment. If BDP was a moderate/big/very big problem, 79.3% had seen healthcare providers and 62% received treatment. Head injuries were associated with BDP, adjusted odds ratio=2.7 (95% confidence interval: 2.0-3.7).

Conclusions: BDP (>5% of children) is common and significant head injuries and concussions in childhood are associated with BDP.

OP26-4 - Sensory impairments and wrist fractures. A case-control study.

9. Epidemiology

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Purpose: To investigate vestibular function, foot sensation, postural control and functional abilities and to evaluate whether these variables are associated with fall-related wrist fracture.

Methods: A case control study was conducted with 98 subjects, age range 50-75 years, who had sustained a fall-related wrist fracture. Forty-eight sex-, age- and physical activity-matched individuals, with no previous history of wrist fracture, served as controls. Measurements included: the head-shake test (HST), a tuning fork, the biothesiometer, Semmes-Weinstein monofilaments (MF), the Sensory Organization Test (SOT), the Five-Times-Sit-to-Stand Test (FTSTS), the 10-m-walk test (10MWT), the Activities-specific Balance Confidence (ABC) scale and the Dizziness Handicap Inventory (DHI). Logistic regression models were used to determine associations of variables with a fall-related wrist fracture.

Results: Vestibular asymmetry was apparent in 82% of wrist fracture subjects and 63% of controls ($p = 0.012$). Plantar pressure sensation ($p < 0.001$), SOT composite scores ($p < 0.001$), 10MWT ($p < 0.001$), FTSTS ($p < 0.001$), ABC ($p < 0.001$) and DHI ($p < 0.005$) were significantly poorer among cases than controls. A positive HST (odds ratio (OR) 5.424; $p = 0.008$) and monofilament sensation (OR 3.886; $p = 0.014$) showed the strongest associations with having a fall-related wrist fracture.

Conclusions: Asymmetric vestibular function and reduced plantar pressure sensation appear to be associated with fall related wrist fractures among the ageing population. Vestibular function and plantar sensation are potential targets for future interventions.

OP26-5 - Stroke Risk after Diagnosis of Benign Vertigo is Lower in Specialty Care than General Practice

9. Epidemiology

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Purpose: To compare stroke risk among patients discharged with “benign vertigo” across medical specialties.

Methods: Patients with first incident vertigo (ICD-9-CM 386.x, 780.4) in outpatient departments from the National Health Insurance Research Database of Taiwan (2002-2009). We excluded patients with emergency department referral or hospitalization at the index visit and index diagnoses that were stroke-related or “vertigo of central origin”. We analyzed short- (1-month) and long-term (~3-year) stroke incidence. We compared stroke risk across general practice and specialty disciplines using a Cox proportional hazards model and incidence rate ratios (1-month rate divided by average 12-36-month rate).

Results: We studied 178,981 patients. One-month/3-year stroke incidence was 0.35%/1.81% in internal medicine, 0.22%/1.61% in family medicine, 0.20%/1.29% in neurology, 0.09%/0.86% in otolaryngology, and 0.07%/0.73% in other specialties. After adjusting for demographic and cardiovascular risk factors, long-term stroke risk in specialty practice (neurology & otolaryngology) was lower than in general practice (internal & family medicine) (aHR=0.78). Stroke incidence in the first month was significantly higher than in later months across all disciplines with incidence rate ratios (misdiagnosis rate) ranging from 4.2 (otolaryngology/other specialties) to 8.8 (internal medicine).

Conclusions: Across disciplines, risk of stroke following a diagnosis of “benign vertigo” is highest in the first month, suggesting misdiagnosis in all ambulatory settings. Both short- and long-term risk vary by discipline of the diagnosing physician, suggesting there are both diagnostic accuracy and patient population differences. Stroke misdiagnosis risk was highest in internal medicine and lowest in otolaryngology. Future research should seek to address root causes.

OP27: Ménière’s disease (II)

OP27-1 - Symptom severity and fluctuations in 192 patients with Hydropic Ear Disease

14. Meniere’s Disease and Related Disorders

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Purpose: Changes in the relative distributions of endolymphatic fluid volumes within the inner ear are assumed to cause paroxysmal symptoms in Hydropic Ear Disease (Ménière’s Disease). Here, we investigate for the first time the relationship between the severity of endolymphatic hydrops (ELH) and the severity and fluctuations of audiovestibular symptoms in a large population of patients with Hydropic Ear Disease.

Methods: 192 patients with clinically definite MD according to the AAOHNS criteria who underwent locally enhanced inner ear MRI (LEIM) were included. Caloric canal paresis, pure tone audiometry and standardized symptom diaries recording vertigo attacks, hearing loss, tinnitus and aural fullness were evaluated. The severity of endolymphatic hydrops (ELH) was graded on a nominal scale (0-3). Spearman rank correlations were calculated.

Results: The disease duration correlated highly significantly with severity of cochlear and vestibular ELH ($p < 0.01$). Moreover, the ELH severity is highly significantly correlated with audiometric hearing loss ($p < 0.01$). The severity of ELH did however not correlate with audiovestibular symptom severity and fluctuations in the short or middle term. Furthermore, the vertigo attack frequency did not decrease with disease duration.

Conclusions: The correlation between hearing loss and ELH severity was confirmed in this large population of patients with Hydropic Ear Disease. The assumed rapid or short-term dynamics of endolymphatic fluid volume changes in Hydropic Ear Disease, however, may be too small to be detected by

clinical inner ear imaging, despite being present in animal models. Furthermore, these data are challenging the concept of “burning out” in Hydropic Ear Disease.

OP27-2 - Outcomes after Surgical Treatment of Meniere’s Disease: Experience from Shanghai Xinhua Hospital

14. Meniere’s Disease and Related Disorders

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Purpose: To report functional outcomes after different surgical treatments of Ménière’s disease in ENT Department of Shanghai Xinhua Hospital from October 2003 to January 2016.

Methods: Patients with Ménière’s disease were categorized into groups based on hearing staging. Individualized surgical procedure was provided including endolymphatic sac shunt or decompression(ESS), vestibular neurectomy(VN), labyrinthectomy(LC), semicircular canals plugging(SCP) and endolymphatic duct blockage(EDB). The functional outcomes after different surgeries in terms of vertigo control, hearing level and quality of life (QOL score of Meniere’s Disease Outcomes Questionnaire) were evaluated.

Results: 374 patients were diagnosed as definite Ménière’s disease according to the AAO-HNS criteria. Four patients had bilateral Ménière’s disease and four received surgery on the same side for twice. Thus, a total of 382 surgeries were carried out such as ESS(n=111), VN(n=206), LC(n=20), SCP(n=23) and EDB(n=22). Vertigo control rate of Grade A and B was 78.4% for patients in ESS, 100% in VN, 100% in LC, 85.7% in SCP and 86.4% in EDB. Hearing was preserved in ESS, VN and EDB with no significant difference between the preoperative and the postoperative levels ($P>0.05$). There is a significant hearing loss after surgery in SCP ($P<0.05$). Postoperatively, the QOL score improved significantly in each group ($P<0.001$).

Conclusions: The functional outcomes after different surgical treatments are generally satisfying. VN is always the last line of defense for eradicate vertigo with residual hearing. Besides, as for VN, compared with retrosigmoid sinus approach, retrolabyrinthine approach could provide a shorter distance between posterior fossa dura and vestibulocochlear nerve, enough exposure and consume less time.

OP27-3 - Prediction of unilateral Meniere’s disease attack using inner ear test battery

14. Meniere’s Disease and Related Disorders

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Purpose: The pure tone audiometry, caloric test, VEMP tests via different stimulation modes were recorded in patients with unilateral meniere’s disease. Furthermore, clinical symptoms were collected via chart review. The results were statistically analyzed to evaluate retrolabyrinthine involvement and to predict vertigo attack.

Methods: We retrospectively enrolled 50 patients with unilateral Meniere’s disease. In addition to clinical symptoms, all results of pure tone audiometry, caloric test, ACS-cVEMPs, GVS-cVEMPs, BCV-oVEMPs, and GVS-oVEMPs were collected via chart review. The frequency score is defined as 0: no attack; 1: one to four times per year; 2: four to twelve times per year; 3: more than twelve times per years. The multiple linear regression method was used to examine which independent variables have a statistically significant influence on vertigo attacks.

Results: In affected ears, the abnormal rate of caloric test, acoustic cVEMPs, galvanic cVEMPs, vibratory oVEMPs and galvanic oVEMPs was 80%, 52%, 30%, 28% and 18%, respectively. According to the regression model, the abnormal GVS-cVEMP response and abnormal GVS-oVEMP response had significant negatively correlations with the frequency of disease attacks. A predictive model for disease attack frequency using significant parameters and their regression coefficients in combination was proposed as: predicted attack frequency score = $2.679 + (-0.829)*(GVS-cVEMP) + (-0.922)*(GVS-oVMEP)$.

Conclusions: The disease attack frequency is significantly negatively correlated to GVS-cVEMPs and GVS-oVEMPs, in contrast to caloric test, acoustic cVEMPs and vibratory oVEMPs. Using the model proposed by these significant parameters, clinicians can easily predict unilateral Meniere's disease attack frequency by galvanic VEMPs.

OP27-4 - Shift of the frequency tuning on Ocular Vestibular-Evoked Myogenic Potentials in Meniere's disease

14. Meniere's Disease and Related Disorders

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Purpose: To study the change of frequency tuning of Ocular Vestibular-Evoked Myogenic Potentials (oVEMP) in patients with unilateral Meniere's disease, by air-conducted tone bursts stimulus in various frequencies.

Methods: 32 cases of patients with unilateral Meniere's were tested for oVEMP in 500Hz and 1000Hz air-conducted tone bursts respectively, and 20 healthy subjects (40 ears) matched for age and sex were used as healthy control. The amplitudes of the N1-P1 wave and the frequency amplitude ratios of 500/1000Hz in affected ears, unaffected ears and normal ears were compared; and receiver operating characteristic curve was analyzed for frequency amplitude ratios of 500/1000Hz.

Results: Amplitudes of N1-P1 waveforms in 500Hz air-conducted tone bursts in affected ears with unilateral Meniere's patients are smaller than in the normal control and contralateral ears. There was significant difference between affected ears and healthy control ears ($t=3.942$, $p=0.000$). There was no significant difference ($t=-0.087$, $p=0.899$, $t=-0.879$, $p=0.175$) in amplitude between affected, contralateral and normal ears in 1000Hz tone bursts. Frequency amplitude ratios of 500/1000Hz in affected ears were significantly under the contralateral and control ears ($t=-0.449$, $p=0.017$; $t=-0.98$, $p=0.000$). The frequency amplitude ratio critical value of frequency tuning is 1.19, the rate of frequency tuning in the affected ear was 55%, and the frequency change was 19% in the contralateral ears,

significantly higher than normal control ears ($5\% \chi^2=22.423$, $p=0.000$).

Conclusions: Compared with healthy people, frequency tuning oVEMP with Meniere's disease was changed and shift from low frequency region to high frequency region. Frequency amplitude ratio is useful for the diagnosis of Meniere's disease.

OP27-5 - Simultaneous triple semicircular canal plugging and cochlear implantation in Meniere's disease

14. Meniere's Disease and Related Disorders

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Purpose: To evaluate the feasibility of combining simultaneous triple semicircular canal plugging (TSCP) and cochlear implantation (CI) to treat vertigo and hearing loss in advanced MD patients.

Methods: Data from 10 patients, who were referred to our hospital and diagnosed with unilateral MD from Jan. 2015 to Jan. 2016, were retrospectively analyzed in this work. All patients had bilateral severe sensorineural hearing loss. One side hearing loss was due to MD and another side was due to other reasons. Ten patients underwent simultaneous TSCP and CI. Postoperative follow-up time was all more than one year. Vertigo control and auditory function were measured. Pure tone audiometry, speech perception scores, caloric test, vestibular evoked myogenic potential (VEMP) were performed for evaluation of audiological and vestibular function.

Results: The total control rate of vertigo was 100.0% in one-year follow-up, with complete control rate of 90.0% and substantial control rate of 10.0%. Improved in hearing threshold and speech perception scores were observed in all study participants. Postoperative average aided hearing threshold was 30.4 dB HL, the average monosyllabic word score was 54.2% and speech perception scores of

sentences tested in quiet was 63.4%. Tinnitus improved in 7 cases (70.0%). One year after treatment, loss of semicircular canal function by caloric test was found in the operation side of all patients and no change in cVEMP or oVEMP test was noted.

Conclusions: A combined approach of TSCP and CI which could control vertigo effectively and improve hearing loss and tinnitus represents an effective therapy for some advanced MD patients.

OP27-6 - Slow-phase velocity of thermally-induced nystagmus is early reduced in Meniere's Disease

14. Meniere's Disease and Related Disorders

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Purpose: to assess whether Meniere's Disease (MD) determines any alteration on caloric vestibular test parameters according with an increased severity of cochlear involvement.

Methods: the study retrospectively analyzed the caloric vestibular test results of 72 patients affected by unilateral "definite MD" according with the Barany Society Diagnostic Criteria. The statistical analysis put in relationship both the frequency and the slow phase velocity of the thermally-induced nystagmus with an increasing severity of the cochlear involvement (American Academy of Otolaryngology-Head & Neck Surgery staging system).

Results: there were 7 patients in stage 1 (9.72%), 27 in stage 2 (37.50%), 35 in stage 3 (48.61%), and 3 in stage 4 (4.16%). No patients had undergone any ablative treatment. The frequency of the thermally-induced nystagmus showed greater values in more severe stages ($p = .033$). Conversely, the slow-phase velocity did not show significant differences among the stages and showed abnormal values even in lower stages of the disease (71% in stage 1, 81% in stage 2, 91% in stage 3, and 100% in stage 4), exclusively on the affected side.

Conclusions: abnormal values of slow-phase velocity on caloric vestibular test can be found in most of patients affected by Meniere's Disease, regardless of

the cochlear involvement. A dissociation between frequency and slow-phase velocity values characterizes the early stages of Meniere's Disease.

OP28: BPPV (II)

OP28-1 - Isolated positional vertigo of vascular origin

6. Central Vestibular Disorders

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Purpose: Review 2 cases of isolated positional vertigo of vascular origin

Methods: Clinical and imaging.

Results: (1) A male 62 without vascular risk factors, tying his kayak to the roof of his car experienced brief isolated vertigo. That night he awoke with vertigo and vomiting. In the emergency room no abnormalities were found; the diagnosis was BPV. Two days later he had more vertigo, now spontaneous, with vomiting and headache. He now had total horizontal ophthalmoplegia. CT angiogram showed total occlusion of the left intracranial vertebral artery. He then developed hemiplegia and apnea. MRI showed bilateral medial medullary and dorsal pontine infarcts. After a month in ICU and 3 months in rehabilitation he went home. (2) A male 61 with pulmonary fibrosis developed vertigo while drinking beer from a can. In our emergency room he had, sitting upright, right-beating spontaneous nystagmus. Three hours later the vestibular examination was normal. CT angiogram showed stenoses in both distal vertebral arteries and the proximal basilar. LDL cholesterol was high. With atorvastatin + clopidogrel + aspirin and has had no further cerebrovascular symptoms after 18 months.

Conclusions: Isolated vascular vertigo, positional or spontaneous is rare but dangerous. Patients are rarely seen by a neuro-otologist during the attack so the diagnosis is based on history. They are difficult to distinguish from common benign aural causes

isolated vertigo attacks. Once the attacks start there is a stroke is likely within a week; the patient who has had many attacks and is only seen weeks later is unlikely to have this problem

OP28-2 - Positional Downbeating Nystagmus due to BPPV variants: our experience

4. Benign Paroxysmal Position Vertigo

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Purpose: Patients suffering from positional vertigo often show positional downbeating nystagmus. This latter is usually thought to be due to BPPV of the Anterior Canal (AC-BPPV), when any central cause has been excluded.

Recently, the existence of AC-BPPV has been questioned and more specifically by the possible existence of apogeotropic variant of Posterior Canal BPPV (aPC-BPPV).

The explanation to justify the presence of downbeating nystagmus in BPPV of the posterior canal is that the otoconia would be in the non-ampullary distal arm of the posterior canal, near the common crus. In such a condition, the Dix-Hallpike test causes the otoconia to move towards the dome, thus producing an inhibitory downward vertical nystagmus with a torsional component.

Methods: We included 20 patients observed in 4 balance centers between January 2016 and April 2017, presenting symptoms and vestibular signs consistent with AC-BPPV and that did not resolve with maneuvers specific for anterior canal.

Results: These patients, subsequently, were diagnosed as having aPC-BPPV, taking as a criterion the lack of response to the replacement maneuvers for AC-BPPV and the resolution of symptoms/signs with maneuvers for PC-BPPV (Semont, Epley).

Conclusions: While it cannot be stated that all BPPV with AC compromise characteristics are an apogeotropic variant of PC-BPPV, the latter being more frequent than the previous one, it is expected that many positional down beating nystagmus are due to apogeotropic variant of the posterior semicircular canal. This last variant should be kept in mind when the patients did not respond to the typical replacement maneuvers for the AC-BPPV.

OP28-3 - Probable benign paroxysmal positional vertigo, spontaneously resolved: incidence and natural course.

4. Benign Paroxysmal Position Vertigo

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Purpose: Probable benign paroxysmal positional vertigo, spontaneously resolved (pBPPVsr) could be a controversial diagnosis since positional testing is negative. However, it is frequent in the population and there are few studies in this regard. Objectives: To calculate the incidence of pBPPVsr in our medical practice, compare its characteristics with BPPV not spontaneously resolved and describe the role of spontaneous resolution in BPPV natural course.

Methods: Prospective multicentric descriptive over BPPV consultant patients during one-year period. The incidence of pBPPVsr over the total of patients with BPPV was calculated. Prevalences of several variables related with the development of BPPV

were compared between both groups. The timing of spontaneous resolution was estimated through Kaplan Meier curves.

Results: 457 patients met the inclusion criteria. Incidence of pBPPVsr was 33.5%. Incidence was statistically significant higher in men, normal bone mass and not-taking-sulpiride patients. Kaplan-Meier curve showed a hyperbolic shape with values of 18% of spontaneous resolution after the first month and 51% after the first year. No relevant or significant increase of this percentage happened after this moment. Curves of male, patients under 50 and patients with normal blood pressure decreased significantly faster.

Conclusions: Spontaneous resolution of BPPV happens in the half of the patient with BPPV during the first year after the onset of the disease, being rare from this point. This phenomenon seems more common in male and could be hindered by sulpiride intake, osteoporosis, advanced age and high blood pressure.

OP28-4 - Significance of repeated positional maneuver in the diagnosis of benign positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: Although the Dix-Hallpike and supine head roll test are considered the gold standard tests for benign paroxysmal positional vertigo (BPPV) diagnosis, accuracy rate of the diagnostic tests is not 100 percent. Aim of this study is to identify diagnostic value of repeated positional maneuver in probable BPPV (Diagnostic criterion of BPPV presented by Barany Society).

Methods: This study was prospectively performed from July 2013 to May 2017. The repeated positional test was performed in patients suspected of having BPPV in their medical history but with negative initial positional test. Repeated test was performed on the same day of the initial diagnosis in Group 1 and 3 days after in Group 2. This grouping was designed to determine whether the same-day repeated posi-

tional test is more effective in increasing diagnostic rate of BPPV.

Results: 82 patients were enrolled (42 in Group 1, 40 in Group 2) and 78 were analyzed. 28 (35.9%) patients were identified as BPPV by repeated positional test. Of these, 19 patients (67.9%) with posterior canal, 7 patients (25.0%) (4 patients; canalolithiasis and 3 patients; cupulolithiasis) with horizontal canal and 2 patients (7.1%) were anterior canal BPPV. The diagnostic rate of BPPV in Group 1 (42.9%) was significantly higher than in Group 2 (27.8%).

Conclusions: The repeated positional maneuver may improve the diagnostic rate of BPPV in patients suspected of having BPPV but with negative initial positional test. In addition, performing repeated positional maneuvers on the same day as the initial diagnosis is recommended.

OP28-5 - Supplementation of Vitamin D and Calcium May Prevent Recurrences of BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: Since vitamin D deficiency and osteoporosis are more common in patients with benign paroxysmal positional vertigo (BPPV) than in normal controls, supplementation of vitamin D and calcium may prevent further attacks of BPPV.

Methods: We performed a multicenter, randomized controlled trial in 8 teaching hospitals in Korea between December, 2013 and May, 2017. After treatment of BPPV with canalith repositioning maneuvers, patients were randomly assigned to either the intervention (n=518) or the observation (n=532) group. The annual recurrence rate was the primary outcome. The patients in the intervention group were instructed to take 800 IU of vitamin D and 1000 mg of calcium as calcium carbonate per day for one year when the serum vitamin D level was < 20 ng/ml. The patients in the observation group were followed up without the evaluation and medication.

Results: The intervention group showed a significant reduction in the annual recurrence rate [0.83 (95% CI: 0.74-0.92) vs. 1.10 (95% CI: 1.00-1.99) with an incident rate ratio of 0.76 (95% CI: 0.66-0.87, $p < 0.001$) and an absolute rate ratio of -0.27 (-0.40 to -0.14)]. The intervention group showed lower proportion of patients with recurrences than the observation group (37.8% vs. 46.7%, $p = 0.005$).

Conclusions: Patients with frequent attacks of BPPV and subnormal serum vitamin D may have a benefit from supplementation of vitamin D and calcium.

OP28-6 - Upright Head Pitch Test to diagnose Posterior Canal Benign Paroxysmal Positional Vertigo.

4. Benign Paroxysmal Position Vertigo

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Purpose: The aim of this work is to evaluate the utility of the Head-Pitch Test in upright position (uHPT), as first step of the bedside examination of patients with history suggestive of Posterior Canal (PC) BPPV

Methods: This study was conducted from January 2015 to January 2017. We evaluated 688 patients (402 women and 286 men, average age 51.8 years) observed for acute positional vertigo and with history suggestive of PC-BPPV. The patients have been divided into 4 groups according to the delay between positional vertigo onset and our clinical observation: short delay (12-24 hours), medium delay (24-72 hours), medium-long delay (4-7 days) and long delay (over 1 week). The uHPT is performed by changing the head bending angle in the pitch plane while sitting. uHPT is considered positive when keeping extended head, it elicits a nystagmus with a double component, torsional and vertical up-beating, both suggesting a PC-BPPV diagnosis. Such a diagnosis is subsequently confirmed bringing the patient down to the Dix-Hallpike position, on the same side the torsional nystagmus was beating to.

Results: The uHPT was positive in 64.2% (442 patients) of the total sample, with a greater frequency as shorter was the delay: first group 42.3% (187 patients), second group 38.9% (172 patients), third group 13.6% (60 patients), fourth group 5.2% (23 patients).

Conclusions: The uHPT allows to early diagnose PC-BPPV in many patients thus enabling us to avoid many diagnostic manoeuvres and stimuli to the patient according to a "Minimum Stimulus approaching Strategy".

OP28-7 - Vestibular evoked myogenic potentials in posterior canal benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: to evaluate the otolith function using vestibular evoked myogenic potentials (VEMP) in patients with idiopathic posterior benign paroxysmal positional vertigo (pBPPV).

Methods: Cervical (cVEMP) and ocular VEMP (oVEMP) in 34 patients 45 to 65 years with idiopathic pBPPV were measured before and 7 days after liberatory maneuver. Repeated Dix-Hallpike test 7 days after liberatory maneuver was negative in 27 patients and positive in 7 patients.

Results: There was no statistically significant difference in the amplitude of cVEMP between healthy and affected ear, either before or after repositioning treatment. Measurement of oVEMP showed decreased amplitude response on the affected side. The average values of the pIn1 on the healthy side were 12.84 ± 1.09 and those on the affected side 4.62 ± 0.69 ($p < 0.05$). The successful repositioning treatment resulted in a significant increase of the oVEMP amplitude on the affected side ($p < 0.05$). In the patients presenting with the persistent symptoms of pBPPV, the repositioning maneuvers didn't cause significant increase in the amplitude of oVEMP on the affected side ($p < 0.05$).

Conclusions: The study reveals that in pBPPV utriculus is impaired, while the function of succulus stays preserved, as abnormal oVEMP on the affected side, and normal cVEMP on both sides were registered. In case of successful pBPPV treatment with liberatory maneuver the amplitude of oVEMP on

affected side increases, asymmetry between both sides decreases, indicating the utriculus' otolith function repair.

OP29: Basic vestibular science/ Animal models (II)

OP29-1 - Effects of Selective Electrical Vestibular Stimulation on the Rat Hippocampus

18. Spatial Orientation

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Purpose: Vestibular dysfunction leads to impairments in learning and memory as well as a disruption of head direction, place and grid cells. Therefore, it is clear that vestibular input is necessary for the normal function of the hippocampus. Less clear is how vestibular sensory information is used by the hippocampus. In these studies we attempted to selectively electrically stimulate the horizontal, anterior and posterior semi-circular canals as well as the utricle and saccule and record field potentials in the hippocampus.

Methods: Rats ($n = 53$) were anesthetized and a 16 electrode microarray was implanted into the bilateral hippocampi. Field potentials were recorded while electrically stimulating specific receptors within the vestibular labyrinth using bipolar electrodes and currents ranging from 50 to 400 mA. c-Fos expression was also analysed following electrical stimulation of the vestibular system.

Results: c-Fos expression was also analysed following electrical stimulation of the vestibular system. Field potentials were evoked throughout the hippocampus by stimulation of the different receptors, with significant differences in amplitude between the anterior, horizontal and posterior canals as well as the utricle and saccule, depending on the current used. Responses were obtained bilaterally from unilateral stimulation and the latencies were usually at least 20 ms; amplitudes were usually greater in dorsal regions compared to ventral regions. c-Fos expression was evoked by stimulation of the vestibular system, especially in the dorsal hippocampus. Double immunolabelling suggested that the neurons involved were adult neurons.

Conclusions: These results demonstrate that vestibular input to the hippocampus is complex and that all sensory receptors are represented.

OP29-2 - Biomechanical Origins of Tullio Phenomena

22. Vestibular and Inner Ear Physiology

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Purpose: Nearly a century ago Pietro Tullio reported that generation of a fistula in the bony labyrinth can lead to pathological vestibular responses to audio frequency sounds. Lloyd Minor and colleagues demonstrated this condition occurs in patients with a dehiscence of the bone overlying the superior semicircular canal. Recordings from semicircular canal afferent neurons in animal models demonstrate phase-locked action potentials that synchronize to audio frequency stimuli up to several kHz, as well as slowly developing sustained changes in action potential discharge rate that build up during the audio

frequency sound. The present study examined origins of these responses.

Methods: Neural responses and endolymph flow were measured in response to audio frequency stimuli using an animal model. Endolymph displacement was measured by introducing fluorescent micro-particles into the endolymph and using particle imaging velocimetry (PIV). A biomechanical model was developed to further examine origins of fluid pumping.

Results: Afferent neurons with irregularly spaced inter-spike intervals (ISIs) synchronized firing with the auditory frequency sound, while afferents with regularly spaced ISIs responded with sustained increases or decreases in discharge rate. PIV revealed continuous endolymph pumping, ampullofugal or ampullopetal dependent on stimulus frequency. Pumping was consistent with predictions of a non-linear mathematical model.

Conclusions: Results demonstrate that synchronization of action potentials occurs due to vibration of hair bundles at the audio frequency, and that the slowly developing change in discharge rate occurs due to endolymph pumping in the membranous labyrinth arising from nonlinear interaction between mechanical waves traveling along the membranous duct and the endolymph inside the canal.

OP29-3 - How does 500Hz sound or vibration cause VEMPs

22. Vestibular and Inner Ear Physiology

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Purpose: To understand how the otolithic sensors, usually regarded as low frequency accelerometers, can respond to stimulus frequencies as high as 3000Hz. Premise; otolithic receptors are activated by deflection of the receptor cilia re the cell body.

Methods: Extracellular recordings from single primary afferent neurons from the utricular and saccular macula in response to air conducted sound and bone conducted vibration in anaesthetized guinea pigs. These data were combined with mathematical modelling of the neural results. Laser Doppler Vibrometry measures of the movement of the utricular macula during sound and vibration stimulation with simultaneous utricular microphonic recording from adjacent macula regions.

Results: Vibrometry shows that during high frequency stimulation the utricular macula moves up and down even to 3000Hz and the adjacent utricular microphonic shows that utricular receptors are activated at these frequencies. Irregular primary afferent neurons originate predominantly from receptors at the striola where the receptor cilia are short and stiff and have poor attachment to the otoconial membrane.

Conclusions: Modelling of the neural results indicates otoliths have two modes of operation: at maintained tilts and low frequencies, the otoliths function as accelerometers but at high frequencies they function as seismometers. We suggest that could happen if in the first case the cilia are deflected re the cell-body, in the second case the cell body is deflected re the cilia. Other modelling shows the stiff striolar cilia respond to the small displacements predicted by the simulation and Vibrometer measurement, while extrastriolar hair bundles respond to larger displacements.

OP29-4 - Development of a non-human primate model for the cervical vestibular evoked myogenic potential

2. Animal Models and Molecular Approach

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Purpose: cVEMPs provide a simple and cost-effective means to assess the patency of vestibulospinal reflexes. Research in gerbils and cats have revealed the mechanisms of excitation in the vestibular apparatus and the processing of such information in the vestibular nuclei. However, there are major differences in the anatomy of the head-neck system of gerbils, cats, and humans. We are developing a non-human primate (NHP) model for cVEMPs, as a more suitable model for human cephalomotor control.

Methods: cVEMPs were recorded in awake, head-restrained NHPs in response to tone bursts (4 ms of a 500 Hz tone delivered at 7.4 Hz for between 30-150s; variable intensity ranging from 95 to 130 dB) in 3 animals, implanted with either acute or chronically-indwelling EMG electrodes in SCM, splenius capitis (SPL), and the dorsal suboccipital muscles obliquus capitis inferior (OCI) and rectus capitis posterior major (RCP maj). Background neck EMG was elicited by exploiting the known coupling between horizontal eye position and neck EMG.

Results: Robust cVEMPs evolved bilaterally on both superficial and deep neck muscles within 10-15 ms. As in humans, cVEMPs on ipsilateral SCM were associated with a temporary decrease in recruitment. Inhibition was also seen on contralateral OCI, RCP maj and SPL. Inhibition was accompanied by excitation of the muscles on the other side (e.g., contralateral SCM, and ipsilateral OCI, RCP maj and SPL).

Conclusions: The NHP is a suitable animal model for the cVEMP. cVEMPs distribute widely to many neck muscles, with a recruitment profile resembling that used for horizontal head turns.

OP29-5 - Probing the role of the efferent vestibular system using direct monosynaptic viral tracing

1. Anatomy and Morphology

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Purpose: Unlike other sensory modalities, the functional role of the efferent vestibular system (EVS) remains elusive. Previous work has focused on the morphology, physiology, and peripheral responses to EVS neuron activation, with few studies investigating EVS neurons directly. Moreover, a lack of understanding regarding EVS neuron circuit dynamics makes it impossible to link vestibular efferent activity to behaviour. Here, we sought to determine the central context within which EVS neurons are activated by tracing the monosynaptic inputs to this group of neurons, and expand on the work presented at the previous Neuroscience meeting.

Methods: We used monosynaptic rabies tracing to determine the direct inputs to EVS neurons. In mice (n =7) expressing Cre under the control of the choline acetyl transferase (ChAT) promoter we expressed the rabies glycoprotein (G) selectively in EVS neurons. Following G expression, we injected glycoprotein-deficient rabies (RABVG) virus expressing a fluorescent protein into the horizontal and posterior semicircular canals in the inner ear of the same animal. Histological analysis was performed to identify the direct inputs to EVS neurons.

Results: We observed >50 direct inputs from diverse regions throughout the brainstem, cerebellum, and forebrain including from structures in the telenchalon and diencephalon.

Conclusions: Identification of direct monosynaptic inputs to mouse EVN neurons with rabies virus will allow us to expand hypothesis regarding EVS function. In addition, this method will allow manipulation of EVS neurons, or their inputs, via electrical, chemical or optogenetic methods providing a means to explore the context-dependent central modulation of peripheral vestibular function.

OP29-6 - Visual Suppression has Minimal Effect on Adaptation to Magnetic Vestibular Stimulation

22. Vestibular and Inner Ear Physiology

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Purpose: A Lorentz force resulting from interactions between strong static magnetic fields and ionic currents in the inner ear endolymph is thought to displace the semicircular canal cupulae in an MRI machine, producing nystagmus. The nystagmus partially adapts; after leaving the magnetic field an aftereffect occurs where the nystagmus reverses direction, reflecting set-point adaptation inside the MRI (rebalancing tonic activity between both vestibular nuclei to prevent unwanted nystagmus when the head is still). The influences of visual fixation and head movements on this vestibular adaptation are unknown.

Methods: Three-dimensional video-oculography was performed in darkness with infrared illumination on in 6 individuals before, during (5 minutes) and after (4 minutes) entering a 7T MRI scanner supine. Trials were repeated entering the magnetic field in darkness, followed by either light with visual fixation or yaw head rotations (2 Hz) in darkness inside the MRI, beginning 60 seconds after entering the MRI. Subjects were placed in darkness again 30 seconds before exiting the bore.

Results: All subjects developed horizontal nystagmus inside the magnetic field, with slow-phase velocity partially decreasing over time, and an aftereffect upon exiting the magnet, developing nystagmus in the opposite direction. Nystagmus was suppressed during fixation; however, after resuming darkness before exiting the magnet, nystagmus returned with velocity close to the control condition and with the same aftereffect. Similar effects occurred with yaw head rotations.

Conclusions: Although vision and retinal slip are critical signals for adaptation of the dynamic components of the VOR, they have minimal impact upon VOR set-point adaptation.

OP29-7 - Sound-evoked vestibular projections to the trapezius muscles in humans

1. Anatomy and Morphology

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Purpose: Vestibular-dependent reflexes have been recorded in trapezius muscles in human subjects, however the nature of the projection (polarity, lateralization and strength) is unknown. Prior studies used varying surface electrode montages and found small reflexes with differing polarity. We therefore used single motor unit to unequivocally demonstrate the nature of projections to trapezius in normal volunteers.

Methods: We recorded single motor unit (N=5 subjects) and surface (N=10) responses following vestibular stimulation with 2ms, 500Hz tone bursts. Concentric needle electrodes and active surface electrodes were placed into or over the upper portion of trapezius, approx. midway between the shoulder and the neck, with reference surface electrodes on the wrist. Trapezius was activated by shoulder elevation and responses were compared to those in sternocleidomastoid (SCM) during head elevation and rotation.

Results: In ipsilateral trapezius we found significant short-latency changes in single motor unit activity in 68% (21/31) of units at approx. 15ms and these were mostly excitatory (67%, 14/21) with median duration 1ms. In contralateral trapezius there were responses in only 52% (13/25) of units (62%

excitatory, at 20ms, 1ms duration). Short-latency biphasic surface responses with initial negativity were present only in ipsilateral trapezius (right ear: 7/10 subjects, left ear: 5/10), with mean amplitude 17.7±15.2mV at initial peak latency 15.8±2.0ms, significantly smaller than those recorded in SCM (146.0±76.9mV, P<0.001).

Conclusions: The vestibular projection to trapezius in humans is ipsilateral and predominantly excitatory, but much weaker than that found in SCM, suggesting a minor role for trapezius in the vestibulo-colic reflex.

OP30: Nystagmus and visual stabilization

OP30-1 - Discussion on the significance of nystagmus detection for continuous variable positional nystagmus

22. Vestibular and Inner Ear Physiology

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Purpose: To explore the clinical application value of the neutral point detection of the persistent lateral geotropic direction-changing positional nystagmus (DCPN)

Methods: In July 2016 - May 2017 in our department outpatient examined positional of vertigo patients with Supine Roll test, 25 patients appeared a double side of persistent DCPN tested neutral point further. The horizontal persistent nystagmus occurred in the supine position. Direction changing positional nystagmus canceled at the head rotation to right or left from the supine position is neutral point, recorded the yaw side and the angel.

Results: The 25 patients all occurred neutral point, there were 9 patients with persistent lateral geotropic DCPN were confirmed light cupula, other 16 patients with persistent lateral ageotropic DCPN were confirmed heavy cupula, the angel of neutral point occurred were 25.67±9.31° and 27.06±6.29°. End

angel were $28.78 \pm 10.00^\circ$ and $30.25 \pm 6.53^\circ$. No statistical significance between the two. The nystagmus direction in the supine position was opposite to the direction of neutral point was considered light cupula, On the contrary, it was considered heavy cupula. The light cupula and heavy cupula with neutral point were both appeared in the affected side

Conclusions: Neutral point detection method is a kind of confirmation in patients with light cupula or heavy cupula of a very effective method

OP30-2 - Gaze Stability in Elite Athletes

7. Clinical Testing for Vestibular Function

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Purpose: Of the variety of symptoms produced in sport-related concussion (SRC), dizziness and balance problems are among the most frequently reported. Gaze stability is part of balance function and is an important aspect of sport performance, contributing to both speed and accuracy. There are a few studies that directly address gaze stability in athletes; however, the sample sizes are fairly small. The purpose of this study was to establish gaze stability ranges of head velocity for elite athletes.

Methods: Subjects were 100 male professional baseball players aged 17 to 31 years (mean age = 23.08) who were assessed during Spring Training as part of a multi-modal preseason baseline assessment. Bertec® Vision Advantage equipment was used to complete the Static Visual Acuity Test, Perception Time Test, and Gaze Stability Test (GST) in high performance range in the yaw plane with the athlete positioned 5 feet from the laptop monitor.

Results: The mean head velocity was 208.15 d/sec (SD= 36.99) with leftward directional movement and 222.79 d/sec (SD = 45.34) with rightward directional movement. The median velocity was 210 d/sec to the left and 215 d/sec to the right. The range for leftward directional movements was 130-335 d/sec and for rightward directional movements was 130-365 d/sec.

Conclusions: Performance of elite athletes on GST measures was observed to be much higher than previously published normative data using non-athlete samples. Thus, it is important to utilize separate norms for elite athletes to ensure optimal clinical management following SRC.

OP30-3 - Comorbid inner ear disorders in patients with congenital nystagmus

7. Clinical Testing for Vestibular Function

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Purpose: This study adopted an inner ear test battery and oculomotor function test by electronystagmography (ENG) in patients with congenital nystagmus. The aim of this study was to investigate how congenital nystagmus confounds the oculomotor function test, and suggest an inner ear test battery to overcome the potential pitfalls.

Methods: Fifty patients with congenital nystagmus underwent audiometry and caloric test with ENG recordings. The cervical vestibulo-evoked myogenic potential (cVEMP) and ocular VEMP (oVEMP) tests were added to the test battery after 2000 and 2008, respectively. MR imaging was performed in some patients.

Results: All congenital nystagmus patients had abnormal oculomotor function, probably because the ongoing nystagmus superimposed on the traces causing a diagnostic pitfall. In contrast, inner ear deficits ran from abnormal mean hearing level (34%) to abnormal oVEMP test (31%), cVEMP test (31%) and caloric test (25%), exhibiting non-significant differences among abnormality rates. Restated, approximately one-third of congenital nystagmus patients had comorbid inner ear disorders, while two-thirds of congenital nystagmus patients were devoid of inner ear disorders but just sought for evaluation at a neurotological clinic.

Conclusions: The ENG provides a diagnostic tool for differentiating congenital nystagmus from other

potentially, hazardous acquired nystagmus, which can be confirmed by MR imaging. In contrast, an inner ear test battery helps investigate a comorbid inner ear disorders in a congenital nystagmus patient.

OP30-4 - Utility Of Positional Testing In Acute Vestibular Syndrome: A Transversal And Longitudinal Study

7. Clinical Testing for Vestibular Function

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Purpose: Positional testing is not usually indicated either in the acute stage or follow up of acute vestibular syndrome (AVS). We sought to evaluate its clinical utility in AVS.

Methods: Consecutive patients with acute vertigo and spontaneous nystagmus underwent ocular motor and positional testing at presentation (<14 days from onset), 3-month and 1-year follow-up, and head MRI.

Results: 31 patients were included, 16 with peripheral AVS (pAVS; 16, vestibular neuritis) and 15 with central AVS (cAVS; 10, stroke/5, demyelination). 23 (74,1%) completed the study. Median age (IQR) was 53 (21) and 58 (22.5) (P=0.429) and there were 13 (86.7%) and 10 (62.5%) (p=0.22) males in pAVS and cAVS groups, respectively. At visit 1, all pAVS patients showed abnormal head impulse test (HIT), absence of gaze-evoked nystagmus (GEN), and 2 (12.5%) showed skew deviation. 13 (86%) cAVS patients showed either skew deviation, GEN or normal HIT. During head hanging positions, 5 (33%) cAVS patients showed paroxysmal vertical nystagmus (3, downbeat). The downbeat form was still present at visit 3. During lateral supine, all pAVS patients

showed greater intensity of spontaneous nystagmus when rotating towards the slow phase side (ie, the lesioned side), while half of (53%) cAVS patients showed the opposite pattern. Lateral supine findings at follow-up were highly variable, with both geotropic and ageotropic forms commonly appearing in both groups.

Conclusions: Up to 50% of patients with central acute vestibular syndrome seem to develop either positional paroxysmal vertical nystagmus during head hanging and/or signs of putative earlier vestibular compensation during lateral supine.

OP30-5 - Video ocular counter-roll (vOCR): A new clinical test of otolith-ocular function

7. Clinical Testing for Vestibular Function

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Purpose: Video-oculography (VOG) is being integrated into the bedside quantification of vestibular function mainly as video head impulse testing (vHIT). Lacking, however, has been a comparable VOG method for evaluation of otolith-ocular function. During a static head tilt, there is a change in torsional position of the eyes in the opposite direction of the head tilt, which is known as the ocular counter-roll (OCR). We have previously shown that VOG quantification of OCR (vOCR) could detect loss of otolith function with an accuracy comparable to vestibular evoked myogenic potentials (VEMPs).

Methods: Here we examined feasibility of vOCR testing at the bedside using simple lateral head-on-body and whole-body tilts of 30 degrees. We recruited patients following CN VIII resection of vestibular schwannoma with acute, subacute, and

chronic unilateral vestibular loss. The vOCR results from the patients were compared to a group of healthy controls.

Results: The average vOCR values from the patients were significantly lower compared with the healthy controls during both head-on-body and whole-body tilts (p values < 0.05). In the acute group, vOCR was reduced on the side of vestibular loss compared to the healthy side (p values < 0.05).

Conclusions: These results show that vOCR can be easily applied at the bedside to detect loss of otolith-ocular function.

OP30-6 - The clinical utility of vibration-induced nystagmus and its role in the vestibular examination

7. Clinical Testing for Vestibular Function

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Purpose: The caloric test, rotational testing, ocular & cervical vestibular evoked myogenic potentials identify peripheral pathology. The purpose of this investigation was to describe the characteristics of ipsilesional mastoid vibration-induced nystagmus (VIN) in patients with varying levels of canal paresis. Secondary objectives were; 1) to determine if a relationship existed between these four tests and VIN; and 2) determine sensitivity/specificity of VIN for detecting horizontal canal impairment.

Methods: 580 adults presenting with symptoms of dizziness underwent caloric, rotational testing, ocular & cervical VEMP and VIN. Patients were stratified by caloric asymmetry (CA) into: 0–25%, 26–50%, 51–75%, & 76–100%. Slow component eye velocity (SCEV) was recorded 10 seconds before, during & after the application of vibration. Correlation coefficients were calculated for CA and VIN SCEV. ANOVA was used to determine significant differences in the amplitude of SCEV & CA groups; ROC analysis was used for sensitivity/specificity.

Results: Significant main effects for ipsilesional VIN SCEV noted ($p \leq 0.000$). Bonferroni-adjusted t tests showed significant differences in ipsilesional VIN SCEV between all of the groups except 26–50% & 51–75%. CA showed a positive correlation with ipsilesional VIN SCEV ($p \leq 0.000$). The ROC for CA groups & identification of peripheral pathology as a function of the VIN SCEV gave ROC curve areas of .78-.95 & .59 respectively.

Conclusions: The study demonstrates that VIN and caloric data are correlated, yet each provides unique information regarding the functional integrity of the horizontal semicircular canal at different points on the frequency spectrum.

OP30-7 - Accuracy of Automated Nystagmus Velocity Calculation by Video-oculography Implications for Eye ECG

7. Clinical Testing for Vestibular Function

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Purpose: Misdiagnosis of acute vertigo in the emergency department (ED) is frequent. Pairing onsite quantitative video-oculography (VOG) with computer-based decision support is one possible solution. The accuracy of automated nystagmus detection by VOG is unknown.

Methods: As part of the AVERT (Acute Video-oculography for Vertigo in Emergency Rooms for Rapid Triage) trial (ClinicalTrials.gov #NCT02483429),

we prospectively recruited consecutive patients with acute vertigo from three hospital EDs (2016-2017). Patients underwent multiple ocular motor tests (~28 per battery) using a portable, lightweight VOG device (ICS Impulse, Otometrics, Taastrup, Denmark). We compared automated nystagmus detection based on peak slow-phase velocity ≥ 10 deg/sec (Otosuite software v4.0) to human expert assessment of pathologic nystagmus by video review. We calculated test accuracy and classified artifacts.

Results: We reviewed 2,656 individual VOG tests in 101 patients (31 with nystagmus). Pathologic nystagmus was present per expert review in 4.1% of tests with automated detection sensitivity 95.2%, specificity 95.3%, positive predictive value 52.1%, negative predictive value 99.7%. Among 91 false-positive tests, 34% had physiologic “artifacts” (normal slow eye movements or end-gaze nystagmus); 49% had pupil-tracking artifacts (blinking, ptosis, pupil out-of-frame, eyelash/long-hair in frame); and 16% had non-classifiable artifacts. At the patient level, there were 1 false negatives and 24 false positives.

Conclusions: Automated nystagmus detection by VOG is both sensitive and specific. However, when used in ED patients with a low likelihood of nystagmus undergoing multi-test batteries, patients without any nystagmus are frequently misclassified as having nystagmus (36.4%). Human review of positive results may be necessary pending improved computer algorithms.

OP31: Bilateral Vestibulopathy

OP31-1 - Impaired spatial orientation in 30 patients with bilateral vestibulopathy

18. Spatial Orientation

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Purpose: Our aim is to evaluate spatial cognition in patients suffering from bilateral vestibulopathy.

Methods: We examined thirty-seven patients with a previous diagnosis of bilateral vestibulopathy (BVP) at our center. All patients underwent vestibular testing by means of caloric irrigation, rotation swing and video-head-impulse-testing. Only patients who met the diagnostic criteria for BVP, as recently proposed by the Bárány Society, were included. The control group consisted of twenty healthy male and female subjects, without vestibular complaints and a zero score on the Dizziness Handicap Inventory. Spatial orientation was measured by performing a virtual version of the Morris Water Maze task with 20 hidden trials, 1 probe trial and 10 visible trials.

Results: Eighteen male (mean age 52 y \pm 12) and twelve female (mean age 57 y \pm 16) patients met the diagnostic criteria for BVP as proposed by the Bárány Society. Overall, patients with BVP took longer paths and more time to find a hidden platform (*mean path length/pool diameter in BVP* 1.42 \pm 0.6, *in controls:* 1.32 \pm 0.4, $p = 0.47$; *mean latency in BVP* 38 s \pm 16, *in controls:* 32s \pm 10, $p=0.15$). The difference in performance between BVP patients and the control group was more pronounced in male subjects (e.g. heading error in probe trial: male BVP patients 38° \pm 32 versus healthy males 11° \pm 11, $p=0.05$).

Conclusions: Our current findings demonstrate that patients with BVP suffer from an impaired spatial cognition. This effect seem to be more pronounced in male patients than in female patients with BVP.

OP31-2 - Etiology and hearing status of 129 patients with bilateral vestibulopathy

5. Bilateral Vestibulopathy

Bieke Dobbels¹

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Purpose: Our primary aim was to determine the definite and probable etiology in patients with bilateral vestibulopathy (BVP) at our center. Our secondary aim was to evaluate the hearing status in these patients.

Methods: A retrospective study was performed on BVP patients diagnosed and followed in a tertiary referral center (University hospital of Antwerp) between 2004 and 2018. Only patients who met the diagnostic criteria proposed by the Bárány Society, were included.

Results: We identified 129 BVP patients, 59% male. The mean age at diagnosis was $57 \pm 15,6$ years (range 10-84 years). The definite cause was determined in 40% of patients and the probable cause in 23% of patients. No cause was identified in 37% of BV patients. In up to 20% of patients, a different etiology was identified on each inner ear. The largest subgroup included patients with a genetic etiology, most frequently DFNA9. Of all patients, 22% had bilateral normal hearing to mild sensorineural hearing loss (SNHL) impairment, 12% had bilateral moderate to severe SNHL and 32% had bilateral profound SNHL. Furthermore, 22% of patients presented unilateral deafness and 7% unilateral moderate to severe SNHL.

Conclusions: Bilateral vestibulopathy is a heterogeneous condition, with over 1/3 of cases remaining idiopathic, and more than 3/4 affected by hearing loss. DFNA9 is the most common cause of BV in our population.

OP31-3 - Cognitive impairment in patients with bilateral vestibulopathy with and without hearing loss

5. Bilateral Vestibulopathy

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Purpose: Recent studies demonstrated cognitive impairment in small groups of patients with bilateral vestibulopathy (BVP). Our aim is to evaluate cognitive performance of 30 BVP patients with and without hearing loss, as this is an independent risk factor for cognitive decline.

Methods: Thirty patients ($53y \pm 12$) with an established diagnosis of bilateral vestibulopathy (BVP) according to the Barany criteria, were included. Eighty-two healthy, normal hearing, controls ($63y \pm 11$) were selected. They had no vestibular complaints and presented a zero score on the Dizziness Handicap Inventory. All subjects underwent audiometric evaluation. Cognition was assessed by means of the Repeatable Battery for the Assessment of Neuropsychological Status, for hearing impaired persons (RBANS-H). This is an adaptation of the original RBANS specifically designed for hearing impaired patients. The RBANS measures 5 domains of cognition: immediate memory, delayed memory, visuospatial abilities, attention and language.

Results: Overall patients with BVP had a worse total score on the RBANS-H comparing to healthy controls, although this was not statistically significant. Interestingly, patients with BVP and hearing loss performed worse than patients with BVP and normal hearing ($p < 0.05$). Mainly, delayed memory and immediate memory seem to be affected in BV patients with hearing loss compared to BV patients without hearing loss ($p = 0.097$ and $p = 0.065$, respectively).

Conclusions: Our results confirm the previous findings of impaired cognition in BVP patients. Further research is needed to evaluate the relative impact of either vestibular or hearing loss on cognition in these patients.

OP31-4 - Extensive exploration of symptoms of bilateral vestibulopathy

5. Bilateral Vestibulopathy

Florence Lucieer¹

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Purpose: To obtain a clear inside in the full spectrum of symptoms of bilateral vestibulopathy (BV).

Methods: Qualitative research was performed in 18 BV patients. All subjects had a reduced caloric response of summated slow phase mean peak velocity of less than 20°/s. An extensive individual interview was performed with open-ended questions. The interviews were transcribed, coded and analyzed by the first two authors. The symptoms were organized in a mindmap and labeled by category. The symptoms were divided in physical symptoms, functional symptoms and emotions.

Results: Inner ear symptoms were reported such as oscillopsia, imbalance, vertigo, unsteadiness when walking or standing, and worsening of unsteadiness in darkness and/or on uneven ground. Moreover, symptoms beyond the inner ear were described by the BV patients, for example negative emotions (fear, agitation, etc), cognitive/memory problems, reduced quality of life, and reduced spatial orientation.

Conclusions: BV symptomatology has a broader spectrum of symptoms than most literature currently focuses on. It reaches beyond symptoms of the inner

ear. It is therefore important to take this into consideration during the development of outcome measures for therapeutic interventions such as the vestibular implant.

OP31-5 - Hierarchical cluster analysis of semicircular canal and otolith deficits in bilateral vestibulopathy

5. Bilateral Vestibulopathy

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Purpose: Gait imbalance and oscillopsia are characteristic for bilateral-vestibular loss (BLV). Video-head-impulse testing (vHIT) of all six semicircular canals (SCCs) has demonstrated varying involvement of the canals. Sparing of anterior-canal function has been linked to aminoglycoside-related vestibulopathy and Menière's disease. We hypothesized that utricular/saccular impairment may be disease-specific also.

Methods: We searched our vHIT-database for patients with bilaterally impaired SCC-function who also received ocular vestibular-evoked myogenic-potentials (oVEMPs) and cervical vestibular-evoked myogenic-potentials (cVEMPs) and identified 101 patients. oVEMP/cVEMP-latencies above the 95th-percentile and peak-to-peak amplitudes below the 5th-percentile of normal were considered abnormal. Frequency of impairment of vestibular end-organs (horizontal/anterior/posterior SCC, utriculus/sacculus) was analyzed with hierarchical cluster-analysis and correlated with the underlying etiology.

Results: Rates of utricular/saccular loss-of-function were similar (87.1% vs. 78.2%, $p=0.136$). oVEMP-abnormalities were found more frequently in aminoglycoside-related BVL compared to Menière's disease (91.7% vs. 54.6%, $p=0.039$). Cluster-analysis indicated distinct patterns of vestibular end-organ

impairment: Individual end-organs on both sides merged early. Sparing of anterior-canal function was reflected in late merging with the other end-organs, emphasizing their distinct state. Average ($\pm 1SD$) number of damaged sensors was $6.8 \pm 2.2/10$. Significantly ($p < 0.001$) more sensors were impaired in patients with aminoglycoside-related BVL (8.1 ± 1.2) or inner-ear infections (8.7 ± 1.8) compared to Menière-related BVL (5.5 ± 1.5).

Conclusions: Hierarchical cluster-analysis may help differentiate characteristic BVL-patterns. With a prevalence of $\approx 80\%$, utricular/saccular impairment was frequent. The extent of SCC and otolith impairment was disease-dependent, showing most extensive damage for inner-ear infection and aminoglycoside-exposure. Furthermore, assessing utricular function may help in the distinction between aminoglycoside-related BVL and bilateral Menière's disease.

OP31-6 - On the effect of noisy galvanic vestibular stimulation on dynamic visual acuity.

5. Bilateral Vestibulopathy

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Purpose: Recent studies have evaluated the potential of noisy galvanic vestibular stimulation (nGVS) to upregulate primary vestibular afferent and hair cell activity in bilateral vestibulopathy (BV) patients by means of stochastic resonance. Improvement in vestibular balance control and postural stability has been observed, however, the impact of nGVS on gaze stabilization has not been investigated. Therefore, the primary aim was to study the effect of nGVS on dynamic visual acuity (DVA) in BV-patients.

Methods: Nine BV-patients were included according to the diagnostic criteria suggested by the Bárány Society. Gaze stabilization was tested with the DVA-

test during treadmill locomotion, both with and without nGVS in a randomized order and patients were blinded to the stimulation protocol. Additionally, health-related quality of life was evaluated through the Dizziness Handicap Inventory (DHI). The correlation between DHI (sub)scores and change in DVA-performance was studied.

Results: Age ranged from 28.13 to 73.27 years (5:4 male-female ratio). Etiologies included idiopathic BV (n=2), gentamicin toxicity (n=2), auto-immune inner ear disorder (n=2), meningitis (n=2) and bilateral vestibular neuritis (n=1). Total DHI scores ranged from 0 (no self-perceived disability) to 84 (severe self-perceived disability). DVA-performance remained stable in 5/9 patients, three patients performed better with nGVS and one patient performed worse. The "Physical" subscore of the DHI demonstrated a strong correlation ($r = -0.684$, $p = 0.042$) with an improvement in DVA scores during nGVS.

Conclusions: This pilot study provides preliminary data suggesting that noisy galvanic vestibular stimulation could be effective in improving gaze stabilization in a subset of patients suffering from bilateral vestibulopathy.

OP31-7 - Vestibular perception in patients with bilateral vestibulopathy

5. Bilateral Vestibulopathy

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Purpose: At this moment clinical vestibular testing mainly focuses on testing reflexes such as the vestibulo-ocular reflex (VOR) and the vestibulo-collic reflex (VCR). The objective of this study was to evaluate the perceptual thresholds in patients with

bilateral vestibular loss using a recently proposed clinically useful test for vestibular perception

Methods: Fifty patients with bilateral vestibular loss and a control group of 55 healthy volunteers were tested on a MOTTEK perception platform in dark. All BV patients had a reduced caloric response of summated slow phase mean peak velocity of less than $20^\circ/s$ and a reduced VOR gain on the rotatory chair (0.1Hz). The platform delivered 12 different movements: 6 translations (forward, backward, right, left, up and down) and 6 rotations/tilt (yaw left, yaw right, pitch forward, pitch backward, roll left and roll right). Thresholds were determined by a staircase paradigm

Results: Perceptual thresholds of translation showed a wide distribution in both groups. Thresholds above $0,4m/s^2$ were more prominent among BV patients. Perceptual thresholds for rotation/tilt movements in BV patients were significantly higher compared to those in healthy volunteers.

Conclusions: BV patients show generally higher perceptual thresholds than healthy volunteers. The spread of perceptual thresholds in BV patients is probably due to the use of other pathways than the regularly evaluated reflexes. Therefore, perception could be used as an additional treatment outcome measurement in the future.

Poster presentations

Exhibition and poster viewing (poster session 1)

PP1-1 - 3D Visualization and Position of Human Inner Ear Graviceptors A Synchrotron Imaging Study

1. Anatomy and Morphology

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Purpose: Receptors located in the inner ear, muscles tendons and joints provide sensory information of body position, static equilibrium and gravitational forces. The saccule and utricle maculae in the labyrinth is a body “gyroscope” that delivers information to the brain of head orientation, gravity and linear acceleration. Their exact position and shape of the sensory tissues within the human skull are still somewhat poorly defined.

Methods: We used synchrotron-phase contrast imaging (SR-PCI) to study the 3D micro-anatomy and position of the graviceptors in the human skull. This was accomplished by reconstructing human soft inner ear tissues including the sensorineural epithelial outline with juxtaposing CT skull images.

Results: The geometric position and outline of the maculae were also assessed relative to the location of the round and oval windows, stapes foot plate, cochlear lateral wall tissue and spiral lamina. Besides this information the 3D outline of the membranous endolymph duct system could be defined.

Conclusions: The exact position and shape of the inner ear graviceptors were mapped in the human skull using synchrotron-phase contrast imaging.

PP1-2 - A multifaceted tailored randomised-controlled trial to reduce the burden of dizziness in middle aged and older people

1. Anatomy and Morphology

J Menant¹

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Purpose: Dizziness is common among middle-aged and older people. Its multifactorial etiology makes it difficult to investigate and if untreated, dizziness can lead to reduced quality of life, functional disability, depression, restricted participation in social activities and falls. Only a few multidisciplinary interventions of dizziness have been conducted to date, all of a pilot nature and none tailoring the intervention to the specific causes of dizziness.

The study aimed to test the hypothesis that a multidisciplinary dizziness assessment followed by a tailored multifaceted intervention would reduce dizziness handicap and self-reported dizziness, and enhance balance and gait in people aged 50 years and over with dizziness.

Methods: 305 community-dwelling people (mean (SD) age 68 (8) years, 62% women) who reported dizziness in the 12 months prior and were not receiving treatment for it, completed the dizziness handicap inventory (DHI) and questionnaires regarding medical history, anxiety and depression. They also underwent assessments of vestibular function, sensorimotor function, balance, stepping and gait. Our multidisciplinary team of scientists and clinicians held case conferences fortnightly to discuss and recommend appropriate therapy(ies) for each participant, based on their baseline assessments. Participants were then randomised to intervention or control groups, and based on their test performances, intervention participants were allocated to one or more interventions: vestibular rehabilitation, cognitive behavioural therapy, medical/medication management by a general practitioner or at a falls clinic and

strength and balance exercises using the Otago exercise program. Primary outcome measures comprised the DHI, frequency of dizziness episodes recorded with monthly calendars over the six-month follow-up, choice stepping reaction time and gait variability.

Results: At trial completion, the DHI scores in the intervention group (pre and post mean (SD): 25.9 (19.2) and 20.4 (17.7), respectively) were significantly reduced when compared to the control group (pre and post mean (SD): 23.0 (15.8) and 21.8 (16.4)), when controlling for baseline scores (mean (95% CI) difference between groups (baseline adjusted): -3.7 (-6.2 to -1.2); $p=0.003$). There were no other significant between-group differences in the primary outcomes. However, there were intervention-specific improvements in those allocated to the four intervention types.

Conclusions: The findings indicate that a multifactorial tailored approach for treating dizziness is effective in reducing dizziness handicap in community-living people aged 50 years and older. Individualised multifaceted evidence-based therapies should be implemented to improve the quality of life of middle-aged and older people with dizziness.

PP1-3 - Developing a Model for Quantification of Heat Transfer to the Vestibular System

1. Anatomy and Morphology

Charles Anzalone¹

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Purpose: Caloric modulation of the vestibular system is an established technique to determine inner ear function. We aim to develop a cadaveric model to determine the role specific anatomic variables play in temperature change at the level of the lateral semicircular canal (LSC)

Methods: Two fresh frozen cadaveric heads were evaluated using a 192 slice computed tomography (CT) scanner to evaluate for standardized anatomy as well as tissue thickness and density. A continuous caloric irrigation system was placed at either the level of the external auditory canal or direct irrigation into the middle ear space; thermocoupling electrodes at the external auditory canal (EAC), middle ear, and LSC provided real time temperature monitoring.

Results: Radiographic analysis of each cadaveric model was performed to quantify anatomic variables: surface area and volume of the EAC, surface area of the tympanic membrane, volume and surface area of the middle ear space, LSC bony thickness, volume, surface area and distance to the tympanic membrane. Specific temperature coefficients were determined based off of contributions of air, bone, and soft tissue densities. Temperature transfer models were constructed from these variables.

Conclusions: Determining the variables affecting the delivery of heat to the LSC are paramount to determining the degree of vestibular stimulation from a given input temperature. Our model provides a reliable method of quantifying temperature transfer across the external, middle and inner ear anatomy. Further study is required to correlate these data to the general population.

PP1-4 - Distribution of extracellular matrix in vestibular nuclei of developing mouse brain stem

1. Anatomy and Morphology

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Purpose: The molecular and structural composition of the extracellular matrix (ECM) in the central nervous system undergoes profound transformation during embryonic and early postnatal development. The aim of this study was to detect the changes of staining pattern of different ECM molecules in the developing mouse brainstem.

Methods: We used using histochemical (Wisteria floribunda agglutinin (WFA), hyaluronic acid probe

(HA)) and immunohistochemical (aggrecan, neurocan, versican (GAG beta), TN-R and HAPLN1) methods.

Results: We found that HA, neurocan and versican reactions showed diffuse neuropil staining at very early embryonic stage (E13.5), but perineuronal net (PNN) composed of these molecules were observed only postnatally (P7). We could not find any aggrecan, WFA or HAPLN1 staining before birth. Postnatally WFA and aggrecan established PNN in the reticular formation and in the vestibular and other brainstem nuclei. HAPLN1 were restricted to the neuropil of some brainstem nuclei, in contrast to HA, neurocan and TN-R which were found throughout the brainstem.

Conclusions: Our results show that at early stages of development only a diffuse staining of ECM molecules is present in the neuropil of the brainstem and the formation of a definitive PNN is recognizable postnatally. We found well developed PNNs in the vestibular nuclei of the brainstem in two weeks old animals. It is expected that the pattern of ECM expression appears to be related to the functional maturation of brainstem neural circuits, which is also evident in other developmental processes such as neurogenesis, synaptogenesis or synaptic plasticity. Supported by OTKA K 115471, and MTA TKI 355.

PP1-5 - Ion Transport Proteins and Claudin 11 Barrier in the Lateral Wall of the Human Cochlea

1. Anatomy and Morphology

Wei Liu¹

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Purpose: The cochlea produces an electric field potential essential for hair cell transduction and hearing. This biological “battery” is situated in the lateral wall of the cochlea and contains highly organized molecular/cellular arrangement that secretes

and recycles K⁺ ions. Its functioning depends on ion-transporting machinery and junctional proteins that guarantee a unidirectional delivery of K⁺ and restrict the para-cellular escape of the ion. Claudin 11 protein has been found to be one of the major constituents at tight junction that maintains ion gradients (Gow et al., 2004; Kitajirietal., 2004). We are the first to elucidate the human Claudin 11 framework and the associated ion transporters (channels/pumps/carriers) using super-resolution structured illumination microscopy (SR-SIM).

Methods: Archived human cochleae obtained during meningioma surgery were used for SR-SIM, together with confocal laser scanning microscopy and transmission electron microscopy after ethical permission as well as patients’ consent.

Results: Claudin 11-expressing cells formed parallel tight junction lamellae that insulated the epithelial layers of the stria vascularis and extended to the suprastrial region. Intercellular gap junctions were found between the barrier cells and fibrocytes.

Conclusions: EM, CLSM and SR-SIM revealed exclusive cell specialization in the various subdomains of the lateral wall of the human cochlea. The Claudin 11-expressing cells exhibited both conductor and isolator characteristics, and these microporous separators may selectively mediate the movement of charged units (mainly K⁺) to the intrastrial space in a manner that is analogous to a conventional electrochemical “battery.” The function and relevance of this “battery” for the development of inner ear diseases are discussed.

PP1-6 - Is there a Neuroimmunoaxis in the Human Inner Ear - Role in Disease and Repair?

1. Anatomy and Morphology

Wei Liu¹

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Purpose: The human inner ear is segregated by a blood/labyrinth barrier but contains resident macrophages/microglia (CD163, IBA1-, and CD68-positive cells) within almost all the tissues including neurons and organ of Corti. In the lateral wall of the

cochlea, these cells lie close to blood vessels as perivascular macrophages. Macrophages are also shown to be recruited from blood-borne monocytes to damaged and dying hair cells induced by noise, ototoxic drugs, aging and diphtheria toxin-induced hair cell degeneration. Precise monitoring may be crucial to avoid self-targeting. Macrophage biology has recently shown that populations of resident tissue macrophages may be fundamentally different from circulating macrophages. Macrophage migration inhibitory factor protein (MIF) signaling is a potential route to develop new therapeutic strategies to repair adult spiral ganglion neurons, hair cell synapses and even form new neurons from stem cells.

Methods: Human cochleae were removed during surgery for treating petro-clival meningioma compressing the brain stem, after ethical consent. Molecular and cellular characterization using immunohistochemistry with antibodies against IBA1, TUJ1, CX3CL1 and type IV collagen, and super-resolution structured illumination microscopy (SR-SIM) were made together with transmission electron microscopy.

Results: High resolution microscopy disclosed remarkable phenotypic variants of IBA1 cells closely associated with the spiral ganglion cells. Monitoring cells adhered to neurons with “synapse-like” specializations and protrusions. Active macrophages migrated occasionally nearby damaged hair cells.

Conclusions: In the human cochlea, the labyrinthine nerves are under the influence of a neurotrophic cytokine/chemokine cross-talk with the immune system. The interaction has possible roles in human inner ear disease, sensorineural injury, and repair processes.

PP1-7 - Microcomputed Tomography Analysis of the the Fundus of the Human Internal Acoustic Canal

1. Anatomy and Morphology

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Purpose: The purpose of the study was to better understand and visualize the anatomy of the human fundus with microcomputed tomography. Identification of the cochleovestibular nerve in the internal acoustic canal is crucial before cochlear implantation and other surgical interventions, such as tumor removal, vestibular nerve section, and decompression procedures. They all require a thorough knowledge of the gross and topographical anatomy in humans.

Methods: Using microcomputed tomography, we analyzed the fundus bone channels in an archival collection of 113 macerated human temporal bones and 325 plastic inner molds. Data were subsequently processed by volume-rendering software using a bony tissue algorithm. Three-dimensional reconstructions were made, and through orthogonal sections, the topographic anatomy was established.

Results: The technique provided additional information regarding the anatomy of the nerve foramina/channels of the human fundus region, including variations and destinations. Channel anastomosis were found beyond the level of the fundus. A foramen of the transverse crest was identified.

Conclusions: Three-dimensional reconstructions and cropping outlined the bone canals and demonstrated the highly variable VIIIth nerve anatomy at the fundus of the human inner acoustic canal. Myriad channel interconnections suggested an intricate system of neural interactive pathways in humans. Particularly striking was the variable anatomy of the saccule nerve channels. The results may assist in the preoperative interpretation of the VIIIth nerve anatomy.

PP1-8 - A new procedure of labyrinthectomy in mice by means of transtympanic injection of p-arsanilic acid

2. Animal Models and Molecular Approach

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Purpose: Unilateral labyrinthectomy (UL) is usually adapted to make an animal model of vestibular dysfunction. However, there are few papers about UL in mice. For further understanding of vestibular compensation, a new method of UL in mice is required. In the present study, we devised a new accessible and reliable method to damage mice inner ear.

Methods: We used 8 weeks old male C57BL/6N mice. A retroauricular incision was made to expose the external ear canal. It was opened just anterior to the exit point of facial nerve and the tympanic membrane was perforated caudally to handle of malleus. After paracentesis, 50 μ l of 0.4M p-arsanilic acid sodium salt solution was instilled into the tympanic cavity and after 5 min, the solution was aspirated. As behavior markers, we recorded head deviation and spontaneous nystagmus using a digital camera. Head deviation was measured once a day, defined as the angle between the horizontal plane and a line passing through the center of the animal's head in the coronal plane. To understand the neurological activities in vestibular nucleus (VN), we counted immunoreactive cells of immediately early genes (IEGs): c-fos, Arc, and Zif268.

Results: The angle of head deviation became the least at 48 hrs and gradually recovered by 168 hrs after UL. The spontaneous nystagmus appeared at 24 hrs and disappeared by 48 hrs after UL. IEGs-immunoreactivities in VN were higher in the injured side than the intact side.

Conclusions: The present UL procedure is simple and reliable for making a mice model of vestibular dysfunction.

PP1-9 - Altered circadian locomotor activity after acute otovestibular failure in rodents.

2. Animal Models and Molecular Approach

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Purpose: Similar to Alzheimer's disease, diurnal rhythm disturbances and cognitive dysfunction have been observed in rodent models of bilateral vestibulopathy (BV). Sleep and circadian disruption can impair hippocampal neurogenesis and subsequently impair hippocampus-dependent learning and memory. Recent insights have explored the connection between the vestibular system and hypothalamic regulation of circadian rhythms.

The aim of this study was to evaluate circadian patterns of locomotor activity before and after acute otovestibular failure in mice.

Methods: We evaluated adult 129S1/SvImJ mice, purchased from Charles River - Jackson Laboratories (JAX), 1 week before and 1 week after allylnitrile exposure (p.o. in 6 ml/kg of corn oil). Vestibular function was evaluated with the validated score reported by Jordi Llorens. Cage activity was evaluated continuously over a period of 47 hours, including a 12-hour dark phase (active) and a 12-hour light phase (less active). Ambulatory movements (e.g. walking through cage) included multiple infrared beams crossed sequentially. Fine movements (e.g. grooming) included one infrared beam disrupted multiple times. Statistical analysis was performed using a mixed model with random and fixed effects.

Results: Allylnitrile exposure resulted in acute-onset and permanent vestibular failure and profound sensorineural hearing loss. A statistically significant interaction was observed on ambulatory ($p < 0.05$) and fine movements ($p < 0.0001$) when comparing measurements before versus after allylnitrile exposure and comparing with the control group.

Conclusions: Our findings support the hypothesis that the vestibular system has a short-term influence on daily rhythm homeostasis in rodents. This circadian rhythm disturbance might play a role in decreased adult hippocampal neurogenesis and spatial cognitive decline.

PP1-10 - Effect of thioperamide on vestibular compensation in rats with immunohistochemistry

2. Animal Models and Molecular Approach

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Purpose: Unilateral labyrinthectomy (UL) causes ocular and postural asymmetries, which disappear over time in the processes of equilibrium recovery known as vestibular compensation.

Vestibular compensation consists of two stages: the inhibition of the contralesional medial vestibular nucleus (contra-MVe) activities at the acute stage after unilateral labyrinthectomy (UL) and the recovery and maintenance of the ipsilesional MVe (ipsi-MVe) spontaneous activities at the chronic stage after UL.

Methods: In rats, the inhibitory N-methyl-D-aspartate (NMDA) receptor systems related to central vestibular system may play an important role for central processes of the vestibular compensation. Therefore, the expression of MK801 (a specific antagonist of NMDA receptors)-induced Fos-like immunoreactive (-LIR) neurons in the contra-MVe after UL demonstrated the time course of vestibular compensation.

We evaluated the progression of vestibular compensation at two stages. The acute stage of vestibular compensation was evaluated with changes of spontaneous nystagmus frequency, the chronic stage of vestibular compensation was evaluated with temporal changes of MK801-induced Fos-LIR neurons in the contra-MVe after UL.

There have been no study directly demonstrating the influence of thioperamide, a pure antagonist of the H3 receptor, on vestibular compensation with immunohistochemistry.

Results: Neither SN frequency nor its rate of compensation were significantly different between Thioperamide-treated group and the control untreated group. In contrast, Thioperamide-treated group significantly decreased earlier the temporal changes of MK801-induced Fos-LIR neurons in the contra-MVe after UL compared with the control group.

Conclusions: In conclusion, Thioperamide improve the chronic stage of vestibular compensation in rats, not the acute stage.

PP1-11 - Evaluating an kinase inhibitor library for effects on hair cells using the zebrafish lateral line

2. Animal Models and Molecular Approach

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Purpose: Zebrafish lateral line hair cells are physiologically and morphologically similar to inner ear hair cells. As the zebrafish lateral line is located on the body surface, damage to the hair cells can be rapidly assessed. Therefore, the zebrafish lateral line is an effective system for the evaluation of drugs that damage or protect hair cells. In this study, we examined the role of kinase in hair cells. A kinase phosphorylates a protein, have an important role for hair cell alive or death. We have screened a library of 18 kinase inhibitor-drugs that protected or damaged hair cells of the zebrafish lateral line.

Methods: 5 days post-fertilization zebrafish were used in this study. Larvae were exposed to kinase inhibitor (0.1-10 ug/ml) with or without neomycin (100 uM) to investigate hair cell protection and toxicity. Anti-parvalbumin was used as a primary antibody, hair cells were immunostained. Hair cells from the SO1, SO2, O1, and OC1 neuromasts were counted with a fluorescent microscope.

Results: One kinase inhibitor drug show toxicity in hair cells. On the other hand, the screen successfully identified four protecting drugs against neomycin.

Conclusions: We examined the relevant of kinase and hair-cell death using the larvae of a zebrafish. Our data suggested that kinase were work as toxic and protective effect in hair cells.

PP1-12 - Extracellular matrix in vestibular compensation

2. Animal Models and Molecular Approach

Botond Gaál¹

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Purpose: Impaired balance function evokes postural, oculomotor and autonomic deficits, which symptoms partly restore by vestibular compensation. The role of extracellular matrix (ECM) has been long suggested in such plastic modifications of a neural network. Our laboratory investigates the ECM environment in the brainstem vestibular nuclei (VN) of rats, mice and frogs both in physiological conditions, and during compensation after unilateral labyrinth lesion. We perform the damage of balance receptors mechanically, by microsurgical exposure of the labyrinth.

Methods: ECM in the mammalian CNS is composed of hyaluronan (HA), chondroitin sulfate proteoglycans (CSPG) and glycoproteins. This ternary complex accumulates as perineuronal net (PNN) surrounding perikaryons and neuronal processes, or is distributed diffusely. The PNNs stabilize synaptic contacts on the perikaryon and neuronal processes, but also influences restoration capacity of the vestibular system. In contrast with mammals, our results confirmed a HA based ECM in the amphibian VN.

Results: In frogs transection and reunion of the vestibular nerve was followed by an in-growth of nerves into VN and re-establishment of synaptic contacts, parallel with restoration of vestibular functions. In normal rats and mice unilateral damage of the inner ear initiated a radical but dynamic alteration of PNNs in the VN, which is temporally parallel with functional recovery, although no evidence proves considerable axonal re-growth.

Conclusions: These experiences suggest that a HA-rich but CSPG-free perineuronal environment

facilitates a high degree of plasticity and regenerative potential in frogs, whereas in rodents the strong presence of CSPGs presumably is against plastic modifications of the vestibular network.

PP1-13 - Locomotor hyperactivity in bilateral vestibulopathic rats: a consequence of spatial disorientation?

2. Animal Models and Molecular Approach

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Purpose: Comparative investigation of the locomotor behaviour in open and restricted space after bilateral labyrinthectomy in the rat.

Methods: Ten Sprague-Dawley rats underwent a bilateral labyrinthectomy (BL) by transtympanic injection of bupivacaine and arsenilate, 10 rats received a bilateral middle-ear injection of saline (sham) as a control group. Behavioural testing was performed 1 day before and at days 1, 2, 3, 7, 15, 30 and 60 after BL/sham injection as follows: 1) quantitative analysis of locomotor and spatial exploration behaviour in a square open field by the Noldus EthoVision System; 2) quantitative analysis of locomotion pattern in a straight corridor by the Noldus CatWalk System.

Results: In the open field, mean locomotor velocity was significantly higher in the BL than in the sham group until day 60. This was mostly due to different movement strategies in open space: rats of the sham group showed a strategically distributed exploration pattern with a preferred movement along the lateral edges at all time points. In contrast, rats of the BL group presented with a omnidirectional exploration strategy and stayed in the central parts of the open field significantly longer. A completely different locomotor behaviour was seen in restricted space:

mean locomotor velocity during CatWalk measurement was lower at the initial time points and adapted consecutively between groups after day 15 post BL/sham injection.

Conclusions: Locomotor hyperactivity following a bilateral vestibular lesion seems to be a consequence of disorientation in open space. Locomotor velocity in restricted space adjusts completely to the level of controls indicating central compensation mechanisms.

PP1-14 - Macrophages in the Human Endolymphatic Sac - Molecular Expression and Interaction

2. Animal Models and Molecular Approach

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Purpose: Several otologic disorders are thought to have an immunologic component. The endolymphatic sac (ES) is endowed with a multitude of white blood cells and may serve as an immunologic defense organ for the inner ear. Recently, the human ES, as well as the rest of the inner ear, were found to contain resident macrophages. To gain more information about their roles, we examined these cells using super resolution structured fluorescence microscopy (SR-SIM).

Methods: Human vestibular aqueducts were removed during trans-labyrinthine surgery for removal of acoustic neuroma. Tissues were placed in fixative, decalcified, and rapidly frozen and cryostat sectioned. Antibodies against IBA-1, fractalkine (CX3CL1) and the major histocompatibility type II (MHCII) were used.

Results: A larger number of IBA1-positive cells than expected were found to reside in the ES populating both the surrounding connective tissue and the epithelial lining. Several epithelial cells expressed IBA1 as well as the major histocompatibility complex II (MHCII). Evidence of macrophage diapedesis into the ES lumen was obtained. The chemokine CX3CL1 was richly expressed in the ES.

Conclusions: Macrophages constitute a large, interactive population of locomotive sub-epithelial, intra-luminal and fixed epithelial cells in the human ES. Molecular expression includes that of antigen-presenting cells important for initiating immune responses.

PP1-15 - Neural Correlates of Galvanic Vestibular Stimulation in the Alert and Behaving Macaque

2. Animal Models and Molecular Approach

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Purpose: The vestibular influence on motor and perceptual responses can be manipulated in isolation by delivering electrical currents over the mastoid processes. This galvanic vestibular stimulation (GVS) evokes stereotypical ocular and postural responses as well as virtual sensations of motion that have been well described in humans. Exactly how this non-invasive tool activates the vestibular system, however, remains an open question.

Methods: To link neuronal and behavioural responses, we recorded eye movements and individual vestibular afferent activity while applying transmastoid GVS in alert macaques.

Results: We found that GVS predominately evoked torsional eye movements, similar to those reported in humans. Our single unit recordings revealed that canal and otolith afferents were similarly activated by GVS. Notably, afferents from both types of sensors displayed high-pass tuning, with irregular afferents showing greater response modulation. This differs markedly from their response to natural motion and overturns previous expectations that afferent response dynamics to GVS are invariant across stimulation frequency.

Conclusions: Taken together, these results reveal the neural correlates underlying GVS-evoked perceptual, ocular and postural responses – a fundamental step into understanding the representation and use of such information in the brain that is critical to advance the applicability of GVS for biomedical uses in humans.

PP1-16 - Photobiomodulation for peripheral vestibular dysfunction induced by aminoglycoside in animal model

2. Animal Models and Molecular Approach

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Purpose: Vertigo is related to the dysfunction of peripheral vestibular system and no specific medical treatment is available to cure the symptom. Gentamicin is known vestibular toxic agent, various degree of balance problem is observed after exposure to this pharmacologic agent. Photobiomodulation using low level laser is widely adopted in medical field, and due to its ability to reach deeply locating organs inner ear is one of the candidate target. But not much studies have shown the effect of photobiomodulation on balance function.

Methods: We used rat model to resemble the human vestibulopathy condition using Gentamicin and evaluated the effect of photobiomodulation on this vestibular toxicity. Both functional and histologic evaluation were aimed to assess the cupula of lateral semicircular canal. Slow Harmonic Acceleration (SHA) rotating chair testing was used for functional evaluation and both qualitative and quantitative epifluorescence analysis of cupula histology was performed. Animals were divided into laser group and Gentamicin only group. Laser was applied in unilateral ear, and function and histology was evaluated in both ear.

Results: After Gentamicin treatment, decrease of function of both ear was observed, showing low gain and no asymmetry. With laser treatment to unilateral ear, this reduction was minimized showing increased gain in laser treated ear and showing

asymmetry of right and left ear function. Histological results corresponded to the functional results showing increased density of hair cell and epifluorescence intensity in laser applied cupula.

Conclusions: Promising outcome was observed showing increased vestibular function after photobiomodulation and this could be alternative approach for vestibulopathy.

PP1-17 - Tissue optical clearing of the mouse temporal bone for downstream applications

2. Animal Models and Molecular Approach

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Purpose: The mouse inner ear histological analysis is challenging due to its membranous structures encapsulated within a small, hard, boney shell, the temporal bone. Tissue optical clearing techniques enable whole organs to be studied without tedious fine dissection. While different organs have been successfully cleared, the temporal bone is one of the more difficult organs to manipulate. Tissue optical clearing needs to be combined with suitable labeling methods in order to be used in downstream studies. Our goal was to establish methods suitable for mouse temporal bone 3D reconstruction using tissue optical clearing methods suitable for single-cell histological analysis.

Methods: Whole temporal bones of C57BL6J, *Casp3* knockout and transgenic *Cib2* mice were fixed, decalcified, labeled and optically cleared. We modified clearing protocols/reagents, SeeDB and Sca/eS, to be suitable for the mouse temporal bone. Imaging was obtained using Zeiss Lightsheet Z.1 lightsheet microscope, two-photon microscope, or light microscope, and 3D reconstruction was obtained using Imaris, Arivis or Fiji software. We used the 3D reconstructed images to determine the spatial planar orientation of the utricle and saccule as an example of a downstream application.

Results: We successfully cleared and 3D reconstructed the mouse temporal bone. We determined the planar orientation of the utricle and the saccule to be approximately 53 ± 8 degrees.

Conclusions: Many labeling methods can be successfully used in combination with tissue clearing, imaging and 3D reconstruction in the mouse temporal bone. We hope to use the whole temporal bone optical clearing in combination with vestibular functional studies.

PP1-18 - Selective otolith organ dysfunction in patients with non-spinning vertigo

3. Autonomic Function and Vestibular Disorders

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Purpose: To elucidate the correlation of non-spinning vertigo symptom with the otolith organ dysfunction in patients with sudden deafness.

Methods: We reviewed the clinical records of 86 patients with sudden deafness and divided them into three groups according to the symptom of vertigo: sudden deafness without vertigo group (n = 36), sudden deafness with non-spinning vertigo group (n = 18) and sudden deafness with spinning vertigo group (n = 32). All the patients underwent testing of cervical and ocular vestibular evoked myogenic potentials (cVEMPs and oVEMPs), caloric testing and video head impulse testing (vHIT).

Results: The abnormal rates of VEMPs (either cVEMPs or oVEMPs or both), vHIT and caloric testing were 36.1%, 19.4%, 38.9% in the sudden deafness without vertigo group, 83.3%, 11.1%, 11.1% in the sudden deafness with non-spinning vertigo group and 75%, 68.8%, 78.1% in the sudden deafness with spinning vertigo group.

Conclusions: The symptom of non-spinning vertigo can be caused by selective otolith organ dysfunction.

PP1-19 - The effect of distraction on motion sickness

3. Autonomic Function and Vestibular Disorders

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Purpose: Motion sickness (MS) can affect children, sailors, rally car drivers, fishermen and astronauts. Motion sickness is of vestibular origin, likely otolithic and newly developed symptoms suggest an abnormality in the structures.

Traditional theories about motion sickness have suggested a “sensory conflict”. Reading a book or an electronic reader in a car will increase the conflict and invoke the related symptoms. However some anecdotal observations by us have revealed that engaging in interactive video games in a car can actually serve to reduce these symptoms.

Methods: We developed a questionnaire for children in English and in French for normal children and their parents to ask them about their habits in the car. This included activities in a car, and also the structure of the vehicle they are in, the type of travel undertaken and the length of trip.

Results: Our long term study has shown that there are many different aspects of vehicle travel that can affect motion sickness, there are certain controllable factors that can alleviate those symptoms.

Conclusions: Although this study was carried out in normal children engaged in daily vehicle travel, we feel the information can be translated into a further understanding of motion sickness in other activities, such as rally car driving or deep-sea fishing, as well

as in the patient with vestibular pathology complaining of newly developed motion sickness. All of these situations are a set of symptoms arising from the balance system.

PP1-20 - Efficacy of the Gufoni maneuver for treating the horizontal canal BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the therapeutic efficacies of Gufoni maneuver in geotropic and apogeotropic type of the horizontal canal variant of benign paroxysmal positional vertigo (HC-BPPV),

Methods: Twenty five patients (19 women and 6 men, age range: 14-88 years, mean age 66.9 years) with HC-BPPV were included in this study. All patients had bi-directional-changing positional nystagmus, 13 patients with geotropic type and 12 with apogeotropic type. We underwent Gufoni maneuver immediately after diagnosis. We evaluated the number of days to resolution of nystagmus and symptom.

Results: After the first session of Gufoni maneuver, 2 patients with geotropic type nystagmus switched to apogeotropic type and 7 patients with apogeotropic type switched to geotropic type. The number of resolution days of geotropic type were 4-42days (average 11.4days), on the other hand, the number of resolution days of apogeotropic type were 11-183 days (average 70.3 days).

Conclusions: In geotropic type, patients with no switch to apogeotropic type were easy to resolution. In apogeotropic type, the patients who switch to geotropic type were easy to resolution; on the other hand, patients with no switch to geotropic type took long time to resolution. Although there are intractable cases, Gufoni maneuver is worth to perform.

PP1-21 - 25 (OH) D3 levels, incidence and recurrence of different clinical forms of BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: The aim of this study was to measure the serum levels of 25-hydroxyvitamin D3 (25-OH D3) in patients with BPPV and determine whether there is a difference in the serum levels of vitamin D3 between patients with and without recurrence, as well as between the different clinical forms of BPPV.

Methods: The study included 40 patients diagnosed with PC-BPPV based on the positive Dix-Hallpike's test. All patients underwent Epley manoeuvre after the diagnosis. Patients were classified according to current guidelines for levels of vitamin D3 in the serum in three groups: the deficiency, insufficiency and adequate level.

Results: The average serum level of 25-OH D3 among respondents was 20.78 ng/mL, indicating a lack or insufficiency of the aforementioned 25-OH D3. According to the levels of 25-OH D3, most patients suffer from deficiency (47.5%). 7 (17.5%) respondents had adequate blood level of 25-OH D3, and 14 (35%) respondents suffer from insufficiency. A significant difference was not found in the serum level of 25-OH D3 between patients with and without BPPV recurrence. There was a significant difference in the serum levels of 25-OH D3 in comparison to the clinical form of the disease. Lower 25-OH D3 values were found in patients with canalithiasis compared to those with cupulolithiasis.

Conclusions: Given that the largest number of patients has decreased values of 25-OH D3, it is recommended that all patients diagnosed with BPPV have 25-OH D3 levels measured and in the event of reduced values implemented adequate replacement therapy.

PP1-22 - Accuracy of Questionnaire-Based Diagnosis of Benign Paroxysmal Positional Vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: To develop an algorithm for self-diagnosis of benign paroxysmal positional vertigo (BPPV) using a simple questionnaire that is feasible for self-administration of an appropriate canalith repositioning procedure (CRP) when BPPV recurs.

Methods: We developed a questionnaire that is consisted of six questions, the first three to diagnose BPPV and the following three to determine the involved canal and type of BPPV. From 2016 to 2017, 578 patients with dizziness completed the questionnaire before the positional tests using a video-oculography at the outpatient Dizziness Clinic of Seoul National University Bundang Hospital.

Results: Of the 578 patients, 200 were screened to have BPPV and 378 were decided to have dizziness/vertigo due to disorders other than BPPV based on the results of questionnaire. The sensitivity and specificity of the questionnaire for diagnosis of BPPV were 87% and 90% respectively. Of the 200 patients with a questionnaire-based diagnosis of BPPV, 30 failed to respond the Q4-6 to determine the involved canal and type of BPPV. The questionnaire and positional tests showed the same results on the subtype and affected side of BPPV in 121 patients (60.5%). Cohen's Kappa indicates a substantial agreement (Kappa index =0.673) between the questionnaire and positional tests. Overall, the questionnaire could identify the affected canal and type accurately in 121 (65%) of the 185 patients with confirmed BPPV on positional tests.

Conclusions: The accuracy of questionnaire-based diagnosis of BPPV is acceptable, and self-treatment of BPPV may be first attempted by adopting an appropriate CRP based on the results of questionnaire.

PP1-23 - Apogeotropic variant of posterior semicircular canal benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: The aim of this study is to verify that debris could sometimes localize into PSC close to the common crus, thus configuring the apogeotropic PSC-BPPV, characterized by torsional down beating-paroxysmal positional nystagmus (TDB-PPN) in Dix-Hallpike position, and to allow the differential diagnosis from Anterior Semicircular Canal (ASC) BPPV, characterized by the same nystagmus direction.

Methods: From January to August 2014 we selected 28 patients complaining of positional vertigo with TDB-PPN in Dix-Hallpike position. All of them were submitted to specific physical therapies aimed to cure apogeotropic PSC-BPPV: in 23 patients we used a liberatory manoeuvre, in 5 patients we used a forced prolonged position. All patients were checked within three days.

Results: The liberatory manoeuvre was effective in 20 out of 23 patients: 13 patients completely recovered and 7 showed a typical PSC-BPPV torsional up-beating paroxysmal positional nystagmus (TUB-PPN). The forced prolonged position had a positive outcome in 3 of 5 patients: one patient was symptoms and signs free and 2 had a typical TUB-PPN.

Conclusions: The described therapeutic techniques were successful in 82.1% of cases, either recovering the apogeotropic PSC-BPPV or transforming it in a typical PSC-BPPV form. Our study confirms both ASC BPPV and apogeotropic PSC-BPPV can manifest with identical TDB-PPN. The TDB-PPN recovery or its transformation into typical PSC-BPPV with TUB-PPN, allow us to distinguish ASC-BPPV from PSC-BPPV apogeotropic variant.

PP1-24 - Asking about dizziness when turning in bed predicts benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: This study aims to assess useful questions when suspecting benign paroxysmal positional vertigo (BPPV) caused dizziness as well as identifying if a single question can usefully identify or distinguish patients with BPPV from other dizziness aetiology.

Methods: A total of 149 patients were included in the study. Patients admitted to the Ear, Nose and Throat department due to complaints of dizziness or vertigo were included. The patients answered a study-specific questionnaire and were investigated with Dix-Hallpike manoeuvre and the supine roll test. The diagnosis of BPPV was set following a positive Dix-Hallpike manoeuvre or supine roll test including presence of canal specific nystagmus.

Results: Two of the 17 questions were of diagnostic importance. Dizziness when laying down or turning over in bed, increased the likelihood of a BPPV diagnosis by an odds ratio (95% CI) of 60 (7.47-481.70) and identified patients with a clinical diagnosis of BPPV at 98% sensitivity and 60% specificity. Continuous dizziness duration as opposed to lasting seconds decreased the likelihood of BPPV with an odds ratio of 0.06 (0.01-0.27).

Conclusions: Dizziness when turning in bed is highly correlated to BPPV. A negative response to the question of dizziness in bed was 98% accurate in ruling out BPPV in a sample with a 39% prevalence. Vertiginous attacks when turning or laying down in bed together with dizziness < 1 minute, are impor-

tant questions when taking a medical history and may help to early identify BPPV, also for non-medical staff, as well as reduce the need of further investigations.

PP1-25 - Canalith jam of the horizontal canal masquerading as acute vestibular loss: role of the video-HIT

4. Benign Paroxysmal Position Vertigo

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Purpose: The differential diagnosis in case of spontaneous horizontal nystagmus (SHN) can be challenging. Thanks to the introduction of the video head impulse test (vHIT), peripheral SHN can be easily differentiated from SHN of central origin. Moreover, diagnosis of selective, partial or total loss of vestibular sensors/afferents can be made by matching vHIT data with cervical- and ocular-VEMPs results. We present a case of SHN where vHIT allowed to hypothesize a spontaneous plug due to a canalith jam as possible underlying mechanism.

Methods: A 74-year old woman presented with a history of acute vertigo, left-beating SHN and a clinical picture consistent with right peripheral acute vestibular loss. Bithermal caloric test (BCT) revealed a severe right unilateral weakness (90%). Nevertheless, both cervical- and ocular-VEMPs were symmetrical and vHIT revealed an isolated hypofunction of the right horizontal canal (RHC).

Results: After repeated head-roll maneuvers, bilateral positional paroxysmal geotropic horizontal nystagmus was evoked by Pagnini-McClure maneuvers suggesting BPPV involving the non-ampullated arm

of the RHC. Restitution of RHC function after repositioning maneuvers was confirmed by vHIT and BCT. A spontaneous canalith jam affecting the RHC, leading to an isolated and transitory canal pseudo-areflexia, could be likely responsible for the presenting signs.

Conclusions: An extensive assessment of vestibular sensors and afferents should always be given in case of SHN. A canalith jam should be considered in case of selective canal dysfunction on vHIT. Similarly, canalith jam of vertical canals could likely account for selective and transient canal dysfunctions leading to spontaneous torsional nystagmus, generally considered of central origin.

PP1-26 - Characteristics of the Recurrence of Idiopathic Benign Paroxysmal Positional Vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the clinical features of the recurrence of idiopathic benign paroxysmal positional vertigo (IBPPV) patients. Methods Patients with IBPPV were enrolled and were followed-up for 36 months after being well controlled. The data of the patients including age, gender, and co-morbidities (hypertension, diabetes, hyperlipidemia,) were analyzed. Characteristics of the recurrent BPPV were compared with those of the former onset.

Methods: Patients with IBPPV were enrolled and were followed-up for 36 months after being well controlled. The data of the patients including age, gender, and co-morbidities (hypertension, diabetes, hyperlipidemia,) were analyzed. Characteristics of the recurrent BPPV were compared with those of the former onset.

Results: Two hundred and one patients were enrolled in study and twenty two (10.5%) patients presented recurrent IBPPV within 36 months. Among them, about 16% showed changes in the involved semicircular canals. 50% recurrence occurred within 6 months after the first treatment. The recurrence rate of BPPV in 5060 years old patients(50%) is

higher than other patients ($P=0.018$). Both the gender, and co-morbidities (hypertension, diabetes, hyperlipidemia) showed no significant difference between the two groups.

Conclusions: The incidence of recurrence in idiopathic BPPV patients was 10.5% in the present study. The mean period of 50% recurrence after a symptom-free interval was about 6 months. Furthermore, about 50% of patients suffered from recurrence of idiopathic BPPV at a different type of canal from the semicircular canal of the initial idiopathic BPPV attack. Age but not gender or co-morbidities might be correlated with BPPV recurrence.

PP1-27 - Characteristics and recurrent risks of Benign Paroxysmal Positional Vertigo in young and elder group

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the characteristics and recurrent risk of the Benign Paroxysmal Positional Vertigo (BPPV) in young and elder patients.

Methods: A total of 354 patients with BPPV treated and completed follow-up in our clinic between January 2010 to June 2015 were enrolled, including 127 patients aging from 18 to 45 years old (young group) and 227 patients more than 60 years old (elder group). The characteristics and recurrent risks of BPPV in young and elder patients were evaluated.

Results: There were 58 males and 69 females in young group, and 81 males and 146 females in elder patients, with no significant difference in gender between two groups ($P=0.065$). There were no significant difference in the frequency of cases with Meniere's disease, sudden hearing loss, migraine, head trauma, and history surgery ($P0.05$). But the prevalence of hypertension, hyperlipemia, diabetes,

coronary heart disease, arterial plaque and cerebral infarction in elder group was higher than in young group ($P<0.05$). The recurrent rate of BPPV one month after repositioning maneuvers was 16.5% in young group and 29.1% in elder group, with significant difference ($P=0.009$). Meniere's disease and hypertension are independent risk factors of the recurrence of BPPV in elder group. The recurrence of the elder than 60 year-old BPPV group combining with 0,1, ≥ 2 cerebrovascular disease risk factors respectively is 7.5%, 10.7%, 47.4%.

Conclusions: The prevalence of hypertension, hyperlipemia, diabetes, coronary heart disease, arterial plaque and cerebral infarction in elder group was higher than in young group. Meniere's disease and hypertension are independent risk factors for the recurrence of BPPV in elder group.

PP1-28 - Characteristics of Benign Positional Vertigo Tested on the Epley Omniax Chair

4. Benign Paroxysmal Position Vertigo

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Purpose: To describe the spatiotemporal characteristics of BPV and its variants.

Methods: We studied 2559 consecutive patients referred to a neuro otology clinic dedicated to the management of BPV. Patients were tested on the Epley Omniax Rotator, a positioning device which allows alignment of the patient in the plane of any given canal and simultaneously display and records video oculography. Video data was extracted and analysed offline using a custom written LabVIEW programme. Nystagmus onset, duration and slow phase velocities were analysed.

Results: BPV was diagnosed in 1207 subjects: 814 had unilateral posterior-canalithiasis while 167 had bilateral posterior-canal involvement and 72 patients had more than 2 canals affected; 96 patients had horizontal-canal BPV. In 11 patients anterior-canal BPV was found. In PC BPV, nystagmus onset

occurred before 1 second in 73% subjects. Nystagmus duration was 13.4 sec (median). The median peak-SPV was 32.4/sec. In horizontal-canalithiasis with the affected ear down, nystagmus onset was <1 s in nearly all subjects. Nystagmus lasted for 22.5 sec (median) and peaked at 56.8/sec (median). When the unaffected ear was lowermost the nystagmus duration was similar 25 s (median) and peak-SPV 18.1/sec. In all subjects with canalithiasis, the time taken for the peak-SPV to halve (T50) was <60 s. In contrast, subjects diagnosed with vestibular migraine ($n=334$) had persistent vertical or horizontal positional nystagmus with a T50 that exceeded 60s.

Conclusions: Canalithiasis uniformly demonstrated a crescendo decrescendo SPV profile. Symptomatic horizontal or vertical positional nystagmus recorded in canalithiasis could be separated from horizontal positional nystagmus recorded in vestibular migraine.

PP1-29 - Clinical analysis of benign paroxysmal positional vertigo with multiple canal involvement

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the clinical features, diagnosis and treatment of multi-canal benign paroxysmal positional vertigo (BPPV).

Methods: 41 patients with multi-canal BPPV who received treatment between January 2015 and December 2017 were included in this study. All included patients were diagnosed according to the nystagmus as confirmed by videonystagmograph during the Dix-Hallpike, straight head hanging and Roll tests and treated according to the involvement of canal (Epley's maneuver for the posterior canal, Yacovino maneuver for the anterior canal, Barbecue or Gufoni maneuver for the lateral canal).

Results: Among 267 patients with BPPV, 41 (15.4%) developed multi-canal BPPV. These 41 patients consisted of 15 (36.6%) males and 26 (63.4%) females,

with an average age of 64.24 ± 13.93 . Seventeen patients (41.5%) had up-beating nystagmus with torsional components and horizontal nystagmus, suggesting BPPV involving both posterior and lateral canals. Eleven patients (26.8%) had up-beating nystagmus with torsional components and down-beating nystagmus with or without torsional components, suggesting BPPV involving both posterior and anterior canals. Eleven patients (26.8%) had down-beating nystagmus with or without torsional components and horizontal nystagmus, suggesting BPPV involving both anterior and lateral canals. Two patients (4.9%) had bilateral up-beating nystagmus with torsional components, suggesting BPPV involving bilateral posterior canals. Thirty-one (75.6%) of the patients were cured after one or two maneuvers. Thirty-seven patients (90.2%) were cured with an average of 2.1 therapeutic sessions per patient.

Conclusions: Multi-canal BPPV is not so rare, and the posterior and horizontal canals are involved in most cases. Repositioning maneuver is effective for multi-canal BPPV.

PP1-30 - Clinical characteristic and risk factor of canal conversion in benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: The purposes of this study were to investigate the incidence of canal conversion in benign paroxysmal positional vertigo (BPPV) and to analyze the risk factors and clinical features of the canal conversion.

Methods: We retrospectively reviewed medical chart in 2450 patients diagnosed with BPPV from March 2012 to December 2017. The following parameters were analyzed in patients with (canal conversion group) and without canal conversion (non-canal conversion group) after canalith repositioning procedure (CRP) for treatment: demographics including age and sex, etiology, side and type of semicircular canal involved, and type and number of CRP.

Results: Canal conversion occurred in 56 of total 2450 patients (2.3%). Demographic, etiology, and side of semicircular canal involved did not differ between the two groups. However, canal conversion occurred more commonly in the lateral semicircular canal (LC) than in the posterior semicircular canal, (PC) which was statistically significant ($P = 0.003$). There were no significant differences in those parameters in patients with and without canal conversion in the PC. In the LC, the parameters did not differ according to the presence of canal conversion. Furthermore, there was no difference in those parameters when analyzed by type of conversion.

Conclusions: There is no difference in the outcome of treatment, such as the number of CRP in patients with or without canal conversion, but canal conversion can occur in approximately 2.3% of BPPV patients. Moreover, the canal conversion is more common in LC than in PC, so the possibility of canal conversion should be considered in treating BPPV in LC.

PP1-31 - Demographics of patients with BPPV and treatment efficacy in the Singapore population

4. Benign Paroxysmal Position Vertigo

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Purpose: BPPV is one the commonest vestibular conditions. This study aims to investigate the demographics of BPPV patients and treatment efficacy for patients with BPPV by physiotherapists in Singapore.

Methods: 536 patients with BPPV referred for vestibular rehabilitation from 2004 to 2015 were retrospectively analysed. Patients were assessed with Dix Hallpike Test and Supine Roll Test (Pagnini-McClure) for vertical and horizontal canals BPPV respectively, and treated with appropriate repositioning maneuvers by three vestibular rehab-trained physiotherapists. Maneuvers were repeated, if vertigo and nystagmus persisted upon re-evaluation of tests until patients were asymptomatic or unable to tolerate further maneuvers. Successful treatment was determined by resolution of symptoms following

re-evaluation of tests 1-2 weeks post treatment. The Dizziness Handicap Inventory (DHI) was also administered to evaluate the self-perceived handicap effects of dizziness pre and post treatment.

Results: The mean age onset of BPPV is 57 years. Females:male ratio = 2:1. 97% of patients have Canalolithiasis is the most common type of BPPV (97%). Canal type was posterior (71%), horizontal (12%), anterior (6.5%) and indeterminate (9.7%).

The success rate of the repositioning techniques is 71% within 2 maneuvers within a single treatment session. 98% of all patients are symptom free after repositioning within 3 physiotherapy sessions. Compared to pre-treatment, there was a significant improvement in self-reported DHI scores post-treatment. ($p = 0.000$, $p < 0.05$).

Conclusions: The demographics and treatment effectiveness of patients with BPPV for the Singapore population is high and comparable with other populations.

PP1-32 - Diagnosis and Treatment of Anterior Canal Benign Paroxysmal Positional Vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the diagnosis and treatment of anterior canal benign paroxysmal positional vertigo (AC-BPPV).

Methods: Forty patients (14 males and 26 female) diagnosed with AC-BPPV were enrolled. All patients were diagnosed based on the presence of nystagmus during the Dix-Hallpike (D-H), straight head hanging (SHH) and Roll tests and were treated by Yacovino maneuver.

Results: In the D-H test, down-beating nystagmus (DBN), and DBN with torsional components were observed in 22 and 18 patients, respectively. In the SHH, DBN, and DBN with torsional components

were observed in 37 and 3 patients, respectively. The type of nystagmus evoked through D-H and SHH tests was statistically different ($P < 0.05$). The right and left sides AC-BPPV were 17 (42.5%) and 12 (30%), and 11 patients (27.5%) were not clear the affected side. 11 patients had combined the posterior canal BPPV, and 11 patients had combined horizontal canal BPPV. 39 patients (1 patient were treated before and recovered) were treated by Yacovino maneuver. 34 patients (87.1%) were cured after treatment for an average 1.8 times. Diagnosis method: 17 patients were diagnosed by the effectiveness of treatment, 20 patients were diagnosed by the combination of other canal typical BPPV, and 3 patients were diagnosed by the canal conversion during follow-up.

Conclusions: D-H often evoke DBN with torsional component, and is more beneficial to identify the affected side of AC-BPPV compared with the SHH. The effectiveness of Yacovino maneuver, the presence of typical BPPV, canal conversion phenomenon and follow-up outcomes contribute to the diagnosis of AC-BPPV. Yacovino maneuver was effective in AC-BPPV patients.

PP1-33 - Effect of Intratympanic Steroid Injection in Light Cupula

4. Benign Paroxysmal Position Vertigo

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Purpose: To evaluate the effects of intratympanic steroid injection in light cupula.

Methods: 47 patients with persistent geotropic direction changing positional nystagmus with null point (light cupula) participated in this study. All study populations were randomly classified into three groups on initial visit day: the intratympanic steroid injection (ITS, $n=15$) group, Vestibular suppressant (VS, $n=16$) group (treated with a vestibular

suppressant [dimenhydrinate 50 mg per day for 1 week]) and canalith repositioning procedures (CRP, n=16) group. Positional nystagmus, dizziness handicap inventory (DHI) questionnaires and dizziness severity by visual analogue scale (VAS) were completed before and after each treatment.

Results: The DHI score before treatment in ITS, CRP and VS groups were 35.8, 34.06, and 34.75, respectively. At 1 week after the 1st treatment, the score had statistically significantly decreased in all groups. But, there were no differences among three groups. At 1 week after the 1st treatment, patients who showed resolution of persistent geotropic DCPN in ITS, CRP and VS groups were 7, 6 and 7, respectively. There were no significant differences between three groups. In ITS group only, however, reversal of stronger side on head roll test after each treatment was observed in 6 patients, and 2 out of 6 patients showed early resolution of DCPN at 3rd day.

Conclusions: ITS was not significantly effective for the light cupula at 1 week follow up. But, some patients of ITS group showed reversal of stronger side in DCPN on head roll test and resolution of DCPN at earlier follow up.

PP1-34 - Efficacy of Gufoni maneuver and head-shaking for treating apogeotropic horizontal BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: To evaluate the efficacy of Gufoni maneuver and Head-shaking for treating apogeotropic horizontal benign paroxysmal positional vertigo HC-BPPV, a randomized, prospective study was conducted.

Methods: A total of 84 patients from October 2014 to October 2017 with apogeotropic HC-BPPV in the Dizziness Clinic in Xiangyang Center Hospital were randomly assigned to group A Gufoni maneuver, n=29, group B (Head-shaking, n=28 and group C (Brandt-Daroff exercise) n=27). These maneuvers were performed once a day until the treat-

ment success. Successful treatment was defined as disappearance of positional nystagmus or as transition into geotropic horizontal nystagmus. The efficacy were evaluated at the 1st hour, 3rd day and 1st week after treatment.

Results: The 1st hour after treatment, the successful cases of group A, B and C were respectively 15/29, 15/28 and 7/27. The efficacy in group AP=0.048 and group BP=0.036 is better than that in group C, but there was no difference between group A and group B (P=0.889). On the 3rd day, the success rate of group A, B and C were respectively 82.76%, 85.71% and 62.96%, the therapeutic effect between group A and B P=0.760 and CP=0.095 and CP=0.053 had no significant difference. One week after treatment, the success rate of group A, B and C were respectively 93.10%, 92.86% and 77.78%, the therapeutic effect between group A and B (P=0.971) and C (P=0.101), B and C (P=0.113) had no difference.

Conclusions: Both Gufoni maneuver and Head-shaking are effective treatment for apogeotropic HC-BPPV and they are better than B-D exercise at immediate (1 hour) effect. However, there is no difference between the three methods on the 3rd day and 1st week after treatment.

PP1-35 - Frequency tuning of ocular vestibular evoked myogenic potential in BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: The aim of this study was to investigate changes in the frequency tuning of the ocular vestibular evoked myogenic potential (oVEMP) in patients with idiopathic benign paroxysmal positional vertigo (IBPPV).

Methods: A total of 103 consecutively consenting patients with IBPPV were included in the study: 42 patients with horizontal semicircular canal IBPPV and 61 patients with posterior semicircular canal

IBPPV. As normal controls, 30 age-matched healthy patients were enrolled in the study. The oVEMP were recorded using air-conducted tone bursts at 500 Hz and 1000 Hz, and the 500/1000 Hz amplitude ratio of oVEMP was determined.

Results: The 500/1000 Hz amplitude ratio of the N1-P1 wave complex of the oVEMP in the affected ears was significantly lower than that of the unaffected ears and normal control ears. The unaffected ears of the IBPPV subjects also showed a lower amplitude ratio compared to that of the healthy controls, but the difference was not statistically significant. No significant differences in the 500/1000 Hz amplitude ratio of the oVEMP were found between the Horizontal Canal IBPPV and Posterior Canal IBPPV patients.

Conclusions: IBPPV can affect the frequency tuning of ocular vestibular evoked myogenic potential and decrease the sensitivity of low-frequency sound signals in the utricular otolith organs.

PP1-36 - Idiopathic benign paroxysmal positional vertigo in the elderly: A long-term follow-up study

4. Benign Paroxysmal Position Vertigo

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Purpose: Benign paroxysmal positional vertigo (BPPV) is the most common cause of peripheral-type vertigo in the elderly. While some studies have investigated BPPV among the elderly, no study has focused on the isolated idiopathic BPPV (iBPPV) in the elderly.

Therefore, this study was to investigate the clinical features and recurrence rate in elderly patients diagnosed with iBPPV.

Methods: The authors prospectively reviewed the medical records of 627 patients diagnosed with BPPV, and a total of 370 patients fulfilled the inclusion criteria. The subjects were divided into two groups by age (experimental group ≥ 65 years

and control group 17-64 years), and the gender, numbers of canalith reposition maneuver (CRM) for successful treatment, time elapsed from onset of symptoms to clinic visit, the affected semicircular canal, and the 1- and 5-year recurrence proportion were analyzed.

Results: The gender, numbers of CRM for successful treatment, affected semicircular canal, and the 1- and 5-year recurrence proportion showed no statistically significant difference between two groups ($p > 0.05$). The only exception was the experimental group which took a longer duration from manifestation of symptoms to hospital visit than control group (student's t test, $p = 0.021$).

Conclusions: The elderly with iBPPV could be treated as effective as general population.

PP1-37 - Immediate efficacy of Gufoni maneuver for HC-BPPV: a meta-analysis

4. Benign Paroxysmal Position Vertigo

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Purpose: Gufoni maneuver is a very common and efficient treatment for horizontal canal benign paroxysmal positional vertigo (HC-BPPV), with which patients with either a canalolithiasis or a cupulolithiasis can be successfully treated. However, there is no evidence-based study to reveal the immediate efficacy of this maneuver for HC-BPPV. Therefore, This meta-analysis aims to systematically measure the immediate efficacy of the Gufoni maneuver for HC-BPPV.

Methods: A extensive search electronic databases, including PubMed, Embase, Web of Science, Cochrane and Chinese medical databases, were searched until to September 1, 2017 for relevant articles. we selected only randomized clinical trials studying with treatment of HC-BPPV employ by the Gufoni maneuver.

Results: Six randomized clinical trials were included in the current meta-analysis with a total of 696

HC-BPPV patients. The pooled odds ratio of efficacy (ORE) and odds ratio of otolith switch (ORos) were used to estimate overall therapeutic performance. The pooled OREs were 4.00 (95% CI, 2.05-7.78, $p < 0.01$, Gufoni VS. Sham), 1.87 (95% CI, 0.42-8.33, $p = 0.41$, Gufoni VS. Barbecue maneuver), while the pooled ORos was 2.17 (95% CI, 0.55-8.53, $p = 0.27$). Subgroup analyses showed that the respective pooled OREs were 3.51 (95% CI, 2.09-5.89, $p < 0.01$) and 3.23 (95% CI, 1.24-8.39, $p < 0.05$) in groups of geotropic nystagmus and geonegative nystagmus.

Conclusions: Gufoni maneuver has a satisfactory immediate efficacy for HC-BPPV and doesn't increase otolith switch.

PP1-38 - Objective Characteristics of Nystagmus in Posterior Semicircular Canal BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: To analyze and discuss the clinical characteristics and mechanism of nystagmus direction, latency, duration time and intensity in posterior semicircular canal benign paroxysmal positional vertigo.

Methods: Subjects in the study were 564 patients with Posterior Semicircular Canal Canalithiasis/PSC-Can BPPV. The induced nystagmus in Dix-Hallpike test was recorded by video nystagmograph (VNG) and the direction, latency, duration time and intensity characteristics of nystagmus were compared in hanging and sitting

Results: Vertical torsional nystagmus were both induced by hanging and sitting in Dix-Hallpike test. The vertical direction of the induced nystagmus is upward and downward respectively. The latency, duration time and intensity turning to lesion side were 12.65 ± 1.92 ; 1.44 ± 1.24 ; 14.90 ± 10.46 ; 15.28 ± 8.06 ; 29.75 ± 21.26 ; 14.08 ± 9.48 . The latency, and intensity in hanging were larger than sit. The intensity rate is about 2:1, the difference is statistically significant. The direction of the induced nystagmus is

opposite to turning in HSC-Can BPPV. The intensity turning to normal side were larger than lesion side obviously. The intensity rate is about 2:1, the difference is statistically significant ($t = 17.296$, $P = 0.01$)

Conclusions: a. The nystagmus intensity rate in Dix-Hallpike test of hanging to lesion side in PSC-Can was 2:1, following Ewald's law; b. BPPV is either a disease, or a physical model to study the single semicircular-nystagmus effect; c. These nystagmus parameters of VNG in Dix-Hallpike test is an objective guideline for BPPV diagnose.

PP1-39 - Optimal reassessment timing after treatment in posterior canal benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: The aim of this study is to evaluate the optimal reassessment time for treatment response in posterior canal benign paroxysmal positional vertigo (p-BPPV) following the initial Epley maneuver.

Methods: This is a prospective, single-blinded, randomized study that included 108 patients with p-BPPV who agreed to participate. All patients included in the study received a single modified Epley maneuver (recommended by the 2008 AAO guideline) daily until the positional nystagmus disappeared during the Dix-Hallpike maneuver 24 hours after the treatment. Repeated Dix-Hallpike testing to reassess the treatment response was performed at 1 hour (post-1 hr), every 24 hours (post-24 hr) until resolution of positional nystagmus, 1 week (post-1 wk), and 1 month (post-1 mo) following the therapeutic maneuver. The difference in the resolution rate at post-1 hr and post-24 hr reassessment was analyzed and the recurrence rates at post-1 wk and post-1 mo were evaluated.

Results: The resolution rate was 67.6% at post-1 hr which increased to 79.6% at post-24 hr reassessment. There was statistically significant difference in the results of the Dix-Hallpike test between post-1

hr and post-24 hr follow-up. After complete resolution, nine of 108 patients (8.3%) demonstrated recurrence within 1 month.

Conclusions: Reassessment after 24 hours following the initial Epley maneuver is more advantageous than 1-hour follow-up in patients with p-BPPV. This information may provide helpful guideline for clinicians in deciding the appropriate follow-up period after treatment in p-BPPV.

PP1-40 - Positional downbeat nystagmus in posterior canal benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: To assess the incidence and clinical significance of positional downbeat nystagmus (pDBN) after treatment of posterior canal benign paroxysmal positional vertigo (PC BPPV).

Methods: We have recruited 77 patients with a diagnosis of PC BPPV. After Epley maneuver, we assessed the presence of DBN during follow-up positional tests. We compared clinical characteristics between pDBN (+) and pDBN (-) group in patients with successful treatment.

Results: Of 57 patients with successful treatment, 22 (39%) showed pDBN during one hour follow-up tests. The mean latency and duration of pDBN were 3.2 ± 2.0 and 12 ± 10.0 s (mean \pm SD), respectively. The maximal SPV of pDBN ranged from 2.0 to 12.2 degree (mean \pm SD = 5.1 ± 2.5 degree). A torsional component was detectable in six patients. At one week follow-up, there was no difference in the questionnaires scores between pDBN (+) and pDBN (-) group, but a recurrence rate was significantly higher in pDBN (+) group (5/22, 23%) than pDBN (-) group (1/31, 3%, $p=0.036$). pDBN disappeared in all patients within 6 months.

Conclusions: Our study shows that transient pDBN can be observed in 40% of patients after a successful treatment of PC BPPV. The patients with pDBN showed a high tendency of recurrence within one week. The pDBN may be caused by the remaining debris in the distal portion of the PC, which can move towards the ampulla producing an ampullopetal endolymphatic flow during positioning.

PP1-41 - Relationship between clinical features and therapeutic approach in benign BPPV outcomes

4. Benign Paroxysmal Position Vertigo

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Purpose: To examine the age and gender distribution of patients, clinical features, treatment methods and outcomes of benign paroxysmal positional vertigo.

Methods: We reviewed 357 BPPV patients for 5 years. Posterior canal BPPV patients were divided into 2 groups, one underwent the Epley manoeuvre and the other received medication. Lateral canal canalolithiasis patients were divided into 2 groups, one underwent the Lempert manoeuvre and the other received medication.

Results: In the posterior canal BPPV group, the average resolution time was 9.6 days. The average resolution time was 7.7 days in the Epley manoeuvre group and 14.1 days in the medication group. In the lateral canal canalolithiasis group, the average resolution time was 11.1 days. The average resolution time was 8.3 days in the Lempert manoeuvre group and 13.4 days in the medication group. In the lateral canal cupulolithiasis group, the average resolution time was 36.7 days. The average age at recurrence was 61.3 years at the 1st recurrence, 64.5 years at the 2nd recurrence, and 68.0 years at the 3rd recurrence. As the number of recurrences increased female gender predominance increased.

Conclusions: In posterior canal BPPV patients, the resolution time in the Epley manoeuvre group was significantly shorter than in the medication group. In

lateral canal canalolithiasis patients, the resolution time in the Lempert manoeuvre group was significantly shorter than in the medication group. The resolution time was significantly longer in the lateral canal cupulolithiasis group than in other types of BPPV. As the number of recurrences increased, average age and female gender predominance increased.

PP1-42 - Residual dizziness after repositioning in BPPV with preexisting central neurologic disorders

4. Benign Paroxysmal Position Vertigo

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Purpose: Diagnosis and treatment of BPPV in patients with preexisting central neurologic disorders is not always straightforward. Except for migraine, the effectiveness of repositioning treatment in patients with preexisting central neurologic disorders is not described before. In addition, the incidence of residual dizziness after successful repositioning treatment in this group remains unclear.

Methods: Clinical information of consecutive BPPV cases over a duration of 18 months are collected from specialized neurologic clinics in an academic university hospital. After excluding secondary cases, the remaining cases are classified into BPPV with preexisting central neurologic disorders (CND+) group and BPPV without preexisting central neurologic disorders (CND-) group. Age, gender, side of BPPV, involved canal, number of trials for successful repositioning and residual dizziness are compared between both groups.

Results: Clinical data of consecutive 108 cases are collected. Fifteen secondary cases and 1 lost follow-up are excluded. CND+ group comprises 29 cases (13 migraine, 11 cerebrovascular disease, 3 Parkinson disease, 1 restless leg syndrome, 1 orthostatic hypotension) and CND- group comprises 63 cases. Group comparisons (CND+ vs. CND-) show mean age 64.6 vs. 62.7 ($p>0.05$), female 89.6% vs. 63.5% ($p<0.05$), right side 75.9% vs.

52.4% ($p<0.05$), posterior canal 86.2% vs. 66.7% ($p>0.05$), success within 2 trials of repositioning 100% vs. 92.1% ($p>0.05$) and residual dizziness 41.4% vs. 31.7% ($p>0.05$).

Conclusions: Similar to CND- group, CND+ group shows female, right side and posterior canal predominance. Number of trials needed to treat patients and incidence of residual dizziness are not significantly higher in BPPV patients with preexisting central neurologic disorders.

PP1-43 - The discussing between premier solution of Roll Test and Dix-Hallpike Test in BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: To analyze the objective characteristics of Roll Test and Dix-Hallpike Test in benign paroxysmal positional vertigo BPPV patients discussing the premier solution of positional test.

Methods: A total of 230 patients with BPPV whereas 170 PSC-Can BPPV and 60 HSC-Can BPPV were involved respectively. The induced nystagmus in Roll Test and Dix-Hallpike Test was recorded by video nystagmograph (VNG), and the direction, intensity and time characteristics of nystagmus were compared in various BPPV.

Results: Vertically upward nystagmus was induced by hanging in 170 PSC-Can Dix-Hallpike Test, and the nystagmus reversed and turned weaker when the subjects came to sit. The intensity of nystagmus at turning to lesion side by hanging and sit were $(30.3\pm 14.1)^\circ/s$ and $(12.6\pm 7.5)^\circ/s$ respectively. However, no nystagmus was induced in PSC-Can Roll Test. Horizontal nystagmus in the same direction with turning were induced in 60 HSC-Can Roll Test. The intensity of nystagmus at turning to lesion side and normal side were $(42.0\pm 18.0)^\circ/s$ and $(20.3\pm 8.7)^\circ/s$ respectively. Furthermore, horizontal nystagmus in the same direction with turning were induced in 57 HSC-Can Dix-Hallpike. With the results of Roll Test for reference, the coherence is 95%.

Conclusions: Dix-Hallpike Test not only can be used to diagnose PSC-Can, but also induce nystagmus in HSC-Can effectively. Whereas the Roll Test only shown significance in diagnosing HSC-Can.

PP1-44 - Trial of a two-item questionnaire for identifying patients with Benign Paroxysmal Positional Vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: Benign paroxysmal positional vertigo (BPPV) accounts for 19% attendances at our specialist Multidisciplinary Balance Clinic (MBC). Patients with BPPV can often be managed with particle repositioning manoeuvres without need for complex MBC assessments. The aim of the study was to assess effectiveness of a postal screening tool and targeted intervention to identify and treat patients with BPPV.

Methods: Patients on the MBC waiting list in June 2017 were posted a brief paper questionnaire:

- Do you experience dizziness when rolling over in bed?
- Does this dizziness last less than 2 minutes?

Patients with negative responses proceeded to full MBC assessment. Those who responded affirmatively to both questions were triaged to a designated physiotherapy clinic for focussed assessment. Patients diagnosed with BPPV were treated with particle repositioning manoeuvres. Patients without BPPV, and those identified as having additional complex presentations, proceeded to the MBC.

Results: 360 patients were sent questionnaires. 64 responded affirmatively to both questions and were offered appointments; of which 52 patients attended. 19 of these had positive positioning tests. 13 had a suggestive history but negative tests (62% in total). Of those with positive positioning tests, 10 (19% of those seen) were discharged without further intervention; the other 9 had residual symptoms

despite successful BPPV treatment. Therefore 42 (81%) required further intervention.

Conclusions: A simple postal screening tool can identify patients with BPPV with a positive predictive value of 62%, allowing appropriate triage to a targeted clinic. However many such patients have needs which cannot be managed with repositioning alone.

PP1-45 - TRV Chair For Diagnosis and Treatment of BPPV

4. Benign Paroxysmal Position Vertigo

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Purpose: We investigate the diagnostic yield and treatment success rate of the TRV Chair for BPPV, which is thought to be the most common cause of vertigo in adults. Although the TRV Chair is not a recent innovation, it is not widely used in the UK and is under-studied.

Methods: We collected data from 150 patients reporting "positional vertigo" as a symptom by performing positional tests on the bedside directly followed by TRV Chair (and Video Frenzel) assessment. If indicated, subjects were treated with repositioning manoeuvres. Success was measured by complete resolution of symptoms and/or absence of nystagmus at follow up (2-4 weeks post-treatment). Treatment manoeuvres used were Epley, Semont and Lempert.

Results: Preliminary normative data suggests up to 5% of subjects who do not have vertigo will have some degree of positional nystagmus. 90% of patients reporting positional vertigo as a symptom were found to have positional nystagmus (and therefore BPPV). We report an 89% success rate for all subjects with positional nystagmus, 97% success for subjects who were identified without Video Frenzel technology and subsequently treated in the TRV Chair, and 100% success for those identified to have lateral canal BPPV.

Conclusions: The TRV Chair is a very effective method for treatment of BPPV, especially for the

lateral canal form and recurrent, treatment resistant BPPV; further study requires comparison with Video Frenzel alone and comparison of long term recurrence rates compared to traditional methods. Preliminary data suggests BPPV may be even more common than previously documented.

PP1-46 - Use of the Brny Society criteria to diagnose benign paroxysmal positional vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: We reviewed the classifications of different subtypes of benign paroxysmal positional vertigo and the problems we encountered using the diagnostic criteria of the Bárány Society.

Methods: Both the Dix–Hallpike maneuver and supine roll test were performed on 568 patients, and diagnoses were made based on patient history and the type of provoked nystagmus (if any). Next, the numbers of patients with each subtype and other parameters, including age and sex, were analyzed.

Results: Posterior semicircular canal BPPV (pc-BPPV) accounted for the largest proportion, followed by horizontal semicircular canal BPPV (hc-BPPV). Both anterior canal BPPV and multiple canal lithiasis BPPV were rare, and no patient was diagnosed with cupulolithiasis of the posterior canal.

Conclusions: pc-BPPV, hc-BPPV, and hc-BPPV-cu were the three major subtypes that could be definitively diagnosed, whereas the diagnoses of pBPPV and pBPPVsr require further investigation, with special attention being paid to appropriate differentiation and repositioning maneuvers.

PP1-47 - Utility of Bow and Lean Test in Predicting Subtype of Benign Paroxysmal Positional Vertigo

4. Benign Paroxysmal Position Vertigo

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Purpose: To investigate the role of “bow and lean test” (BLT) in the diagnosis of benign paroxysmal positional vertigo (BPPV).

Methods: Between March 2015 and June 2017, we enrolled 113 patients with posterior semicircular canal (PSCC) BPPV, 74 patients with lateral semicircular canal (LSCC) canalolithiasis, 53 patients with LSCC cupulolithiasis, and 32 patients with light cupula. We retrospectively assessed bowing nystagmus (BN) and leaning nystagmus (LN).

Results: In PSCC BPPV, 75% of the patients showed at least one of BN and LN, and direction of nystagmus provoked by a Dix-Hallpike test on the affected side was consistent with that of LN and opposite to that of BN. In LSCC canalolithiasis, 65% (48 of 74) of the patients showed both BN and LN which were in the same direction in 38 patients (of 48) and in the opposite direction in 10 patients (of 48). The affected side can be determined according to the results of BLT in 74% (55 of 74) of LSCC canalolithiasis patients, and among them, the side determined according to the results of head-roll test was discordant with that according to BLT in 20 patients (of 55, 36%). In LSCC cupulopathy ($n = 85$), both BN and LN were persistent and observed in all cases, but we could not distinguish LSCC cupulolithiasis from light cupula according to nystagmus direction in BLT.

Conclusions: Although a BLT yields better lateralization in LSCC canalolithiasis, it may be more useful in predicting the diagnosis and lateralization of PSCC BPPV than LSCC canalolithiasis.

PP1-48 - Vitamin D deficiency and Benign Paroxysmal Positional Vertigo recurrence.

4. Benign Paroxysmal Position Vertigo

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Purpose: The study was carried out to verify the effect of supplementation with Vitamin D (VD) or VD + alpha lipoic acid (ALA) on BPPV recurrence.

Methods: From January 2015 to July 2015 we enrolled 125 patients with recurrent BPPV (78 women and 47 men; average age 56 years). All patients underwent physical therapy and venous blood sampling with dosage of VD. Patients with VD deficiency or insufficiency were supplemented with oral VD or VD + ALA. All patients were checked after 3 (T1), 6 (T2) and 12 (T3) months.

Results: All the patients supplemented with only VD, completely compensated their VD deficiency, showing no BPPV recurrence or lower recurrence at T2. Patients showing longer time to recovery VD deficiency (4 patients were still insufficient at T1) had decreased BPPV recurrence at T3. Patients supplemented with VD + ALA, showed lower BPPV recurrence at T2, and no BPPV recurrence or its decrease at T3. All the patients with VD deficiency and still insufficient at T1 (6 patients) had lower BPPV recurrence. All the patients treated adding ALA had no BPPV recurrence at T3, included 6 patients deficient at T0 and insufficient at T1, 4 patients still insufficient at T1 treated with only VD, despite correcting the VD deficit at T2, showed a decreased BPPV recurrence at T3.

Conclusions: VD supplementation reduces the BPPV recurrence in all the treated patients. The addition of alpha lipoic acid, thanks to its antioxidant properties, further improves these results, especially in patients with higher initial deficit (deficiency) and longer recovery time.

PP1-49 - Cogans syndrome: An autoimmune inner ear disease

5. Bilateral Vestibulopathy

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Purpose: Cogan's syndrome is a rare disease characterized by coexisting audiovestibular and ocular symptoms. We report a case of clinical manifestation, audiovestibular function, treatment and prognosis of Cogan's syndrome to have a better understanding of it.

Methods: We describe a case of Cogan's syndrome in patients with clinical manifestations. The Patient was assessed by Pure tone audiometer, the head impulse protocol and suppression head impulse protocol (HIMPs and SHIMPs), caloric test, vestibular-evoked myogenic potentials (VEMPs) at the initial visit and then then evaluated for symptomatic improvement after 6 months.

Results: The patient had recurrent ocular symptoms for more than ten years, and gradually appeared repeated right knee, right foot pain, accompanied by the collapse nose, ear cartilage bilateral integration, After the emergence of vestibular dysfunction, ears have developed into deafness. The audiovestibular function tests were all abnormal.

Conclusions: Cogan's syndrome is a rare syndrome with multiple symptoms of ocular symptoms and ear symptoms. The symptoms are not specific and the early diagnosis is difficult. However, the auditory-vestibular system is often poorly predicted and needs to be diagnosed by early diagnosis and treatment.

PP1-50 - Etiology analysis and vestibular assessment of bilateral vestibulopathy

5. Bilateral Vestibulopathy

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Purpose: To define clinical and laboratory characteristics of bilateral vestibulopathy (BVP) and to propose diagnostic criteria of this disorder based on clinical and laboratory vestibular function test findings.

Methods: 42 case series with a clinical suspicion of BVP were retrospectively analyzed, in an attempt to determine etiology. Presenting auditory-vestibular symptoms, bedside dynamic visual acuity tests and laboratory test were reviewed, including bithermal caloric test, rotatory chair tests, video head impulse test (vHIT), vestibular-evoked myogenic potentials (VEMP).

Results: Among these 42 patients, dizziness was seen in 42 cases (100%) oscillopsia was seen in 21 cases (50%) Hearing loss was seen in 30 (71.4%). Eight cases (19%) had tinnitus 25 cases showed vestibular loss in dynamic visual acuity test (69.4%). Definite diagnosis of complete BVP was made in 36 patients when the patients showed abnormal findings on caloric test, rotatory chair test and vHIT tests in addition to the symptoms. Whereas probable diagnosis of partial BVP was obtained in 6 patients with abnormal caloric test and rotatory chair test but no pathological vHIT. VEMP (ocular or cervical) could be recorded in 20 patients. 14 cases were caused by ototoxic drugs while no causes could be determined in 6 cases among these 42 cases.

Conclusions: The diagnosis of BVP is challenging. Vestibular laboratory test battery which reflect full frequency function of VOR has great value to confirming the diagnosis and differentiate definite complete BVP to possible partial BVP. Diagnosis standard shall be made combining clinical history, characteristic symptoms and the results of auditory-vestibular function testing. Ototoxic drugs contribute most considering etiology.

PP1-51 - Frequency properties of postural sway in bilateral vestibulopathy and somatosensory disorder

5. Bilateral Vestibulopathy

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Purpose: To assess the frequency characteristics of postural instability in patients with idiopathic bilateral vestibulopathy (IBV) in comparison with those with somatosensory disorder.

Methods: 36 patients with IBV, 26 patients with somatosensory disorder, and 194 healthy controls were included. In posturography test, two-legged stance tasks were performed in 4 conditions: eyes open with and without foam rubber, and eyes closed with and without foam rubber. We normalized frequency distribution provided by maximum entropy method from 0.01 Hz to 10 Hz every 0.5 Hz about the anterior-posterior and the left-right direction. We defined the "eyes-open-closed difference" as the difference between the normalized values with the eyes closed and that with the eyes open. In addition, we defined the "rubber difference" as the difference between the normalized values with and without foam rubber. We regarded power beyond averages $\pm 2SD$ of healthy controls as abnormal.

Results: In IBV patients, postural abnormalities were observed in widespread frequencies in the conditions with eyes closed with and without foam rubber. On the other hand, in patients with somatosensory disorder, those were especially observed above 6 Hz in the conditions with eyes closed with and without foam rubber. The abnormality of the rubber difference was characteristic of IBV patients, and the abnormality of the eyes-open-closed difference was characteristic of patients with somatosensory disorder.

Conclusions: The frequency power spectrum analysis of postural stability is useful for the differentiation between IBV and somatosensory disorder.

PP1-52 - Impact of Bilateral Vestibulopathy on Spatial and non-Spatial Cognition: a Systematic Review

5. Bilateral Vestibulopathy

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Purpose: Growing evidence in animal and human studies suggest that not only hearing loss, but also vestibular loss might result in cognitive deficits. In this review our aim is to evaluate the presence of spatial and non-spatial cognitive deficits in patients with bilateral vestibulopathy (BVP), with and without hearing loss.

Methods: We performed a systematic review according to the PRISMA guidelines on studies considering cognitive performances in BVP patients. Three independent researchers explored Medline and the Cochrane Library. Studies reporting on cognition in BV patients were included according to a predefined eligibility assessment. Data of the patients' characteristics and their cognitive outcomes were extracted.

Results: Seven studies reporting on 73 BVP patients matched the inclusion criteria. Overall, the methodology of the included papers was of good quality. Criteria for including BVP patients varied widely across studies. Cognitive domains evaluated in patients included visuospatial abilities, memory, language, attention and executive function. Only in one of the seven studies hearing performance of the included patients was briefly described. Nearly all studies demonstrated a significant impairment of spatial cognition in BVP patients. Only recent papers investigated other cognitive domains than spatial cognition. In these papers a negative impact of BVP on the other cognitive domains was also described.

Conclusions: Strong evidence exists that BVP patients suffer from impaired spatial cognition and possibly even general cognitive deficits. However, in all previous studies conclusions on the link between cognitive performance and BVP were drawn without taken hearing loss into consideration as a possible cause of the cognitive impairment.

PP1-53 - Progressive central and peripheral vestibulopathy in superficial siderosis

5. Bilateral Vestibulopathy

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Purpose: Superficial siderosis (SS) is a rare condition in which hemosiderin, an iron-storage complex, is deposited in neuronal tissues due to recurrent sub-arachnoid bleeding. Since it is still not clear how the vestibule-cochlear dysfunction and cerebellar ataxia progress, we reviewed the clinical course, patterns of vestibulopathy and progression of cochleovestibular dysfunction over the long term follow-up period, and correlated with radiologic finding in MRI.

Methods: Six patients who diagnosed with SS by magnetic resonance imaging were enrolled. The medical records and radiologic findings of the case series were retrospectively reviewed, particularly, we described the progression of vestibulo-cochlear manifestations and radiologic characteristics of each case.

Results: All patients showed SNHL. Five out of 6 showed progressive hearing deterioration over years and the progression was asymmetric between ears in 4 patients. Based on the most recent evaluations, four out of six patients showed CA and bilateral vestibulopathy, namely, bilateral combined central- and peripheral vestibulopathy. Remaining two patients demonstrated the bilateral peripheral vestibulopathy, isolated central vestibulopathy, respectively. Hypointensity lesions on T2 weighted images surrounding cerebellum were remarkable in all patients but such lesion surrounding brain stem was not remarkable 1 patients. Though cochlea-vestibular dysfunction was mostly asymmetrically progressed, there was no left-right asymmetry on MRI.

Conclusions: Typically, SS presents bilateral asymmetrically progressive cochleovestibular dysfunction with cerebellar ataxia. Pattern of vestibular dysfunction is most frequently bilateral combined

central- and peripheral vestibulopathy. In this perspective, identification of the exact vestibular status and central signs through the regular comprehensive and neurotological evaluations is crucial for treatments and prognosis in SS.

PP1-54 - Are gonadal hormones involved in the pathophysiology of Mal de Debarquement Syndrome?

6. Central Vestibular Disorders

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Purpose: Mal de Debarquement Syndrome (MdDS) is a neurological condition which is characterised by a phantom sensation of motion, following exposure to passive motion (e.g. cruise, flight, etc.). This is defined as *motion triggered* (MT) MdDS. However,

it is known that some patients develop typical MdDS symptoms without an apparent motion trigger. This is named *spontaneous* or *other onset* (SO) MdDS. For both subtypes, a female predominance has been previously described. The role of gonadal hormones in MdDS pathophysiology has never been investigated. Similarly to what observed in migraine, hormonally regulated mechanism is here hypothesised as a potential contributor to MdDS pathogenesis. Our study aimed to evaluate if MdDS patients report abnormal hormonal profiles and assess possible hormonal influences in the pathophysiology of MdDS.

Methods: This assessment was performed via a retrospective online questionnaire study for both subtypes (MT and SO MdDS).

Results: A total of 370 patients participated in the questionnaires; including 334 females, 25 males and 11 with unspecified gender. Naturally cycling female respondents (from the MT group) reported a significant aggravation of symptoms during ovulation and menstruation.

Conclusions: The results of this study clearly demonstrate a link between hormone fluctuation and symptom aggravation in the MdDS MT group. This provides a strong basis for further hormonal investigation. Our next step is to evaluate hormonal levels through blood sampling, to identify if abnormal hormonal fluctuations or profiles are present in reproductive female patients. We hope this study will help the medical community to broaden their awareness and hormonal knowledge of this condition.

PP1-55 - Central Positional Vertigo

6. Central Vestibular Disorders

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Purpose: To review the central positional vertigo etiology and diagnosis

Background: Benign paroxymal positional vertigo (BPPV) is the most frequent cause of episodic vertigo. Central positional vertigo and nystagmus

(CPV) are also precipitated by positional testing; though infrequent it must be recognized for proper triaging, as it requires an expeditious neurologic work-up. CPV and nystagmus may account for 1% of all causes of vertigo

Methods: Retrospective 16-year analysis of patients with CPV. We excluded all cases with previous history of BPPV and included patients with positional paroxysmal and non-paroxysmal DBN or central horizontal apogeotropic nystagmus examined in two large medical centers in North and South America.

Results: 21 patients with CPV and nystagmus of different etiologies were found.

Main diagnosis were: CNS tumor, post-surgical tumor resection and superior canal dehiscence, vascular, infectious, demyelinating, familial ataxia, and episodic ataxia syndromes. In one cerebellar glioma positional vertigo was the first manifestation of disease. Positional DBN was largely the most common nystagmus found, followed by horizontal apogeotropic-nystagmus. Nystagmus pattern was decrescendo and no latency was found in the series. Most patients presented other neurological features associated.

Conclusions: Migraine may be a benign cause of CPV, however, a broad spectrum of diseases including tumors, stroke, infections and neurodegenerative disorders may be responsible. Earlier detection of posterior fossa lesions is critical to improve the outcome. Moreover, central positional vertigo could be the very first manifestation of the underlying disease.

PP1-56 - Dissociation between semicircular canals and saccular function in Machado-Joseph Disease

6. Central Vestibular Disorders

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Purpose: Although ocular motor abnormalities are frequent in all forms of Spinocerebellar ataxias (SCAs), vestibulo-ocular reflex (VOR) deficit seems to be a characteristic of SCA-3 (Machado-Joseph disease -MJD). However, all previous studies were focused on lateral semicircular canals function without information regarding the anterior and posterior canal responses and the otolithic function. The aim of this study was to evaluate the three semicircular canals VOR responses and otolithic function in Jew Yemenite patients with MJD in a search for a better neurophysiologic biomarker of the disease.

Methods: Sixteen MJD patients underwent a detailed clinical and laboratory neuro-otological evaluation including horizontal and vertical VOR recordings with the video head impulse test (vHIT) system. Eight of them underwent also cervical vestibular evoked myogenic potentials (cVEMPs) by bilateral tone burst stimulation measuring otolithic saccular function

Results: All MJD patients had significant angular VOR gain decrease (about 50% of normal values) in both horizontal and vertical planes. cVEMPs responses (latency and amplitude of P13 and N23) were normal in all eight examined patients. Ataxia severity evaluated by the Scale for the Assessment and Rating of Ataxia (SARA) was mildly correlated with the degree of VOR impairment.

Conclusions: Angular VOR impairment in horizontal and vertical planes seems to be a distinctive feature of MJD and could be explained by selective rostral vestibular nuclei degeneration. We suggest that quantitative VOR measures could probably be a neurophysiologic biomarker for detecting the appearance and progression of neuro-degeneration in MJD.

PP1-57 - Evaluation of gravitational recognition in patients with spinocerebellar degeneration

6. Central Vestibular Disorders

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Purpose: Spinocerebellar degeneration (SCD) is neurodegenerative disorder and demonstrates symptoms with progressive cerebellar ataxia resulting in instability of gravitational recognition. The gravitational recognition associated with SCD has hardly been evaluated and only a limited number of studies exist. We recently develop a method of calculating Listing's plane obtained from video-oculograms (VOGs), which reflects gravitational recognition constructed through integration of visual, vestibular, and proprioceptive sensory inputs. The purpose of this study is to establish the methods of evaluating gravitational recognition in patients with SCD, using the thickness of the Listing's plane as a parameter.

Methods: The subjects were wearing infrared CCD-mounted goggles in the sitting and supine position, leaving both eyes unobstructed. 50 cm in front, we placed a screen on which were 9 fixation points. The subjects were instructed to fixate for 1 s on each of the 9 fixation points consecutively. We digitized the video recording using a macro program for ImageJ and calculated thickness of the Listing's plane on each SCD subjects and healthy controls. In this time, we succeeded to improve the accuracy of measurement, by setting the upper limit of rotational values per frame, to eliminate large rotational artifacts in analyzing data of VOGs.

Results: We identified thickening of Listing's plane on sitting position in SCD patients than healthy controls, and on sitting position against supine position in SCD patients.

Conclusions: The thickness of Listing's plane could serve as a parameter which reflects the instability of gravitational recognition in SCD patients.

PP1-58 - Long term observation of slow saccades and caloric response in a SCA2 patient

6. Central Vestibular Disorders

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Purpose: To follow up long term of slow saccades and caloric responses in a patient with spinocerebellar ataxia type2 (SCA2)

Methods: The subject was a male patient with SCA2. At age of 32 years old, he was referred to the Department of Otolaryngology - Head and Neck Surgery, Kyoto Prefectural University of Medicine for the evaluation of eye movements and vestibular function. Saccadic, and smooth pursuit eye movements and caloric stimulation were examined. Saccadic eye movements were also examined at the angles of 10, 20, 30, 60 and 90 degrees. To calculate main sequence of saccadic eye movements, maximum velocities were plotted against amplitudes and were exponentially fitted as follows: $V_{max} = k \times (1 - \exp(-\text{amp}/\tau))$. Eye movements were measured with electronystagmography. We compared saccadic, and smooth pursuit eye movements and maximum slow phase velocity of caloric nystagmus every year.

Results: Slow saccades were observed from one year later (first examination) to five years later. Six years later, tremor was superimposed. Eight years later, he could not pursuit target. Smooth pursuit eye movements were normal until five years later. However, maximum slow phase velocity of caloric nystagmus fluctuated depending on years. The coefficient k also increased and decreased as caloric responses changed by year. k was 93.6, 212.9, 249.3, 194.8 for three, four, five, six years later, respectively. In normal subject, k was 824.9.

Conclusions: These results suggest that slow saccades may not monotonically be aggravated by year. In this case, rehabilitation probably improved the saccadic eye movements but only for several years.

PP1-59 - Metabolic and Visuospatial Memory Function Changes in Transient Mal de Debarquement Syndrome

6. Central Vestibular Disorders

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Purpose: Mal de débarquement syndrome (MdDS) is a subjective perception of self-motion after a period of travel, classically by boat. It is not commonly encountered in clinical practice, but an enigmatic neurotological disorder with high morbidity. The pathogenesis of MdDS is not well-understood and therefore, treatment options are limited.

Methods: We studied 29 subjects who were fishermen at Buan, including 16 subjects (6 males) who had transient MdDS (t-MdDS) or land sickness (less than 12 hours of symptoms after boating) and 13 subjects who do not have symptoms. They were undertaken a neurotological examination, vestibular function tests and visuospatial function tests including Corsi block task. Brain MRI and ¹⁸F-FDG brain PET were also performed.

Results: Vestibular functions were within normal range and structural brain lesion was not detected in any subjects. However, the Corsi block test was scored as a mean of 6.40 in t-MdDS subjects and 5.31 in the control group ($p=0.016$). ¹⁸F-FDG brain PET imaging revealed increased glucose metabolism in the primary visual cortex, prefrontal and inferior parietal lobules bilaterally in the setting of decreased inferior cerebellum metabolism in subjects with transient MdDS.

Conclusions: Our results show that the patients of t-MdDS revealed better performance of visuospatial memory task and hypermetabolism in neural systems involving visual spatial working memory with hypometabolism in cerebellum. These findings indicate that MdDS maybe a disorder of over-synchroni-

zation of visuospatial memory networks caused by persistent background low-amplitude oscillating environments coupled with an inability to subsequently desynchronize the activity of these networks reflected by hypometabolism in the cerebellum.

PP1-60 - Nystagmus and vestibular loss in autoimmune and paraneoplastic ataxia syndromes

6. Central Vestibular Disorders

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Purpose: To investigate oculomotor and vestibular evaluation results and to correlate them with immunophenotypes in autoimmune ataxia (AA).

Methods: Retrospective neurotologic chart reviews of adult AA patients examined from 2001-2016. None of the patients had a history of familial ataxia (FA)

Results: 13 patients met the diagnostic criteria of AA, 12 had one specific antibody that was presumably the cause of the ataxia. The initial MRI of the brain was normal in all instances. Six patient had an anti-Gad antibody, two had ant-Yo, two anti-Hu and two had miscellaneous antibodies. Seven had the ataxia as the first symptom of cancer and two had previous cancer in remission. One had a previous thymoma resection. The remaining four cases were autoimmune. One had RA and other Chron's disease. The most common primary gaze nystagmus was downbeat (DBN) in n= six, one had Opsoclonus and the remaining had gaze evoked nystagmus (GEN) and abnormal pursuit. Three patients had bilateral, symmetric vestibular paresis. Six patient had a lymphocytic meningitis, the CSF was normal in the anti-GAD antibody patients.

Conclusions: A syndrome characterized by acute or subacute ataxia and imbalance associated with a

normal MRI and no history of FA, suggests AA. The ant-GAD antibody syndrome was less frequently associated with cancer than other autoantibodies; common findings included DBN, GEN, impaired pursuit, bilateral vestibular paresis and Opsoclonus. Rapid initiation of immunosuppression, plasma exchange and search for an occult cancer are the first step in management. The anti-Gad antibody syndrome has better prognosis even if cancer is present.

PP1-61 - Positional tests under Videonistagmography for Central Positional Vertigo Diagnosis

6. Central Vestibular Disorders

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Purpose: Positional vertigo is vertigo triggered by and occurring after a change of head position in space relative to gravity.

Central vestibular disorders are caused by lesions along the vestibular pathways in the brainstem. It can manifest the same symptoms than peripheral disorders. The clinical examination of eye movements and of nystagmus is important for differential diagnostics. The positional test under Videonistagmography can be very helpful, specially for the patients that didn't present any abnormality in MRI.

Methods: This study selected patients that had positional vertigo and were evaluated under Videonistagmography. They didn't fulfilled the diagnostic criteria for vestibular migraine, presented nystagmus that didn't fulfilled the criteria for peripheral disorders and had normal MRI. Eye movements were recorded in darkness in the following positions: sitting with head upright, sitting with chin to chest position, lying, lying with the left and right ear down. Oculomotor test were also taken.

Results: Seventeen patients with positional vertigo were evaluated under VNG and presents abnormal nystagmus with central characteristics during the exam. Two patients were male and fifteen were female. The mean age was sixty five years. Fourteen patients had their nystagmus inverted after head position changes.

Conclusions: The Videonistagmography positional test allows an easily evaluation of nystagmus and play a decisive role in the diagnosis of Central Positional Vertigo. It can give an effective measure for diagnose and follow-up in these patients.

PP1-62 - Subjective visual vertical in typical Alzheimer's disease and posterior cortical atrophy

6. Central Vestibular Disorders

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Purpose: The parietal lobes, an area fundamental for integrating multimodal sensory input, have been implicated in the misperception of verticality, suggesting a possible link between damage in this area and inappropriate internal representation of verticality which has been associated with imbalance. The current project investigated perception of verticality in posterior cortical atrophy (PCA) and typical Alzheimer's disease (tAD) under varying visual cue conditions using the Rod-and-Frame task.

Methods: Twenty PCA, 16 tAD and 13 healthy control participants performed the 'rod and frame' test, where they were asked to align an oblique white rod presented on a screen with the perceived vertical while seated (24 trials). The Rod was presented at 45° tilt with or without the presence of a visual cue (square frame) which was randomly presented under two tilt conditions (18° left/right). Task performance measures included orientation error between perceived and absolute vertical.

Results: In the absence of visual cues, orientation error was greater in PCA relative to tAD and control groups; there was no evidence of an overall difference between tAD and control groups. Visual cues

exerted greater influence upon the perception of verticality in both PCA and tAD relative to control groups, with cue orientation inducing particular bias in patient responses. We observed lateralized effects of visual cues in PCA, but not tAD or control groups.

Conclusions: Findings support erroneous internal representation of verticality in both PCA and tAD, but also suggest differences between clinical phenotypes. Results are interpreted in the context of differences in structural imaging profiles.

PP1-63 - The Semicircular Canal Coordinate System and Its Relation to Neural Circuits for Saccades

6. Central Vestibular Disorders

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Purpose: It is generally accepted the saccadic system uses horizontal and vertical Cartesian coordinate system. Brainstem centers for horizontal and vertical saccades were identified in the PPRF and the riMLF, respectively. However, the neural pathways from the superior colliculus (SC) to ocular motoneurons (MNs) via these lower centers had not been understood well.

Methods: We analyzed output pathways for horizontal and vertical saccades by using intracellular recording and HRP-staining methods in anesthetized cats.

Results: The shortest excitatory and inhibitory pathways from the SC to abducens MNs were tacitly assumed trisynaptic and quadrisynaptic, respectively, but the main shortest pathways were disynaptic: excitation in contra-abd MNs via excitatory burst neurons (EBNs) and inhibition in ipsi-abd MNs via contra-inhibitory BNs (IBNs). All vertical MNs received disynaptic excitation from ipsi-SC via EBNs in ipsi-riMLF, and disynaptic inhibition from contra-SC via IBNs in contra-interstitial nucleus of Cajal. The medial and lateral SC representing upward and downward saccades innervated superior rectus and inferior oblique MNs, and inferior rectus and superior oblique MNs, respectively, and strong

reciprocal commissural inhibition existed between the medial and lateral SCs.

Conclusions: These innervation patterns are similar to those in vertical VOR, where the anterior canal system on one side inhibits via vestibulo-nuclear commissural inhibition the posterior canal system on the opposite, and vice versa. There was also reciprocal inhibition between the upward saccade system on one side and the downward saccade system on the opposite side. This similarity of reciprocal inhibition implies that the saccade system uses the same semicircular canal coordinate as the VOR.

PP1-64 - Tumor size of vestibular schwannoma impair vestibular function and compensation

6. Central Vestibular Disorders

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Purpose: To investigate the relationship between vestibular schwannoma (VS) size and the dysfunction and compensation of the vestibular system.

Methods: A total of 152 patients with unilateral VS were investigated by auditory-vestibular function tests such as audiometry, sensory organization test (SOT), caloric test, cervical and ocular vestibular evoked myogenic potential (cVEMP and oVEMP) tests.

Results: In this study, 89% patients with unilateral VS had mild to severe hearing loss. Lower waveform elicited rates and higher thresholds in both cVEMP and oVEMP tests had been found in affected sides of patients, compared with the unaffected sides. Patients with tumor size ≥ 30 mm showed significantly lower equilibrium scores of C5 and C6 in SOT test, higher rates of canal paresis and lower waveform elicited rates in cVEMP and oVEMP tests in the affected sides compared with the patients with tumor size ≤ 29 mm.

Conclusions: There was no significant relationship between tumor size and hearing loss level. Patients with large VS might be more prone to vestibular

dysfunction and showed decompensation with poor postural performance.

PP1-65 - Use of proprioception differentiates postural control in peripheral and central vestibular patients

6. Central Vestibular Disorders

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Purpose: Imbalance is an accompanying symptom of vertigo but may vary between central and peripheral origin. As this differentiation has a tremendous clinical impact, but often is difficult to achieve, the systematic identification of the postural control process may add to this distinction.

Methods: Unperturbed and perturbed stance of patients with a central (Vsc, n=7), or a peripheral vestibular deficit (Vsp, n=14) and 15 healthy control subjects (Np) were examined on a custom-built motion platform. Data was analyzed using transfer functions (Gain, Phase, and Coherence) of motor responses, followed by a parameter identification procedure.

Results: Sway amplitude (RMS) and velocity (MV) were significantly higher in Vsp, compared to Np and Vsc. Transfer functions were different in Vsp, Vsc and Np. Vsc patients relied more on proprioception, compared to NP with both eyes open and eyes closed, whereas Vsp patients showed an increased reliance on proprioception only with eyes closed. Moreover, Vsp displayed an overall larger time delay between stimulus and response, as compared to Np and Vsc.

Conclusions: Postural control of patients with a peripheral vestibular deficit is different from patients with a central vestibular deficit during both unperturbed and perturbed stance. Characteristic features relate to the role of proprioception when comparing the eyes open and eyes closed-condition as well as

the role of the time delay between stimulus and response. These postural abnormalities may help to distinguish peripheral from central vestibular deficits.

PP1-66 - Vestibular dysfunction in Wernickes encephalopathy: selective impairment of the horizontal canals

6. Central Vestibular Disorders

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Purpose: To better characterize the pattern of vestibular impairment in patients with Wernicke's encephalopathy (WE) using quantitative video head-impulse testing and to review the literature regarding this topic.

Methods: From January 2014 to December 2016, we retrospectively enrolled five cases of WE that received quantitative video-head-impulse testing. We retrieved the clinical features from the medical records and reviewed quantitative head-impulse testing and caloric irrigation. Based on the gain and the number of corrective saccades, the function of each semicircular canal was rated. In addition, we conducted a Medline and EMBASE search to identify other published cases of WE that had received quantitative head-impulse testing. Neuro-otologic findings and vestibular-testing results were extracted.

Results: A total of 17 patients (12 published cases) were included. Key neurologic findings were ataxia of stance and gait (100%), spontaneous nystagmus (50%), gaze-evoked nystagmus (100%), positive bedside head-impulse testing for the horizontal canals (94%) and memory impairment and mental changes (54.5%). Regarding vestibular testing, quantitative head-impulse testing documented selective bilateral horizontal canal dysfunction with normal or minimal vertical canal impairment (100%). On caloric irrigation, bilateral horizontal canal paresis was noted in most cases (91%).

Conclusions: In WE, signs of both peripheral and central vestibular dysfunction were common.

Selective or predominant impairment of the horizontal canals seems to be a characteristic finding of WE likely related to enhanced vulnerability of the medial vestibular nuclei neurons to thiamine deficiency. Quantitative video-head-impulse testing of all six canals is a useful tool for the diagnosis and should be applied in all patients with suspected WE.

PP1-67 - Visual fixation suppression of caloric nystagmus in progressive supranuclear palsy

6. Central Vestibular Disorders

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Purpose: Progressive supranuclear palsy (PSP) is a degenerative disease of the basal ganglia, characterized by decreased muscle tone, postural instability, and abnormal eye movements. However, impaired visual fixation suppression (VS) in PSP is not well documented in the literature. We investigated visual fixation suppression (VS) of caloric nystagmus and radiological findings in PSP.

Methods: Subjects comprised 26 patients (14 males, 12 females) without horizontal gaze palsy, diagnosed in the Department of Neurology at Tokyo Metropolitan Neurological Hospital. As a control group, 26 patients (11 males, 15 females) with Parkinson disease (PD) also diagnosed in the Department of Neurology at our hospital were investigated. We retrospectively investigated neuro-otological findings, including VS of caloric nystagmus recorded on DC electronystagmography, and radiological findings such as brain magnetic resonance imaging (MRI) and single photon emission computed tomography (SPECT) for patients with PSP and PD.

Results: VS of caloric nystagmus was remarkably impaired in PSP compared to that in PD. Brain MRI showed atrophy of the superior colliculi in all 26 cases of PSP, of the cerebellum in 4 of 26 PSP, and of the subthalamic nucleus in 15 of 25 PSP. In contrast, PD patients did not exhibit any significant findings on MRI. SPECT revealed decreased blood flow in the frontal lobe in 20 of 22 PSP, and in 11 of 22 PD patients.

Conclusions: VS would be very useful for PSP diagnosis. Cerebellar networks with the cerebral cortex and basal ganglia might contribute to impaired VS of caloric nystagmus in PSP.

PP1-68 - 3D analysis of VOR and spatial orientation during eccentric rotation while right ear downwards

7. Clinical Testing for Vestibular Function

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Purpose: To develop the functional test of saccule by analyzing vertical component of vestibulo-ocular reflex (VOR) during eccentric rotation (ER). When ER, subjects were rotated sinusoidally while displaced from the axis of rotation. And we analyzed the relationship between the VOR and the spatial orientation.

Methods: Ten participants underwent sinusoidal ER at 0.1, 0.3, 0.5, and 0.7 Hz while right ear downwards in a dark room. The participants sat on the chair either directly above the center of rotation (CR), or with their nose out (NO-ER), nose in (NI-ER), right-side out (RO-ER), or left-side out (LO-ER) against the center of rotation. The radius of rotation was 90 cm. We analyzed linear VOR (IVOR) three-dimensionally using our own video-oculography system. Every participants were instructed to

report their sitting position before and after each rotation in order to evaluate their spatial orientation.

Results: At 0.1 and 0.3 Hz rotation, we observed the VOR gain during NI-ER was lower, and that during NO-ER was higher at 0.5 and 0.7 Hz than during CR. These results indicated that IVOR played a role at 0.5 and 0.7 Hz during ER and the opposite direction of IVOR resulted in the increment and decrement of VOR gain during NO-ER and NI-ER respectively. The accuracy of spatial orientation was higher in 0.5 and 0.7 Hz than that in 0.1 and 0.3 Hz.

Conclusions: The function of saccule can be assessed via rotation test of NO-ER and NI-ER. The spatial orientation is related to frequency, and is governed by IVOR.

PP1-69 - A normative study of the Dynamic Visual Acuity test, with comparison of two vertical test methods

7. Clinical Testing for Vestibular Function

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Purpose: The purpose of this study was to obtain normative test-retest data of the Dynamic Visual Acuity test and to compare two vertical DVA test protocols (vertical head movement vs. walking on treadmill).

Methods: 31 healthy subjects (15 women, 16 men) between 18 and 31 years were tested and retested on different test days. Static Visual Acuity (SVA) test was done, followed by horizontal DVA (hDVA) testing (active head rotations around the yaw-axis) at four different frequencies: 0.7, 1.0, 1.4 and 2.0 Hz. Vertical DVA (vDVA) testing was done in 2 ways: firstly, by active pitch head movements (0.7, 1.0, 1.4 and 2.0Hz) and secondly by walking on a treadmill at walking speeds of 2, 4 and 6 km/h. For each test modality, a logMAR score was calculated as the smallest recognized optotype.

Results: There were no significant test-retest differences, besides for SVA testing ($p=0.009$, logMAR test = $-0.0230 (\pm 0.077)$; logMAR retest = $-0.273 (\pm 0.020)$). There was no significant difference between the following test frequencies: 0.7 Hz vs 1.0 Hz and between 1.0 and 1.4 Hz, for both hDVA and vDVA. There were no significant vDVA differences between the logMAR scores of all walking velocities on the treadmill. Correlation between vDVA obtained on the treadmill and with active head movements was weak ($R^2 = 27.4\%$).

Conclusions: Except for SVA, we found no significant differences between test and retest values, indicating that our test protocol is reliable. The clinical significance of the abovementioned results will be analysed further in vestibular patients.

PP1-70 - Analysis of the result of normal youth sinusoidal harmonic acceleration test by NKI rotation chair

7. Clinical Testing for Vestibular Function

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Purpose: Frequency doubling is used in the previous sinusoidal harmonic acceleration test. However, the frequency doubling test is too large in the high frequency area to show the vestibular function. We test more frequency of the sinusoidal harmonic acceleration test by the NKI rotation chair, aimed to analysis the result of the normal youth.

Methods: Fifty normal young people were tested with sinusoidal harmonic acceleration by NKI rotation chair. Age from 20 to 40 years (Median age27), there 24 men, and 26 women, with no vestibular dysfunction participated in this study. All the volunteers accept the sinusoidal harmonic acceleration test by the NKI rotation chair, the frequency include 0.01Hz, 0.02Hz, 0.03Hz, 0.05Hz, 0.1Hz, 0.2Hz, 0.3Hz, 0.6Hz, 1.0Hz, 1.5Hz, 2.0Hz, 3.0Hz. The gain, phase and asymmetric values are analyzed as parameters.

Results: The gain in the different frequency were 0.01Hz ($0.30 \pm .082$), 0.02Hz (0.40 ± 0.09), 0.03Hz

(0.47±0.10), 0.05Hz (0.51±0.13), 0.1Hz (0.53±0.15), 0.2Hz (0.55±0.15), 0.3Hz (0.59±0.18), 0.6Hz (0.63±0.19), 1.0Hz (0.83±0.13), 1.5Hz (0.95±0.12), 2.0Hz (0.85±0.20), 3.0Hz (0.71±0.32). The phase in the different frequency were 0.01Hz (44.97±7.72), 0.02Hz (25.83±5.25), 0.03Hz (17.20±5.20), 0.05Hz (9.19±3.27), 0.1Hz (2.84±2.79), 0.2Hz (0.42±3.52), 0.3Hz (0.88±2.93), 0.6Hz (0.54±4.79), 1.0Hz (-0.38±4.28), 1.5Hz (-3.87±5.00), 2.0Hz (-13.91±10.59), 3.0Hz (-27.84±52.91). The asymmetry in the frequency were 0.01Hz (16.39±9.84), 0.02Hz (18.08±8.44), 0.03Hz (12.85±8.64), 0.05Hz (9.36±7.88), 0.1Hz (5.91±7.73), 0.2Hz (5.81±6.26), 0.3Hz (5.07±6.17), 0.6Hz (3.70±3.51), 1.0Hz (1.77±2.74), 1.5Hz (-0.28±3.60), 2.0Hz (-2.50±11.81), 3.0Hz (-7.56±1.19).

Conclusions: From 0.01Hz to 1.5Hz, the gain increases close to 1 gradually. And with a slight drop at the 2.0Hz, 3.0Hz frequency. The phase decrease as frequencies increased. The asymmetry from 0.01Hz to 3.0Hz is gradually approaching to 0, and present negative values in the frequency 1.5Hz, 2.0Hz, 3.0Hz. It is important to make sure that the head of the patient is well fixed in the high frequency test.

PP1-71 - Anxiety, depression, and visual dependence assessment in neuro-vestibular physical therapy

7. Clinical Testing for Vestibular Function

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Purpose: Anxiety, depression, and visual dependence (ADVD) are associated with less than optimal functional outcomes for people with vestibular disorders. The aim of this study was to determine if ADV D are being assessed in outpatient neuro-vestibular physical therapy and if the methods used for assessment are standardized.

Methods: Thirty-two outpatient physical therapists (PT's) identified as primarily treating people with neurologic and vestibular diagnoses were invited to complete an electronic survey about the assessment and treatment of ADV D.

Results: Survey completion rate was 53%. Twenty-nine percent of the therapists "always" assess for anxiety (35% "most of time"; 6% "half the time"; 24% "sometimes"; and 6% "never"). Depression assessment ratings were similar. The PT's reported that assessments of anxiety and depression were gathered during patient interviews (88%) and from the medical record (94%).

Visual dependence was assessed slightly more frequently by the PTs (57% "always"; 38% "most of time"; 5% "half the time"). Eight different methods were reported and six of the eight methods were not measures of visual dependence. The most common methods reported to assess visual dependence were the modified Clinical Test of Sensory Interaction and Balance (67%), Romberg (43%), and Computerized Dynamic Posturography (33%).

Conclusions: Only 50% of the PT's are attempting to assess anxiety, depression or visual dependence in persons seen with vestibular disorders and when they do assess the patients the methods used are often not optimal to clinically assess the construct.

PP1-72 - Balance and Eye Movement Responses to Electrical Vestibular stimulation in Vestibular Schwannoma

7. Clinical Testing for Vestibular Function

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Purpose: Many patients are unable to perform postural tests due to instability and the inherent variability of caloric irrigation suggests a new technique is required. We examine the viability of electrical vestibular stimulation (EVS) to detect

vestibular dysfunction in vestibular schwannoma patients (VS), who have a known unilateral deficiency.

Methods: EVS induces a sense of head roll around the naso-occipital axis, evoking compensatory torsional eye movements. Here we aim to determine if this technique can detect asymmetry between ears. Participants received sinusoidal EVS (2hz,±2mA) in a monaural configuration. An infrared camera and illuminator were used to record torsional eye movements. The *response-EVS* gain was calculated for each and an asymmetry ratio (AR) was determined.

Results: We found there to be a difference in the gain of the response between healthy and diseased ears (AR:10-50%), with the diseased ear's response being significantly attenuated ($T_{(24)}=3.04, p<0.05$). When participants were grouped according to tumour size, using Koos classification system, we found larger tumours resulted in smaller torsional responses leading to a greater asymmetry.

Conclusions: These results provide a novel method of assessing vestibular function in a population where normal postural tests are unsuitable due to some participants, inability to remain upright during the test. The relationship between tumour size and response can potentially provide additional information regarding tumour size and potentially location. The information provided about vestibular function can be considered when planning an appropriately course of treatment for the participant (i.e. balance therapy may be advised for those with significant vestibular loss).

PP1-73 - Can HIT and oVEMP evaluate the superior vestibular nerve function in substitution for caloric test?

7. Clinical Testing for Vestibular Function

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Purpose: Although caloric test and video head impulse test (vHIT) reflect function of the lateral semi-circular canal ampulla, the former relate to the type 2 hair cell and regular neuron and the later relate to

type 1 hair cell and irregular neuron. Ocular vestibular evoked myogenic potential (oVEMP) reflects function of the utricular organ. While all the afferent pathways are superior vestibular nerve, the sensory receptors and afferent neuron differ, This study aims to clarify whether the examinations can substitute for each other in evaluating the nerve function.

Methods: Subjects were seventeen patients diagnosed with vestibular schwannoma in MRI scans and underwent caloric test, vHIT and oVEMP. The positive results of each examination was evaluated. The cut-off criteria as abnormal in each examination were as follows: 1) CP> 25% in caloric test, 2) VOR gain <0.88 in vHIT, 3) AR> 31.6% in oVEMP. Predictive ability from caloric test was analyzed with ROC.

Results: Positive rate was 59% in caloric test, 53% in vHIT and 69% in oVEMP. The sensitivity, specificity and AUC of ROC analyze were 0.88, 0.91 and 0.87 on the result of vHIT, respectively and 0.80, 1.00 and 0.90 on the results of oVEMP, respectively.

Conclusions: Due to the difference of the sensory receptor and afferent neuron, we had speculated that there might be differences in the results of the three tests, however, there was no statistical difference. The caloric test can be replaced with vHIT or oVEMP in the patients with vestibular schwannoma.

PP1-74 - Cervico-Ocular Reflex Induced by Manual stimulus of the Sternocleidomastoid Muscle: The First Report

7. Clinical Testing for Vestibular Function

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Purpose: To describe a novel afferent pathway for the cervico-ocular reflex (COR), as the first report of detecting COR without use of a rotational chair.

Methods: A patient with complete right canal paralysis and incomplete left canal paralysis, caused by aseptic meningitis, was examined through manual

stimulation by compressing or grasping each sternocleidomastoid muscle (SCM) in turn. Vibrational stimulation was also applied to each side of SCM and mastoid process of this patient to differ this nystagmus from previously reported vibration induced nystagmus (VIN). Electronystagmography recordings were assessed under this manual stimulation and vibrational stimulation.

Results: Nystagmus similar to previously reported COR was observed with above mentioned manual stimulation of the SCM, which directed toward the stimulated side. However, due to conductive diffusion, the direction of VIN was not affected by stimulated side. In this case, VIN was consistently directed toward the left side, on which canal paralysis was incomplete.

Conclusions: COR is one of the visual stabilizing eye movement like the vestibulo-ocular reflex and optokinetic reflex, elicited by passive rotation of the neck. It has widely been considered to be generated only by the cues from the facet joints of cervical spine and the dorsal neck muscles. This case provides the evidence that cues from SCM also generate COR.

PP1-75 - Clinical features of otolith organ-specific vestibular dysfunction

7. Clinical Testing for Vestibular Function

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Purpose: To elucidate the clinical features and vestibular symptoms of patients with otolith organ dysfunction in the presence of normal function of the semicircular canals (SCCs).

Methods: We reviewed the clinical records of 277 consecutive new patients with balance disorders who underwent testing of cervical and ocular vestibular evoked myogenic potentials (cVEMPs and oVEMPs) as well as caloric testing and video head impulse testing (vHIT).

Results: We identified 76 patients who showed normal caloric responses and normal vHIT findings in each SCC plane, but abnormal responses in cVEMP and/or oVEMP testing. Benign paroxysmal positional vertigo (BPPV) was the most common diagnosis. 37% of patients could not be categorized into any of the established clinical entities that could cause a balance disorder and did not show sensorineural hearing loss. The most common clinical manifestation in the idiopathic cases was recurrent rotatory vertigo with a duration of 1–12 h.

Conclusions: The most common diagnosis of otolith organ-specific vestibular dysfunction was BPPV. On the other hand, otolith organ-specific vestibular dysfunction occurs in association with some of the undiagnosed patients with recurrent rotatory vertigo.

PP1-76 - Clinical study of the new three dimensional rotating equipment in vestibular function detection

7. Clinical Testing for Vestibular Function

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Purpose: To explore the effectiveness of new vestibular function detection, correction and training equipment for healthy person's vestibular function.

Methods: 35 healthy persons in the equipment in the dark field were stimulated by rotation with the spindle rotating 1570° while the auxiliary axis rotating 1565° of the 3D rotation stimulus. The difference was compared between the residual angle of gravity, the residual angle of the horizontal plane and the time of the third active adjustment after three rotations and to monitor the change of blood pressure before and after rotation.

Results: There was no significant difference between the residual angle of gravity (6.04±10.70°, 3.57±3.97°, 3.41±2.93°, P=0.199), however, The residual angle of the horizontal plane is statistically significant 94.930±58.826°, 66.736±45.989°, 65.494±47.989°, P=0.028<0.05. There was no difference in active adjustment time after three rotations 190.114±87.328s, 178.014±110.811s, 173.743±87.332s, P=0.760, and there was no sig-

nificant difference in the systolic and diastolic blood pressure before and after the three rotations.

Conclusions: The new vestibular function detection, correction and training equipment is a three-dimensional rotating instrument that can detect three pairs of semicircular canal, two pairs of otolithic organ function, including benign paroxysmal positional vertigo, semicircular canal function correction and rehabilitation training, and quantitative detection of the function of oval sac, saccule and rehabilitation training, according to the results of the study found that adaptive training of the saccule is effective. Therefore, the research group will gradually carry out the controlled study of vestibular related disease detection, correction and training, expand and deepen the real use of research equipment.

PP1-77 - Clinical usefulness of dizziness diagnosis in the foam posturography analysis system

7. Clinical Testing for Vestibular Function

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Purpose: The foam posturography analysis system is useful to detect the peripheral vestibulopathy and can easily screen for it. The foam posturography by company Anima has evaluations of the four level, Aa(most likely to have vestibulopathy), Ab(likely), B(possibly), C(unlikely) which is based on the romberg's ratio under the foam rubber and the foam ratios (ratios of measured parameter with to without the foam rubber).The purpose of this study is to assess the clinical utility by comparing clinical diagnosis and the results.

Methods: We divided into two groups, vestibulopathy group and non vestibulopathy group. The clinical diagnosis and the results in the foam posturography analysis system were reviewed.

Results: Ninety three patients diagnosed clinically out of 117 patients who underwent the test were enrolled this study. We compared the vestibulopathy

group and the non vestibulopathy group. The vestibulopathy group were 61 patients. Non vestibulopathy group were 32 patients. Twenty four patients were not diagnosed. There were 11 patients with Aa, 27 patients with Ab, 21 patients with B, 4 patients with C in the vestibulopathy group. There were 5 patients with Aa, 7 patients with Ab, 15 patients with B, 3 patients with C in the non vestibulopathy group. Many of the patients in vestibulopathy group showed Aa or Ab. Most of BPPV patients showed B or C. In the result of A, 75.7% of patients was vestibulopathy group.

Conclusions: The foam posturography analysis system is considered useful and practical method for screening peripheral vestibulopathy in clinical practice.

PP1-78 - Comparing the video Head Impulse to the Suppression Head Impulse as target distance is varied

7. Clinical Testing for Vestibular Function

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Purpose: Does the different visual stimulus in the video Head Impulse (HIMPs) versus the Suppression Head Impulse (SHIMPs) make a difference at different target distances?

Methods: 10 normal subjects were tested with horizontal HIMPs and SHIMPs at target distances of 120 cm and 50 cm. Gain was calculated by area under the curve for both the full HIMP impulse and the "first half" of both the HIMP and SHIMP impulses to avoid the fastest observed SHIMP saccades which can occur during the "second half".

Results: In HIMPs there is an increase in VOR gain for the 50cm versus the 120cm distance when gain is calculated over the full impulse of about 7% (eg: rightwards gains mean +/- S.E.M: at 120cm 0.95 +/- .003 : at 50cm 1.02 +/- .004) However, for the HIMPs when gain is calculated during the "first half" of the impulse, the increase is about half of that

(eg: rightwards first half gains mean +/- S.E.M: at 120cm 0.77 +/- .004 : at 50cm 0.80 +/- .004) indicating that the extra distance scaling takes place during the later parts of the impulse.

This is not so in the SHIMPs where target distance scaling equivalent to the full HIMP impulse (about 6.5%) takes place during the "first half" (eg: rightwards first half gains mean +/- S.E.M: at 120cm 0.73 +/- .004 : at 50 cm 0.78 +/- .006).

Conclusions: In addition to slightly reducing the gain of SHIMP versus the HIMP, the different visual stimulus also moves the distance scaling to earlier in the impulse.

PP1-79 - Comparison of video Head Impulse Test with Head Impulse Test and calorics: a retrospective study

7. Clinical Testing for Vestibular Function

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Purpose: We studied the relationship between Head Impulse Test (HIT) and video HIT (vHIT), and between the caloric test and the vHIT.

Methods: Retrospective clinical study on vHIT, HIT and caloric test patient data. vHIT results were considered unilaterally pathological when: 1) VOR-gain was below 0.79 and 2) when left-right gain-difference was equal or above 0.21 In case of unilateral correction saccades, the vHIT was also considered as unilaterally pathological. In case of a bilateral gain of 0.60 or lower OR in case of bilateral correction saccades, the vHIT was bilaterally pathological.

Results: For the comparison between HIT and vHIT, the time between both tests was limited to 7 days (n=69). In 22 (31.9%) patients, the HIT was pathological. However, only in 36.4% (n=8) of these pathological HITs, the vHIT was also abnormal. In 47 patients (68.1%), the HIT was normal. In 43 (91.5%) of these patients, the vHIT was also normal.

For the comparison between the caloric test and vHIT, the time between both tests was limited to 180 days (n= 164). 93 patients (56.7%) showed pathological caloric results. In this cohort, 22.6% (n=21) and 77.4% (n=72) had abnormal and normal vHIT results respectively. Normal calorics were observed in 71 cases (43.3%), 60 of them (84.5%) also had normal vHIT, and only 15.5% (n=11) showed abnormal vHIT results.

Conclusions: The vHIT is an essential test in a vestibular clinic, giving additional information to the results of the clinical HIT (especially when the HIT is abnormal) and the standard caloric test.

PP1-80 - Comparison of video-head impulse, rotatory chair and bithermal caloric test in vestibular disease

7. Clinical Testing for Vestibular Function

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Purpose: Bithermal caloric irrigation and the video-head impulse test have different sensitivities in identifying various not-acute vestibular disease. The diagnostic benefit of rotatory chair testing in addition to the other two method remains unknown so far.

Methods: We analyzed retrospectively 1600 patients with non-acute vertigo/dizziness which presented to the in- and outpatient clinic of a specialized vertigo/dizziness center in Altoetting, Germany. All patients were routinely examined with the horizontal video-head-impulse test (vHIT), bithermal caloric irrigation (CI) with water and the rotatory intensity damping test (RIDT: initial acceleration 3°/s², velocity plateau of 90°/s for 120s followed by a sudden stop). To analyze the RIDT test we fitted the data for each direction separately by a non-linear model of vestibular processing including the vestibular, two adaptation and a velocity storage time constant and gain values. Statistical analysis was performed with a multifactorial ANOVA.

Results: Results showed that in identified unilateral vestibular failure (by vHIT and/or CI), RIDT was most sensitive using the velocity ramp compared to the step stimulus and could identify additional vestibular failure in about 5%. Analyzing different diseases showed that on a group level Morbus Menière could be distinguished from vestibular migraine. Rotatory tests altogether were very good in identifying bilateral vestibular failure.

Conclusions: Careful analysis of rotatory chair testing could gain further information in addition to vHIT and CI on a group level, especially using ramp paradigms. Rotatory chair testing should be part of the vestibular test battery.

PP1-81 - Development of real-time video-oculography using high quality infrared video Frenzel.

7. Clinical Testing for Vestibular Function

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Purpose: It is essential to use an infrared CCD camera in clinical examination of the vestibular system. Devices are currently available that can quite accurately record human eye movements, based on the principle of video-oculography (VOG). We devised an original VOG (HI-VOG) system using a commercialized infrared CCD camera, a personal computer and public domain software program (ImageJ) for data analysis. In the present study, we revised the VOG and image filing system for real-time 3D analysis of nystagmus, yVOG.

Methods: The video image from a Frenzel with high quality image camera was captured at 60 frames per second at a resolution of 640*480 pixels. For real-time analysis of the horizontal and vertical components, the X-Y center of the pupil was calculated. For real-time analysis of torsional components, the whole iris pattern was overlaid with the same area of the next iris pattern, and the angle at which both iris patterns showed the greatest match was calculated.

Results: Accurate measurements of horizontal, vertical and torsional eye movement were taken while recording the video image in real-time. For quantitative analysis, the slow phase velocity of each occurrence of nystagmus and the average value of the slow phase velocity were analyzed automatically.

Conclusions: Using the revised yVOG system, it was possible to perform real-time quantitative 3D analysis of nystagmus from video images recorded with high quality video Frenzel.

PP1-82 - Differences of VOR gain in the conventional head impulse test and the suppression head impulse test

7. Clinical Testing for Vestibular Function

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Purpose: In this study, we examined some parameters of VOR gain and catch up saccade of the conventional head impulse paradigm (HIMP) and the suppression head impulse paradigm (SHIMP).

Methods: We examined the horizontal semicircular canal function by video head impulse test and caloric test in patients with unilateral vestibular loss (UVL). The examiner performed 20 horizontal head impulses to each side with unpredictable timing and direction for patients.

Results: VOR gain of lesion side of HIMP was positively correlated with that of SHIMP ($p < 0.01$) in patients with UVL. Similarly, between intact side VOR gain of HIMP and SHIMP, we found a positive correlation ($p < 0.01$). VOR gain of SHIMP was significantly smaller than that of HIMP both with lesion and intact side ($p < 0.01$). Moreover, VOR gain of lesion side of SHIMP was positively correlated with the peak saccade velocity of SHIMP in patients with UVL ($p < 0.01$). There were no correlations between the peak saccade velocity of lesion side both of SHIMP and HIMP in patients with UVL ($p > 0.05$).

Conclusions: We showed that VOR gain of HIMP had more reliable than that of SHIMP because VOR gain of SHIMP might be small by early catch up saccade of SHIMP. The assessment of the peak saccade

velocity of SHIMP is easily than that of HIMP because catch up saccade of SHIMP mainly appeared after the head thrust. Thus, the peak saccade velocity of SHIMP was useful for an index of the remaining vestibular function in patients with UVL.

PP1-83 - Effect of gaze direction on vertical VOR gain during the video head impulse test

7. Clinical Testing for Vestibular Function

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Purpose: The vestibulo-ocular reflex (VOR) gain for vertical head impulses may be affected by gaze direction due to the presence of torsional eye movements (McGarvie et al. 2015). There are differences in the recommended gaze direction for different devices. The purpose of this study was to investigate the effect of horizontal gaze direction on the vertical VOR across two different video head impulse test (vHIT) devices.

Methods: 24 controls and 3 subjects with bilateral vestibular loss have participated. One experienced clinician administered vHIT in the plane of the left anterior and right posterior (LARP) canals using ICS Impulse (Otometrics) and EyeSeeCam (Interacoustics). LARP impulses were performed at three gaze angles (+45, 0, -45).

Results: For controls, VOR gains were generally higher for EyeSeeCam. For both devices, when the gaze was aligned with the plane of the stimulated canals (+45), VOR gains were higher and decreased as gaze moved away from the plane of the canal (0, -45). However, the gains became abnormal only when the gaze direction was aligned with the opposite canal pairs (-45). Repeatable reset saccades were not observed. In the three bilateral vestibular loss subjects, gains were low with repeatable reset saccades but no differences were noted for different gaze directions. Data collection is ongoing for vestibular patients.

Conclusions: Gaze direction affects vertical VOR gains; however, gains are within normal limits for both devices when performed according to each manufacturer's protocol.

PP1-84 - Effect of intratympanic gentamicin injection on lateral and vertical canals using HIMPs and SHIMPs

7. Clinical Testing for Vestibular Function

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Purpose: This study is to determine whether intratympanic gentamicin injection (ITG) similarly affects all three semicircular canals in patients suffering from Menière's disease, and whether the decrease of vestibulo-ocular reflex (VOR) gain in lateral and vertical planes correlated with vertigo control six months after the last injection.

Methods: 34 patients suffering from Menière's disease and treated by ITG were tested before and six months after the injection. The gain of VOR in all three canals was quantified by HIMPs and SHIMPs. Whether patients had complaint on rotatory vertigo was systematically asked before each test. Horizontal VOR gain inferior to 0.8 and vertical VOR gain lower than 0.7 were considered as lesioned.

Results: Lateral canals were always lesioned with a gain ranging from 0.38 to 0.74. All these patients were areflexic to Caloric test and exhibited vibratory-induced ocular nystagmus with quick phase oriented towards the intact side. In contrast, in 47% and 35% patients, anterior and posterior canals were not affected. Nevertheless, patients with lesion on horizontal but not vertical canals had no complaint on rotatory vertigo after the last injection.

Conclusions: ITG injection caused a significant decrease of HVOR gain in all patients. However, the gain of posterior and anterior canals could be within normal range after the last injection. Moreover, a residual function of the lateral and vertical canals is always observed, in contrast to vestibular neurectomy. Despite different sensitivity to gentamicin in three canals, the loss of HVOR itself appears to ensure the control of vertigo recurrence.

PP1-85 - Eliciting cVEMPs and oVEMPs from newborns through the elderly-a review

7. Clinical Testing for Vestibular Function

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Purpose: This study reviewed our experience in eliciting cervical and ocular vestibular-evoked myogenic potentials (cVEMPs and oVEMPs) from newborns via children, adolescents, adults to the elderly.

Methods: Loud sound stimuli were utilized to elicit oVEMPs and cVEMP in children aged below 3 years old. For small children and the elderly who cannot maintain neck contraction, cVEMP test can be performed by head rotation method instead of head elevation method. For small children who cannot maintain upward gaze, oVEMP test was conducted by eyes closed method. For young adults, tapping at the Fpz site is preferred for eliciting bilateral oVEMPs, if fails, tapping at the Fz site alternatively. If both Fpz and Fz taps fail to induce oVEMPs, tapping at the mastoid is performed to assess the residual otolithic function.

Results: The cVEMPs can be elicited in newborns at day 5, whereas the oVEMPs are absent in neonatal period. When children grow to 2 years old, the oVEMPs can be induced with eyes closed condition, while the oVEMPs with eyes up condition can be elicited in children aged > 3 years old, with the characteristic parameters similar to adult levels. In contrast with cVEMPs, it is until the neck length > 15.3 cm, one need not account for neck length in evaluating cVEMP latency. For those elderly aged > 60 years, absent oVEMP and cVEMP may arise from either underlying pathology or aging effect.

Conclusions: Defining appropriate test stimuli/paradigms in subjects of various ages may improve the reliability of the oVEMP and cVEMP results, which is in evolution.

PP1-86 - Eye tracking during caloric nystagmus: a sensitive test to identify central vestibular disorder

7. Clinical Testing for Vestibular Function

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Purpose: In 1975, Sakata et al. demonstrated that eye-tracking patterns during caloric nystagmus (CN) were useful for differentiating between peripheral and central vestibular disorders (CVD). We report that the degree of suppression of CN by eye-tracking could be a sensitive indicator for detection of central vestibular disorders.

Methods: For induction of CN, the subjects were placed in a supine position with the head anteflexed at 30 degrees and their ear was stimulated with cold air (10°C) for 60 s. After CN was established, subjects were instructed to follow a target oscillating with 30° amplitude, at a frequency of 0.3 Hz. A total of 32 waveforms during 3 eye-tracking periods were quantitatively examined with spectral analysis by discrete Fourier transformation; these were obtained from 14 ears of 7 healthy subjects and 18 ears of 9 patients with central vestibular disorder. The CN induced by eye-tracking was compared with that induced by visual-fixation.

Results: Unlike in healthy subjects, eye-tracking during CN was not maintained smoothly in most patients with central vestibular disorder, including patients who showed normal visual-fixation. The suppression-rates of CN by eye-tracking were 72.0% ± 8.6 for healthy subjects and 36.3% ± 19.6 for patients when the eye-tracking was directed to the slow phase of CN, and 65.1% ± 14.9 and -2.1% ± 42.0 respectively, when the eye-tracking was directed to the fast phase.

Conclusions: Eye-tracking during CN is a sensitive diagnostic method for detection of central vestibular disorder.

PP1-87 - Functional Measure of Gaze Shifting in Healthy and Unilateral Vestibular Hypofunction Individuals

7. Clinical Testing for Vestibular Function

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Purpose: A gaze shift involves an initial eye rotation to the target of interest, followed by a head rotation towards the same target. We incorporated dynamic visual acuity test to develop a functional measure of gaze shift called gaze shift DVA (gsDVA) and compared the differences among the young (< 65 y/o) vs (65 y/o) populations and patients with unilateral vestibular hypofunction.

Methods: At the beginning of the test, the center monitor flashed an arrow randomly pointed to the left or right. The subject followed the direction given and turned her/his head to the left/right side monitor until the central axis of the face was aligned with the monitor. Once the subject's head rotated to a 60-degree range, an optotype would flash on the side monitor for the subject to identify its orientation. The Optotype would disappear after an examiner entered the response. gsDVA, reaction time (RT) and head velocity were measured both in stance and walking at a self-selected speed.

Results: We recruited a total of n=105 subjects (71 healthy; 21 left and 13 right vestibular hypofunction). gsDVA was worse healthy subjects aged 60-80 years, followed by gsDVA in 20-40y/o, and best in 40-60 y/o. Patients with UVH displayed worse gsDVA scores during ipsilesional head rotation

Conclusions: Significantly reduced gsDVA was found in the old. This phenomenon was also noted in

vestibular hypofunction patients on ipsilesional gsDVA. We believe this measure will be a useful metric in evaluating dynamic visual acuity in different age groups and patients with vestibular hypofunction.

PP1-88 - Head Movement During Functional Gait Assessment Predicts Clinical Measures in Vestibular Patients

7. Clinical Testing for Vestibular Function

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Purpose: A wide range of functions, from basic reflexes to high-level behaviors, depend on the vestibular system. It has been shown that following unilateral vestibular loss, patients experience dizziness, headache, and impaired balance, postural, and gaze control. Here, we assessed whether functional Gait Assessment Can Predict Clinical Measures in Vestibular Schwannoma Patients

Methods: Head movements were recorded during Functional Gait Assessment (FGA) using a six dimensional motion sensor in (1) healthy volunteers and (2) patients before and six weeks after surgery. We computed measures of gait speed, asymmetry, and variability during FGA and then compared these with the clinical measures; dizziness handicap inventory (DHI), activities-specific balance confidence (ABC), Beck anxiety inventory (BA), FGA score, postural sway, and vestibulo-ocular reflex gain.

Results: Our results showed negligible correlations between gait parameters and clinical measures in the healthy volunteers. In contrast, we found significant correlations with multiple clinical measures in patients. First, before surgery, patients with higher head movement variability during walking also had larger postural sway. Correlations between gait parameters and clinical measures were even more common six weeks after surgery. Notably, gait variability correlated with multiple the clinical measures. Moreover, patients with lower anxiety and dizziness and higher confidence and FGA scores

showed higher variability, and patients who walked faster had more dizziness and less FGA scores.

Conclusions: Taken together, our results suggest that computed measures of gait speed, asymmetry, and variability from the FGA can be a predictor of the clinical measures and can be used for monitoring patients with unilateral vestibular loss.

PP1-89 - High-frequency VOR in certain Hydropic Ear Disease

7. Clinical Testing for Vestibular Function

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Purpose: Little is known about the VOR physiology in Hydropic Ear Disease (Menière's Disease), and previous studies have yielded variable results, partly due to a mainly symptom-based diagnostic verification. Here, we present the first detailed study of the VOR in a well-defined patient population with certain Hydropic Ear Disease with maximal diagnostic accuracy.

Methods: 54 patients with certain Hydropic Ear Disease, i.e. clinically definite Menière's Disease according to the AAO-HNS criteria and evidence of endolymphatic hydrops on magnetic resonance imaging were included. Patients were examined with video head impulse test (vHIT), caloric videonystagmography, VEMP and audiometry.

Results: Clearly pathological vHITs with a gain below 0.7 were relatively rare (13%) in patients with certain Hydropic Ear Disease. However, the majority of patients (61%) revealed refixation saccades with a saccade frequency of > 50%. The VOR gain was highly significantly correlated with saccade frequency and velocity. There was no correlation between vHIT gain/saccade frequency/saccade velocity and caloric canal paresis/VEMP/audiometry. Furthermore, refixation saccades were not correlated with disease duration, in contrast to the situation in acute peripheral vestibulopathy.

Conclusions: When examining the vHIT in patients with suspected Hydropic Ear Disease, it is important to not only consider the VOR gain, but also examine refixation saccades. The occurrence of refixation saccades may be an indicator for an impaired VOR even in the presence of a "normal" VOR gain value. Furthermore, the process of vestibular compensation seems to be impaired in Hydropic Ear Disease, probably due to the fluctuating nature of the disease.

PP1-90 - Horizontal ocular deviation on brain MRI in acute vertigo patients

7. Clinical Testing for Vestibular Function

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Purpose: Magnetic resonance imaging (MRI) has been increasingly used for screening central acute vertigo in the ER. Recently horizontal ocular deviation (OD, measured from T2 MRI) is shown to well correlate with vestibular function tests which reflect the vestibular static and dynamic imbalance and can be used as an indicator of unilateral vestibular weakness. The aim of this study is to compare the horizontal OD among different disease and to evaluate the correlation of OD direction and lesion side in each disease respectively.

Methods: This study was retrospective review including 188 patients who visited ER due to acute vertigo. The final clinical diagnosis are as followed: BPPV, definite Meniere's disease (dMD), probable and possible MD (pMD), migraine associated vertigo (MAV), vestibular neuritis (VN), and others. PICA infarction patients was also included. The control group included 30 healthy individuals without previous vertigo history or ophthalmopathy. OD was quantified by using the axial planes of the eyeball lenses in T2 brain MRI.

Results: Acute vertigo patients showed variable OD value depending on diagnosis. The average value of absolute OD in dMD ($19.5^\circ \pm 12.2^\circ$), pMD ($15.8^\circ \pm 11.2^\circ$), VN ($22.8^\circ \pm 10.6^\circ$) was significantly higher than that of control ($5.9^\circ \pm 3.0^\circ$) ($p < 0.01$). BPPV did not show abnormal OD compared to control. VN

showed statistically higher lesion side OD. MD, PICA showed contralesionside OD (43%) compared to control.

Conclusions: Horizontal OD reflecting the vestibular imbalance was variable depending on pathology and significantly higher in MD, pMD, VN and PICA patients than in control group.

PP1-91 - How many sweeps are needed for Clinical OVEMP testing

7. Clinical Testing for Vestibular Function

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Purpose: OVEMPs in our hands provide us with reproducible and consistent results but it has been shown that OVEMP amplitude decreases with increased stimulus duration. The exact number of stimuli for OVEMP recording is not consistent through the published papers describing this test. We wished to determine how many stimuli are needed to produce a satisfactory OVEMP response and the consequences of more prolonged stimulation to the OVEMP response.

Methods: We retrospectively analyzed our previous 50 OVEMP patient recordings and found that the average number of sweeps carried out was 26. We carried out 3 different OVEMP recordings; using our standard protocol of

- 1 a "standard" OVEMP recording without looking at the number of sweeps and recording until the OVEMP wave becomes obvious.
- 2 OVEMP recording with our average of 26 sweeps.
- 3 OVEMP recording with twice as many sweeps.

Results: OVEMP latencies did not change when using different numbers of sweeps, but amplitudes showed a significant decrease with an increasing number of sweeps.

Conclusions: OVEMPs can be completed in a satisfactory manner with a much lower number of stimu-

li than are usually carried out. Reducing stimulus number reduces the time that the test takes, minimizes the cochlear insult while not reducing the valuable information obtained, and maximizes the amplitude of the stimulus, possibly increasing accuracy of measuring interaural amplitudes, helping to measure asymmetry.

PP1-92 - How well does clinical history correlate with results of vestibular assessment?

7. Clinical Testing for Vestibular Function

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Purpose: It is well documented that patient histories do not correlate with abnormal test results. It is also well established that normal test results do not rule out pathology, and we wished to test this hypothesis in a controlled manner. This study tested the intuition of two Neuro-otologists to predict test results based only on history and clinical exam. In addition, the assessor of all the patients also used his intuition to try and determine if the Neuro-otologists would be successful in their predictions.

Methods: All patients underwent a full battery of tests (VEMPs, Calorics, posturography, HIT). The neuro-otologists predicted the abnormalities after history taking and patient examination but before being supplied with any results.

Results: There was very poor accuracy of prediction and discussion of the usefulness of clinical assessments related to measured abnormalities. The assessor of the patients (who had taken a detailed history and carried out all assessments) was also poor at predicting what conclusions would be arrived at by the clinicians.

Conclusions: The paramount factor in assessing a dizzy patient is in the history. Normal test results do

not override a history, and abnormal results assist in confirming the clinical impression.

PP1-93 - Isolated posterior canal hypofunction on video-HIT: association with additional inner ear deficits

7. Clinical Testing for Vestibular Function

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Purpose: Since video head impulse testing (vHIT) has been introduced, a functional assessment of each semicircular canal (SC) has been easily provided in clinical setting. Isolated posterior SC (PSC) hypofunction, though occasionally described, has not been extensively characterized yet. Here we aimed to assess all different patterns of concomitant abnormalities on audiometry, caloric test (CT) and cervical/ocular VEMPs by air/bone conduction in patients with isolated PSC hypofunction and to correlate with underlying diagnoses.

Methods: We retrospectively reviewed the clinical and instrumental records of 49 patients with isolated PSC hypofunction (25 right, 23 left, bilateral in 1 case). We determined vHIT gains and correlated them with other instrumental data.

Results: Recent or previous acute vestibular deficit (AVD) was diagnosed in 12 patients (24.5%, 8 with cochlear involvement), Meniere's disease (MD) in 11 (22.4%) and cerebellopontine angle (CPA) lesion in 9 (18.4%). Additional abnormalities on BCT and/or VEMPs due to horizontal SC and/or maculae involvement was seen in 85% of patients. Cochlear involvement was diagnosed in 69% with pure tone

average significantly higher in patients with AVD with hearing loss ($p < 0.05$). Overall involvement of labyrinthine receptors or afferents was highest in patients with AVD with hearing loss ($p < 0.01$) and CPA lesion ($p < 0.05$).

Conclusions: Isolated loss of PSC function on vHIT is mostly accompanied by additional labyrinthine deficits. It should always be tested in patients with vestibulo-cochlear symptoms. Assessment of all inner ear receptors and afferents is mandatory in order to identify the site of the lesion, thus hypothesizing underlying pathophysiological mechanisms.

PP1-94 - New protocol to optimize ocular-VEMP stimulation and recording with High-Force Level Bone Conductors

7. Clinical Testing for Vestibular Function

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Purpose: Ocular vestibular evoked myogenic potentials (oVEMPs) provide information about utricular function and neural pathway between utricle and inferior oblique muscle. Although oVEMPs are more easily obtained by using high-force level bone conductors (HFBC) instead of clinical B71 or B81 bone conductors, clinical protocols for HFBC recordings are lacking.

The aim of this study is to investigate the use of different stimuli, different scalp locations and different electrode recording configurations for clinical implementation of oVEMPs using HFBC

Methods: Subjects (n=20) without neuro-otological medical history underwent oVEMP testing using different parameter settings: 1) oVEMP responses of bone-conducted (BC) stimuli are obtained at different scalp locations (Cz, Fz, M1/2) to uni- and bilateral responses 2) stimuli consist of 250 to 1000 Hz tone bursts, generated by a high-force level B&K 4810 'Mini-Shaker'. Response amplitude (uV), latency (ms), response reproducibility (%), inter-ocular ratio (%) and vibratory stimulation threshold (dBFL) were determined for different tapping scalp positions. Left- and right oVEMP responses (inter-ocular ratio: IOR) were compared.

Results: Significant differences in response amplitude, latency, response reproducibility and IOR were found depending on tapping scalp position. Left and right differences were most prominent during mastoid stimulation. Tone burst stimuli with rise-plateau-fall times of 1-1-1 ms of 500 Hz reveal best oVEMPs when presented at Fz with single reference recordings and bilateral belly-tendon locations of the inferior oblique muscles.

Conclusions: An new improved standard clinical protocol is proposed for clinical assessment of oVEMPs with HFBC stimulators

PP1-95 - Non compensation in the vestibular patient

7. Clinical Testing for Vestibular Function

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Purpose: VEMP assessment is a powerful diagnostic assessment. Documented abnormalities can persist for long periods of time, in which case compensation is required. We oftenn see patients who have had persistent problems for years. These abnormalities can persist, but do not give an indication of clinical recovery. Computerized dynamic posturography however in our hands, is a more effective measure of a patient's clinical recovery.

We have wondered why certain patients do not compensate. History taking is of utmost importance in these patients as some of them have a history of more than one discrete event (either traumatic or nontraumatic). This suggests sequential contralateral or ipsilateral pathology, which presents an added challenge to compensate for.

Methods: We studied patients who had suffered only one discrete event and compared them to patients who had suffered multiple vestibular events. We looked at posturography performance in both groups of patients.

We have always wondered why some patients complain predominately of nausea and others predominately of imbalance. The presence of autonomic symptoms may inhibit compensation due to reduced physical activity. We also documented autonomic symptoms in our "single event" and the "multiple event" patients.

Results: Although VEMP assessment was similar in our two groups of patients, we found that patients with a history of multiple events and with a predominance of autonomic symptoms compensated less effectively as shown on posturography.

Conclusions: Recovery after a significant single vestibular event is better than with multiple events, and patients with persistent autonomic symptoms do not do as well.

PP1-96 - Normal values of video-head impulse test for healthy people in different age

7. Clinical Testing for Vestibular Function

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Purpose: To explore the normal values of video-head impulse test (vHIT) and age-related changes in healthy volunteers.

Methods: One hundred and eleven healthy volunteers were distributed to seven age groups, all subjects accepted video-head impulse tests. The vestibulo-ocular reflex (VOR) gain and gain asymmetry ratio were analyzed and compared among groups.

Results: For all the healthy subjects, the mean horizontal VOR gain was 1.04 ± 0.09 (range: 0.70-1.26), the mean anterior VOR gain and the posterior VOR gain were 0.89 ± 0.13 (range: 0.61-1.25) and 0.88 ± 0.12 (range: 0.62-1.24). There were no significant differences among different age groups in horizontal VOR gain and in vertical VOR gain ($P > 0.05$). The mean left and right horizontal gain asymmetry ratio was $6.83 \pm 4.01\%$, the mean left-anterior and

right-posteriorLARPgain asymmetry ratio and the mean right-anterior and left-posteriorRALPgain asymmetry ratio were $6.03 \pm 5.31\%$ and $7.36 \pm 5.03\%$. There were no significant differences among different age groups in gain asymmetry ratio ($P < 0.05$).

Conclusions: There were no obvious age-related changes in VOR gain and gain asymmetry ratio in healthy people.

PP1-97 - Outcome prediction of sudden sensorineural hearing loss using neurotological tests

7. Clinical Testing for Vestibular Function

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Purpose: This study investigated whether audiovestibular function tests, namely auditory brain stem response (ABR) and vestibular-evoked myogenic potential (VEMP) tests were correlated to hearing outcomes in sudden sensorineural hearing loss (SSHL).

Methods: Patients with sudden SSHL were enrolled in this study. Pretreatment hearing levels, results of audiovestibular function tests, and final hearing outcomes were recorded from retrospective chart reviews. Other factors, including age, gender, delay of treatment, vertigo, diabetes mellitus, and hypertension, were collected as well. Comparative analysis between multiple variables and hearing outcomes was conducted using the cumulative logits model in overall subjects.

Results: Multivariate analysis showed that pretreatment hearing levels, presence of vertigo, and results of ABR and VEMP testing were significant outcome predictors in the overall subjects. Stratification analysis demonstrated that both the presence of ABR and VEMP waveforms were significantly correlated with better hearing outcomes in the group of severe SSHL, whereas the presence of vertigo was the only significant negative prognostic factor in the group of profound SSHL

Conclusions: ABR and VEMP tests should be included in the battery of neurootological examinations in patients with severe SSHL because the presence of both waveforms might indicate favorable hearing outcomes.

PP1-98 - Postural control, vestibular restoration and disability perception in vestibular neuritis

7. Clinical Testing for Vestibular Function

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Purpose: To evaluate vestibular restoration and the evolution of the compensatory saccades in vestibular neuritis and its correlation with computerized dynamic posturography (CDP) values and disability questionnaires.

Methods: Longitudinal and prospective study of 27 consecutive patients diagnosed of vestibular neuritis. After the initial diagnosis, every patient was followed up in a three-month basis for at least 12 months. vHIT, Caloric and Vestibular Evoked Myogenic Potentials were performed in the moment of the diagnosis. Subsequently vHIT, was performed 1 week, 1 month, 3 months, 6 months and 12 months after the initial diagnosis. A Computerized Dynamic Posturography and disability questionnaires were completed every three months.

Results: The different vHIT tests showed a progressive VOR restoration along the time. A pattern of decrease in the velocity and latency values of the saccades, and a progressive grouping was identified. A significant correlation between the vHIT gain values and the sensory organization test as with the disability questionnaires, were observed. There is a significant correlation between evolution disability questionnaires punctuation and vHIT gain and also with postural control described in CDP.

Conclusions: The VOR restoration, the reduction of latency and velocity and the organization of compensatory saccades play a role in vestibular compensation. These findings have a significant influence in postural control and the perceived disability of the patients

PP1-99 - Posturographic pattern of patients with peripheral vestibular dysfunction at vertigo interval period

7. Clinical Testing for Vestibular Function

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Purpose: Posturography (PG) is used to study equilibrium-functions, but the accuracy to detect the focus of peripheral vestibular disease (PVD) is unclear. This study aimed to examine the difference of PG pattern in PVD patients.

Methods: In this study, 425 patients were examined PG parameters at first meeting. 220 patients with Meniere's disease, 101 patients with posterior canal type benign paroxysmal positional vertigo (P-BPPV), 53 patients with horizontal canal type BPPV (H-BPPV), 20 patients with sudden hearing loss with vertigo and 31 patients with vestibular neuritis were included. In 126 patients, caloric test was performed. We studied relationship of damaged side and mean value of center of left to right movement (MX). In patients who were performed caloric test, we evaluated the relationship of canal paresis side and MX.

Results: There were significant differences at total length movement (LNG) with eyes open and closed between patients with Meniere's disease and patients with BPPV. In addition, there was a significant difference in age between patients with Meniere's disease and patients with BPPV. Multiple analysis was performed, age was correlate with LNG, and the difference between patients with Meniere's disease and patients with BPPV was negative. There were no correlations with PG parameters and damaged side, and canal paresis side. In any PG parameters, there were no significant differences between patients with P-BPPV and patients with H-BPPV.

Conclusions: There was significant difference between patients with Meniere's disease and patients with BPPV, but it depended only on the age distribution.

PP1-100 - Preliminary results of video Head Impulse Testing (vHIT) in children with dizziness or vertigo

7. Clinical Testing for Vestibular Function

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Purpose: This study was to describe our preliminary experience with vHIT in children with dizziness or vertigo, and determine its efficacy for detecting dysfunction of the semicircular canals in this population.

Methods: 48 children (21 males and 27 females, age range 4-12 years) with different types of vertigo or dizziness were performed. All these children without hearing loss or absence of skull abnormality as assessed by CT scan or MRI. The caloric test was performed with air at two different temperatures in which both ears were irrigated alternately. Then, the video head-impulse test was carried out. Main outcome measures were the gain of vestibulo-ocular reflex, gain asymmetry, and refixation saccades in the vHIT.

Results: In all subjects, 30 children complete the bi-thermal caloric tests, 19 patients were normal and the other 11 patients were abnormal. By vHIT, in 30 patients (62.5%) is, while abnormal findings were found in 18 patients (37.5%). Single canal affection was seen in 8 patients whereas 10 patients had combined canal affection. The right side was affected in 15 and left side in 17 patients. The most common pattern was affection of right posterior canals and left posterior canals. The average gain in different canals was 1.06 ± 0.24 , 1.08 ± 0.22 , 1.00 ± 0.32 , 0.90 ± 0.32 , 1.22 ± 0.37 , 1.67 ± 0.35 in Horizontal left, Horizontal right, Left anterior, Right posterior, Right anterior, Left posterior, respectively.

Conclusions: vHIT is a simple tool to evaluate each of the 6 semicircular canals in children, which can offers some potential clinical information for assessing the vestibular dysfunction in children with dizziness or vertigo.

PP1-101 - Quantitative analysis of smooth pursuit eye movement by video-oculography (VOG)

7. Clinical Testing for Vestibular Function

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Purpose: Abnormalities of smooth pursuit eye movement (SPEM) are a clinical finding in central equilibrium disorders. In recent years, the evaluation of SPEM using video-oculography (VOG) has been conducted clinically. However, evaluation criteria for determining a saccadic pattern have not been clearly defined. In this study, we report SPEM using VOG performed with commercially available equipment. The results were then quantitatively evaluated.

Methods: Twelve patients treated at the Department of Otolaryngology at our hospital underwent SPEM testing using simultaneous electronystamography (ENG) and VOG. Eye movements were binarized using ImageJ software and these data were used for statistical analysis. Evaluation criteria included the number of saccadic eye movements, average eye movement velocity, average difference between target and eye movement velocities, and phase lag between target and eye movements.

Results: We examined a healthy pattern group (n = 6) and saccadic pattern group (n = 6). A significant difference between the healthy and saccadic pattern groups in the number of saccadic eye movements, average eye movement velocity, and average difference between target and eye movement velocities were identified.

Conclusions: Quantitative evaluation of SPEM using VOG was possible and useful evaluation criteria were identified. SPEM testing can non-invasively evaluate brain stem and cerebellar function. Screening may be possible using this simple method.

PP1-102 - Relationship of Vestibulo Ocular Reflex and Gait in Patients with Vestibular Schwannoma

7. Clinical Testing for Vestibular Function

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Purpose: Growth of vestibular schwannomas (VS) causes progressive vestibular symptoms and postural instability. Since the tumor grows slowly, compensation of disturbing vestibular input may decrease subjective symptoms of dizziness. The goal of this study was to determine if testing of static and dynamic vestibulo ocular reflex correlates with clinical gait tests in patients with VS.

Methods: A prospective review of 18 patients newly diagnosed with VS. The results of vestibulo ocular tests including dynamic visual acuity during passive head motion and deviation of subjective visual vertical. These outcome measures were compared to results of Timed Up and Go Test, Four Step Square Test, Functional Gait Assessment and Tinetti Performance Oriented Mobility Assessment. Nonparametric Spearman's correlation was used for statistical analysis.

Results: There was significant correlation between deviation of subjective visual vertical and dynamic visual acuity. We did not observe significant correlation between deviation of subjective visual vertical and gait tests but significant correlation between dynamic visual acuity test and Timed Up and Go Test, Four Step Square and Tinetti Performance Oriented Mobility Assessment was found.

Conclusions: We found possible effects of dynamic vestibulo ocular reflex dysfunction on walking impairment. Our findings confirmed that dynamic

visual acuity test correlate significantly with gait tests in patients diagnosed with VS.

PP1-103 - Reliability of the Suppression Head Impulse Test and Role of Test Predictability

7. Clinical Testing for Vestibular Function

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Purpose: Suppression Head Impulse Paradigm (SHIMP) was recently discovered as a version of vHIT protocol that provides additional information about the vestibule-Ocular Reflex (VOR) in vestibular dysfunction. Objectives: To examine the test-retest reliability of (SHIMP) and to test the influence of predictability on the latency of SHIMP saccadic responses for both healthy participants and participants with vestibular function deficiency.

Methods: The study included 3 patients with unilateral vestibular hypofunction and 5 healthy subjects. Participants were tested twice by two examiners. SHIMP eye movements responses were recorded with the Video Head Impulse Test. SHIMPS were performed by turning the head 10 times at high velocities to the left and to the right side, respectively. Every examiner performed the test in two different algorithms: predictable SHIMP and unpredictable SHIMP depending on the target predictability. Saccades latency and velocity and VOR gain were recorded for every subject.

Results: The intraclass correlation coefficient (ICC) of the test-retest of SHIMP by two examiners was at least (0.746) in both latency and velocity of the SHIMP saccadic responses in both groups ($p < 0.01$). There was no significant influence of the predictability of head movement between the two groups.

Conclusions: The reliability of SHIMP test was demonstrated in our study, but the lack of the influence of the predictability may be related to the small number subjects included in our preliminary study.

PP1-104 - Simultaneous recording of cervical and ocular vestibular-evoked myogenic potentials

7. Clinical Testing for Vestibular Function

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Purpose: To improve the clinical application of vestibular-evoked myogenic potentials (VEMPs) in real-world practices, we evaluated whether simultaneous recording of ocular and cervical VEMPs could be achieved while preserving diagnostic accuracy compared to conventional recording methods.

Methods: Simultaneous recording of ocular and cervical VEMPs on each side during monaural stimulation, bilateral simultaneous recording of each VEMP with binaural stimulation, and conventional sequential recording of both VEMPs on each side using air-conducted sound (500 Hz, 5ms tone-burst) were investigated in healthy controls (n=40) and in patients with acute vestibular neuritis (n=20).

Results: Either simultaneous recording during monaural and binaural stimulation effectively reduced the testing time less than 60% of that for conventional sequential recordings in both healthy controls and the patients group. The simultaneous recording with monaural stimulation led to plausible evoked potentials in terms of latencies, thresholds, and amplitudes as in the conventional recording methods, except for larger ocular VEMP amplitudes (156%) in both groups. In contrast, simultaneous recording of each VEMP during binaural stimulation showed amplitudes attenuation (31%) and increased thresholds for cervical VEMPs in both groups.

Conclusions: Simultaneous recording of cervical and ocular VEMPs using monaural stimulation elicited eletrodiagnostic indices without a loss of diagnostic validity whilst reducing the time to record both VEMPs on each side.

PP1-105 - Splenius capitis: Target for the cVEMP in older and neurodegenerative patients

7. Clinical Testing for Vestibular Function

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Purpose: The vestibular evoked myogenic potential (VEMP) is a technique used to assess vestibular function. Conventionally, cervical VEMPs (cVEMPs) are obtained from the sternocleidomastoid (SCM) muscle of the neck. Recent work has shown that splenius capitis (SPL) is also a robust target for measuring the cVEMP in young healthy subjects. It remains unclear however, if SPL-cVEMPs are also useful targets for assessment in older or patient populations.

Methods: Here, we used surface electromyography to measure cVEMPs from young subjects (mean age 21.9 ± 2.1 ; $n=13$), older subjects (64.8 ± 6.1 ; $n=14$), and age matched Parkinson's disease (PD) patients (68.7 ± 6.5 ; $n=6$) in two positions: the clinical posture and simple seated head turns.

Results: The incidence of both clinical and seated SCM-cVEMPs diminished significantly in older and PD patients in comparison with young subjects ($p < 0.01$ and 0.001 respectively). In contrast, no differences were found in SPL-cVEMPs across groups. Importantly, SPL-cVEMPs were present significantly more often than seated SCM-cVEMPs in PD patients ($p = 0.003$), highlighting the utility of this muscle target in clinical populations. cVEMP parameters including peak amplitude and latencies were comparable across groups.

Conclusions: These findings show that the SPL is a reliable target for cVEMP measurements in older

and clinical patients. Further, the changes in SCM cVEMP in older populations are not replicated in the SPL. Together these data hint at the potential of SPL as a means to limit false positive cVEMP measurements in clinical populations.

PP1-106 - Suppression head impulse paradigm in normal adults: values and parameters

7. Clinical Testing for Vestibular Function

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Purpose: To study the normal range of parameters of suppression head impulse paradigm (SHIMP) in normal Chinese adult population.

Methods: 30 healthy adults were selected as subjects and all of them underwent conventional SHIMP examination. Parameters provided by the video head pulse software include gain, the latency and the peak velocity of saccades were calculated.

Results: All the subjects were elicited anti-compensatory saccades in SHIMP test. The normal values of left and right VOR gain were 1.01, 1.10 in HIMP and 0.93, 1.01 in SHIMP respectively. The left and right saccade latency were 201.1 ± 50.8 ms, 187 ± 42.9 ms and the peak saccadic velocity were 302.7 ± 58.5 degree/s, 291.5 ± 46.5 degree/s in SHIMP. No significant difference could be found between bilateral ears ($p > 0.05$).

Conclusions: SHIMP is a promising examination which could be used to evaluate anti-compensatory saccades and provide us further information on VOR function.

PP1-107 - Systemic Aminoglycosides-Induced Vestibulotoxicity in Humans

7. Clinical Testing for Vestibular Function

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Purpose: This systematic review aimed to investigate the prevalence and characteristics of vestibular adverse effects of aminoglycoside (AG) therapy in humans and to analyze objective vestibular tests for the detection of AG-induced vestibulotoxicity.

Methods: PubMed, Cochrane Database, Web of Science, and reference lists of all included studies were screened by two independent researchers. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were followed. Studies were included according to preset inclusion criteria and reported outcomes of studies evaluating vestibular function using one or more objective vestibular function tests in adults and children after systemic AG administration. The methodological quality of each study was assessed using the quality assessment tool for quantitative studies. Interrater reliability was established using Cohen's Kappa.

Results: Twenty-seven studies were included, with the vast majority showing AG-induced vestibulotoxic side effects, ranging from 0 to 60%. Most studies reported AG-induced abnormalities by caloric and rotatory testing, whereas only a few studies reported using video Head Impulse Test and vestibular evoked myogenic potential testing.

Conclusions: Because type I hair cells (particularly of the semicircular canals) are more susceptible to ototoxicity, video Head Impulse Test and vestibular evoked myogenic potential testing seem more promising for the early detection of vestibulotoxicity than caloric and rotatory testing. Prospective studies using an extensive vestibular test battery are needed to further characterize the impact of AGs on the different vestibular end organs and to identify the most sensitive vestibular technique for the early detection of vestibulotoxicity.

PP1-108 - The analysis of the value of spontaneous nystagmus in peripheral vestibular hypofunction.

7. Clinical Testing for Vestibular Function

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Purpose: To study the characteristics and clinical value of peripheral vestibular dysfunction.

Methods: 98 cases of acute unilateral vestibular peripheral vertigo patients were studied. The characteristics of SN, the relationship between SN and course of disease, DP and UW were analyzed according to the course.

Results: There were 62 patients with SN and 36 without SN out of 98 cases accounting for 63.3% and 36.7% respectively. SN was within intensity range of 0.5°/s 20.4 °/s and had negative correlation with the disease duration ($r=-0.365$, $P=0.04$). SN was divided into 3 degrees according to its intensity, with median duration of disease course were 10d, 5d and 3d respectively. The result of the caloric test were the following unilateral weakness 45 cases 72.6% with 7 cases having the direction of SN towards the weakness side and 38 cases pointing towards the opposite direction; bilateral weakness 9 cases 14.5% and normal 8 cases 12.9%. There were no relationship between the intensity of SN and UW value $r=-0.051$, $P=0.692$. The UW value of patients with SN ($47.5 \pm 22.5\%$) was compared to the group without SN ($29.9 \pm 18.8\%$).

Conclusions: The intensity of SN in patients with acute unilateral vestibular peripheral vertigo majority was moderate and severe. Intensity with the course of the disease gradually weakened or change the direction, The degree of vestibular injury was higher than those without SN.

PP1-109 - The diagnostic value of the bone-conduction cervical vestibular evoked myogenic potentials (cVEMP)

7. Clinical Testing for Vestibular Function

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Purpose: Defining the value of bone-conduction cervical vestibular evoked myogenic potential (BC VEMP) in patients with conductive hearing loss.

Methods: Both normative and patient data was obtained for air- and bone-conduction cervical VEMP (AC and BC VEMP, respectively). Tone bursts of 500 Hz (2-2-2 ms, repetition rate: 5.1 Hz) were delivered through insert earphones (130 dB sound pressure level (dB pSPL)) and with a B71 bone vibrator attached to an additional amplifier increasing the gain up to 20 dB (137 dB peak SPL (dB pSPL)), for AC VEMP and BC VEMP, respectively.

Results: A response rate of 100% was obtained for both AC and BC VEMP in the healthy participants. Several parameters were significantly different between the two stimulation methods (p13 latency ($p = 0.010$; $Z = -2,6$; $\text{mean}_{AC} = 14,4$ ms (standard deviation ($\text{SD}_{AC} = 0.70$ ms); $\text{mean}_{BC} = 14,0$ ms ($\text{SD}_{BC} = 0.84$ ms)), p13-n23 amplitude ($p = 0.005$; $Z = -2,8$; $\text{mean}_{AC} = 419,7$ μV ($\text{SD}_{AC} = 171,80$ μV); $\text{mean}_{BC} = 299,9$ μV ($\text{SD}_{BC} = 128,33$ μV)), and corrected amplitude ($p = 0.002$; $Z = -3,2$; $\text{mean}_{AC} = 2,2$ ($\text{SD}_{AC} = 0,59$); $\text{mean}_{BC} = 1,5$ ($\text{SD}_{BC} = 0,57$))). In the patient group, a significant air-bone gap was detected in 13 patients (13/143, 9%). Six of them had normal BC VEMPs (4/6, 67%). Some specific cases of comorbidity were found.

Conclusions: The standard B71 bone vibrator attached to an additional amplifier was capable of bypassing the conductive hearing loss in 67% of the cases. Therefore, BC VEMP should be considered whenever an ABG is present (even when falsely induced by a semicircular canal dehiscence (SCD) or when co-existing with one).

PP1-110 - The Role of Predictability in the Suppression Head Impulse Test

7. Clinical Testing for Vestibular Function

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Purpose: To analyze the main characteristics of the early saccadic responses in participants according to three SHIMP protocols, depending on the predictability of the head impulse.

Methods: A prospective cohort non-randomized study was designed. For the SHIMP protocol, recorded with the ICS Impulse ver. 4.0[®] (Otometrics, Denmark) vHIT device, three different algorithms were performed: “predictable,” “less predictable,” and “unpredictable” depending on the target’s predictability. A mathematical method was developed to analyze the responses.

Results: In cohort 1, 52 participants were included in “predictable” SHIMP protocol. In cohort 2, 60 patients were included for the “less predictable” and 35 patients for the “unpredictable” SHIMP protocol. The participants made more early saccades when instructed to perform the “predictable” paradigm compared with the “less predictable” paradigm ($p < 0.001$). The less predictable protocol did not reveal any significant difference when compared with the unpredictable protocol ($p = 0.189$). For the latency of the first saccade, there was statistical difference between the “unpredictable” and “predictable” protocols ($p < 0.001$) and between the “less predictable” and “predictable” protocols ($p < 0.001$). Finally, we did not find any relationship between the horizontal vestibulo-ocular reflex (hVOR) gain and the latency of the saccades.

Conclusions: Our findings offer evidence regarding the influence of predictability on the latency of the SHIMP saccadic responses, suggesting that early saccades are probably caused by a conditioned response of the participant. The lack of relationship between the hVOR gain and the latency of the saccades suggests that the predictive behavior that caused the early eye saccades are independent of the vestibular function.

PP1-111 - The use of virtual reality in the assessment BPPV-related otolithic dysfunction a pilot study.

7. Clinical Testing for Vestibular Function

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Purpose: Residual dizziness (RD) following successful canalith repositioning manoeuvre (CRM) for benign paroxysmal positional vertigo (BPPV) is relatively common yet poorly understood. One possible mechanism is otolithic dysfunction (OD) – concurrent and/or following CRM. There is an uncertainty in the literature whether abnormality of subjective visual vertical testing (SVV) is associated with RD.

Methods: A new bedside quantitative test – virtual reality-based SVV (VR-SVV), was employed. VR-SVV was measured before and after CRM, and then

weekly, up to 4 visits. In addition to this, symptoms were recorded. Control data was obtained. Ethical approval was obtained from the Eye and Ear Hospital's Human Research Ethics Committee.

Results: 33 patients (33-85yo, 22F, 11M) with BPPV and 19 controls (22-56 yo, 8F, 11M) were assessed. 16/33 (48%) complained of either concurrent or RD. The VR-SVV was abnormal in 18/82 (23%) testing episodes. There was a significant correlation between dizziness and the presence of abnormal VR-SVV ($p < 0.05$). In the RD cohort, there was also a significant correlation between abnormal VR-SVV value and RD ($p < 0.05$). The incidence of false-positive VR-SVV results was similar in both the study and the control groups.

Conclusions: This pilot study indicates that VR-SVV is a promising new tool for the research assessment and clinical diagnosis of BPPV-related dizziness, but a larger sample size will supply a more definitive result.

PP1-112 - Updated screening tests of balance for vestibular disorders

7. Clinical Testing for Vestibular Function

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Purpose: We previously studied one manner of testing tandem walking and the Romberg on foam with head still and head moving in pitch. We found moderate ROC values, sensitivity and specificity. The goal of this study was to approach population norms with larger samples.

Methods: We tested Romberg on foam with eyes closed/ feet together: head still, and moving in yaw and pitch at 0.3 Hz. The sample included controls, $n = 355$; and patients with vestibular disorders, $n = 140$. We also tested subjects on tandem walking with eyes closed (controls, $n = 291$; patients, $n = 92$); the total number of correct steps was counted, on

three consecutive trials. Logistic regression was performed for estimation of area under the curve (AUC), where cut offs for best combinations of sensitivity/specificity were determined. $P < .05$ was considered significant.

Results: Durations of Romberg trials with head moving in controls were significantly shorter than head still trials but did not differ from each other; trial durations decreased gradually and significantly with age. ROC values were moderate, depending on the exact cut of the age range, but were approximately 0.75. On Tandem Walking subjects improved slightly on the second trial but fatigued on the third trial. ROC values were moderately high, better for younger subjects, $< \text{age } 60$, than subjects $> \text{age } 60$: ROC=0.8 younger subjects but ROC=0.72 older subjects.

Conclusions: Romberg head still and moving trials were useful. The first trial of tandem walking is a good indicator of performance. These screening tests are moderately useful for screening patients with vestibular disorders.

PP1-113 - Variacin del dhi en pacientes de rehabilitacion vestibular, independientemente de la patologia

7. Clinical Testing for Vestibular Function

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Purpose: The evaluation of the vestibular system is somewhat complex because of what happens with technological advances, the possibility of changing the reflection of the speaker of the eye with a high-speed camera attached to the glasses, register changes in this reflection. Serving this method as an effective diagnosis for pathologies of this system.

Methods: Retrospective, longitudinal, descriptive and observational study in which a video test of cephalic impulse was performed in patients with acute vestibular neuritis in which the variation of the pre and post treatment result was analyzed, taking into account the age and laterality.

Results: The average of the gain of all the groups increased, being the group of 10-24 the most significant with a variation of 10 point 0.66 in differential contrast with that of 75-100 which was only 0.1 point of gain 0,62.

Conclusions: The low response to the treatment of the group of 75-100 years could be explained due to a physiological decrease in the functioning of the RVO, which could be presenting a new plateau

PP1-114 - Variation of v-hit in patients with vestibular neuritis pre and post treatment.

7. Clinical Testing for Vestibular Function

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Purpose: The evaluation of vestibular system is somewhat complex with technological advances, it is possible to evaluate the vestibular reflex with an accelerometer and a high speed camera attached to a pair of glasses, allowing to record alterations in this reflex. Serving this as an affective diagnostic method for pathologies of this system.

Methods: Retrospective, longitudinal, descriptive and observational study in which cephalic impulse video test was performed in patients with acute vestibular neuritis, analyzing the variation of pre and post treatment result.

Results: The results gave the mayor an incidence on the right channels that on the sides at the front and at the end of this there is a difference of 0,005 point of gain favor of the left side and only 0,03 point for the right.

Conclusions: The v-hit is shown as an important tool not only as a diagnostic method but also as an important element for the pathological follow-up of the pathology and its response to vestibular kinesic treatment. The result show an effective variation to the treatment for both sides. With a better response to the treatment of the left channels with respect to the right.

PP1-115 - VEMP characteristics of vestibular paroxysm

7. Clinical Testing for Vestibular Function

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Purpose: Vestibular paroxysmia (VP) is a syndrome consisting of frequent short episodes of vertigo, which is attributed to neurovascular cross-compression (NVCC). Although VP was described by Jannetta and colleagues more than 30 years ago, there are few researches of VEMP features on vestibular function of VP. The purpose of this study is to identify the VEMP manifestations of vestibular paroxysmal.

Methods: A total of 19 patients were included in the study from January 2014 to December 2016. All patients underwent pure tone audiometry, tympanometry, caloric test, VEMP examination and and 3.0T MRI examination. Summarize the correlation between the VEMP features and MRI findings in the patients with paroxysmal vestibular.

Results: There were 8 males and 11 females were included in the study and followed up with a median age of 43 years old. In all the 19 cases, 17 cases were confirmed by cross-oppression of vestibular nerves and blood vessels with MRI examination. Among these cases, 5 were bilateral and 12 were unilateral. Abnormal caloric tests were found in 5 cases and high frequency hearing loss were found in 8 cases. VEMP abnormalities were found in 14 patients (7 cases latent period prolonged, 5 cases unilateral absent responses; 2 cases bilateral absent responses).

Conclusions: The abnormal expression of VEMP is close to that of vascular and nerve intersecting compression by MRI test. The abnormal rate of VEMP was significantly higher than that of caloric tests and pure tone audiometry. VEMP examination can be used as detection means in the evaluation of vestibular function in VP.

PP1-116 - VEMP using a new low frequency bone conduction transducer

7. Clinical Testing for Vestibular Function

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Purpose: A new prototype bone conduction transducer, called B250 which has an improved low frequency response, is evaluated in vestibular evoked myogenic potential (VEMP) investigations. The B250 offers a possibility to measure VEMP at a lower frequency than possible with a standard B71/B81 audiometric transducer and at a lower sound stimulation level than needed using air conduction (AC) stimulation. The aim is to compare cervical (cVEMP) and ocular (oVEMP) responses with focus on stimuli hearing levels required to reach threshold using bone conduction (BC) versus AC stimulation.

Methods: Three subjects from our research group with normal vestibular function were investigated in a pilot study. BC stimulation was applied to the mastoids in cVEMP, and both mastoid and forehead in oVEMP investigations.

Results: BC stimulation was found to reach VEMP thresholds at considerably lower hearing levels than in AC stimulation (39 dB lower oVEMP threshold at 250 Hz). Clinically useful cVEMP and oVEMP responses were obtained at 250 Hz for mastoid stimulation with the B250 transducer in all subjects. These results also means the VEMP investigations are possible also for patients having a pronounced bone conduction hearing loss. If forehead stimulation is provided, this study indicate that a more powerful vibration output may be needed.

Conclusions: Hearing sound levels required to evoke cVEMP and oVEMP were found to be considerably lower and more pleasant with BC stimulation than with AC. Clinically useful cVEMP and oVEMP responses were reached in all subjects with a new low frequency transducer at 250 Hz when applied to the mastoid.

PP1-117 - Vestibular function in children with congenital cytomegalovirus infection: A two-year follow-up

7. Clinical Testing for Vestibular Function

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Purpose: Congenital cytomegalovirus (cCMV) infection is the main cause of non-hereditary sensorineural hearing loss (SNHL) in children. The alleged underlying mechanism, cCMV-related labyrinthitis, can also affect the vestibular system which can have important consequences on the motor development in children. Therefore, longitudinal vestibular follow-up in all cCMV-infected children was initiated in our hospital in June 2016.

Methods: The follow-up protocol consists of a baseline-testing around 6 and 12 months, followed by an annual re-evaluation until the age of 6 years, with the video Head Impulse Test, rotatory test and cervical Vestibular Evoked Myogenic Potential test. Since 2016, 58 cCMV-patients were enrolled for follow-up, of which 37 already had more than one, and 12 had more than two follow-up examinations.

Results: Of all cCMV-patients included in this study, 28 were asymptomatic and 30 symptomatic. Within the latter group, 12 had SNHL (7 bilateral, 5 unilateral). Apparent saccular and horizontal canal dysfunction was determined in 33% (4/12) of this hearing-impaired group (3 bilateral, 1 unilateral). The vestibular dysfunction was present at first examination in 3 and delayed in onset in 1 of these children. Progression of the vestibular deficit during the course of the follow-up was found in 1 patient. Up until now, no apparent vestibular deficits were confirmed in asymptomatic cCMV-patients or normal-hearing symptomatic cCMV-patients.

Conclusions: The results of this study show that symptomatic cCMV-infected children with hearing loss are most at risk for vestibular deficits. As these can be delayed in onset and/or progressive, longitudinal follow-up is recommended.

PP1-118 - Vestibular Infant Screening-Flanders (VIS-Flanders): the start of an exciting project.

7. Clinical Testing for Vestibular Function

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Purpose: A vestibular dysfunction can compromise a child's development on many levels. Because of the anatomical relationship between the auditory and vestibular end organs, hearing-impaired children are considered a vulnerable group. Although research demonstrated that 20 to 85% of all hearing-

impaired children have some kind of vestibular dysfunction, vestibular testing is not yet established in their multidisciplinary approach. Consequently, vestibular deficits often go unnoticed, giving rise to associated disorders such as delayed motor development, behavioral disorders, etc. The **purpose** of this project is the implementation of a vestibular screening test in order to guarantee a basic vestibular assessment in hearing-impaired children at a young age and enable early referral for rehabilitation.

Methods: VIS-Flanders is financially supported by the Research Foundation – Flanders, with participation of all reference centres responsible for the neonatal hearing screening program in Flanders. Each child with a confirmed hearing loss will be referred for a vestibular screening at the age of 6 months. Being short and child-friendly, feasible from a young age and highly correlated with motor performance and static balance, the cervical vestibular evoked myogenic potential test was elected for this purpose.

Results: Data collection in all reference centres will start in June 2018. In this presentation/poster, an overview will be provided of all the steps that will be undertaken during this 4-year project.

Conclusions: A standard vestibular screening for all hearing-impaired children should lead to early identification of vestibular deficits and subsequent prompt referral for vestibular rehabilitation, in order to limit its impact in developing children.

PP1-119 - Vestibular testing results in a world-famous extreme tightrope walker

7. Clinical Testing for Vestibular Function

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Purpose: For accurate and precise navigation in space and postural stability, multisensory (vestibular, proprioceptive, visual) input is centrally integrated and weighted based on its reliability to continuously update the internal estimate of direction of gravity. In a world-famous 53-year-old male tightrope walker we sought to examine both peripheral and central vestibular functions and examined to which extent such extraordinary performance is reflected in our recordings.

Methods: Both semicircular canal (caloric irrigation, rotatory-chair testing, video-head-impulse testing of all six canals, dynamic visual acuity) and otolith (subjective visual vertical, fundus photography, ocular/cervical vestibular-evoked myogenic potentials (oVEMPs/cVEMPs)) test batteries were obtained. In addition, static and dynamic posturography and video-oculography (smooth-pursuit eye-movements, saccades, nystagmus testing) were performed. The subject's results were compared to normative values.

Results: Semicircular canal testing was normal except for a slightly reduced response on right-sided caloric irrigation (26% asymmetry ratio, cut-off = 25%), whereas on otolith testing a significant asymmetry ratio of oVEMP-amplitudes was confirmed using two devices from different companies (37% and 53% weaker on the left side, cut-off = 30%). Bone-conducted cVEMP-amplitudes were marginally reduced on both sides. Posturography, video-oculography and subjective-visual-vertical testing results were all within normal range.

Conclusions: Extraordinary balance skills in this professional tightrope walker contrasted with significant peripheral-vestibular (otolithic) deficits. This emphasizes the role of central computational mechanisms, optimizing multisensory input signals and fully compensating for vestibular asymmetries in this case.

PP1-120 - VHIT and the influence of daily use of spectacles to correct a refractive error

7. Clinical Testing for Vestibular Function

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Purpose: To determine the influence of daily use of spectacles to correct a refractive error, on the VOR gain measured with the video head impulse test (vHIT).

Methods: This prospective study enrolled subjects between 18 and 80 years old with and without a refractive error. Subjects were classified into three groups: (1) contact lenses, (2) spectacles and (3) control group without visual impairment. Exclusion criteria comprised ophthalmic pathology, history of vestibular disorders and alternated use of spectacles and contact lenses in daily life. One examiner performed all vHIT's under standardized circumstances using the EyeSeeCam system. This system calculated the horizontal VOR-gain for rightward and leftward head rotations separately.

Results: No statistically significant difference was found in VOR gain between the control group (n=16), spectacles group (n=48) and contact lenses group (n=15) (p = 0.111). Both the spectacles group and contact lenses group showed no statistically significant difference in VOR gain between different refractive error, for rightwards (p= 0.071) and leftwards (p= 0.716) head rotations. There was no statistical significant difference in VOR gain between testing monocularly or binocularly (p = 0.132) and between testing with or without wearing contact lenses (p = 0.800).

Conclusions: In this study VOR gain was not influenced by wearing corrective spectacles or contact lenses on a daily basis. Based on this study, no cor-

rective measures are necessary when performing the vHIT on subjects with a refractive error, regardless of the way of correction.

PP1-121 - vHIT using a smart phone.

7. Clinical Testing for Vestibular Function

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Purpose: The features of the test are simpler, easier, and less discomfort than conventional caloric test.

Methods: We searched the appropriate machine which can examine vHIT.

Results: To examine vHIT, we decided using a high-speed camera built-in smartphone.

Conclusions: We show a prototype implement for examine vHIT.

PP1-122 - VVOR and VORS tests as a tool in the diagnosis of unilateral and bilateral vestibular hypofunction

7. Clinical Testing for Vestibular Function

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Purpose: In clinical practice, exams such as video head impulse test (vHIT) and suppression head impulse paradigm (SHIMP) stimulates high frequency head movements so the visual and somatosensory system are somehow suppressed. In low frequencies two tests could be useful tools to vestibular assessment: VVOR (visually enhanced vestibular-ocular reflex) and VORS (Vestibulo-ocular reflex suppression). The aims of this study is to explain the eye

movements typically found in VVOR and VORS tests in patients with unilateral and bilateral vestibular hypofunction.

Methods: Seven patients with unilateral vestibular hypofunction, two patients with bilateral vestibular hypofunction and ten patients without vestibular symptoms (control group) were analysed retrospectively according to the VVOR and VORS tests using an Otometrics ICS Impulse system.

Results: Patients with unilateral vestibular hypofunction exhibited catch up saccades beating to the healthy side when moved the head to the affected side in the VVOR test. Patients with bilateral vestibular hypofunction showed catch up saccades beating to the opposite side of the head movement. Patients with unilateral vestibular hypofunction showed in the VORS test catch-up saccades to the healthy side when moved the head to this side. Patients with bilateral vestibular hypofunction did not show catch up saccades during the head movement for both sides.

Conclusions: Our data suggest that VVOR and VORS tests exhibited the same findings as the VHIT and SHIMP tests in unilateral and bilateral vestibular hypofunction and contribute to confirm the peripheral etiology as well as the affected side.

PP1-123 - Assessment of horizontal semicircular canal after cochlear implantation by vHIT and caloric test

8. Cochlear Implant and Vestibular Function

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Purpose: The focus of this work is to investigate the function and characteristic of horizontal semicircular canals from patients after cochlear implantation (CI).

Methods: We retrospectively evaluated vestibular function of 18 patients (both side=4, single side=14) who were treated with CI surgery by using caloric test and video head impulse test. Three time points were recorded: 1 week before CI, 1 week after CI and 1 month after CI. We also observed the param-

eters of the unilateral weakness (UW), slow phase velocity (SPV) and video head impulse test gain (vHIT-G).

Results: In caloric test, the SPV (cold water; hot water (mean±SD)) of the implant-ear were 1 week before CI (10.36±8.01°/s;14.77±14.24°/s), 1 week after CI (6.45±7.52°/s;5.14±4.67°/s) and 1 month after CI (6.05±3.86°/s;6.27±4.17°/s), respectively. The SPV in the groups of 1 week and 1 month after CI were both significantly decreased than the group of 1 week before CI. (*p*0.05).

In video head impulse test, the vHIT-G (mean±SD) of the implant-ear were 1 week before CI (0.73±0.33), 1 week after CI (0.65±0.32) and 1 month after CI (0.71±0.36), and no significant difference of vHIT-G were found between the groups of before CI and after CI (1 week and 1 month) (*p*>0.05). In addition, we did not find any correlation between the symptom of vertigo and age, gender, implanted ear and the outcome of vestibular test.

Conclusions: Our results suggest that CI can affect the function of horizontal semicircular canal, and the combination of video head impulse test and caloric test leads to complementarities.

PP1-124 - Assessment of the otolith function of the cochlear implant surgery using eccentric rotation test

8. Cochlear Implant and Vestibular Function

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Purpose: To evaluate the effects of cochlear implant surgery on otolith function.

Methods: We evaluated 12 patients with sensorineural hearing loss or congenital deafness who underwent unilateral cochlear implantation (CI). To assess the otolith function, we use vestibulo-ocular reflex during eccentric rotation (ER). When a patient is rotated while displaced from the axis of rotation during ER, the vestibulo-ocular reflex (VOR) caused by the utricle (linear VOR; IVOR) is induced. All patients sat on a chair at three different positions: on the axis (center rotation, CR), at 90cm behind the axis (nose-in ER, NI-ER) and at 90cm in front of the axis (nose-out ER, NO-ER) and were rotated sinusoidally. We judged that patients' utricle function was normal when their VOR gain during NI-ER was higher and that during NO-ER was lower than during CR. Ocular vestibular evoked myogenic potential (VEMP, oVEMP) test and cervical VEMP (cVEMP) test were also performed before and 4 weeks after surgery.

Results: The VEMPs on the operated side decreased or disappeared after CI, the abnormal VEMPs rates were 33.3% and 58.3%. 7 of 8 patients whose ER response was normal before CI showed also normal ER response after CI.

Conclusions: Disappearance and impairment of oVEMPs could be observed after CI. However, the response of ER didn't change before and after CI. This study shows the effect on the otolith function of cochlear implant is not severe enough to influence the IVOR failure induced by utricle during ER.

PP1-125 - Correlation between hearing and vestibular function preservation after cochlear implantation

8. Cochlear Implant and Vestibular Function

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Purpose: In general, vestibular function after cochlear implant(CI) is known to worsen, But recently, there are several reports about preserving vestibular

function after soft CI surgery. So, we reviewed our data about hearing preservation and vestibular function preservation

Methods: We reviewed 29 cases of adult CI patients. We applied the calculating method of hearing preservation rate from consensus on a hearing preservation classification system (Acta Otolaryngol Suppl. 2013;(564):3-13). And we grouped HP group (HP rate>26%) and non-HP group(HP rate<25%). We yielded maximum slow phase velocity (SPV) and canal paresis (CP) of caloric test. We defined SPV preservation rate as post-op. SPV/ pre-op. SPV (%) and we divided into caloric preservation group as results of pre-op. and post-op. canal paresis values. We evaluated correlation between HP rate and caloric test values.

Results: There were 21 patients in HP group and 8 patients in non-HP group. SPV preservation rate was an average of 62.12 % in the HP group and the non-HP group was 49.15 %. And the result of correlation analysis showed that there was no correlation (Spearman's Rho=0.203 p=0.292) In addition, in caloric preservation group, there were 17 patients (81.0%) in the HP group and 2 patients (25.0%) in non-HP group. There were significant differences at HP and caloric preservation groups. (Chi square test, P = 0.009)

Conclusions: Hearing preservation rate and SPV preservation rate showed low correlation rate. But, distribution of hearing preservation group and caloric preservation group showed significant correlation. So, there is some correlation between hearing and vestibular preservation after CI.

PP1-126 - Effects of Cochlear Implantation on Visual, Postural and Haptic Verticality Perceptions

8. Cochlear Implant and Vestibular Function

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Purpose: To investigate the effects of cochlear implantation (CI) on verticality perceptions and dizziness related disability in adults with sensorineural hearing loss (SNHL) and to analyze the correlation between verticality perceptions and disability in this population.

Methods: Patients with SNHL eligible for CI were recruited. Evaluation protocol was composed by Dizziness Handicap Inventory (DHI), evaluation of subjective postural vertical (SPV) and subjective haptic vertical (SHV) in roll and pitch planes and subjective visual vertical (SVV) in the roll plane before CI surgery (T0), immediately after the first activation of the speech processor (T1), and 6 months after the surgery (T2). We analyzed verticality perceptions in numerical and absolute values.

Results: Participants included 21 adults (39.6±13 years). At T1 in relation to T0 and T2, there were significant increases of SPV in absolute values (T0-T1: $p=0.04$; T1-T2: $p=0.007$) and DHI scores (T0-T1: $p=0.001$; T1-T2: $p=0.002$). There was a decrease of SHV in the roll plane in absolute values from T1 to T2 ($p=0.002$). With Bonferroni correction, we found positive correlations of DHI with absolute values of SVV ($r=0.37$; $p=0.005$), SPV in the roll plane ($r=0.37$; $p=0.005$), and SPV in the pitch plane ($r=0.42$; $p=0.001$).

Conclusions: The CI reduced SHV misperception 6 months after surgery. The activation of speech processor produced a transient increase in SPV misperception that was restored 6 months after surgery. Disability is related to SVV and SPV in patients with SNHL submitted to CI. These results highlight the relevance of the assessment of verticality perceptions in this population.

PP1-127 - Intra-cochlear Figuration of Implant Electrodes using Synchrotron Phase Contrast Imaging

8. Cochlear Implant and Vestibular Function

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Purpose: Cochlear implant has been used for many years to restore hearing in patients, however its electrode positioning in the cochlea is less studied.

Methods: We used synchrotron-phase contrast imaging (SR-PCI) and volume-rendering software with bony and soft tissue algorithms to evaluate the positioning of electrodes after cadaveric cochlear implantation. Micro-CT with 3D rendering was used for comparison.

Results: Micro-CT displayed the round window and osseous spiral laminae while SR-PCI allowed reproduction of the soft tissues such as the basilar membrane, spiral ligament, Reissner and round window membranes. Artefact-free reproduction, figuration and topographic localization of the electrodes' metallic constituents and the silicon casing could be assessed.

Conclusions: The positioning of cochlear implant electrode is important as it may interfere with normal physiological function.

PP1-128 - Long term effects of cochlear implantation on vestibular evoked myogenic potentials

8. Cochlear Implant and Vestibular Function

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Purpose: To observe relatively long-term effect of cochlear implantation on vestibular otolithic end organs.

Methods: 17 patients (17 ears) underwent cochlear implants in our department from February, 2013 to October, 2015 were selected as the patient group. Both cervical vestibular evoked myogenic potentials (cVEMP) and ocular vestibular evoked myogenic potential (oVEMP) were performed pre- and post-operatively. The data before and after surgery were collected and compared between each other.

Results: Before cochlear implantation, cVEMP and oVEMP were elicited in 59% and 53% of all ears respectively. After surgery, the response rates of cVEMP and oVEMP were decreased to 24% and 12% (whatever CI device on or off), and waveform parameters changed.

Conclusions: Our results suggest that cochlear implantation may have some effects on the performance of the vestibule otolithic end organs.

PP1-129 - Long-term evaluation of the vestibular function after cochlear implantation(CI) in children

8. Cochlear Implant and Vestibular Function

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Purpose: Long-term evaluation of vestibular function of CI -patients implanted during childhood

Methods: 49 patients (18 females;31 males), aged from 7-34 years (mean=15.89) were included into our study. CI Implantation was performed on both sides (n=31), on right side (n=10), on left side (n=8); children were implanted between ages of 0.7 to 15.5 years (mean=5). Deafness was congenital (n=37), consequential to meningitis (n=2), skull fracture (n=1), perinatal CMV infection (n=1), ototoxic drugs (n=1). The etiology remained unknown within 7 patients. Vestibular function was measured with a time delay of 3 to 22 years (mean: 11) after CI, including VNG, v-HIT, c-VEPMS.

Results: Nine out of patients (18%) were symptomatic. Three patients complained of recurrent transient vertigo episodes at the adult age with either normal vestibular function (n=1), bilateral hyporeflexia (n=1) or unilateral areflexia to the side of delayed endolymphatic hydrops (n=1). Three patients complained of dizziness in darkness with bilateral areflexia (confirmed by calorics/vHT/cVEMP) before CI (meningitis: n=1; perinatal CMV: n=1; unknown etiology: n=1). Dizziness was central in origin after medulloblastoma excision (n=1). Vestibular neuritis with hyporeflexia, contralateral to CI was diagnosed within two patients. Among the 40 asymptomatic patients (82%), vestibular function was normal (n=16), decreased bilaterally (n=4), unilaterally (n=18; right side (n=8), left side (n=10)). Results were not interpretable because of lack of collaboration (n=2).

Conclusions: This first long-term evaluation in CI-children pointed out that 82% have no vestibular symptoms 3-22 years after CI. Vestibular function depends first of the etiology of the inner ear disease: it is particularly true in case of bilateral vestibular loss.

PP1-130 - The Effect of Cochlear Implant on Postural Control

8. Cochlear Implant and Vestibular Function

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Purpose: Some patients are having balance problems after cochlear implant surgery. There are contradictory reports about the effect of implant on postural control. While cochlear implant is working, an electrical current is continuously stimulating the cochlear nerve which is in close proximity with vestibular ganglion and nerve. This stimulation may contribute to vestibular signals to the central system. Our purpose is to investigate if this stimulation have any effect on postural control.

Methods: Eighteen adult patients who had unilateral cochlear implantation ages between 21 and 80 were included. Postural stability measurements were done by Biodex Balance System. Three preprogrammed main tests and their 9 subtests were applied. Postural stability, fall index, sensory integration were calculated. All tests were done in four conditions; implant off(1), implant on(2), implant on music on(3) and implant off again(4).

Results: Six male and 12 female patients were tested. Mean age was 49.9 ± 18.42 . When patients were tested, average postural stability overall score were measured 3.66 ± 2.23 , 3.33 ± 2.23 , 2.8 ± 1.64 , 3.16 ± 1.69 according to first, second, third and fourth conditions consecutively. Fall index were calculated as 3.12 ± 2.04 , 2.58 ± 1.61 , 3.22 ± 2.08 , 2.98 ± 1.5 consecutively. The change in the sensory organization test composite score was observed as 1.6 ± 0.44 , 1.79 ± 0.51 , 1.88 ± 0.72 , 1.97 ± 0.67 . There are statistically significant differences in some parameters. If the group divided with a cut off point age 50, this difference became more prominent.

Conclusions: Cochlear implant effects the vestibular system in some patients and current flowing through the cochlear nerve may have a positive effect on postural control.

PP1-131 - A questionnaire for the patient with benign paroxysmal positional vertigo: a pilot study

9. Epidemiology

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Purpose: The questionnaire items to diagnose the patient with benign paroxysmal positional vertigo (BPPV) were investigated.

Methods: The questionnaire of 77 items consisted of age, gender, past history, characteristics of vertigo/dizziness including cause, lasting time, intensity, frequency, quality and associated symptoms, and usually existing symptom was made in Department of Otolaryngology, University of Toyama. From January 2015 to June 2017, 392 patients with vertigo/dizziness filled out our questionnaire. All patients were diagnosed by two specialized neurotologists based on the diagnostic criteria drafted by the Japan Society for Equilibrium Research. The results were analyzed by multivariate logistic regression to investigate the relationship between questionnaire items and BPPV.

Results: Twenty-three of 392 patients (5.8%) were diagnosed as BPPV. BPPV was detected by the combination of our questionnaire items with a specificity of 99% and a sensitivity of 73%, where mild attack of vertigo, tinnitus, attacks when reclining the head and lying down were included.

Conclusions: The combination of our questionnaire items might be useful for diagnosing BPPV.

PP1-132 - Epidemiology of acute isolated vertigo in an italian emergency department: a retrospective study

9. Epidemiology

Claudio Fantino¹

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Purpose: To evaluate epidemiology, etiology and use of resources on patients with a complaint of

acute isolated vertigo (AIV) presenting in a North-western Italian Emergency Department (ED).

Methods: A retrospective study of patients older than 16ys old presenting to the ED from January 1st to December 31st 2015 was made. Incidence of AIV as main presenting symptom and etiologies were registered. Rate of admission and disposition were analyzed. Use of head CT scan was registered and its accuracy in diagnosing central nervous causes was calculated.

Results: During the whole period of the study AIV accounted for 1,3% (1.021/77.939) of all visits. Women were more often involved (58,4%). The mean age of the study population was 58.7 years. Central neurological diseases accounted for only 6.4% of AIV, while for 36% of patients an otorhinolaryngoiatric diagnosis was made. 146 patients (14,3%) needed to be admitted in hospital. Neurology and Emergency ones were the more involved departments for admitted patients. In 480 patients a head CT scan was requested and in only 13 (2,71%) it was diagnostic.

Conclusions: AIV is a frequent symptom in ED. Central nervous diseases represent a minimal but significant cause of AIV. The study confirm the low accuracy of head CT scan in finding central nervous etiologies.

PP1-133 - Multicenter databanking in management of dizzy patients first results from the DizzyNet registry

9. Epidemiology

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Purpose: Comprehensive phenotypical data across countries is needed to understand the determinants, prognosis and consequences of vestibular disease. The project is a data repository for the members of the European DizzyNet. We report results from a pilot study using data from Turkey and Germany.

Methods: The pilot study included a convenience sample of patients aged 18 or above referred to the Ege University Medical School Hospital, Izmir, Turkey, and the German Center for German Center for Vertigo and Balance Disorders, University on Munich, Germany, with symptoms of vertigo or dizziness. Health-related quality of life was assessed with the EQ5-D and the Dizziness Handicap Inventory (DHI). To obtain comparable groups we matched data from the two study centres for age, sex and diagnosis by propensity score.

Results: We included 80 adult patients, 40 from each study centre (60% female, mean age 54.1, SD 12.4). Matching was successful. Vestibular migraine (34%) was the most frequent diagnosis, followed by benign paroxysmal positional vertigo (29%) and Menière's disease (12%). Clinical signs and symptoms were comparable in both countries. Patients from Turkey were more likely to report headaches (65% vs. 32%) and to show gait unsteadiness (51% vs. 5%). Patients from Germany reported significantly higher quality of life and lower values of the DHI score and all DHI subscales.

Conclusions: Sharing data facilitates research, enhances translation from basic science into clinical applications, and increases transparency. The registry is a first step to data sharing in vestibular research across Europe.

PP1-134 - The prevalence of persistent tinnitus and dizziness in an elderly population in southern Taiwan

9. Epidemiology

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Purpose: This study was to investigate the prevalence of persistent tinnitus and chronic/recurrent dizziness in an elderly population and to analyze the associations of certain comorbidities with tinnitus and dizziness in southern Taiwan.

Methods: This was a community-based study performed in a metropolitan hospital. Volunteers ages \geq 65 years were recruited, and hearing tests were performed. The pure tone average (PTA) and hearing handicap score (HH) were calculated. Questionnaires about the histories of hypertension, diabetes, and symptoms of tinnitus and dizziness were administered. The associations of sex, age, PTA/HH, body mass index (BMI), hypertension, diabetes, and metabolic syndrome (MetS) with tinnitus and dizziness were analyzed.

Results: A total of 597 participants, with 322 (53.9%) men and 275 (46.1%) women, were included. The prevalence of persistent tinnitus and chronic/recurrent dizziness was 32.0% and 24.1%, respectively. Age, BMI, hypertension, diabetes, and MetS were not associated with tinnitus or dizziness. Hearing impairment was associated with tinnitus. Women and those with fasting glucose levels <100 mg/dL (5.55 mmol/L) were more likely to have symptoms of dizziness.

Conclusions: Persistent tinnitus and dizziness were common in an elderly population in southern Taiwan. These findings may help develop strategies to promote the quality of life in an elderly population.

PP1-135 - Cognitive impairment in persistent postural-perceptual dizziness: working vs. non-working patients

10. Functional and Psychiatric Vestibular Disorders

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Purpose: Patients with chronic vestibular disorders often complain of cognitive difficulties that interfere with job performance. Previous data showed that patients with bilateral peripheral vestibular loss had reduced performance on spatial memory tests that correlated with bilateral hippocampal atrophy on neuroimaging. Patients with unilateral peripheral vestibular loss had more nuanced deficits on spatial tasks and neuroimaging. The aim of this pilot study was to exam cognitive performance in patients with persistent postural-perceptual dizziness (PPPD), who often report difficulties with attention, memory, and concentration in the workplace, even when not afflicted with uncompensated structural vestibular deficits.

Methods: In this retrospective investigation, we identified 13 patients who received a primary diagnosis of PPPD after undergoing multidisciplinary neuro-otologic evaluations for chronic dizziness and separately completing neuropsychological testing for cognitive complaints. None had uncompensated otologic deficits or neurologic/psychiatric disorders that explained their cognitive symptoms.

Results: Working (N=5) and non-working (N=8) patients had similar mean intelligence scores, but the group that was not actively employed had relative deficiencies on tests of auditory working memory (Letter Number Sequencing) and executive functioning, specifically cognitive flexibility affecting visual processing speed, scanning, and tracking (Trail Making B) and response inhibition (Stroop Color Word Tests). In contrast, group performances did not differ on simpler tests of memory (Digit

Span, Word List Retention) or executive functioning (Trail Making A).

Conclusions: Our pilot results suggest that PPPD may be associated with cognitive impairments that interfere with productive employment and that cognitive performance may be linked to functional as well as structural alterations in the vestibular system.

PP1-136 - Dr

10. Functional and Psychiatric Vestibular Disorders

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Purpose: To translate and examine the psychometric properties of the Vestibular Activities and Participation questionnaire in Chinese language (VAP-C).

Methods: A standard “forward-backward” procedure was adopted to translate VAP into Chinese version. The VAP-C was administered to a convenience sample of 121 patients complaining of dizziness due to peripheral vestibular dysfunctions. Internal consistency was estimated using Cronbach’s alpha and test-retest reliability examined by intraclass correlation coefficients (ICCs). Validity was confirmed using convergent and a principal components factor analysis with Varimax rotation. Convergent was assessed by exploring correlations with VAP-C and Dizziness Handicap Inventory (DHI) dimensions and total score.

Results: Minor revisions were made during translation to ensure content equivalence and to better suit a Chinese population. The Cronbach’s alpha coefficients for the two subscales of VAP-C were 0.83 and 0.91, respectively, suggesting good internal consistency. ICCs for the two subscales were greater than 0.75 and thus determined good reproducibility. Factor analysis confirmed two-factor solution which is as hypothesized. Two factors showed clearly item matching with all items loaded > 0.5 on either factor one or factor two. The VAP-C was significantly

correlated with the DHI ($\rho=0.61-0.73$), demonstrating a convergent construct validity.

Conclusions: The VAP-C shows evidence of reliability and construct validity, which can be considered a reliable measurement for evaluating the impact of the vestibular disorder on patients’ activities and participation.

PP1-137 - Influence of Visual and Vestibular Hypersensitivity on Depersonalization/Derealization in Dizziness

10. Functional and Psychiatric Vestibular Disorders

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Purpose: The aim of this study was to investigate the relation between visual and vestibular hypersensitivity and Depersonalization/Derealization symptoms in patients with chronic dizziness.

Methods: 319 adult patients with chronic dizziness for more than 3 months (214 females and 105 males, mean age: 58 years, range: 13-90) were included in this prospective cross-sectional study. Patients underwent a complete audio-vestibular workup and 3 auto questionnaires: Hospital Anxiety and Depression (HAD), Depersonalization/Derealization Inventory (DDI), and an in-house questionnaire (Dizziness in Daily Activity, DDA) assessing 9 activities with a score ranging from 0 (no difficulty) to 10 (maximal discomfort) and 11 (avoidance) to detect patients with visual and vestibular hypersensitivity (VVH, a score > 41 corresponding to mean + 1 standard deviation).

Results: DDI scores were higher in case of VVH (6.9 ± 6.79 , $n=55$ versus 4.2 ± 4.81 , $n=256$ without VVH, $p<0.001$, unpaired t-test), migraine ($6.1 \pm$

6.40, n=110 versus 4.0 ± 4.42 , n=208 no migraine, $p < 0.001$, unpaired t-test) and motion sickness (6.8 ± 5.93 , n=41 versus 4.4 ± 5.11 , n=277 no motion sickness, $p < 0.01$, unpaired t-test). Women scored DDI higher than men (5.1 ± 5.42 , n=213 versus 3.9 ± 4.91 , n=105 respectively, $p < 0.05$, unpaired t-test). DDI scores were also related to depression and anxiety. DDI score was also higher during spells than during the basal state.

Conclusions: During chronic dizziness, depersonalization/derealization symptoms seem to be related to anxiety and depression. Moreover, they were prominent in women, in those with visual and vestibular hypersensitivity, migraine, and motion sickness.

PP1-138 - Persistent Postural-Perceptual Dizziness in the Light of New Diagnostic Criteria

10. Functional and Psychiatric Vestibular Disorders

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Purpose: The Behavioral Subcommittee of the Bárány Society Committee for Classification of Vestibular Disorders recently established the diagnostic criteria for persistent postural-perceptive dizziness (PPPD), including most elements of the functional dizziness described earlier, but not anxiety and depression, some of their prominent features. This study aims to determine how significant the degree of anxiety and depression of PPPD patients is when compared to the patients with other causes of dizziness.

Methods: The study was conducted on 78 patients, 39 (50%) of whom suffer from PPPD, and of a control group consisting of the same number of patients with other types of dizziness. Upon arrival, all the patients filled out the DHI and HADS questionnaire and were subjected to a VNG and VEMP examination.

Results: The DHI showed severe disability in 48 (62%) patients, slightly more in the group of other dizziness (72%). The HADS indicated pathological depression in 18 (23%) patients and borderline amounted to 41 (53%), slightly more common in patients with other dizziness (62%). A mild anxiety level was similar in both groups of patients. Laboratory tests did not show significant differences between groups.

Conclusions: Our research showed that the majority of patients in both groups experienced mild anxiety, while those with the pathological degree were somewhat more represented in the PPPD group. Depression was more expressed in the group of other dizziness and has manifested itself in a mild form in nearly half of all patients.

PP1-139 - Selective serotonin reuptake inhibitor (SSRI) and vestibular function

10. Functional and Psychiatric Vestibular Disorders

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Purpose: It is well known that selective serotonin reuptake inhibitor (SSRI) is effective for patients with dizziness and depression. However, there are only few papers about vestibular function for those patients. We therefore performed vestibular ocular reflex tests in rotation (VOR tests) and utilized Dizziness Handicap Inventory (DHI) questionnaire before and after SSRI therapy.

Methods: Out of 135 depressive patients in 1089 patients with dizziness in our psychiatric hospital,

the subjects were 13 patients (4 men, 9 women) (mean age, 58.9 years) experiencing dizziness and depression with the following conditions (SSRI group); 1)regular treatment including anti-vertiginous drugs, physical therapy, minor tranquilizer or sleep medications were not effective, 2)non-acute phase, 3)non-prescription of antidepressants, 4)signature of consent form approved by the ethics committee in University of Yamaguchi. VOR tests were performed using video-oculograph (Nystamo21 type 2, IRN-2, Morita Manufacturing corporation, Tokyo). Eye movements were monitored using an infrared eye camera installed in the goggles. Head movements were transduced to d.c. signals (range 0-5 V) by a small angular velocity sensor.

Results: After about 4 weeks of using additional SSRI treatment, DHI scores were improved significantly (66.2-30.0). In VOR tests, DP% scores (vestibular function) were improved significantly (23.2-9.57).

Conclusions: These results of the present clinical research suggested that SSRI might have some effects which improved the vestibular function in patients with dizziness and depression.

PP1-140 - Sensory Organization Test Profile for Patients with Persistent Postural-Perceptual Dizziness

10. Functional and Psychiatric Vestibular Disorders

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Purpose: Söhsten, et al. (2016) reported significant differences between patients diagnosed with Persistent Postural-Perceptual Dizziness (PPPD) (n=20) versus normal subjects (n=15) and peripheral vestibular patients (n=15) on conditions 1-6 of the Sensory Organization Test (SOT) of the EquiTest™. This study expanded on the number of subjects and investigated the efficacy of the SOT pattern in the identification of PPPD.

Methods: Retrospective equilibrium scores on SOT with the Bertec™ equipment were compared for 96

PPPD patients, 72 unilateral vestibular hypofunction patients & 53 patients with both unilateral hypofunction and PPPD via Wilcoxon/Kruskal-Wallis test. The diagnostic groups were stratified by age group. Logistic regressions with ROC analysis were used to investigate the SOT pattern for identification of PPPD patients.

Results: Significantly (p<.05) poorer performance for the PPPD patients on the easier conditions (1-3) were noted with the differences on the more difficult conditions (4-6) most likely an age effect. Logistic regressions demonstrate that the values of the equilibrium scores do have a relationship with the diagnostic categories via ChiSq (p< 0.05) for each of the SOT conditions. However, ROC analysis showed that predicting the diagnostic category from the SOT pattern was typically poor (area under the curves from. 46-.77).

Conclusions: This work shows a pattern of performance on SOT for the pure PPPD or the PPPD with unilateral hypofunction patients that is significantly different from that of unilateral vestibular hypofunction patients with the performance poorer on the easier conditions. However, while distinctive it cannot be used as a biomarker for the PPPD patient.

PP1-141 - Structure Changes of Superior longitudinal fasciculus in Persistent Postural-Perceptual Dizziness

10. Functional and Psychiatric Vestibular Disorders

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Purpose: To investigate the changes of white matter fibers in patients with persistent postural-perceptual dizziness (PPPD).

Methods: 7 patients (three males and four females) diagnosed with PPPD were enrolled. All patients underwent detailed medical history acquisition; meanwhile, cranial MRI, peripheral vestibular function evaluation, internal medicine and laboratory tests were performed to exclude other chronic dizziness lesions. SVDSCVS, DHI score were performed to assess the patient's symptoms. The patients confirmed PPPD were further scanned by Diffusion

Tensor Imaging (DTI). Fractional anisotropy (FA) and mean diffusivity (MD) were calculated, and then voxel-based analysis (VBA) was performed to investigate the changes of white matter fibers in patients with PPPD.

Results: (1) All patients were right-handed. The average age was 51.71 ± 13.41 years old. The mean duration of the disease was 7.77 ± 7.60 years. The average SVDS score was 9.86 ± 6.04 . The average CVS score was 5.57 ± 3.25 . The DHI score was 51.29 ± 11.09 . (2) The FA values of the right superior longitudinal fasciculus in PPPD patients were significantly lower than in healthy subjects ($P < 0.001$, uncorrected). The MD values of white matter fibers in the postcentral gyrus were significantly lower than healthy subjects ($P < 0.05$, FDR corrected).

Conclusions: The changes of white matter fibers in superior longitudinal fasciculus, postcentral gyrus in PPPD patients suggest that the transmission of information from the PIVC area to the postcentral gyrus and precentral gyrus may be abnormal and may be related to the persistent symptoms of dizziness and postural instability.

PP1-142 - A study on auto-scoring algorithm for balance assessment

11. Gait, Posture, and Locomotion

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Purpose: We studied scoring algorithm for Berg balance scale assessment using inertial measurement unit and machine learning methods.

Methods: Thirty-five patients with brain disease, aged 50 to 80 years, participated in the experiment. The IMU sensors were placed on their forehead, back, left wrist, right wrist, left ankle, and right ankle. The data of 3-axis acceleration roll, yaw, and pitch from each IMU were measured and the sampling rate of all signal was 100Hz. Support vector

machine and multi-layer perceptron were compared as machine learning techniques. According to each motion of BBS task, different data from 6 IMUs was selected.

Results: Average classification accuracy of SVM is 92% and MLP is 86%. It is higher performance than other prior paper about BBS scoring algorithm.

Conclusions: In this study, we can confirmed the possibility of automation of Bergs balance scale. Objective quantification can be measured through the improvement of scoring algorithm.

PP1-143 - Assessment of vestibular compensation in static posturography tests.

11. Gait, Posture, and Locomotion

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Purpose: Static posturography is usually falsely negative in compensated vestibular disorders. Adding head movements may increase clinical utility of the examination for diagnosing subjects with vestibular pathology.

Methods: Results of standard static posturography and static posturography with added head movements (HS-posturography, 30° side to side, 1 Hz) were analysed. Four tests were performed and then repeated with head movements on: a firm surface with eyes open (1) and closed (2), a foam with eyes open (3) and closed (4). Four groups participated in the study: BPPV - 44 patients (mean age 58 SD 11.7, range 27-87 years) without canal paresis in calorics, UC - 55 patients with uncompensated unilateral weakness (mean age 55 SD 13.6, range 29-83 years); C- 46 patients (56 SD 14.8, range 25-85 years) with compensated unilateral weakness and 55 healthy control (50 SD 15.5, range 24-78 years).

Results: The results of standard and HS posturographs were different depending on the group tested. BPPV revealed higher mean body sways than control in one standard test (2) and two HS tests (1, 4), the C group shows the differences in one standard test (2) and in all HS tests. All tests in the UC group were higher than in control. There were statistically significant sway differences between UC and C groups.

Conclusions: Adding head movements to static posturography may improve its clinical utility in diagnosing of vestibular patients.

PP1-144 - Balance disorder of patients with Mnire's disease: assessing with posturography and gait analysis

11. Gait, Posture, and Locomotion

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Purpose: Here, we aimed to investigate static and dynamic unequilibrium ability of patients with Ménière's disease (MD) applying static posturography and three-dimensional gait analysis.

Methods: Thirty-two MD patients were collected in this study, along with 15 normal controls. A sensory organization test (SOT) and three-dimensional gait analysis were used to quantify the patients' static and dynamic ability to maintain balance.

Results: Compared with the normal subjects, MD patients showed significantly lower vestibular weight (68.82 ± 21.04) and visual weight (80.94 ± 18.28) in the medial-lateral direction in SOT test ($p < 0.05$). In the anterior-posterior direction, the vestibular score (64.19 ± 19.02) was significantly decreased ($p < 0.05$). During the gait analysis, the MD patients showed slower walking speed (2.15 ± 0.69 km/h) and higher cadence (0.86 ± 0.12 steps/min). The normalized stride width in the MD patients (79.25 ± 9.50 %) was larger than that in the controls ($p < 0.05$). In patients with unilateral vestibular hypofunction, we found that the stance phase lasted significantly longer on the lesion side (53.19 ± 6.57 % vs. 48.49 ± 7.82 % on the healthy side, $p < 0.05$).

Conclusions: Both in static posture control and dynamic continuous walking, MD patients exhibited poor stability in the medial-lateral direction. Especially, patients with unilateral vestibular hypofunction are inclined to enhance somatosensory feedback by extending stance phase in lesion side.

PP1-145 - Correlations between multiplane vHIT and balance control after acute unilateral vestibular deficit.

11. Gait, Posture, and Locomotion

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Purpose: Clinically, balance deficits in the pitch and roll planes at onset of an acute unilateral peripheral vestibular deficit (aUPVD) are assumed to be correlated with deficits in vestibular ocular reflex (VOR) responses. Previous studies have shown that correlations for lateral canal (yaw) VOR responses are weak. However, stronger correlations with balance measures should be expected for anterior and posterior canal responses as these indicate deficits in roll and pitch. Therefore, we investigated this expectation.

Methods: 27 patients were examined at aUPVD onset. 3D VOR vHIT measures in each canal plane were converted to roll and pitch response asymmetries, and then correlated with balance measures. To measure balance control during stance and gait, body-worn gyroscopes mounted at lumbar 1-3 recorded trunk angular velocity in roll and pitch.

Results: Average vHIT yaw VOR response gain asymmetry (35.6 ± 10.5) was greater than roll VOR asymmetry (14.6 ± 10.5 , $p < 0.05$) and correlated ($p = 0.03$). Average Pitch gain VOR asymmetry was considerably less (5.9 ± 10.1). No significant correlations between VOR roll and pitch asymmetries and trunk sway were found for stance ($R < 0.25$). In contrast several gait roll balance measures were significantly correlated with VOR roll asymmetry: walking 8 tandem steps ($R = 0.51$), walking while pitching the head up and down ($R = 0.72$), walking with eyes closed ($R = 0.59$). No correlations were found with pitch asymmetry.

Conclusions: This is the first report to link roll balance control deficits with roll VOR deficits. This report emphasises the need to perform 3D vHIT to judge the effect of an aUPVD on balance control.

PP1-146 - Disordered gait pattern after craniocervical trauma a case study

11. Gait, Posture, and Locomotion

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Purpose: We analyzed gait and muscular activation patterns of an uncommon gait disorder patient with locomotor abnormality emerging after a craniocervical trauma. Our aim was to elucidate the sensorimotor mechanisms of the disorder.

Methods: A healthy 43-year-old farmer was attacked and tossed about by a raging bull. Immediately, he experienced inability to carry his head upright and maintain bipedal gait. Subsequent slow recovery was interrupted by spells of vertigo pushing him forwards and leftwards. Years after, he was victim to an electric shock, followed by increasing left-sided muscle tone. Within months, he developed a gait disorder manifesting in involuntary leftward stepping provoked by turning or rising up from a chair to walk. The gait disorder seemed dependent on the position of both head and trunk. His MRI findings were suggestive of a left-sided atlantoaxial subluxation.

We assessed his gait using 3D-motion analysis with electromyography recordings of the main lower extremity muscles.

Results: The patient had apparent difficulty in initiating gait and maintaining static standing balance.

His gait was interrupted with hopping movements resembling reduplication of his left-pedal step. Especially soleus, gastrocnemius, and peroneal EMGs displayed rhythmic bursts of activity bilaterally throughout the main muscle activation, with approximately normal timing of the activation phase. Forward bending of spine enabled fairly normal gait, despite prevailing abnormal bursts.

Conclusions: The described unusual gait disorder, associated with traumatic craniocervical misalignment, is suggested to be due to abnormal propriospinal activation.

PP1-147 - Dissociated objective and subjective stability in the elderly due to postural anxiety

11. Gait, Posture, and Locomotion

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Purpose: Under static conditions, the subjective perception of instability correlates well with objective measures of postural sway. Here we investigate this correlation as a function of age and anxiety in dynamic challenging conditions.

Methods: 50 healthy participants (aged 18-83 years) stood upright on a moving platform. Six pseudo-random oscillatory stimuli of different magnitude, each lasting 30s, were delivered twice, with and without a fall-preventing harness (aimed at reducing task-related anxiety). We measured sway path, hip angular velocity, foot-lift counts and subjective instability and task-related anxiety.

Results: The subjective perception of stability accurately matched objective body sway, following a logarithmic function profile ($r^2=0.72$, $p<0.001$). This function did not change significantly with age, harness or task presentation order (harness or no-harness first). A strong relationship was observed between the subjective measures of stability and task-related anxiety ($r=0.812$, $p<0.001$). Repetition of the task induced age-specific adaptive changes: anxiety decreased in the young but postural sway decreased in the old. This resulted in an uncoupling between change in anxiety and subjective instability in the young but not in the elderly. Higher anxiety levels were associated with increased subjective unsteadiness in the older subjects.

Conclusions: Subjects accurately rate their own instability during dynamic postural challenges, irrespective of age and actual fall risk. However, anxiety has greater influence upon the subjective perception of instability in the elderly. Our data suggest that anxiety contributes to “fear of falling” in the elderly. Wearing a harness does not influence subjective/objective postural stability, a useful finding for postural researchers

PP1-148 - Does the sensory organization test discriminate between athletes and non-athletes?

11. Gait, Posture, and Locomotion

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Purpose: Evidence in literature indicates that sports activities may contribute to enhanced postural stability in athletes. It has been suggested that practice of highly skilled movements that involve sensory systems for postural control leads to improvements in balance. Performing the Sensory Organization Test (SOT), a standard test for evaluating sensory interactions in balance control, we aim at investigating whether: (1)athletes have a more stable standing posture than non-athletes; (2)different postural

strategies are used across different sports; (3)SOT can detect subtle balance changes.

Methods: 120 athletes (70 hockey, 20 football, 30 handball) and 20 non-athletes were recruited. SOT was performed using a computerized dynamic posturography system(EquiTest) to assess subjects' ability to use visual, proprioceptive and vestibular cues for maintaining postural stability in upright stance. Specifically, 20 features were computed from COM and COP signals as measures of postural steadiness.

Results: Standard COM-based features provided by EquiTest did not show any significant difference between athletes and non-athletes, although they are commonly used to identify balance problem in elderly and vestibular patients. More surprising, no significant differences between athletes and non-athletes as well as among the different sports were detected using our CoP-based feature set.

Conclusions: Our negative findings suggest two possible explanations: (1)considering that the discriminatory ability of a test depends on task complexity, SOT is not challenging enough to differentiate between athletes and non-athletes; (2) the specific modalities of postural control developed within sports activities are not always transferable to the upright stance situations, as such abilities can be specific to a particular task.

Support:Schulthess Foundation.

PP1-149 - Effects of visuo-ocular state on vestibular-evoked behaviors during standing balance

11. Gait, Posture, and Locomotion

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Purpose: Vestibular signals are integrated with visual/somatosensory information, such that, when standing, removal of vision increases vestibular-

evoked whole-body responses. This contrasts with the vestibulo-ocular reflex (VOR), whose efficacy decreases in absence of visual signals. The current study investigates differential modulatory effects of visuo-ocular states (i.e. eyes open/closed and light/darkness) on vestibular-evoked eye and balance responses.

Methods: Ten healthy subjects received electrical vestibular stimulation (0–20Hz, ±5mA) while standing to evoke balance (force/EMG) and VOR responses during three conditions: eyes open in the light, eyes open in darkness, and eyes closed in darkness. Subjects were then exposed to repeated transitions between lights on-off conditions with eyes open, and eyes open-closed conditions in darkness. We estimated modulatory effects of visuo-ocular state by comparing vestibular-evoked muscle and VOR responses across conditions.

Results: Contrary to previous reports, we found no effect of visuo-ocular state on vestibular-evoked balance responses ($p > 0.05$). VOR responses, in contrast, decreased significantly with lights off (~30%, $p < 0.05$), and even further with eye closure (~80%, $p < 0.05$). VOR responses with shorter latencies than turning lights on. When opening and closing the eyes, VOR responses were rapidly distorted by eye movements initiating prior to lid motion, but stabilized to expected levels shortly (1-2 sec) thereafter.

Conclusions: We demonstrate differential effects of visual signals and eye-state on the vestibular control of gaze stabilization and balance when standing. Shorter latencies in VOR modulation when removing vision may reflect the need for faster modulation to reduced sensory input, or alternatively, increased processing demand to re-integrate sensory signals when vision is returned.

PP1-150 - Evaluation of balance performance in vestibular loss patients using virtual reality system

11. Gait, Posture, and Locomotion

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Purpose: This study is to evaluate the balance performance in vestibular loss patients by using a new visual perturbation system including virtual reality (VR), Wii Balance Board (WBB), rubber foam, and a wearable accelerometer for body sway parameter quantification.

Methods: 46 normal subjects and 27 patients suffering from unilateral vestibular loss were recruited. Subjects were instructed to stand on WBB plus foam, and to wear a goggle delivering VR image. Two visual conditions were assessed: stable visual world (VR0.0) and perturbed visual world (VR0.1). Each condition lasted for 25s. Subjects wore one 3D accelerometer attached on the site of the L5 vertebra. The balance performance was quantified by calculating the average “jerk” value at X, Y, and Z axis during the test. Patients who fell during the test were removed from “jerk” analysis.

Results: All normal subjects and patients completed VR0.0 without falling. No normal subjects fell at VR0.0, but 33% patients fell at this condition. At VR0.0, the average “jerk” in healthy subjects is 2.10 ± 0.98 (min-max: 0.68-5.59), and in patients is 4.97 ± 2.84 (min-max: 0.80-14.82). At VR0.1, the average “jerk” in normal subjects is 3.54 ± 1.73 (min-max: 0.68-8.68), while in patients is 10.62 ± 4.70 (min-max: 1.10-16.33).

Conclusions: The new visual perturbation system with WBB and foam, and VR allows clinicians to efficiently evaluate balance performance and visual

dependency at clinical settings. The body sway parameter “jerk” successfully distinguished vestibular deficit patients from healthy subjects. This system may be used in rehabilitation program to follow the improvement of balance performance in patients with inefficient vestibular compensation.

PP1-151 - Influence of arteriosclerosis on balance function Data from Iwaki health promotion project

11. Gait, Posture, and Locomotion

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Purpose: There are multiple factors that can deteriorate balance function. Vascular insufficiency to vestibule and the central nervous system is one of the causes of balance dysfunction. Therefore, to examine the relationship between vascular sclerosis and balance function, we conducted an epidemiological survey in a community-dwelling population in Japan.

Methods: We included volunteers who had participated in the Iwaki Health Promotion Project in 2015 and 2016. This project is performed every year, with the aim of improving health and longevity in the Iwaki district. In total, 1078 subjects (405 males, 673 females) were analyzed. We examined the brachial–ankle pulse wave velocity (baPWV), which is an objective index that quantifies arterial stiffness. We also analyzed static posturography using the path length to evaluate balance function. We assessed the effect of baPWV on the path length using multiple regression models.

Results: There was significant correlation between baPWV and the path length with eyes opened in males and with eyes opened and closed in females.

Conclusions: This study was targeted toward the general population, rather than patients experiencing dizziness, and demonstrated the correlation of baPWV and static posturography parameters. Herein, we suggested that the progression of vascular sclerosis is related to balance dysfunction.

PP1-152 - Postural control instability caused by virtual reality

11. Gait, Posture, and Locomotion

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Purpose: To study possible adaptation of postural control to responses evoked by a virtual reality surrounding with provocative elements including possible gender effects.

Methods: Twenty healthy subjects participated in the study (10 females). A custom-built force platform was used to measure postural sway. The virtual reality stimulation comprised a VR movie containing a roller coaster like simulation of travelling on a railroad track situated in a mountainous terrain. Quiet stance was measured with eyes open and eyes closed. VR stimuli tests were performed 5 times with a three-minute rest between each of the runs. The torque variance values during the tests were analysed using repeated measures GLM ANOVA on log-transformed values.

Results: During VR perturbations, repeatedly watching the same movie significantly reduced the energy used ($p < 0.001$). Females adapted more slowly to the VR stimuli as reflected by higher use of energy for all movement frequencies ($p = 0.007$) as well as for low frequency ($p = 0.027$) and high frequency ($p = 0.026$). Females adapted particularly more poorly in lateral direction to the VR stimuli as reflected by higher energy consumption in all frequencies ($p < 0.001$) as well as in high frequency movement energy ($p = 0.005$).

Conclusions: Being repeatedly exposed to the same virtual reality movie with provocative environment, initiated an adaptation that significantly reduced the energy used in postural control. This was true both for total energy as well as for high and low frequency movement responses. Females were found to

adapt more slowly to a visual VR stimuli than male subjects.

PP1-153 - Postural instability according to the Virtual Reality program

11. Gait, Posture, and Locomotion

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Purpose: Over the recent years the popularity and the market size of VR grew rapidly. It is absolutely necessary for the user to realize how much potentially dangerous VR is. The purpose of this study is to investigate the effect of VR images on balance in normal people.

Methods: This study was carried out on fifteen adults in their 20's and 30's who have normal sense of balance with SOT. Condition 1 and Condition 2 was performed once respectively, Condition 3 was performed three times while watching three different VR programs. The VR programs which were used for condition 3 tests were classified as mild-, moderate- and severe- image motion before the test. And then, the equilibrium score of SOT was analyzed to find the difference of each test.

Results: The MES of mild VR image of Condition 3 was 93.888, the moderate one was 92.422 and the severe one was 75.422. There was no difference in MES between the condition 1 and the mild and moderate VR image of Condition 3 (Paired T-test, $p>0.05$), but the MES of severe VR image of Condition 3 was statistically lower than Condition 1. In addition, the MES of severe VR image, which could feel heavy movement in 3-dimensional world, was lower than that of mild VR image that could not feel any movement.

Conclusions: VR images can reduce the equilibrium score of even in normal subjects. It is necessary to provide a standardized safety rating for each image with sufficient warnings of balance impairment.

PP1-154 - Relationship between cognitive function and balance in a community-dwelling population in Japan.

11. Gait, Posture, and Locomotion

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Purpose: There has been not yet found treatment that cure dementia. For that, it is important to establish the evaluation index of cognitive decline before becoming dementia. The purpose of this study was to clarify the effective balance test indicating early cognitive decline by gender.

Methods: A total of 218 volunteers (60 years of age and over) who participated in the Iwaki promotion health project in 2015 were recruited. We performed three balance tests: one leg standing test, functional reach test and static posturography, and we used mini-mental state examination (MMSE) to investigate cognitive function.

Results: The MMSE scores were significantly lower in men than women. As a result of analysis of covariance, there was a statistically significant trend in only men that the more the MMSE score declined, the longer became the path length with both eyes opened and closed. In the result of multiple regression analysis, there was a significant negative association with MMSE score and path length with eyes opened or closed in men. There was no significant association with MMSE scores and balance tests in women.

Conclusions: The study suggests that static posturography might be a useful balance test to assess early cognitive decline in men.

PP1-155 - Spatiotemporal parameters and variability with changes in gait velocity in bilateral vestibulopathy

11. Gait, Posture, and Locomotion

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Purpose: The vestibular influence on gait appears to be suppressed with increased velocity. In this preliminary study, we aimed to assess spatiotemporal gait characteristics and their variability across different walking speeds in patients with bilateral vestibulopathy (BVP) and healthy controls.

Methods: 19 participants (Age: 55±13y) with BVP who could walk independently and 10 healthy control participants (Age: 25±3) participated. Experiments were conducted on the CAREN (combined motion capture, split-belt force plate-instrumented treadmill and virtual environment; Motekforce Link, Amsterdam) using a retroreflective marker on each hallux in combination with force plate data. Following familiarisation, participants completed two-minute walking bouts at seven different speeds (0.4m/s, 0.6m/s, 0.8m/s, 1.0m/s, 1.2m/s, 1.4m/s, 1.6m/s). Means and coefficients of variation (CV) of stride length and time, step width and double support time were calculated from 60 strides per speed. Two way ANOVAs with speed and participant group as factors were conducted.

Results: Walking speed effects were found for all parameters ($P<0.0001$). Group effects were found for the means of stride time and length (BVP led to faster, shorter strides; $P<0.05$) and for the CV of stride length, double support and step width (BVP more variable). Interactions were found for the

means of all parameters ($P<0.05$), whereas the only interaction found for CV was step width ($P<0.0001$), where BVP led to greater increases in step width CV with increasing speed.

Conclusions: BVP led to increased gait variability compared to controls. It seems that vestibular sensory information may be especially important for regulating step width variability, in particular at faster walking speeds.

PP1-156 - Stabilogram of patients with otolithic vertigo

11. Gait, Posture, and Locomotion

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Purpose: Due to the development of VEMP test, clinical concept of the otolithic vertigo (OV) has been established. Pathogenic linear moving sensation with up-to-down direction, anteroposterior direction, and right-and-left direction relate to the otolith disorders. To date, it has not been discussed in detail whether posture control is accompanied in patients with OV. To clarify the relationship between posture control and OV, we investigated the result of their stabilogram.

Methods: Thirty patients with OV were enrolled in this study. The tentative diagnostic criteria of OV was following as;

- 1) the complaint was of non-rotatory disequilibrium,
- 2) abnormal results were shown on cVEMP and/or oVEMP,
- 3) there were no abnormal results from routine examinations,
- 4) there were no cerebellar signs or intracranial lesions detected by brain MRI. For the control group, five subjects who have 1),2),4),but don't have 3) were enrolled. The results of stabilography such as enveloped area (ENV area) and deviations of X, Y were evaluated, the obtained values were evaluated using deviation values to avoid influences of age and gender. The function of saccule and utricle were evaluated by cVEMP and oVEMP respectively.

Results: In the OV group, the ENV area tended to be larger as compared with the control group. In addition, among the Utricle disorder group, ENV area and maximum amplitude indicated larger than the other two groups.

Conclusions: Abnormal postural control which was associated with OV patients, and in particular the utricular organs had more influence on the postural control than saccular organs.

PP1-157 - The characteristics of balance sensory weight of sudden hearing loss with vertigo

11. Gait, Posture, and Locomotion

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Purpose: To discuss the characteristics of balance sensory weight and evaluate the clinical significance of dynamic balance test for sudden hearing loss with vertigo.

Methods: Experimental group: 36 cases of sudden hearing loss (all patients were unilateral sudden deafness); Control group: 59 healthy volunteers. Both groups were accepted caloric test and dynamic balance test.

Results: The dynamic balance test detected the abnormal sensation weight under different conditions of SOT in experimental group. Balance score Median(Q25Q75) of experimental group was lower than control group in 6 conditions. SOT comprehensive score of control group 80.24 ± 5.37 , experimental group 57.78 ± 11.28 ; Median(Q25Q75) of somesthetic weight, visual weight, vestibule weight were abnormal distribution, SOT comprehensive score of experimental group was lower than control group. According to the SOT comprehensive score and the sense weight, divide the patients into three types. The peripheral injury of vestibule is mainly visual vestibule disorder and simple vestibule disorder. Compared the detection rate of caloric test and

dynamic balance test in the experimental group, caloric test was positive 36 cases (100%), SOT was positive 33 cases 91.7%, both tests were positive 33 case 91.7%, both tests were negative 0 case, just caloric test was positive 3 cases 8.3%, just SOT was positive 0 cases 0.0%.

Conclusions: SOT is an important and effective method to evaluate the balance function of patients in sudden hearing loss with vertigo.

PP1-158 - Episodic ataxia type 2 characterized by recurrent dizziness/vertigo: a report of four cases

12. Genetics, Development, and Regeneration

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Purpose: To report the clinical features and gene mutations in four episodic ataxia type 2 (EA2) patients whose main presentation was recurrent dizziness/vertigo.

Methods: Clinical data of four EA2 patients (three familial EA2 cases and one sporadic case) with recurrent dizziness/vertigo were collected to assess nystagmus and eye movement. Gene mutations were identified by whole exome sequencing.

Results: The three patients in family 1 experienced disease onset before 8 years of age, mainly manifesting as episodic dizziness and muscle weakness of the lower limbs and the inability to walk. These symptoms lasted a few hours and then subsided. The proband also had gaze-evoked nystagmus during attacks. Videonystagmography demonstrated that the saccade velocity was low, smooth pursuit was type III, and gain was abnormal at 0.1 Hz, 0.2 Hz, and 0.4 Hz. The optokinetic nystagmus test showed that the left eye optokinetic nystagmus disappeared, and the right eye optokinetic nystagmus weakened. The head shaking test produced a left horizontal nystagmus. Gene analysis identified a novel c.1558+2T>G splice site mutation in the CACNA1A gene in the proband and his mother. The fourth patient was sporadic, with an onset age of 3 years. He mainly suf-

ferred from episodic vertigo, accompanied by severe anxiety and depression. He carried a CACNA1A mutation, c.4636C>T, which is a previously reported pathogenic mutation.

Conclusions: The onset of symptoms in these EA2 patients was early. The patients mainly presented recurrent dizziness/vertigo, with the absence of characteristic episodic ataxia. Detection of CACNA1A mutations facilitates the diagnosis of EA2.

PP1-159 - Genome-wide association study in downbeat nystagmus

12. Genetics, Development, and Regeneration

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Purpose: In order to identify genetic variants associated with downbeat nystagmus (DBN), which is mostly caused by a bilateral hypofunction of the cerebellar flocculus and whose etiology remains often unclear, we conducted a genome-wide association study (GWAS).

Methods: 106 patients (46 females) with DBN of unknown etiology and 2609 healthy controls of European ancestry were included. Association was assessed using approx. 8 million single nucleotide polymorphisms after imputation in 7 batches.

Results: Two loci comprising three genes were identified to be genome-wide significant: fibroblast growth factor 14 (FGF14) on chromosome 13 and

on chromosome 5 the dihydrofolate reductase (DHFR) and the mutS (Mutase S) homolog 3 (MSH3), a component of the post-replicative DNA mismatch repair system (MMR). DHFR and MSH3 have an overlapping area in their exons 1.

Conclusions: By using a GWAS approach to determine the etiology of downbeat nystagmus three genes were identified which are known to be associated with cerebellar impairment, a feature discussed in the context of DBN etiology. These findings provide candidate genes which could be involved in the underlying pathophysiology of downbeat nystagmus.

PP1-160 - Molecular genetic studies of Familial Menieres disease: a systematic review

12. Genetics, Development, and Regeneration

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Purpose: Familial Meniere's disease (FMD), which defined as at least one other relative (first or second degree) fulfills all the criteria of MD. FMD can offer a common genetic background for the subjects in studies and a growing number of FMD genetic studies have been reported with the rapid development of molecular genetic technology in recent decades, particular the application of next generation sequencing (NGS) technology. This systematic review summarized overall published articles with molecular genetic studies of FMD, which benefits to explore a more elaborated search strategy to identify novel causal genes and ultimately unveil the mysterious causes of MD.

Methods: We searched three electronic databases and reference lists up to August 2017. Three collaborators reviewed all the articles and disagreement was resolved through discussion.

Results: 13 studies met the eligibility criteria in this systematic review and more than 102 FMD pedigrees from six ethnic origins exhibited complex

clinical and genetic heterogeneity of MD. A majority of FMD pedigrees exhibited autosomal dominant inheritance with incomplete penetrance and anticipation also observed in some enrolled researches. Linkage studies in FMD have found candidate loci at 5q14–15 and 12p12.3. By exome sequencing, DTN A, FAM136A, SEMA3D, DPT and PRKCB II genes had been identified.

Conclusions: Combination NGS followed by advanced Bioinformatics analysis on multi-generation families FMD and the latest diagnostic criteria of MD can bright a beam of new light to genetic basis studies of FMD, which is also a quite reliable strategy to identify novel mutated genes and further unveil the underlying causes of MD.

PP1-161 - Regenerative medicine for vestibular disorders

12. Genetics, Development, and Regeneration

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Purpose: It has become possible to restore the function for highly hearing-impaired patients using advanced artificial auditory instruments such as cochlear implants. However, treatment method for severely vestibular disordered patients has not been established.

Vestibular hair cells and vestibular ganglion cells are the main regions of peripheral vestibular damage. Both are related with age - related equilibrium disorders, as the number of those cells decrease with aging.

Once mammalian those cells are injured with aging or some other reasons, regeneration of those cells is considered difficult.

Methods: In recent years, regenerative medicine using stem cells such as embryonic stem cells (ES cells) and induced pluripotent stem cells (iPS cells) has developed. Clinical applications are gradually advanced in various fields such as ophthalmic field and cardiovascular field. In the field of ophthalmology

retinal pigmented epithelium prepared from iPS cells was transplanted to patients of age-related macular degeneration and iPS-derived nerve cell transplantation is planned to transplant for patients of Parkinson's disease and spinal cord injury. Realization of regenerative medicine for vestibular disordered patients is expected.

Results: We have tried to transplant stem cells into the inner ear of normal and peripheral vestibular damaged model animals. As donor stem cells we have used mouse or human iPS cells. We have confirmed whether transplanted stem cells can survive in the environment of vestibular organs. Then we have investigated the effectiveness of cell transplantation using animal models of vestibular damaged.

Conclusions: The present situation on vestibular regeneration medicine and the future prospect for regenerative medicine will be presented.

PP1-162 - Voltage-gated Ion Channels in the Developing Human Inner Ear

12. Genetics, Development, and Regeneration

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Purpose: Studies investigating inner ear development focus primarily on rodent models. The aim of this study was to determine the expression patterns of important potassium and calcium channels in the utricle, cristae, and cochlea of the human developing inner ear.

Methods: Inner ears from human foetus aged 9 to 17 weeks gestation were dissected to isolate vestibular (utricle and cristae) and cochlea (apex, middle, and base) regions. Tissue was homogenised and RNA isolated using QIAGEN miRNeasy Mini Kits. RNA was reverse transcribed into cDNA using Superscript III Reverse Transcriptase and qPCR run to assess ion channel expression (KCNQ4, CACNA1C) in the inner ear.

Results: Expression of potassium (KCNQ4), calcium (CACNA1C) channels were significantly higher in the middle region of the cochlea than other

regions. KCNQ4 showed significantly lower expression in the cristae than utricle or cochlea regions, but did increase with gestational age in most regions of the inner ear. In contrast, there is a divergent pattern of CACNA1C expression with a decrease in vestibular organs, but increase in cochlea with gestational age.

Conclusions: Our results show that ion channel expression in developing human fetus varies with gestational age and across inner ear regions. The reason for these regional differences is unclear. Identifying key ion channels involved in functional development of HCs and their spatial expression may allow us to promote regenerative HC growth from pluripotent stem cells. This in turn, may lead to targeted treatments for deafness and balance disorders of the inner ear.

Exhibition and poster viewing (poster session 2)

PP2-1 - Auditory-Vestibular Integration at the Posterior Superior Temporal Gyrus and Posterior Insula Gyrus

13. Imaging of the Inner Ear & Vestibular System

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Purpose: Multisensory convergence and sensorimotor integration are important aspects for the mediation of higher vestibular cognitive functions at the cortical level. Much less is known about the neural mechanism that mediates the integration of vestibular-otolith (linear acceleration/translation/gravity detection) and auditory processing. Vestibular-otolith and auditory afferents can be simultaneously activated using loud sound pressure stimulation, which are routinely used for testing cervical and ocular vestibular evoked myogenic potentials (VEMPs) in

clinical testing. Due to the simultaneous activation of afferents there is always an auditory confound problem in fMRI studies of the neural topology of these systems. Here, we demonstrate that the auditory confounding problem can be overcome in a novel way that does not require the assumption of simple subtraction and additionally allows detection of non-linear changes in the response due to vestibular-otolith interference.

Methods: We used a parametric sound pressure stimulation design that takes each subject's vestibular stimulation threshold into account and analysed for changes in BOLD-response below and above vestibular-otolith threshold.

Results: Results revealed that auditory and vestibular convergence are contained in overlapping regions of the caudal part of the superior temporal gyrus (STG) and the posterior insula. In addition, there are regions that were responsive only to supra-threshold stimulations, suggesting vestibular (otolith) signal processing in these areas.

Conclusions: Based on these parametric analyses, we suggest that the caudal part of the STG and posterior insula could be areas of vestibular contribution to auditory processing, i.e., higher vestibular cortices that provide multisensory integration that is important to tasks such as spatial localization of sound

PP2-2 - Imaging analysis of patients with Menieres disease treated with endolymphatic sac shunt surgery

13. Imaging of the Inner Ear & Vestibular System

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Purpose: To investigate the mechanism by which endolymphatic sac-mastoid shunt surgery is effective in treating Meniere's disease.

Methods: Eleven patients with intractable Meniere's disease underwent 3D-FLAIR MRI with a

3-Tesla unit 24 h after intratympanic administration of gadolinium before and six months after endolymphatic sac-mastoid shunt surgery. The enhanced perilymphatic space in the bilateral cochlea, vestibules and canals was visualized and compared with that in the endolymphatic space by scoring the scala tympani and scala vestibuli of the cochlear basal turn and by measuring the developing area of the vestibules quantitatively.

Results: Gadolinium was present in the perilymph of the inner ear in the cochlea, vestibules and canals of all 11 patients. Significant differences were observed in scala vestibuli scores between the affected and healthy sides ($Z=3.426$, $P<0.05$) and in the developing areas of the vestibules on the affected and healthy sides (5.76 ± 2.99 mm² vs. 8.89 ± 2.52 mm², $t=2.65$, $P<0.05$). The scala vestibuli scores before and after surgery did not differ on either the affected ($Z=0.447$, $P>0.05$) or healthy ($Z=0.0$, $P>0.05$) side. The developing area of the vestibule before and after surgery was also similar on the affected ($t=0.74$, $P>0.05$) and healthy ($t=0.66$, $P>0.05$) sides.

Conclusions: Hydrops was not significantly reduced by surgery. The mechanism by which endolymphatic sac-mastoid shunt surgery controls vertigo may be unrelated to improvements in endolymphatic hydrops.

PP2-3 - Multiplanar visualization of vestibular endolymphatic hydrops

13. Imaging of the Inner Ear & Vestibular System

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Purpose: Recently developed magnetic resonance (MR) image acquisition techniques have enabled the visualization of endolymphatic hydrops (ELH). MR images are most commonly viewed in the axial plane; with studies attempting to visualize/quantify ELH in the sagittal and coronal planes being rather

scarce. Therefore, our aim in this study was to provide a visual, colour-coded anatomical account of ELH in the three planes.

Methods: The inner ear region acquired with a 3D Real-IR sequence was extracted in four patients with varying degrees of ELH: 1) Normal inner ear fluid spaces, 2) Mild ELH, 3) Moderate ELH, 4) Severe ELH. For each patient, axial images were viewed alongside the sagittal and coronal images using a designated software. A 3D model constructed from histological image data of the inner ear was used as a visual reference.

Results: All ELH regions were identified and marked with different colour codes in the three planes. In the axial and coronal planes, mild dilatation of the sacculus is well recognized. In the sagittal plane, the shape of the utriculus is well recognized and facilitates the interpretation of axial images. With increasing severity of ELH, the utricular and saccular endolymph fluid spaces are converging and cannot be individually quantified in all given planes.

Conclusions: Multiplanar visualization of vestibular endolymphatic hydrops is highly informative and may serve as a better basis for the estimation and quantification of ELH than a uniplanar analysis

PP2-4 - New strategy for diagnosis of Menieres disease using three dimensional MRI

13. Imaging of the Inner Ear & Vestibular System

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Purpose: It has long been considered difficult to detect endolymphatic hydrops (EH) in patients with Meniere's disease (MD) clinically using morphological examinations. In 2006, the Nagoya

University group first succeeded in visualizing EH using MRI enhanced by intravenous administration of Gadolinium (Gd). The purpose of the present is to establish the criteria for diagnosis of MD using MRI.

Methods: Seventy patients with unilateral MD (uMD) were enrolled in the present. We also enrolled 47 healthy volunteers as controls. MRI measurements were performed 4 h after intravenous administration of a single dose of Gd contrast agent. The imaging was performed on a 3 tesla MRI unit using a 32-channel array head coil. The original MRI images were transferred to a workstation, and three-dimensional images were made. On this workstation, inner ears (cochlea, vestibule and semi-circular canals) were separated from brain and the volume of each structure was calculated. We also calculated the ratio of endolymphatic space size to total fluid space (ELS ratio). Comparing the ELS ratio of uMD with controls, we established the criteria for diagnosis of MD.

Results: The average of ELS ratio of uMD was 25.4% in cochlea, 37.0% in vestibule and 27.8% in semi-circular canals. On the other hand, the average of controls was 10.2% in cochlea, 17.7% in vestibule and 14.8% in semi-circular canals. Drawing the ROC curve with consideration of the relationship among all three parts, the AUC was 0.903 and AIC was 171.4.

Conclusions: The volumetric measurement of endolymphatic space size is useful for the diagnosis of MD.

PP2-5 - Progression of Hydrops in Meniere's disease continues over time though the symptoms are relieved

13. Imaging of the Inner Ear & Vestibular System

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Purpose: To evaluate the change of endolymphatic hydrops (EHs) in patients with unilateral MD, as a function of disease duration and clinical symptoms by intravenous Gd-enhanced inner ear MRI.

Methods: Total 26 patients with unilateral definite MD were enrolled in this study. Intravenous Gd-enhanced inner ear MRI was performed to visualize the endolymphatic hydrops of affected ear. Clinical features such as disease duration, pure tone audiometry (PTA), electrocochleography (ECoG), Caloric tests were assessed. The relationship between the hydrops ratio of cochlea and vestibule and disease duration was analyzed. Also, in 14 patients out of 26 participants, intravenous Gd MRI was repeatedly checked after the disappearance of vertigo spell for at least six months after medical treatment. In these patients, the sequential MRI in the same patients was compared to evaluate the change of hydrops ratio over at least 1-year duration and after the disappearance of vertigo for at least 6 months.

Results: The hydrops ratio of the patients was 0.38 ± 0.19 in the cochlea and 0.61 ± 0.25 in the vestibule. The mean disease duration was 34.4 months. The hydrops ratio in the cochlea and vestibule has increased over time. In addition, in 14 patients having sequential MRI, the hydrops ratio in cochlea and vestibule increased from 0.29 to 0.35, and from 0.65 to 0.73, respectively, despite the similar hearing thresholds.

Conclusions: The endolymphatic hydrops level has increased over time in the patients with MD despite the controlled vertigo spell. These indicated that the endolymphatic hydrops might be the irreversible and progressive phenomenon in MD.

PP2-6 - The Feasibility of MRI in the Differential Diagnosis of a patient with Acute Audiovestibular Loss

13. Imaging of the Inner Ear & Vestibular System

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Purpose: Acute audiovestibular loss is characterized by acute onset of prolonged vertigo and hearing loss. Many neurologic conditions should be considered in the differential diagnosis of audiovestibular loss. Some authors suggest that acute audiovestibular loss is more often caused by vascular factors rather than viral causes. The purpose of this study is aimed to identify the feasibility of MRI in the differential diagnosis of patients with acute audiovestibular loss.

Methods: We retrospectively enrolled 31 patients who fulfilled the criteria for sudden hearing loss at symptom onset and showed spontaneous nystagmus from March 2007 to December 2017. Patients were excluded if the examination indicated Meniere's disease or chronic otitis media. Temporal MRI including Diffusion-Weighted Imaging (DWI) and Fast Imaging Employing Steady-state Acquisition (FIESTA) were taken in all patients

Results: Fifteen patients showed increased signal of labyrinth on FLuid-Attenuated Inversion Recovery (FLAIR) image and 9 patients showed negative findings on MRI. Two patients showed an infarction of AICA territory in DWI MRI and 3 patients showed vestibular schwannoma in the internal auditory canal. There was no significant relevance between hearing recovery after treatment and the FLAIR image

Conclusions: Although MRI examination is mandatory to distinguish central vertigo in acute audiovestibular loss, the presence of AICA infarction was rarely seen and few patients showed central, non-stroke cases such as vestibular schwannoma

PP2-7 - Usefulness of intravital multi-photon microscopy in visualizing study of the scala media

13. Imaging of the Inner Ear & Vestibular System

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Purpose: Currently, no vestibular or auditory diagnostic test is available for endolymphatic hydrops or dilation of the scala media. Clinical diagnosis for endolymphatic hydrops is based on doctor's obser-

vation and patient's medical history, symptomatic and symptomatic pattern. By using near-infrared lasers for multi-photon excitation, intravital multi-photon microscopy (MPM) can detect endogenous fluorescence and second harmonic generation of tissues. In this study, we used intravital MPM to visualise various cochlear microstructures without any staining and non-invasively analyse the volume changes of the scala media without removing the overlying cochlear bone.

Methods: .

Results: The intravital MPM images revealed various tissue types, ranging from thin membranes to dense bone, as well as the spiral ganglion beneath the cochlear bone. The two-dimensional cross-sectional and serial z-stack intravital MPM images also revealed the spatial dilation of the scala media in the temporal bone of pendrin-deficient mice.

Conclusions: These findings suggest that intravital MPM might serve as a new method for obtaining microanatomical information regarding the cochlea, similar to standard histopathological analyses in the animal study for the cochlea. Given the capability of intravital MPM for detecting an increase in the volume of the scala media in pendrin-deficient mice, it might be a promising new tool for assessing the pathophysiology of hearing loss in the future.

PP2-8 - Antigen in the Endolymphatic Duct results in Chronic Hydrops and an Enlarged Endolymphatic Duct

14. Meniere's Disease and Related Disorders

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Purpose: Antigen within the endolymphatic space is said to be transported to the endolymphatic sac. It has been suggested that permanent damage of the sac via excessive immune activity can result in chronic endolymphatic hydrops. However, the injection of antigen, such as Lipopolysaccharide (LPS), into inner ear perilymph results in a temporary endolymphatic hydrops that lasts only 2 to 3 weeks. Here,

we investigated changes induced by antigen injected directly into the endolymphatic space.

Methods: Various concentrations of LPS in 1ml of artificial endolymph were injected into scala media of anaesthetized guinea pigs via a glass micropipette, with subsequent recovery for 1 to 6 weeks. Artificial endolymph injections and contralateral ears served as controls. After the recovery period, cochlear and vestibular function was measured, and inner ears were imaged using light-sheet fluorescence microscopy. The relative volume of scala media and the endolymphatic duct was quantified.

Results: Functional and morphological changes varied with LPS concentration, ranging from severe fibrosis and hearing loss (0.1%LPS), to no fibrosis with moderate endolymphatic hydrops with only mild hearing loss (0.005% LPS). Interestingly fibrosis and hydrops in scala media coincided with an enlarged, patent endolymphatic duct.

Conclusions: Injections of 0.001% LPS produced hydrops lasting at least 6 weeks, with less than 20 dB hearing loss. This may offer a more reliable method of inducing chronic endolymphatic hydrops in guinea pigs for Meniere's disease research. Moreover, our results highlight that immunological damage of the endolymphatic sac may not result in blockage of the duct.

PP2-9 - Bilateral Meniere's disease or autoimmune inner ear disease presenting to the Emergency Department

14. Meniere's Disease and Related Disorders

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Purpose: To describe the clinical presentations of patients with bilateral Meniere's Disease (MD) or Autoimmune Inner Ear Disease (AIED) to our Emergency Department (ED) of the Royal Victorian

Eye and Ear Hospital. This ED provides a Statewide service for ear-related disease.

Methods: Search strategy: Patients presenting to ED between Jan 2015-Dec 2017, with a diagnostic code of MD (134 patients), who were followed up with at least one audiogram, and met the recent Barany Society criteria for definite MD (in 2015). Thirty nine met these criteria, and of these eight had bilateral disease.

Results: The period of time between diagnosis of unilateral disease, and emergence of bilateral MD was 3-16 years. In six cases, the hearing loss was sequential commencing as a low-to-middle frequency hearing loss in one ear and then the other. Two cases exhibited bilateral simultaneous hearing fluctuation. Most patients exhibited a high frequency hearing loss. It was the better-hearing ear that fluctuated. Three of these patients were seropositive for c-ANCA or the antinuclear antibody. Other patients had associated autoimmune conditions, including inflammatory arthritis and diabetes mellitus. One patient showed inflammation of the cervical spine, with rapidly progressive bilateral SNHL. Three people required cochlear implantation, including the rapidly progressive bilateral hearing loss patient. Fluctuation of the better-hearing ear caused considerable disability for the patient.

Conclusions: Approximately 20 % cases of Meniere's presented with bilateral disease. Autoimmune disease was frequently associated, and in one case the condition was associated with serious neurological disease. Progression to bilateral MD can occur many years after initial presentation.

PP2-10 - Cervical and Ocular Vestibular-evoked Myogenic Potentials in Patients with Menieres Disease

14. Meniere's Disease and Related Disorders

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Purpose: To observe the features of air-conducted sound elicited ocular vestibular-evoked myogenic potential(ACS-oVEMP) and cervical vestibular-evoked myogenic potential(ACS-cVEMP) in patients with Meniere's disease (MD).

Methods: Fifty six patients with MD and 50 normal subjects (100 ears) were recruited for conventional cVEMP and oVEMP examinations. Grade of vestibular function was also collected for patients with MD. The relationship between VEMPs abnormality, grades of vestibular function and clinical stages of MD were analyzed.

Results: The abnormal rates of cVEMP and oVEMP in MD patients were 57.1% (32/56) and 64.3% (36/56), significantly higher than that in normal subjects respectively ($X^2=22.286P=0.000X^2=15.217P=0.000$). The abnormal rates of cVEMP and oVEMP in MD patients of stage to stage were 20.0% (1/5) and 40.0% (2/5), 50.0% (9/18) and 50.0% (9/18), 59.3% (16/27) and 70.4% (19/27), 100.0% (6/6) and 100.0% (6/6). There was a significant difference in cVEMP abnormality between four stages of MD patients ($P=0.046$). Significant correlation was found between clinical stages and the grades of vestibular dysfunction ($r_s=0.417P=0.001$).

Conclusions: Dysfunction of vestibular otolithic organs and their input pathways in patients with MD can be detected by cVEMP and oVEMP tests. The abnormal rates of VEMP showed an gradually increasing trend with the development of MD stages. And the extent of vestibular lesions can be detected by cVEMP and oVEMP tests, which may provide a reference for clinical staging of MD.

PP2-11 - Clinical application of glycerol test with endolymphatic sac decompression in Meniere 's disease

14. Meniere's Disease and Related Disorders

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Purpose: To study the clinical value of glycerin test in the operation of inner ear lymphatic sac decompression in Meniere's disease.

Methods: 82 patients with stage and Meniere's disease with poor conservative treatment and definite diagnosis were given preoperative glycerol test and DARS score was recorded. After 2 years of follow-up, the DARS score was applied again. The correlation between glycerin test results and postoperative efficacy was analyzed.

Results: In 82 cases with Meniere's disease, the positive result of hearing test in glycerin test was 57.32% of the total, 17 cases of positive hearing loss type was 20.73% and 18 cases of glycerin test negative rate was 21.95%. The DARS scores of 82 patients before and after surgery were 31.48 ± 7.05 and 8.44 ± 8.17 respectively ($P < 0.01$). The lowest preoperative DARS score was 7 and the highest was 36. The lowest DARS score was 0 and the highest was 29 at 2 years after operation. The DARS score of 8 patients was ≥ 18 and the operative efficiency was 78.92%. Among them, the positive rate of DARS in patients with positive glycerol test was (6.56 ± 1.28) and negative in patients with glycerin test (10.47 ± 3.09), there was a significant difference ($P < 0.05$).

Conclusions: This studies have shown that the glycerol test for patients of Meniere's disease with endolymphatic sac decompression has instructive significance. The positive result of the Glycerol test in the patients of Meniere's disease with endolymphatic sac decompression was efficacy than the negative effect.

PP2-12 - Clinical features of symptom and audiovestibular test for Menieres disease and vestibular migraine

14. Meniere's Disease and Related Disorders

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Purpose: The diagnosis of Meniere's disease (MD) and vestibular migraine (VM) is principally based on clinical symptoms. Currently, no specific diagnostic tests and biological markers are available. Comorbidity is common between MD and VM, and their symptoms overlap, which renders the differential diagnosis difficult. Due to the

similarities between MD and VM in the clinical symptoms and diagnostic criteria, and differences in their management, our research effort was mainly directed at their differentiation.

Methods: We examined the clinical features of MD, VM and MDVM in terms of demographics, symptoms and findings of neurologic tests, audiometry and vestibular laboratory assessment.

Results: We investigated 252 patients with only VM, 168 with only MD, and 62 with MDVM. Clinical features that differentiated VM from MD were found in all groups. MD tended to have an advanced age of onset, more fluctuating or low tone hearing loss, progressive hearing loss, tinnitus, ear fullness, abnormal caloric asymmetry, abnormal vestibular evoked myogenic potential and endolymphatic hydrops (ELH on ECOG, -SP/AP amplitude ratio). On the other hand, VM tended to have family history of vertigo/dizziness, involved females more, and had higher attack frequency. Moreover, VM patients had more headaches, photophobia, phonophobia and visual aura, high tone hearing loss, abnormal nystagmus, and abnormal findings of vestibular autorotation test.

Conclusions: In conclusion, this study confirmed a considerable overlap of clinical symptoms among MD, VM and MDVM. Integrating clinical symptoms, the findings audiovestibular tests and follow-up can help differentiate the two conditions and find the comorbidity.

PP2-13 - Delayed contrast 3-dimensional MRI and regional hydrops in Meniere's disease and variants.

14. Meniere's Disease and Related Disorders

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Purpose: To use high resolution MRI to evaluate endolymphatic hydrops in patients with Meniere's disease (MD) and related entities.

Methods: MRI sequences with 3T scanner using high resolution 4 hour-delayed intravenous-enhanced 3D FLAIR including cisternographic T2 and delayed iv-enhanced 3D fluid-attenuation inversion recovery (DIVE-3D-FLAIR). Clinical history, audiovestibular testing, and evaluation by neurotologist. All sequential MRI imaging using hydrops protocol were evaluated during a 9 month period.

Results: There were 15 patients with MD with ipsilateral isolated saccular hydrops; 18 patients with MD with ipsilateral hydrops isolated to the saccule and cochlear duct and 15 patients with MD with hydrops in the saccule, cochlear duct, and utricle. Patients with isolated saccular hydrops had full MD with vertigo, aural fullness and ipsilateral hearing loss. In one case, serial MRI demonstrated isolated saccular hydrops progressing to cochleo-saccular hydrops as symptoms progressed. Six patients had isolated cochlear hydrops. 5 out of 6 of the isolated cochlear hydrops presented with fluctuating hearing loss without associated vertigo spells, while one had full MD with vertigo spells.

Conclusions: There was a significant predominance of saccular endolymphatic hydrops with only one patient out of 48 MD patients without hydrops of the saccule. These findings are consistent with endolymphatic hydrops initiating from the saccule, then progressing to involve the cochlea and then utricle. There were 5 patients with isolated cochlear hydrops; it is unknown whether these patients will later go on to develop MD. High resolution MRI is useful to delineate the natural history of MD and other variants such as cochlear hydrops.

PP2-14 - Delayed effect and gain restoration after intratympanic gentamicin for Menieres Disease

14. Meniere's Disease and Related Disorders

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Purpose: To determine the clinical value of the video Head Impulse Test for monitoring the effect of intratympanic gentamicin in MD patients.

Methods: Twenty definite MD patients treated with intratympanic gentamicin were enrolled in this prospective study. Patients underwent a complete neuro-otologic examination, audiometry, caloric testing and a vHIT before beginning this protocol. Patients returned for weekly follow-up examination during the course of the treatment protocol. Subsequently were monitored 1 month after the completion of the therapy and were then seen at intervals of 3 months. Every patient was monitored for at least one year.

Results: Complete vertigo control (class A) was achieved in 14 patients at the 12-month follow-up. A significant reduction in the hVOR gain values was observed at the three weeks follow up after the instillation, with a maximum gain reduction at the one month evaluation after the gentamicin injection. Once this reduction was achieved, no additional was detected in subsequent testing. The ROC analysis showed that a hVOR gain diminution over 33% in the 1 month follow-up, results in a higher vertigo free period. In the mid-term, 10 patients had a significant partial recovery of the hVOR gain. Six out those 10 patients suffered vertigo recurrence, which paralleled the recovery of the hVOR gain.

Conclusions: Our results suggest that a monthly interval between injections, is a sufficiently safe period to wait until a reduction of the hVOR gain appears. Our findings are consistent with a mild relationship between gain restoration and vertigo recurrence.

PP2-15 - Detecting endolymphatic hydrops with posterior tympanic medial wall Gd-DTPA delivery and 8 min-MRI

14. Meniere's Disease and Related Disorders

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Purpose: To optimize targeted posterior tympanic medial wall delivery of gadolinium chelate and MRI sequence for detection of endolymphatic hydrops (EH) in patients with peripheral vertigo.

Methods: 13 patients with periphery vertigo were enrolled in the study. 0.1-0.2 ml diluted (10,20, and 40-fold) gadolinium-diethylenetriamine pentaacetic acid (Gd-DTPA) were delivered onto the posterior tympanic medial wall using a soft-tipped needle. Heavily T2-weighted 3-dimensional fluid-attenuated inversion recovery (hT2W-3D-FLAIR) MRI with imaging time of either 8min 35sec or 15min 11sec was performed 8h or 24 h after administration using a 3T machine in combination with 20-channel Tim 4G head/neck coil.

Results: High signal to noise ratio MRI was generated in patients receiving delivery of 0.15-0.2ml of 10-fold diluted Gd-DTPA. At 8h after delivery, significant uptake was detected in the perilymphatic compartments of hook region and basal turn of cochlea and vestibule. At 24 h, Gd-DTPA distributed homogenously in the inner ear. Obvious individual variance existed in the uptake when 0.1 ml of 40-fold diluted Gd-DTPA was delivered. Stable inner ear uptake and high quality images demonstrating EH were gained in patients receiving 0.1ml of 20-fold diluted Gd-DTPA. There was insignificant difference in the image quality associated with different scanning time. EH were detected in 6 cochleae and 11 vestibule. Cochlear EH was detected in definite Meniere's disease patients.

Conclusions: Targeted posterior tympanic medial wall delivery of 0.1ml of 20-fold diluted Gd-DTPA in combination with 8min 35sec hT2W-3D-FLAIR MRI is clinically practical to detect EH. The study was supported by National Natural Science Foundation of China (contract 81771006).

PP2-16 - Diagnostic Diversity of Acute Vestibular Syndrome with Negative Video Head Impulse Test

14. Meniere's Disease and Related Disorders

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Purpose: To analyze the clinical characteristics of patients with acute vestibular syndrome (AVS) who showed negative video head impulse test (vHIT)

Methods: During 16 months, 155 of AVS were identified due to presence of spontaneous nystagmus and postural imbalance. Of these 155, 30(19.4%) were finally enrolled in this study due to both of the negative horizontal vHIT. Data on demographics (age, gender), results of vestibular function tests [videonystagmography, horizontal vHIT, caloric test, and cervical vestibular evoked myogenic potential (cVEMP)] were analyzed. All cases were checked brain MRI including diffusion scan to evaluate central lesion.

Results: All 30 patients consisted of 17 cases of Meniere's disease (MD), 7 of sudden sensorineural hearing loss (SSNHL) with vertigo, and only 3 cases (3/30, 10%) were finally diagnosed as acute vascular stroke. In MD, 5 patients showed negative vHIT even in unilateral canal paresis on caloric test. Except for hearing loss in the lesion side, the direction of nystagmus or cVEMP asymmetry were inconsistent to clarify the diagnosis. All 7 patients with SSNHL with vertigo did not have caloric canal paresis, but 6 patients showed amplitude of cVEMP was significantly smaller on the lesion side.

Conclusions: In patients with AVS, even in negative vHIT, peripheral vestibulopathy were still more common compared with stroke. Of these patients, it is mandatory to confirm hearing because of a high possibility of MD or SSNHL. In particular, negative vHIT in SSNHL with vertigo might be affected by involvement of inferior vestibular nerve or saccule.

PP2-17 - Diagnostic Value of the Multifrequency Tympanometry in the Patients with Menieres Disease

14. Meniere's Disease and Related Disorders

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Purpose: Meniere's disease (MD) is characterized by an idiopathic endolymph hydrops which reflects an increase in the pressure of inner ear. Multifrequency tympanometry (MFT) can evaluate the change in the pressure of inner ear. The aim of this study was to compare the efficacy of the pressure of inner ear in the patients with MD in order to measure G width (the width of bimodal peaks for the waveform obtained in measuring a conductance at 2000Hz) using MFT.

Methods: We have recruited 80 healthy control subjects and 51 patients who were referred to our department and were diagnosed as MD. MFT measured G width at a resonance frequency of 2000Hz in both ears of all subjects. This work was approved by an ethics committee at Chidoribashi General Hospital.

Results: G width in the affected ears with MD was significantly more elevated than that in the healthy ears in the control group. The cutoff value was set at 200daPa with a sensitivity of 35.1% and a specificity of 95.6%. On the other hand, There was no significant difference between resonance frequency of ears in the control group and ears with MD. Both ears in the MD group had a wider G width than that in the control group.

Conclusions: MFT is a noninvasive and easy device. These results suggest that MFT may be a useful tool to find out the elevated pressure of inner ear in the patients with MD.

PP2-18 - Discrepancies between vHIT and caloric tests in congenital and acquired endolymphatic hydrops

14. Meniere's Disease and Related Disorders

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Purpose: We investigated the video head impulse test (vHIT) and caloric test in enlarged vestibular aqueduct (EVA) patients and compared the findings with Ménière's disease (MD) and acute vestibular neuritis results to clarify vestibular dysfunction characteristics in enlarged vestibular aqueduct patients and suggest the cause of discrepancy between the video head impulse and caloric tests in endolymphatic hydrops.

Methods: Ten enlarged vestibular aqueduct patients with genotypically proven bi-allelic *SLC26A4* mutations were enrolled. The results of video head impulse and caloric tests were analyzed and compared with those of MD (n = 76) and acute vestibular neuritis (n = 19).

Results: In EVA patients, 40% showed unilateral caloric weakness and 30% had recurrent vertigo spells. All the patients with recurrent vertigo had caloric weakness. However, only 25% of patients with abnormal caloric test results showed abnormal vHIT results. The discrepancy between the caloric test and vHIT results was also found in patients with MD, but not in patients with acute vestibular neuritis (abnormal vHIT results in 47.3% and 94.7% of patients with unilateral caloric weakness, respectively).

Conclusions: Unilateral vestibular dysfunction was identified in 40% of EVA patients by caloric test, and caloric test results were not correlated with vHIT results, of which the finding was also similar in MD patients. It is tempting to speculate that endolymphatic hydrops, a common pathologic feature of EVA and MD, could cause the discrepancy, and vestibulopathy in endolymphatic hydrops might be restricted in the low-frequency range.

PP2-19 - Discrepancy between results of vHIT and those of caloric test in the cases with Menieres disease

14. Meniere's Disease and Related Disorders

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Purpose: It is well known that video head impulse test (vHIT) is a simple and reliable examination for vestibular function. The results are identical with those of the caloric test for cases with vestibular neuritis and acoustic tumor. On the contrary, the results of two tests diverge for the cases with Meniere's disease. The aim of this study was to clarify the cause of the discrepancy.

Methods: Subjects were 22 cases of unilateral Meniere's disease who showed unilateral dysfunction on the caloric test. We studied factors which affect the results of vHIT using logistic regression analysis.

Results: There was no association with respect to age, duration of disease, stage, frequency of vertigo or hearing level ($p > 0.05$). On the contrary, the results of vHIT associated with those of the Futaki's furosemide test ($p = 0.03$).

Conclusions: The cause of the discrepancy had been controversial. One presumed cause was the difference of type of impaired hair cells. Type 2 cells which relates to caloric response are more susceptible to damage than type I cells which relates to response of vHIT in Ménière's disease. Numbers of type 2 cells decrease with age, but the discrepancy is not related to age, so the theory is denied. Another presumed cause is changes of the lymph flow due to the hydrops. Since the Futaki's furosemide test inspect having endolymphatic hydrops in the lateral semicircular canal, we sustain that enlarged endolymphatic space should cause the discrepancy between the results of vHIT and those of caloric test in Meniere's disease.

PP2-20 - Dissociated vestibular tests result in patients with Menieres is not due to central dysfunction

14. Meniere's Disease and Related Disorders

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Purpose: In patients with Ménière's disease the most frequent finding in vestibular testing is a discrepancy of results such that the caloric test is usually abnormal while the video-head impulse test is normal. The hypothesis to test is that if an abnormal velocity storage function is the basis for a discrepant result, then the time constant of the nystagmic response during rotatory chair testing should also be found abnormal (lower) and phase advance should be an expected finding.

Methods: A complete vestibular evaluation that included the caloric and video head-impulse test was performed to 50 patients diagnosed of unilateral definite Ménière's disease and classified according to results in both tests. All then and 12 normal subjects, were also evaluated with the rotatory chair test. The time constant of the nystagmic response and the results in the test (gain and phase shift) were compared in the different groups and multivariate analysis was performed to analyze differences adjusted by age.

Results: The mean time constant and phase lead were only different to results in normal subjects when both the caloric and vHIT were abnormal. None of these results were different to those in normal subjects in patients with both tests normal neither in those in whom the results were discrepant.

Conclusions: In patients with unilateral Ménière's disease, discrepant results in the vHIT and caloric test do not indicate an abnormal central vestibular processing of the information coming from the periphery when stimulated with hot or cold water.

PP2-21 - Eye Movement Response Patterns during vHIT in Menieres Disease or Migraine Related Vertigo

14. Meniere's Disease and Related Disorders

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Purpose: To compare the eye velocity response profiles of healthy subjects on vHIT to the response profiles of patients with early Meniere's Disease or Migraine Related Vertigo.

Methods: Patients with stage 3 *Definite Meniere's Disease (MD)* were enrolled and patients diagnosed as Migraine Related Vertigo (MRV). Healthy subjects in the same age range were tested as controls. MD patients had to be less than two years into MD. The ICS Impulse system measured the eye movement response to head impulses by vHIT using the HIMP paradigm: the subject or patient was instructed to maintain fixation on an earth-fixed target during small, abrupt, passive, unpredictable horizontal head turns in the plane of the horizontal canal.

Results: There are systematic differences between healthy subjects and both groups of patients in the eye velocity response. In healthy subjects the eye velocity closely matches head velocity at all parts of the head impulse and the area VOR gain is around 1.0, however typically MD and MRV patients show an early large eye acceleration, resulting in an eye velocity time series which looks saccadic. Not surprisingly, not all MD and MRV patients showed this "early onset" eye movement pattern.

Conclusions: We suggest that this early enhanced eye velocity in vHIT is due to hydrops. Fluid dynamic modelling of the effect of hydrops on the semicircular canal response during the head impulse (Grieser et al 2014) predicted the enhanced eye velocity we found.

PP2-22 - Fn14 and NF-B underlying inflammation in peripheral blood mononuclear cells in Meniere disease

14. Meniere's Disease and Related Disorders

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Purpose: The aim of this study was to identify susceptibility loci using the Immunochip genotyping array to define a subset of patients with MD which may have an autoimmune dysfunction.

Methods: We conducted a case-control study in two phases using an immune genotyping array in a total of 420 patients with bilateral MD and 1630 controls. We also performed a gene expression assay in homozygous genotype-selected peripheral blood mononuclear cells (PBMCs). Lymphoblastoid cell lines (LCL) were generated from the selected genotypes and qPCR, Western blot and confocal image analysis were performed to validate the expression array results. A phosphorylation assay was carried out to measure the amount of total and phosphorylated NFκB.

Results: We have identified the first locus, at 6p21.33, suggesting an association with bilateral MD (meta-analysis leading signal rs4947296, OR= 2.089 (1.661-2.627); P= 1.39×10^{-09}). Gene expression profiles of homozygous genotype-selected peripheral blood mononuclear cells (PBMCs) demonstrated that this region is a trans-expression quantitative trait locus (eQTL) in PBMCs. Signaling analysis predicted several TNF-related pathways, being the TWEAK/Fn14 pathway the top candidate (P= 2.42×10^{-11}).

Conclusions: These findings suggest that the carriers of the risk genotype may develop an NF- κ B-mediated inflammatory response in PBMCs in MD.

PP2-23 - Incidence of progression Into Mnires Disease from idiopathic sudden sensorineural hearing loss

14. Meniere's Disease and Related Disorders

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Purpose: Ménière's disease is a clinical syndrome characterized by the four major symptoms of episodic vertigo, sensorineural hearing loss, tinnitus and aural fullness. Sensorineural hearing loss, especially low frequency, is the characteristic type of audiogram in Ménière's disease.

We retrospectively analyzed the incidence of low frequency idiopathic sudden sensorineural hearing loss (ISSNHL) and progression of ISSNHL into Ménière's disease.

Methods: We reviewed the medical records of 240 patients with ISSNHL from 2013 to 2015 retrospectively. The patients were 11 to 86 years old, 103 female and 137 male. These patients were divided into low, middle, high and all frequency hearing loss group according to type of pure tone audiogram. All patients received oral high dose oral corticosteroids therapy and low frequency hearing loss group was also given diuretics.

Results: In total 240 patients with ISSNHL were enrolled. 89 patients(37%) had hearing loss at low frequency, 5 patients(2%) at middle frequency, 43 patients(18%) at high frequency and 103 patients(43%) at all frequency. 14 patients(5.8%) were progressed to definite Ménière's disease. In low frequency hearing loss group, 13 patients(14.6%) were progressed to definite Ménière's disease. In all frequency group, 1 patient(0.97%) was progressed to definite Ménière's disease. The recovery rate of hearing was significantly higher in progressed group(70.3%) than in not progressed group(36.9%)

Conclusions: We should not overlook the possibility of progression to Ménière's disease through accurate

history taking and physical exam when low frequency hearing loss patients come, and we need to take appropriate evaluation and treatment accordingly.

PP2-24 - Intratympanic latanoprost for Menires - A randomized, double-blind, placebo-controlled study

14. Meniere's Disease and Related Disorders

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Purpose: To assess the effects on hearing, tinnitus and vertigo of 1 or 3 intratympanic injections of latanoprost in patients with definite Meniere's disease in a prospective, randomized, double-blind, placebo-controlled, parallel group study.

Two placebo-controlled cross-over studies in patients with long-standing Meniere have shown positive effects on hearing, tinnitus and vertigo after intratympanic latanoprost, a F2 α -prostaglandin analogue commonly used to treat glaucoma, but the low number of patients made firm conclusions difficult.

Methods: 100 patients recruited at 13 Swedish ENT-departments. Inclusion criteria: unilateral definite Meniere's disease stage II-IV; speech discrimination < 85%; > 2 vertigo attacks during the previous 3

months. Patients randomized to 1 injection latanoprost 0.005% (n=27), 1 injection placebo (n=13), 3 injections latanoprost 0.005% (n=40) or 3 injections placebo (n=20) on 3 consecutive days. Before treatment there was a run-in period of 28-42 days.

Primary endpoint: speech discrimination score in noise (SDSN) at day 14 after first injection. Secondary endpoints: total number of vertigo/drop attacks during 3 months, SDSN, pure tone audiometry, Tinnitus Handicap Inventory (THI), subjective assessment of tinnitus, hearing and vertigo by Likert scales at Days 28, 42, 56 and 84.

Results: No significant differences between placebo and latanoprost in any of the endpoints. However, trends of improved hearing following 1 intratympanic injection as pure tone audiometry (all frequencies; 250 - 8 KHz) and SDSN, and a trend of an improvement in THI-score following 3 injections.

Conclusions: In perspective of the trends of both hearing and tinnitus improvements it appears logical to increase the exposure to latanoprost in a future clinical study.

PP2-25 - Low- & high-frequency VOR disparity may differentiate Meniere disease from vestibular migraine

14. Meniere's Disease and Related Disorders

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Purpose: The study primarily aims to evaluate how a "normal" video head impulse test (vHIT) plus unilateral/bilateral "abnormal" caloric irrigation can differentiate Menière's disease (MD) from vestibular migraine (VM). Secondly, this combination was applied to differentiate MD from other vestibular disorders.

Methods: Patients with unilateral MD, bilateral MD and VM who fulfilled the current diagnostic criteria were prospectively recruited. Patients with MD were

symptomatic in the last 6 months. MD patients who had surgical or gentamicin treatment or overlapping VM/MD were excluded. Patients with various central and other peripheral vestibular disorders were recruited as comparators. All patients underwent complete diagnostic work-up, including vHIT and caloric testing. The test combination was applied to differentiate MD vs. VM, and MD vs. "others". We defined normal vHIT gain >0.7, abnormal calorics = unilateral weakness >25 deg/s and/or sum of bilateral calorics < 10 deg/s.

Results: Unilateral MD (n=72) vs. VM (n=55): sensitivity 62.5%, specificity 81.8%, PPV 81.8%, NPV 62.5%. Bilateral MD (n=30) vs. VM: sensitivity 10%, specificity 100%, PPV 100%, NPV 67%.

Unilateral MD vs. "others" (n=521): sensitivity 62.5%, specificity 79.6%, PPV 29.8%, NPV 93.9%. Bilateral MD vs. "others": sensitivity 10%, specificity 98.3%, PPV 25%, NPV 95%.

Conclusions: The discrepancy between a normal vHIT and abnormal calorics is context-sensitive and is most useful for differentiating MD from VM (high specificity and PPV). In a mixed vestibular disorders setting, the high specificity and NPV also makes it a good screening test for MD.

PP2-26 - Meniere and friends: Classification of Hydropic Ear Disease

14. Meniere's Disease and Related Disorders

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Purpose: More than 150 years after its initial description by Prosper Menière, the disease named after him is still in the centre of scientific debates. Two recent developments have specifically created a breeding ground for controversy: 1) The MRI diagnosis of endolymphatic hydrops in living patients. 2) The Bárány Society classification committee's (BSCC) diagnostic criteria in 2015 proposed a concept of Menière's Disease without endolymphatic hydrops. In order to promote the understanding of the underlying

arguments, this presentation discusses relevant classification proposals for MD, including the new classification system of Hydropic Ear Disease.

Methods: The most influential MD classifications of the last decades are reviewed, and differences are highlighted. The recent proposal by the BSCC is reviewed and critically analyzed. The role of Endolymphatic Hydrops and other objective clinical tests for the diagnosis of MD is reviewed.

Results: Since 1995, the globally accepted standard was defined by the AAOHNS criteria for MD. The recent Barany classification committee proposal lacks precision and clarity in the description of the audiometric criteria. Furthermore, it negates the central role of Endolymphatic Hydrops. The novel concept of Hydropic Ear Disease reunites the cochlear, vestibular and cochleovestibular variants of MD and the primary as well as the secondary forms.

Conclusions: With today's diagnostic possibilities - not only inner ear imaging - it is time to move from a subjective symptom based classification towards a classification including objective diagnostic tests. The concept of Hydropic Ear Disease provides a suitable framework to be used in high-tech as well as low-tech settings.

PP2-27 - Meniere's disease: combined pharmacotherapy with betahistine and the MAO B inhibitor selegiline

14. Meniere's Disease and Related Disorders

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Purpose: Since oral betahistine has a very high first-pass effect (ca. 99%), metabolized by monoamine-oxidases (MAO), the benefits of a high-dosage betahistine monotherapy were compared with those of a lower dosage of betahistine in combination with

the MAO B inhibitor (MAO-B) selegiline on the frequency of acute attacks of vertigo in patients with Menière's disease (MD).

Methods: Thirteen adults had initially been treated with a high dosage of betahistine-dihydrochloride for at least one year. Under this high dosage all of them had ≤ 1 attack for at least three months prior to the combination pharmacotherapy. Subsequently, the dosage of betahistine was reduced to about one tenth to one fifth and combined with 5 mg Selegiline.

Results: The initial dosage for the long-term "titration" of the attacks of vertigo was 216 – 1920 mg/d (mean 895.4 mg/d), after the combination it was 72 to 864 mg/d (mean 204.9 mg/d, $p < 0.001$ (paired t-test)) with the same therapeutic effect.

Conclusions: The achievement of the same clinical effect with a significantly lower (about 1/5) dosage of betahistine can be explained by the inhibition of the MAO-B by selegiline leading to higher serum concentrations of betahistine and – according to animal studies – for instance, by a dose-dependent increase of inner ear blood flow. Despite the substantial methodological limitations of such an observational study, a combined therapy could be an alternative to a very high-dosage monotherapy of MD with betahistine.

PP2-28 - P.M34T variant on GJB2 gene associated to familial deafness and Ménière's disease

14. Meniere's Disease and Related Disorders

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Purpose: The frequency of familial forms of Ménière's disease is estimated in 7-15% according to several publications. The GJB2 gene pathogenic

variant causes a cochleovestibular compromise that clinically manifests itself as hearing loss with vestibular compromise. In the family presented here affected subjects with clinical manifestations compatible with MD, fulfilling the current diagnostic criteria. We can state that this pathogenic variant is a candidate to be considered when evaluating patients with familiar Ménière's disease.

Methods: Five members of a family with a family history of MD were assessed by whole exome sequencing. Of the five subjects that were studied, 3 were affected and 2 were asymptomatic.

Results: The variants obtained in whole exome analysis of the affected subjects (I-1, II-1 y II-2), an heterozygous mutation was detected in gene *GJB2* (NM_004004.5:c.101T>C). The gene for connexin 26 (*GJB2*, MIM 121011), encodes protein CX26, which is part of a protein family that constitutes gap junctional channels and intercellular communication shown at the level of different inner ear structures (vascular stria, spiral prominence and spiral limbus of the cochlea). The main function of the CX26 channel in the inner ear structures is that of potassium ion homeostasis necessary for the hearing physiological mechanism. The *GJB2* gene pathogenic variant causes a cochleovestibular compromise that clinically manifests itself as hearing loss with vestibular compromise. In the family presented here affected subjects with clinical manifestations compatible with MD, fulfilling the current diagnostic criteria.

Conclusions: This pathogenic variant is a candidate to be considered when evaluating patients with familiar Ménière's disease.

PP2-29 - Pressure therapy of intractable Menieres disease using transtympanic membrane massage device.

14. Meniere's Disease and Related Disorders

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Purpose: The effects of the TMM device were evaluated in patients with Meniere's disease (MD) and delayed endolymphatic hydrops (DEH) according to the 1995 Japan Society for Equilibrium Research criteria.

Methods: Thirty-six ears of 30 patients were treated with the TMM device. All of the patients had failed to respond to medical treatment including diuretics prior to each pressure treatment, and were followed up for more than 24 months after treatment. The TMM device is an electrically controlled, low-pressure pulse generator that delivers pressure oscillating with a frequency of about 7 Hz. The tympanotomy is unnecessary for the TMM device. The intensity of the peak pressure can be controlled between -12cm H₂O and +12cm H₂O. The positive-negative pressure pulse are continuously delivered for 3 minutes.

Results: During the 19-24 month period after treatment, 24 of 30 patients experienced freedom from vertiginous spells; 3 patients responded with a significant decrease in frequency of definitive spells. In 3 patient, the definitive spells were unchanged by the TMM device, and then, the 2nd treatment was applied. As for the hearing outcomes in 19-24 month after treatment, 25 of 36 ears were classified into the unchanged. No complication was directly attributable to treatment by the TMM device.

Conclusions: Middle ear pressure treatment by the TMM device is an effective and minimal invasive option for intractable vertigo in the patients with the MD and DEH.

PP2-30 - Prognostic value of glycerol test of ECoChG in patients undergoing sac decompression surgery

14. Meniere's Disease and Related Disorders

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Purpose: The aim of this study is to determine whether the preoperative results of glycerol test of electrocochleography has a prognostic value on the effects of endolymphatic sac decompression surgery in patients with unilateral Meniere's disease.

Methods: A retrospective case review study was conducted of 58 unilateral Meniere's disease patients who underwent endolymphatic sac decompression surgery between 2003 and 2016. All of the patients underwent regular follow-up examinations for at least 2 years. The main outcome measures were vertigo control. The correlation between the preoperative results of glycerol test of electrocochleography and vertigo control was analyzed by Mann-Whitney-U-test.

Results: In 25 of 58 patients of positive glycerol test of electrocochleography, according to AAO-HNS committee on hearing and equilibrium reporting guidelines, the vertigo control was Class A in 8 patients, Class B in 8 patients, Class C in 4 patients, Class D in 2 patients, Class E in 1 patients, Class F in 2 patients. In 33 of 58 patients of negative glycerol test of electrocochleography, the vertigo control was Class A in 4 patients, Class B in 7 patients, Class C in 8 patients, Class D in 9 patients, Class E in 2 patients, Class F in 3 patients. There was a significant difference between the two groups in vertigo control ($P=0.026$).

Conclusions: The present findings suggest that the positive preoperative results of glycerol test of electrocochleography may indicate a better effects of endolymphatic sac decompression surgery in patients with unilateral Meniere's disease.

PP2-31 - Pure-tone follow-up study of Meniere's disease

14. Meniere's Disease and Related Disorders

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Purpose: Meniere's disease is a progressive, disabling disease of inner ear. The aim of this study was to investigate the characteristics of hearing loss associated with Meniere's disease.

Methods: forty-four patients who were diagnosed with definite unilateral Meniere's disease at our Hearing and Vestibular Clinic were recruited in this study. As part of the protocol, audiometry was performed at the first visit, 3-month, 6-month and 12-month.

Results: Affected ears of patients show reduced hearing in pure-tone tests with average threshold of 39.81 ± 19.58 dB HL. The majority of the patients (40.9%) were in Stage 3. The audiograms more frequently showed "Upward-sloping", "inverted 'V'", and "flat pattern". Thirty-eight (86.4%) patients got improvement of 17.65 ± 9.52 dB HL after treatment. The average hearing thresholds at 3-month, 6-month and 12-month after diagnosis were significantly better than that at first visit ($P < 0.01$), and were not significantly different between each other. Patients with onset-age of more than 40 years old always get more severe hearing loss than that of below 40 years old ($P < 0.01$). Whether the onset-age is younger or older, both can get same amount of hearing improvements ($P < 0.05$). But the patients with older onset-age seem likely to get hearing redeclined after 12 months ($P < 0.01$).

Conclusions: Patients with definite Meniere's disease always have moderate to severe sensorineural hearing loss before diagnosis. Most patients improved after treatment. Compared with the patients with younger onset-age, patients with older onset-age appear to have more severe hearing loss, but can get same-level hearing improvement after treatment, and tend to get hearing redeclined after 12 months.

PP2-32 - Revision surgery after triple semicircular canal plugging

14. Meniere's Disease and Related Disorders

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Purpose: To investigate the causes of vertigo relapse after triple semicircular canal plugging (TSCP) in patients with intractable Meniere's disease (MD) and to explore the possible mechanism of post-TSCP vertigo in patients with MD

Methods: Eight patients with intractable unilateral definite MD who initially underwent TSCP and later experienced episodic vertigo recurrence, were enrolled. All eight patients underwent revision surgery, including four who underwent labyrinthectomy and four who underwent repeat TSCP. Audiological and vestibular functions were evaluated by pure tone test, caloric test, cervical vestibular evoked myogenic potential (cVEMP) and video-head impulse test (v-HIT). Morphological changes in the membranous labyrinth were assessed by magnetic resonance labyrinthography. Canal plugging materials and vestibular end organs (ampulla, saccule and utricle) were obtained from patients who underwent labyrinthectomy. Mineralization and other histological characteristics of canal plugging material were assessed by von Kossa staining.

Results: Incomplete occlusion and/or ossification was observed in the semicircular canals (SCs) of all eight patients, with the superior SC affected in five patients, the horizontal SC in one and all three SCs in two. The results of v-HIT, which reflected the respective function of the three SCs, were in accordance with intraoperative findings. Magnetic resonance labyrinthography showed semicircular canal defects in all eight patients. Few mineralized nodules and multiple cavities were present in the von Kossa-stained canal plugging materials.

Conclusions: Incomplete occlusion or ossification of SCs was the primary cause of vertigo recurrence following TSCP. v-HIT was useful, whereas magnetic resonance labyrinthography was limited, in determining the responsible SCs.

PP2-33 - The Detection of Endolymph Hydrops in the Patients using a Multifrequency Tympanometry

14. Meniere's Disease and Related Disorders

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Purpose: Multifrequency tympanometry (MFT) is able to detect the change in the pressure of inner ear. The aim of this study was to compare the detection rate of the endolymph hydrops in the patients with Meniere's disease (MD) and other diseases on G width (the width of bimodal peaks for the waveform obtained in measuring a conductance at 2000Hz) using MFT.

Methods: We have recruited 136 patients who complained vertigo or dizziness and were referred to our department. MFT measured G width at a resonance frequency of 2000Hz in all subjects. This work was approved by an ethics committee at Chidoribashi General Hospital.

Results: When the cutoff value was set at 200daPa, G width in the affected ears with MD and acute low-tone sensorineural hearing loss was significantly more elevated than that in the affected ears with benign paroxysmal positional vertigo and idiopathic sudden sensorineural hearing loss. Interestingly, no subjects had the elevated G width in the patients with such orthostatic dysfunction or functional hearing loss as non-inner ear diseases.

Conclusions: MFT is a noninvasive and easy device. These results suggest that MFT may be a useful tool to find out the endolymph hydrops of inner ear and to diagnose the patients exactly.

PP2-34 - The Effect of Intratympanic Dexamethasone for Sudden Sensorineural Hearing Loss

14. Meniere's Disease and Related Disorders

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Purpose: The more and more otolaryngologists are pay close attention to the intratympanic injection for patient of the sudden sensorineural hearing loss, because the intratympanic injection can avoid blood-labyrinth barrier and have high drug concentration in the membrane labyrinth. the patient's hearing recovering with the sudden sensorineural hearing loss by treatment of intratympanic Dexamethasone injection were observed in this paper.

Methods: Two groups were observed from Jan,2016 to Dec,2017.Observed group were 90 patients with the sudden sensorineural hearing loss by treatment of intratympanic Dexamethasone injection besides conventional therapy, Control groups were 120 patients with the sudden sensorineural hearing loss by treatment of conventional therapy no intratympanic Dexamethasone injection.

Results: Our research showed that hearing level recovering by intratympanic Dexamethasone injection were elevated than conventional therapy.

Conclusions: intratympanic Dexamethasone injection in early phase will be better method for patients of the sudden sensorineural hearing loss.

PP2-35 - The effect of transtympanic ventilation tube insertion in people with intractable

14. Meniere's Disease and Related Disorders

Tessei Kuruma¹

¹ Department of otorhinolaryngology, Aichi Medical University, Japan

Purpose: Transtympanic ventilation tube as a treatment option for Meniere's disease has been reported but its results have been controversial. As a treatment for patients with intractable Meniere's

disease, insertion of a ventilation tube in tympanic membrane was carried out, and the effect of the therapy was analysed.

Methods: Fourteen patients (nine males and six females, age ranged 15-79years) with active Meniere's disease were placed with ventilating tubes in the affected ear and postoperative change in symptoms, i.e, incapacitating vertigo and hearing loss were investigated. The efficacy of treatment in vertigo attacks and hearing loss of this disease was evaluated according to AAO-HNS (1985) criteria.

Results: At 42 months of treatment, one of eight patients showed complete control of vertigo, and six did substantial and four insignificant control. On the other hand, patient's hearing level was no affected by the treatment.

Conclusions: This treatment might represent a short term effect for the reduction of persistent vertigo in some patients with Meniere's disease and so it might be an additional treatment option because of its simple and less-invasive procedure.

PP2-36 - The effect of transtympanic ventilation tube insertion in people with intractable Meniere's disease

14. Meniere's Disease and Related Disorders

Tessei Kuruma¹

¹ Department of otorhinolaryngology, Aichi Medical University, Japan

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Conclusions: This treatment might represent a short term effect for the reduction of persistent vertigo in some patients with Meniere's disease and so it might be an additional treatment option because of its simple and less-invasive procedure.

PP2-37 - The importance of temporal 3T MRI in the diagnostics of menieres disease in Lithuania

14. Meniere's Disease and Related Disorders

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Purpose: Determine, whether the temporal 3T MRI could be a new objective criteria for Meniere's disease diagnostics.

Methods: Prospective study was carried out at the VUH SK ENT center: the importance of temporal 3T MRI in the diagnostics of Meniere's disease (MD) in Lithuania. The study included 81 patients with MD, diagnosed based on clinical criteria. Patients were divided into two groups, according to Subjective Diagnostic Criteria for MD formed by AAO-HNS and improved by Barany International Otoneurological Society. Patients were evaluated for endolymphatic hydrops using temporal 3T MRI with gadolinium contrast. Peripheral vestibular system and auditory examinations were also performed for all patients.

Results: Based on clinical criteria we diagnosed 81 patients with MD (probable MD -31 patients (38.3%, N = 81), and definite MD -50 patients (61.7%, N = 81)). Signs of endolymphatic hydrops were observed with MRI in 59 patients (72.8%, N = 81). Endolymphatic hydrops were detected in 45 (90%, N = 50)

patients with definite MD and 14 patients (45.16%, N = 31) with probable MD. Changes in MRI (endolymphatic hydrops and the intensity of contrast accumulation) were observed in all 50 patients (100%, N = 50) with definite MD and 18 (58.06%, N = 31) with probable MD. Our methodology for MRI is clinically relevant to confirm the definite diagnosis of MD (P = 0.000019).

Conclusions: Therefore, the temporal 3T MRI could be one of the objective diagnostic criteria for MD.

PP2-38 - Treatment for intractable delayed endolymphatic hydropstriple semicircular canal plugging

14. Meniere's Disease and Related Disorders

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Purpose: Here, we explored the effectiveness of triple semicircular canal plugging for patients with intractable delayed endolymphatic hydrops

Methods: Five patients (1 females and 4 males, age 55 ± 4.95 years) with intractable ipsilateral delayed endolymphatic hydrops (DEH) were accepted treatment in our department from 2013 to 2017. Patients have taken the treatments of medication and Intra-tympanic injection for 9 months and showed no improvement on the attack of vertigo. All the patients were finally accepted surgery of triple semicircular canal plugging. After the surgery, the patients took audio-vestibular examinations and Imaging examinations during the 36 months follow up period.

Results: All the five patients were cured of their vertigo attacks after the surgery, and no postoperative recidivation was reported. Four patients showed residual hearing after the surgery. Hearing loss remain unchanged in 3 patients. One patient showed no response of operated ear in pure tone audiometry test. According to the results of caloric test, the degree of vestibular function deficit was enlarged in 5 patients. One patient was absent of reproducible waves in C-Vemp test after the surgery. The 5 patients complained about locomotion instability after the surgery, and improved their equilibrium

ability through the 3 months vestibular rehabilitation treatment.

Conclusions: To reduce the symptom of vertigo, triple semicircular canal plugging is an effective surgical treatment for intractable delayed endolymphatic hydrops.

PP2-39 - Unilateral Menieres disease with downbeat nystagmus in 2 cases

14. Meniere's Disease and Related Disorders

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Purpose: The present study presented with 2 cases with Meniere's disease who exhibited spontaneous nystagmus with downbeat component and the possible mechanism was analyzed.

Methods: The spontaneous nystagmus and provoked nystagmus by positioning tests in 2 patients with definite Meniere's disease was retrospectively analyzed. The nystagmus induced by single or combined 2 or 3 semicircular canals' excitation or inhibition was used to analyze the above nystagmus.

Results: 2 patients showed spontaneous downbeat nystagmus, which can be exaggerated by Dix-Hallpike maneuver. The vector sum of all unilateral semicircular canal excitation induced nystagmus can explain the downbeat nystagmus.

Conclusions: Downbeat nystagmus can be seen in Meniere's disease.

PP2-40 - Vertical nystagmus during attacks of menieres disease or delayed endolymphatic hydrops.

14. Meniere's Disease and Related Disorders

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Purpose: Spontaneous nystagmus during vertigo attacks of Meniere's disease or delayed endolymphatic hydrops has essentially been described as horizontal

or horizonto-torsional beating either on the side or on the other side of the hearing loss. Our objective was to show videos of vertical nystagmus during vertigo attacks.

Methods: Patients suffered either from Meniere's disease (2 patients) or delayed endolymphatic hydrops (1 patient) and presented with an essentially vertical nystagmus (on videonystagmoscopy examination) during a vertigo attack.

Results: One patient with Meniere's disease had an essentially down beating nystagmus. Another patient with Meniere's disease had a fall (Tumarkin crisis) that occurred in the waiting room. Videonystagmoscopy, just after the fall, revealed a downbeating nystagmus with a slight rotatory component. During the crisis, the nystagmus later changed into a right horizontal nystagmus. The last patient had a history of delayed endolymphatic hydrops and an initial vertical upbeating nystagmus with a slight torsional component that later changed into a horizonto-torsional nystagmus.

Conclusions: The direction of the nystagmus during a vertigo attack can be essentially vertical which, to our knowledge, has never been reported in Meniere's disease or DEH. This nystagmus might reflect an inhibition or excitation of the superior semicircular canal (on the side of the hearing loss) suggesting that the hydrops started in this canal. The nystagmus can be variable during avertigo attack and may later changed into a more typical horizontal or horizonto-torsional nystagmus.

PP2-41 - Vertigo and istamine: atopic reactions and histamin intolerance (HIT)

14. Meniere's Disease and Related Disorders

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Purpose: The potential etiopathogenetic link between intestinal hyper-permeability, psychogenic stress, histamine intolerance, migraine and pathology of the inner ear may represent a new line of investigation to explain the onset of a chronic and disabling pathology such as Meniere's Disease

Methods: A clinical experience was conducted on a population of 65 patients (60 F, 5 M, age 15-50 years) with suspected histamine intolerance (HIT) associated with vertigo and/or fullness, postural disorders, sprain and / or diploacusia and hearing loss at low frequencies. Clinical tests have been conducted on the whole population, in particular Puretone Audiometry, ECochG by TM-Wick Electrode, C-Vemps, O-Vemps, VHIT (HIMP and SHIMP)

Results: Most of these patients presented altered Ecogh suggesting hydrops, pathological vHIT results in HIMP and SHIMP, of the lateral channel and some with altered OVEMP results, in the fluctuation phase, as well as altered cVEMPs. In the observed migraine patients, VHIT presented mono or bilateral over-gains, mono or bicanalar of the vertical and/or lateral channels, but over-gain was also found in subjects with Meniere during the fluctuation phase. All patients improved with rigid dietary patterns, characterized by reduced intake of histamine and with non-irritating foods for the intestinal mucosa, and an adequate control of body weight

Conclusions: Food education in menieric and migraine patient represents a heterodox approach useful to reduce food intolerances that through histamine-like, histaminergic reactions, IGE-mediated or not, due to histamine intolerance, promote systemic conditions of histamine increase (HIT) with mastocytosis and eosinophilia able to alter intestinal, cerebral and internal ear homeostasis, inducing migraine and vertigo

PP2-42 - Vestibular findings in patients with persistent apogeotropic nystagmus

14. Meniere's Disease and Related Disorders

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Purpose: We have analyzed the characteristics of the non-paroxysmal nystagmus in patients with a heavy cupula in the lateral semicircular canal, irresistible to repositioning procedure. Two nystagmus patterns indicating the affected side has been reported; a) directional preponderance of the apogeotropic

nystagmus towards the unaffected ear and b) nystagmus directed to the affected side in supination (ampullopetal cupula deviation).

Methods: The study comprised 26 patients (mean age 63 years) free from symptoms of CNS disorders. Patients were submitted to different tests at onset and at follow up (FU) without akut vestibular symptoms (20 patients). The nystagmus direction and slow phase velocity (SPV) with head in supine and prone position was studied. Connected to examinations the patients were submitted to caloric test and c-VEMP.

Results: Among 16 (62%) patients with caloric weakness, there was no significant correlation between side with caloric weakness and the direction of nystagmus in supine position. The median SPV for left beating nystagmus was 6°/s and for right beating nystagmus 5,5°/s. Nystagmus side difference exceeded 10°/s in four patients. At follow up thirteen of 20 (65%) patients demonstrated apogeotropic nystagmus with low value in SPV.

Conclusions: The affected side is difficult to judge, there is no consistent pattern between nystagmus in supine position and the directional preponderance of the apogeotropic nystagmus. There is no correlation between the direction of nystagmus in supine position and unilateral caloric weakness.

PP2-43 - A Case of Pendular Nystagmus: Delayed onset congenital nystagmus or acquired form by head trauma

15. Ocular Motility: Physiology and Pathology

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Purpose: Pendular nystagmus (PN) is characterized by quasi-sinusoidal oscillations of the eyes disrupting visual acuity and causing oscillopsia. PN can be classified into congenital and acquired form.

Methods: A 33-year-old man presented with binocular horizontal PN, dizziness and oscillopsia. These symptoms have been felt by the patient since the age of 20.

Results: In past medical history, the patient had no specific medical or surgical history, and the patient's head was shocked by the traffic accident a few months before he felt the symptoms. The nystagmus was unaffected by convergence, vibration, head shaking, hyperventilation, or changes in body position. Brain MRI showed normal findings. Despite various drug treatments including memantine, there were no changes in patient symptoms and nystagmus. The congenital nystagmus (CN) occasionally presents during adult life, when it may create a diagnostic problem, especially if the patient has other symptoms such as headache or dizziness. Acquired PN may affect one or both eyes, and can occur in any axis or combination of axes. Although acquired PN may be idiopathic, the most common cause of secondary acquired PN is disorders of central myelin, namely multiple sclerosis (MS). Unfortunately, no abnormal findings were found in this patient, including various gene, blood and imaging studies. In addition, No PN has been reported after head trauma such as concussion.

Conclusions: Therefore, the author report a rare case of medication unresponsive PN and suggest that more research is needed.

PP2-44 - An Algorithm as a Diagnostic Tool for Central Ocular Motor Disorders

15. Ocular Motility: Physiology and Pathology

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Purpose: To create an algorithm which can assist physicians as a “digital expert” with the diagnosis of central ocular motor disorders, in particular due to lesions and the brainstem and cerebellum, which are often associated with vertigo or dizziness.

Methods: The algorithm's input consists of a maximum of 60 neurological and oculomotor symptoms. The output is a list of the most probable diagnoses out of 14 alternatives and the most likely topographical

anatomical localizations out of 8 alternatives. Positive points are given for disease-associated symptoms and negative points for symptoms that are unlikely to be found in a specific disease. The algorithm was evaluated using the two diagnoses and two brain zones with the highest scores. A dataset of 102 patients (56 males, age 48.0 ±22yrs) was used as the basis for developing the algorithm in an iterative way. In a second step, the algorithm was validated with a dataset of 104 patients (59 males, age 46.0 ±23yrs).

Results: For 12/14 diseases the algorithm showed a sensitivity between 80 and 100% and the specificity of 9/14 diseases was between 82 and 95%. In terms of a topographic anatomical diagnosis, the sensitivity was between 77 and 100 % for 4/8 brain zones, and the specificity of 5/8 zones ranged between 79 and 99%.

Conclusions: This algorithm using our knowledge on the functional anatomy of the central ocular system and possible underlying diseases is a useful tool, in particular for the diseases affecting the brainstem or cerebellum which are otherwise often overlooked.

PP2-45 - Living in the dark: self-induced visual deprivation leading to pendular nystagmus.

15. Ocular Motility: Physiology and Pathology

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Purpose: To describe the case of a patient with a background history of chronic migraine, who developed continuous nystagmus following prolonged visual deprivation, resolving following light re-exposure.

Methods: A 64-year-old right-handed artist with chronic migraine associated with marked photophobia and phonophobia, refractory to multiple preven-

tative medications, neuromodulators (including the Gammacore, Cefaly and TMS), acupuncture, greater occipital nerve blocks and multiple cranial nerve blocks. More recently her headaches have been partially controlled with intravenous Magnesium Sulphate and Botox injections. In view of the marked photophobia she has confined herself to the dark for the last 4 years, achieved by living in a blacked-out house with the only illumination being from a small camping light set to a nocturnal mode, and using a set of two eye occluders when leaving the house. She presented with progressive torsional and horizontal oscillopsia when viewing in low-level lighting conditions. She was found to have rotational nystagmus in the primary position and on lateral gaze, with otherwise normal pursuit, saccades, and OKN.

Results: We report detailed audiovestibular investigations and functional brain MRI, including arterial spin labelling and NODDI. We show functional visual pathway deafferentation and propose that this developed secondary to self-induced visual deprivation. We report imaging changes following gradual light re-sensitisation, correlating with clinical outcome.

Conclusions: We discuss possible underlying mechanisms to explain the development of nystagmus following self-imposed visual deprivation. We consider inferior olive deafferentation secondary to visual deprivation, affection of brainstem neural integrators, unmasking of a congenital nystagmus, and a light-dependent feedback loop.

PP2-46 - Long-term course of progression of clinical ocular motor signs in progressive supranuclear palsy

15. Ocular Motility: Physiology and Pathology

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Purpose: To investigate the natural course of progression of ocular motor signs in patients with progressive supranuclear palsy (PSP).

Methods: 114 patients with a possible or probable PSP following NINDS-SPSP criteria were included in this retrospective study. All patients underwent structured neuro-ophthalmological testing at initial diagnostic evaluation, 35 patients several times during their course of disease. The following ocular motor signs were analysed: Saccadic slowing/paresis in vertical/horizontal direction, up-/downward/horizontal ocular motility, square wave jerks, VOR-function. Ocular motor signs were investigated in relation to disease duration.

Results: In the whole group of PSP patients saccadic abnormalities showed the following distribution over time: at 1y of disease duration 10% showed only saccadic slowing on upgaze, 40% on up- and downgaze, 21% saccadic paresis on upgaze and 29% complete vertical saccade paresis; at 2y the proportion of vertical saccade paresis was 32%, at 3y 65% and at 4y 82%. Progression of horizontal saccade paresis was slower (1y: 6%, 2y: 9%, 3y: 21%, 4y: 41%). The subgroup of patients with longitudinal follow-up showed a similar tendency. Ocular motility in this group decreased by a mean of 1.5mm/y on upgaze, 1.6mm/y on downgaze and 1.4mm/y on horizontal gaze. The degree of motility loss on up-/downgaze over time showed a good correlation ($R^2=0.71$).

Conclusions: Ocular motor examination can be used as a robust marker of disease progression. Variability between patients however is considerable. Prospective clinical and apparatusive quantification of ocular motor markers in well-characterized cohorts of PSP patients is needed.

PP2-47 - Rebound nystagmus, a window to the oculomotor integrator

15. Ocular Motility: Physiology and Pathology

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Purpose: Accurate and stable gaze holding is achieved by the oculomotor integrator, a complex network within the brainstem and cerebellum. Adaptation of this network can result in rebound nystagmus when looking straight ahead after holding eccentric gaze. Rebound nystagmus, typical in cerebellar dysfunction, also occurs in healthy individuals. Here we studied whether rebound nystagmus was influenced by fixation at the eccentric position or by the eye movement used to move eccentrically.

Methods: We recorded eye movements of 6 healthy subjects in darkness looking at a red target, which was on continuously or flashed 10ms every 500ms. In experiment 1, subjects fixated a continuous or flashing target at $\pm 40^\circ$ for 30s, then a central flashing target for 15s. In experiment 2 a continuous eccentric target was reached with smooth pursuit, single saccade, or ten small saccades.

Results: We found more pronounced rebound nystagmus after continuous than flashing peripheral target and no change regardless of how the eyes moved eccentrically. The intensity of nystagmus decreased between first and fifth trial. In some subjects, was asymmetric depending on the direction of gaze holding and could reverse direction during central fixation.

Conclusions: Rebound nystagmus offers an opportunity to study the adaptive mechanisms of the gaze holding networks. Because the continuous target generated a more robust rebound nystagmus, we hypothesize that a retinal slip (i.e., velocity) signal is at least partially responsible for rebound nystagmus. Future experiments and modeling studies will determine the relative contribution of velocity vs. position signals.

PP2-48 - Vertical Component of Horizontal Nystagmus due to Impairment of Vertical Semicircular Canals

15. Ocular Motility: Physiology and Pathology

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Purpose: The purpose of the study was to evaluate a vertical or torsional component of horizontal spontaneous nystagmus in acute vestibular lesions according to damage in vertical semicircular canals.

Methods: Retrospective study, 32 patients involved (28 peripheral, 4 central), inclusion criteria - presence of spontaneous nystagmus (SPN). VOG (Vid-eooculography) measures the slow phase velocity (aSVP), the number of beats. VHIT (Video Head Impulse Test) measures the gain of vestibuloocular reflex, under 0.70 in vertical canals is pathological (also corrective saccades).

Results: The direction of the nystagmus corresponded with the VHIT results. The damage of the lateral canal provokes the main – horizontal – direction of the nystagmus. The damage in vertical canals provokes the measured vertical component. The vertical portion is also determined with a slow phase and fast phase. A lesion of anterior SCC provokes the up-beating component, and a lesion of posterior SCC provokes the down-beating component. The vertical component of the horizontal nystagmus is common in peripheral vestibular lesions (PVS) as well as in some cases of central vestibular lesions (CVS). The main direction of the nystagmus of peripheral origin was horizontal with an up-beating portion due to the most frequent diagnosis of superior vestibular neuronitis. The PVS or CVS that affect all 3 canals, had often rather a torsional than vertical component, or changing up/down component, or only horizontal direction.

Conclusions: In vestibular lesions, the vertical component of the horizontal nystagmus is a common condition. This up- or down-beat component correlates with the damage of the anterior or posterior canal function.

PP2-49 - Two case reports of perilymphatic fistula after nose blowing with review of possible mechanisms

16. Perilymphatic Fistula

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Purpose: We report two cases of perilymphatic fistula after nose blowing without trauma. In both cases, the symptom of the patients resolved spontaneously after conservative treatment. We report the cases with review of possible mechanisms of perilymphatic fistula

Methods: A 15-year-old female presented with dizziness after excessive nose blowing. It had been 2 days before visiting to clinic. Associated symptoms were nausea, tinnitus and fullness on the left ear. The physical examination including otoscopic exam and vestibular function test found to be normal. Pure tone audiometry showed 22dB of bone, 14dB of air conduction on the left ear. The high resolution temporal bone CT scan was done which documented multiple air densities in left vestibule. A 46-year-old female visited with hearing impairment with tinnitus on left ear after same event of the first patient which started 4 days before. There was no pathologic finding on physical examination. The result of pure tone audiometry was left sid air conduction of 31dB, bone conduction of 29dB. High resolution temporal bone CT scan noted to be normal.

Results: The clinical result of hearing loss and CT scan was highly suggested of perilymphatic fistula. Both patients were given high dose steroid and broad spectrum antibiotics. Gradual improvement of hearing symptom was seen. The result of pure tone audiometry each 8, 10 days after admission was improved.

Conclusions: Based on two different cases, perilymphatic fistula which occurred by excessive pressure change in inner ear can be treated by conservative treatment.

PP2-50 - A prospective study of Cochlin-tomoprotein detection test in sudden sensorineural hearing loss cases

16. Perilymphatic Fistula

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Purpose: Sudden sensorineural hearing loss (SSNHL) occurs as an unexplained, rapid loss of hearing and concomitant vestibular symptoms. In general, 20~50% of SSNHL has vestibular symptoms. Various theories have been proposed for the cause of the disease including viral infection, vascular insufficiency, and perilymphatic fistula (PLF). PLF has been a controversial disease entity but recent proteomic and molecular analysis identified a novel diagnostic marker CTP (Cochlin-tomoprotein) to detect perilymph leakage. CTP detection test from middle ear lavage (MEL) is available in 170 hospitals throughout Japan and it dramatically changed the current status of the diagnosis of PLF (Matsuda H, Acta Otolaryngol 2017). The purpose of this prospective study is to elucidate the prevalence of PLF in SSNHL patients and to characterize the clinical characteristics of those cases.

Methods: According to the inclusion/exclusion criteria, 104 SSSL cases were enrolled and 74 cases were subjected for analysis. For CTP testing, we performed myringotomy by a CO₂ laser, the middle ear was rinsed with 0.3ml saline, middle ear lavage (MEL) was collected. Polyclonal antibody ELISA (hCTP ELISA) was performed (Ikezono T, PLoS one 2018).

Results: CTP was positive in 16 out of 74 cases (22%). The incidence of CTP positive case was higher in the elderly and a significant correlation between age and CTP values was recognized. Patients with CTP positive cases had higher tendency to complain of vestibular problems (63%) than those with CTP negative cases (48%).

Conclusions: Our study delineated that PLF can be one of the main causes of SSNHL especially in the elderly.

PP2-51 - Proposal of the diagnostic criteria for barotraumatic perilymph fistula (PLF)

16. Perilymphatic Fistula

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Purpose: The aim of this study was to propose the diagnostic criteria for PLF based on clinical manifestations.

Methods: Forty-four patients (46 ears) who underwent surgical repair by the clinical suspicion of barotraumatic PLF were enrolled. The clinical symptoms and hearing improvement were analyzed according to the surgical findings.

Results: Eighteen of the patients (definite PLF) was confirmed by the evidence of perilymph leak through the oval and round window via surgery. For the other twenty-one patients (probable PLF), even though there was no evidence of perilymph leak, their clinical manifestations were similar to definite PLF. In addition, the cases that were satisfied at least two of 3 criteria (hearing loss, dizziness and preceding barotraumatic history) in probable PLF was identified in 5 patients (possible PLF). After surgical repair of PLF, the hearing was improved in 28 out of 44 patients when hearing improvement defined as postoperative 4-frequency pure tone average (0.5, 1k, 2k, and 4kHz) of bone conduction ≤ 25 dB or hearing gain ≥ 15 dB. Hearing improvement was also identified in 4 of the possible PLF patients after early surgical exploration. The period of operation after symptom onset was significantly ($p < 0.05$) shorter in the hearing improvement group (mean 6.7 days; range 1-17 days) than that in the no improvement group (mean 108 days; range 1-671 days).

Conclusions: We proposed the diagnostic criteria of barotraumatic PLF as definite, probable, and possible PLF. Once the barotraumatic PLF was suspected, hearing and dizziness were improved by early surgical repair.

PP2-52 - Oxidative stress in leukoaraiosis dizziness patients, effect of a polyphenol supplementation

17. Pharmacotherapy

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Purpose: Leukoaraiosis (LA) is a common radiological finding in elderly, frequently associated with several clinical disorders, including unexplained dizziness. Aim of this study was to analyse some oxidative stress biomarkers in patients with LA and unexplained dizziness, and to perform an open study to evaluate if 60-day supplementation with a polyphenol compound may modify these biomarkers and influence quality of life.

Methods: a cohort of 33 patients were enrolled in the study and studied basally and after 60-day polyphenol compound supplementation. The main outcome measure were: oxidative stress markers (advanced oxidation proteins products, AOPP, ferric reducing antioxidant power, FRAP), and Thiols and the Dizziness Handicap Inventory (DHI) scale.

Results: At baseline, blood oxidative stress parameters values were outside normal ranges. After the two months supplementation, we observed a significant decrement of AOPP values and a significant improvement of DHI.

Oxidative stress load was not influenced by age, gender, hypertension, diabetes, smoking or dyslipidemia. No relation was found between chronic ischemic burden evaluated at CT or MRI scans and oxidative stress biomarkers.

Conclusions: patients with LA and dizziness have an impaired oxidative stress balance. Oxidative stress biomarkers may be useful to detect redox imbalance in LA and to provide non-invasive tools to monitor disease status and response to therapy. The supplementation with polyphenol compound reduces oxidative stress load in patients with a pre-existing imbalance, and seems to improve dizziness symptoms. Oxidative stress biomarkers may be useful to detect redox imbalance in LK and to provide

non-invasive tools to monitor disease status and response to therapy.

PP2-53 - Acute topographical disorientation due to right-sided hippocampal haemorrhage

18. Spatial Orientation

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Purpose: Acute presentations of topographical disorientation are rare and mostly caused by focal lesions in the cerebral navigation network. Deficits are predominantly in landmark recognition and path planning (egocentric navigation deficit), or a disturbance of the spatial cognitive map (allocentric navigation deficit). Here we report the spatial orientation performance in a 55-year old patient with isolated topographic disorientation as the single symptom of right-sided hippocampal haemorrhage, and the follow-up performance 4 months later.

Methods: Utilising a gaze-monitoring head camera, we analysed the path-finding strategy and visual exploration behaviour in a real-space environment navigation paradigm. The patient was shown the location of five target items, and subsequently had to relocate items in a pseudo-randomised order. Parameter analyses included saccades and fixations, error rates in item location, time spent at crossroads, trajectory, and were compared with a healthy cohort (N=10). The experiment was repeated four months later, upon recovery. MRI was obtained upon admission and four months later.

Results: The patient had severe allocentric and egocentric navigation deficits on admission, as indicated by higher error rates, extensive use of search saccades, and fixations to landmarks. These deficits recovered after 4 months, when the patient performed above-average in the real-space navigation task.

Conclusions: This case report underlines the integral function and right-sided dominance of the hip-

poampal formation in spatial orientation, where a strategic lesion causes a profound navigational deficit. We show that navigation, specifically allocentric navigation, can be fully restored despite a residual hippocampal lesion, illustrating the neural plasticity of the cerebral navigation network.

PP2-54 - Astronauts Gaze Behavior during Visual Target Acquisition during and after Space Shuttle Flights

18. Spatial Orientation

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Purpose: We aimed to explore how exposure to weightlessness changed gaze behavior and eye-head coordination during the acquisition of visual targets during and after orbital space flight.

Methods: Using a forced time optimal strategy thirty-four astronauts were required to acquire as quickly as possible targets with angular offsets of ± 20 , ± 30 and $\pm 49^\circ$ in the horizontal plane. Eye movements were measured with electro-oculography. Head movements were measured with a triaxial rate sensor system mounted on a headband.

Results: Measurements of eye, head and gaze movement duration, amplitude, velocity and acceleration during visual target acquisition in weightlessness indicated changes in eye-head coordination strategies that varied across target distances. Changes also varied as a function of flight days.

Conclusions: The changes in eye-head coordination in flight are presumably the result of a combination of several factors. These factors could include the change from allocentric to egocentric reference for spatial orientation in absence of a gravitational reference, the generation of slower head movements to prevent space motion sickness, and a decrease in smooth pursuit and vestibulo-ocular reflex perfor-

mance. These results are in agreement with the hypothesis that humans have several strategies for gaze behavior, between which they are able to switch depending on the environmental conditions.

PP2-55 - Body-based spatial reasoning selectively disrupted by vertigo after a decelerating velocity step

18. Spatial Orientation

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Purpose: Spatial reasoning has been found to be the cognitive faculty most impaired by misperceptions of self-motion. The objective of this study was to determine whether vertigo, elicited by a standard velocity step in a motorised rotating chair, selectively impacts different spatial reasoning processes.

Methods: Seventy-eight healthy participants undertook the ‘Single Figure Stimuli’ (SFS) task, invoking body-based mental rotations, the ‘Dual Figure Stimuli’ (DFS) task, invoking object-based mental rotations, or the ‘Single Object Stimuli’ (SOS) task, requiring non-rotational, rule-based responses. The SFS and SOS tasks had equivalent difficulty. All spatial reasoning tasks were administered six times, in one-minute trial blocks, after one minute of constant angular velocity (90°/s). Halfway through alternating trial blocks, chair velocity reduced from 90 to 0°/s in 4.5 seconds. Participants wore wireless heart rate monitors throughout.

Results: Performance on the DFS and SOS tasks was not affected by the velocity step. In contrast, error rate on the SFS task was significantly greater during the 30 seconds after impulse deceleration (5.4%) than after zero deceleration (3.4%), $p = .028$. There was no effect of the velocity step on Heart Rate Variability (HRV), hence on autonomic balance, in any of the task groups.

Conclusions: The confined disruption of performance on the SFS task following the velocity step indicates a selective vulnerability of body-based spatial reasoning to vertigo induced by incongruous vestibular stimulation. Moreover, the absence of au-

tonomic changes following the velocity step suggests there is a direct coupling between self-motion perception and simulated body-based action.

PP2-56 - Changes in Heart Rate Variability due to Continuous Stimulation in the Head with a mini-Vibrator

18. Spatial Orientation

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Purpose: No vestibular exercise or Vestibular implant has been tried for afferent signal restoration of the otolithic organ. This is because the quantitative input stimulation of the otolithic organ and the measurement of the effector are incomplete. Hypergravity, based on previous experiments to induce degeneration of otoconia itself, was intended to investigate whether sustained otolithic organ vibration stimulation could prevent such hypergravity changes.

Methods: Subjects were divided two groups, as normal and experimental group. All animal were fixed the miniature vibrator to the head under general anesthesia. Experimental group included an ICR mouse that lived for 7 days under 4G hypergravity environment. We then recorded the ECG to measure heart rate variability as control of an otolithic autonomic reflex.

Results: Compared to control group, the Heart rate of the experimental group was significantly decreased ($p < 0.01$), and the change of the heart rate before and after vibration stimulation was 4.3 ± 0.232 , which was significantly higher than the 2.5 ± 0.232 of the control group.

Conclusions: Although the action mechanism of stimulation has not been elucidated, vibration as an input signal modulator, it can not be denied that the otolithic organ will be affected. The vibration

stimulation increased the heart rate in mice with reduced otolithic function, confirming the possibility of a functional modulator of the otolithic organ.

PP2-57 - Comparison of Haptic and Visual Perception of Upright and the Effect of Handedness

18. Spatial Orientation

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Purpose: Perception of upright depends on multi-sensory integration including vestibular, visual and proprioceptive inputs. Here we studied systematic biases in upright perception measured by visual and haptic modalities. We also investigated the role of laterality in cerebral function on measurements of upright perception in each modality.

Methods: Subjects performed three tasks comparing a visual line with perceived upright (visual-vertical), a haptic bar with perceived upright (haptic-vertical), and a visual line with a haptic bar (visual-haptic). All tasks were repeated in three head tilt positions: upright and 20° tilted to the right and left. The haptic task was repeated using the left and right hands.

Results: Regardless of the task, upright perception was biased by the head tilt position. In the haptic task, there was an independent bias by the hand used to touch the haptic stimulus. We dissociated the effects of hand and spatial location of the haptic stimulus by repeating the task with the haptic bar at the midline. The results showed that the hand bias was indeed from the effect of the hand itself rather than the spatial location of the haptic bar. Both head and hand also had similar effects when the task did not involve vertical measurement (i.e., the visual-haptic task). Finally, there was no difference in the hand and head biases between left-handed and right-handed subjects in either visual or haptic tasks.

Conclusions: Our findings show that systematic biases in visual and haptic vertical measurements can be dissociated, suggesting a common mechanism for perception of upright.

PP2-58 - Cortical integration of vestibular and visual inputs during forward self-motion

18. Spatial Orientation

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Purpose: It is crucial to characterize the cortical networks that integrate vestibular and visual signals, the main sensory inputs during navigation. In a previous work, we used Galvanic Vestibular Stimulation (GVS) and functional Magnetic Resonance Imaging (fMRI) to show that visual areas V6 and the ventral intraparietal (VIP) area are activated by locomotion-consistent, anteroposterior vestibular inputs. Here we combined binaural monopolar GVS with optic flow visual stimuli that were either consistent with forward (expanding flow) or backward (contracting flow) self-motion.

Methods: Our GVS had an amplitude of 1.5mA, lasted 2s, for the 2 polarities, either forward or backward. We recorded the BOLD responses to different congruent and incongruent combinations of these visuovestibular stimuli in 5 human subjects. We focused our analyses on responses within functionally-defined areas that are strongly activated by egomotion-consistent optic flow patterns: the human middle temporal complex (hMT+), V6, the ventral intraparietal (VIP) area, the cingulate sulcus visual (CSv) area and the posterior insular cortex (PIC).

Results: The contrast between bimodal (ie vestibular and visual) vs monomodal, (ie visual only) conditions revealed significantly stronger activations in areas V6 and PIC, and to a lesser extent in area CSv. This was found for both congruent and incongruent designs. Interestingly, area VIP was significantly more activated during congruent versus incongruent conditions in 3 out of 5 subjects.

Conclusions: Altogether, our results suggest that anteroposterior self-motion is integrated within a cortical network that includes non-specific bimodal areas (V6, PIC, and CSv) and an area that more particularly processes congruent visuo-vestibular inputs (VIP).

PP2-59 - Effects of space perception on unilateral vestibular loss mice

18. Spatial Orientation

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Purpose: Space perception and direction of locomotion are based on direction & place cell and short term memory of hippocampus. All information regulated in the hippocampus is based on visual input and vestibular information. Therefore, the change of the vestibular function causes distortion of the object's space perception and decision of locomotion. To demonstrate this, a behavioral test using Y-Maze was performed on semicircular canal and otolithic organ destroyed animal models.

Methods: The Y-maze test was performed by dividing the otolithic organ function changing group (n = 10) and a labyrinthectomy group (n = 10, POD #3). The information obtained from the Maze test was coded as the order of selection from each arm to the other of maze, and finally the dominancy of left-right side was calculated as %.

Results: The otolithic function changing group had no dominancy of the left-right side regardless of centrifuge direction ($p > 0.05$), and the locomotion selection dominance was observed in the labyrinthectomy group toward the vestibular loss.

Conclusions: In the Hippocampus, space-related information processing seems to be determined by semicircular canal information rather than otolithic organ.

PP2-60 - Effects of vestibular disorders on vestibular reflex and imagery

18. Spatial Orientation

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Purpose: The aim of this study was to establish the effect of vestibular lesion on vestibular imagery. Subjects were required to estimate verbally their passively travelled rotation angles in complete darkness, i.e., to activate vestibular imagery. During motion the

Vestibulo-Ocular Reflex (VOR) was measured. Thus we examined the coherence between the vestibulo-ocular reflex and self-rotation imagery, with vestibular-lesioned patients and healthy participants.

Methods: Unilateral acute and chronic patients, bilateral patients and healthy subjects were compared. The stimulus was a sequence of eight successive passive rotations, with four amplitudes (from 90° to 360°) in two directions.

Results: The VOR gain was lower in patients with unilateral lesions, for ipsilateral rotations. The healthy subjects had the highest gain and the bilateral group the lowest, on both rotation sides. Thanks to vestibular compensation after acute unilateral neuritis the VOR gain increased in lesion side and decreased in healthy side, resulting in a similar gain in both sides. A deficit of vestibular imagery was found exclusively in patients with bilateral hypoflexia, on both sides. The performance in vestibular imagery was good in the control group and correct in the unilateral patients.

Conclusions: Finally we found a significant correlation between the efficiency of VOR and that of vestibular imagery, exclusively in the bilateral patients.

The present study shows the complex relationship between vestibular imagery and the VOR. This

imagery test contributes to another assessment of the spatial handicap of vestibular patients. It seems particularly interesting for patients with bilateral canal paresis and could be used to confirm this diagnosis.

PP2-61 - Impact of alcohol on self-motion perception and reflexive eye movements: the role of the cerebellum

18. Spatial Orientation

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Purpose: Acute alcohol intoxication is well-known to alter the performances of visual and vestibular systems at different levels of signal processing, from reflexive responses to spatial orientation. However, how alcohol interferes with the processing of the visual-vestibular integration is still an open question. We hypothesized that alcohol-induced disorientation is due to a detuning of the multisensory integration process responsible for merging self-motion cues.

Methods: To test our hypothesis, we compared reflexive and perceptual responses of twelve healthy subjects before (BA) and 30min after (AA) intake of the estimated amount of alcohol needed to reach BAC of 0.06%. Specifically, a passive sustained yaw-rotation at 90°/s for 60s were delivered to test vestibulo-ocular reflex (VOR) and perceived rotational velocity (PRV), while a constant yaw-rotation of an optokinetic drum at 30°/s for 60s was provided to measure the optokinetic after-nystagmus (OKAN) and the generated circularvection.

Results: The VOR time constant significantly decreased from 14.0±1.2s BA to 9.5±1.9s AA, while the PRV time constant was 13.1 ±2.1s BA and 11.1 ±2.0s AA. In contrast, the OKAN was enhanced by alcohol consumption. The area under the curve (AUC) of the OKAN showed an increase from 174.4 ±36.0° BA to 206.0 ±76.2° AA, while the AUC of the vection decreased from 19.8 ±27.4#round BA to 8.1 ±11.0#round AA.

Conclusions: Our results suggested that alcohol affects visuo-vestibular processing of self-motion signals by altering the cerebellar velocity storage

mechanism. Similar patterns have been observed in patients with cerebellar degeneration, further suggesting that alcohol affects the vestibulo-cerebellar functionality altering self-motion perception. Support: SSA.

PP2-62 - Subjective cognitive dysfunction in patients with dizziness and vertigo

18. Spatial Orientation

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Purpose: Patients with vestibular disorders sometimes report cognitive difficulties and there are documented effects of vestibular loss on cognitive functions such as visuospatial ability. Two studies recently found high levels of perceived cognitive difficulty in these patients, but there is no consensus about the cognitive functions affected. We therefore investigated subjective cognitive dysfunction in a broad range of neuro-otology patients and compared cognitive complaints to reports of emotional distress and functional disability.

Methods: We asked 131 neuro-otology clinic outpatients whether they experienced difficulties with thinking, memory or concentration as a result of dizziness. They (and 37 non-vertiginous control subjects) also completed four questionnaires: neuropsychological vertigo inventory (NVI), everyday memory questionnaire (EMQ), depression, anxiety and stress scales (DASS) and dizziness handicap inventory (DHI).

Results: Many patients (65%) reported experiencing cognitive difficulties. Compared to controls, patients scored significantly worse on five NVI subtests (assessing perceptions of space and time, attention, emotions and motor function, $P < 0.05$), DASS ($d = 0.80$, $P < 0.001$) and DHI ($d = 2.1$, $P < < 0.001$), but not on the memory or vision NVI subtests or EMQ. Correlations between the NVI and DASS

($r=0.57$) as well as between the NVI and DHI ($r=0.53$) were significant ($P<0.001$). NVI space-perception subtest scores remained elevated after covarying DASS and DHI scores.

Conclusions: Patients with dizziness and vertigo reported high levels of subjective cognitive dysfunction, affecting spatial ability, orientation in time, and attention, but did not report significant memory difficulties. Perceptions of cognitive dysfunction covaried with emotional distress and functional disability. The most robust finding was subjective difficulty in navigation.

PP2-63 - Treatment of Mal de Debarquement Syndrome (MdDS) by readaptation of the vestibuloocular reflex (VOR)

18. Spatial Orientation

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Purpose: MdDS is continuous sensation of motion which occurs after prolong travel (classic), or spontaneously. The common motion sensations (primary) are rocking, swaying. There are other accompanying (secondary) symptoms such as sensitivity to light, noise, head pressure, ear fullness, fussy vision, brain fog, anxiety, and depression, which are experienced by most patients.

Methods: Both the primary and secondary symptoms are varied in their presence among patients. Only rocking and swaying can be easily quantified. MdDS patients were treated by readaptation (Dai et al., 2014). Effectiveness of treatment was determined by patients' self-assigned 10-point scale of overall symptoms.

Results: Before treatment, 431 patients (82% female, 350 classic, 81%) reported sensations of rocking (80%), swaying (73%), bobbing (43%), walking on trampoline (50%), and gravitational pull (64%). No primary symptoms were reported in 2% patients. Posturography determined significant rocking in 37% and swaying in 12% patients or both motions in 35% and 16% had only gravitational pull. Treatment

was successful for 77% of patients with classic and 58% of patients with spontaneous MdDS. There was no correlation between improvement in postural stability and overall score. Treated patients also reported a reduction in secondary symptoms.

Conclusions: Thus, the lack of correlation between primary symptoms and overall score indicates that secondary symptoms are a very significant factor in treatment of MdDS. We demonstrated (Dai et al., 2017) that in some patients, symptoms returned in the first 2 weeks after treatment. Thus, control of secondary symptoms is a critical factor for the success of treatment by readaptation of VOR.

PP2-64 - Vestibular Function and Hippocampal Volume in the Baltimore Longitudinal Study of Aging

18. Spatial Orientation

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Purpose: To evaluate whether reduced vestibular function in aging adults is associated with lower hippocampal volume.

Methods: This is a cross-sectional study using data from the Baltimore Longitudinal Study of Aging (BLSA), a long-running longitudinal cohort study of healthy aging. Participants were age ≥ 60 years and had both vestibular physiological testing and brain MRI at the same visit. Vestibular testing consisted of the cervical vestibular-evoked myogenic potential (cVEMP) to assess saccular function, ocular VEMP (oVEMP) to assess utricular function, and video head-impulse testing (VHIT) to assess the horizontal semicircular canal vestibulo-ocular reflex (VOR). The main outcome measure was hippocampal volume, calculated using diffeomorphometry.

Results: The study sample included 103 participants (range of 35-90 participants in sub-analyses) with mean (\pm SD) age 77.2 years (± 8.71). Multivariate linear models including age, intracranial volume, sex, and race showed that 1 μ V amplitude increase of

cVEMP was associated with an increase of 319.1 mm³ (p=0.003) in mean hippocampal volume. We did not observe a significant relationship between oVEMP amplitude or VOR gain and mean hippocampal volume.

Conclusions: Lower cVEMP amplitude (i.e. reduced saccular function) was significantly associated with lower mean hippocampal volume. This is in line with prior work demonstrating a link between saccular function and spatial cognition. Hippocampal atrophy may be a mechanism by which vestibular loss contributes to impaired spatial cognition in older adults. Future work using longitudinal data will be needed to evaluate the causal nature of the association between vestibular loss and hippocampal atrophy.

PP2-65 - Visual dependency in spatial orientation: The effect of body tilt and hemispheric lateralization

18. Spatial Orientation

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Purpose: Perception of spatial orientation requires multisensory integration including visual, vestibular, and proprioceptive inputs. In this process, the degree of reliance on visual inputs is known as visual dependency. Here we used a Rod and Disc paradigm to measure visual dependency. In this paradigm, a full-field optokinetic stimulation (30%/s in clockwise and counter-clockwise directions) is used to induce tilt perception, which is measured by adjusting a visual line to upright orientation. We studied hemispheric lateralization using transcranial direct current stimulation (tDCS) over the left parietal region in comparison with a sham stimulation.

Methods: Visual dependency was measured in 24 participants (eight in each cathodal tDCS, anodal tDCS and sham stimulation groups) with 20° lateral head-on-body and whole-body tilts.

Results: Overall, visual dependency was biased towards the tilt direction when the head was tilted on the body, and was biased away from the tilt direction when the whole body was tilted. In the anodal group, compared with the cathodal and sham groups, the effect of body tilt on visual dependency was significantly biased toward the left side, and the effect of visually-induced roll tilt was significantly biased in the CCW direction.

Conclusions: These findings show that 1) visual dependency is affected by the relative head and body tilt positions, 2) the facilitatory -and not inhibitory- tDCS over the left hemisphere lead to a bias in visual dependency towards the side of stimulation, and 3) this bias is related to neural processing of both body tilt position and visual inputs.

PP2-66 - Visual gravitational motions affect estimation of subjective visual vertical (SVV)

18. Spatial Orientation

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Purpose: Information on the orientation of gravity can be extracted both by static and moving visual clues. However, it is unknown whether the processing of static cues and that of dynamic cues are related. To clarify this point, we investigated whether gravitational motion might affect the perceptual judgment of SVV.

Methods: Twenty volunteers lying on the left side viewed a sphere on a screen moving under the simulated effect of gravity along a parabolic trajectory. They were instructed to intercept the sphere at the end of the trajectory. Trials were administered in blocks of 24. In each block the axis of the parabola was oriented either along the direction of Earth's

gravity (angle = 0°) or tilted relative to it (30°, 60° or 90°). To estimate the SVV, participants oriented vertically a luminous bar for 10 trials after each interception block.

Results: The estimation of SVV was affected by the tilt angle of the parabola seen in the previous interception block. In particular, the SVV errors were smaller in the early trials after the exposure to the parabolic trajectories aligned with Earth's gravity. In the interception task, timing errors were reduced when the tilt angle of the parabola was closer to Earth's gravity.

Conclusions: These data suggest that visual gravitational motions can contribute to estimating SVV. Moreover, the finding that the tilt angle modulated timing errors could reflect an internalized model able to predict the effect of gravity on moving objects.

PP2-67 - A diagnostic dilemma: beyond high resolution computed tomography (CT) scan, thinning versus fistula.

19. Superior Canal Dehiscence Syndrome

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Purpose: We present two cases of computed tomography (CT) confirmed, Superior Semi-circular Canal Dehiscence (SSCD), with atypical Audiological findings. CT reformatted in the plane of Stenver and Poschl revealed a dehiscence on the left in the first patient and bilaterally in the second patient. However, the audio-vestibular test findings were not typical of SSCD.

Methods: Serial audiograms with immittance and acoustic reflexes were tested. Frenzel goggles were used to record eye movements for Tulios, Hennebert and Valsava signs. Vestibular evoked myogenic potential (VEMP) thresholds were sought and as the second patient was more symptomatic, she was referred for vestibular physiotherapy after a full vestibular assessment.

Results: Repeated audiograms showed no significant air-bone gaps in the SSCD ears. No nystagmus

was recorded. VEMP threshold seeking was inconclusive in the first patient due to insufficient sternocleidomastoid muscle contractions and negative for the second patient on the left. The second patient also had confounding underlying vestibulopathy with absent right VEMP, reduced visual acuity, plantar flexors strength and standing balance.

Conclusions: Given the multiple clinical variations of SSCD, short of surgical confirmation, it was beyond the resolution of CT scans to discern between thinning and fistula. Here, we report unusual variants of sensorineural hearing loss that did not correlate with pure-tone audiometric air bone gaps as studies have suggested. VEMP thresholds for the diagnosis of SSCD may be challenging for older patients with poor muscle contractions. A full vestibular battery of tests should be performed to rule out underlying vestibular deficits that will confound the diagnosis of SSCD.

PP2-68 - Aggregating the symptoms of superior semicircular canal dehiscence syndrome

19. Superior Canal Dehiscence Syndrome

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Purpose: Superior canal dehiscence syndrome (SCDS) is caused by an absence of bone overlying the superior semicircular canal creating a third mobile window into the inner ear. When patients report their symptoms are causing significant impairments to their quality of life (QoL), surgeons have offered

a variety of surgical procedures. Comparing the effectiveness of these procedures, however, is challenging, as there is no patient-reported outcome measure (PROM) designed specifically for evaluating SCDS-specific health-related QoL. The aim of this study was to perform a systematic review of all symptoms reported by patients with SCDS, with the goal of enabling the design of a condition-specific PROM.

Methods: Medline and PubMed databases were searched for articles that reported the preoperative symptoms of SCDS patients. Articles were excluded if they reported on associated diseases or did not report symptoms.

Results: Of the 397 articles retrieved, 66 were retained for quantitative analysis. Among 431 patients with SCDS, 1,253 symptoms were identified and 91 symptom terms were reported. After combining synonymous terms, 22 symptoms were derived by consensus. Of the raw total number of reported symptoms 92.5% can be attributed to 5 common symptoms: spontaneous dizziness (51%), autophony (42.5%), pressure-induced vertigo (37.4%), hearing loss (39.9%) and sound-induced vertigo (42.7%).

Conclusions: This systematic review of symptoms reported by SCDS patients identified a 22-item common symptom set. The 5 most frequently reported symptoms were spontaneous dizziness, sound-induced vertigo, autophony, hearing loss and pressure-induced vertigo. These items can be used towards creating a novel validated PROM in patients with SCDS.

PP2-69 - Correlation of neuroradiological and post-mortem autopsy findings in SCDS

19. Superior Canal Dehiscence Syndrome

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Purpose: SCDS is a disorder which is – apart from the variable patient's history - routinely diagnosed

by audiological and neurotological testing and final confirmation by means of a HR-CT of the temporal bones. This is the routine diagnostic approach, but it has always been discussed in how far these findings reliably confirm the actual dehiscence.

Methods: In the present series, 22 suicide victims (44 temporal bones) were thoroughly investigated while undergoing an autopsy for medicolegal reasons (suicide by hanging – 17; by carbon monoxide intoxication – 3; by bleeding to death – 2). They were evenly distributed with respect to gender (age 23-75, 55.3 mean). Before the autopsy, the subjects were scanned with a HR-CT (1 mm slice thickness, 128 lines' MS-CT, Brilliance, Philips Medical, Netherlands).

Results: In this series, the photographic documentation of the middle cranial fossa demonstrated a visibly open superior semicircular canal (SSC) in 3 subjects unilaterally and in one subject (bilaterally). The CT findings revealed an open SCC only in the one bilateral case which was confirmed by autopsy, but produced falsely positive results in five cases when the autopsy could not reveal any open SCC. In essence, the correlations between the autopsy and the CT findings was positive in 75 % of the cases, but negative in 35 %.

Conclusions: This, in turn, indicated that the clinical decision making should primarily be based on the clinical findings and the major complaints of the patients, but only secondarily on the neuroradiological findings. As produced by HR-CT of the temporal bones with its possible technical artifacts.

PP2-70 - Fremitus Nystagmus - a simple and objective clinical sign for SCDS

19. Superior Canal Dehiscence Syndrome

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Purpose: Superior Canal Dehiscence Syndrome (SCDS) is a great mimicker among the neurotological diagnoses. Its clinical manifestations and subjectively

reported symptoms are variable and the response to surgical treatment is still not completely predictable. Diagnostic certainty is therefore of utmost importance. Here, we present a case series in which a simple diagnostic clinical sign emerged: Fremitus nystagmus.

Methods: Four patients with SCDS were included. The patients were examined with audiometry, head impulse test, caloric videonystagmography, cVEMP and oVEMP, high-resolution temporal bone CT. Eye movements were examined in response to Valsalva manoeuvres and to the patients voice (humming). A video recording of eye movements is presented at the poster.

Results: All four patients had SCDS confirmed by temporal bone CT and VEMP. oVEMP had the highest diagnostic value of all functional test procedures, with an asymmetry ratio of more than 75% in all SCDS patients and a specificity of 100% among our general neurotologic patient population of more than 1000 patients (cut-off at an amplitude of 30 μ V). The audiometric air-bone gap was small (<10 dB). Valsalva manoeuvres could only provoke a very faint – if any – nystagmus. In contrast, the vertical-torsional Fremitus Nystagmus, in response to the patient's own voice, was clearly and easily observable under Frenzel goggles.

Conclusions: Fremitus Nystagmus is a clear and easy to perform objective clinical diagnostic sign for SCDS and more readily visible than nystagmus in response to Valsalva manoeuvres. Physicians examining patients suspected of SCDS are encouraged to evaluate the presence of Fremitus Nystagmus.

PP2-71 - Hearing eyeball and/or eyelid movements on the side of a unilateral superior canal dehiscence

19. Superior Canal Dehiscence Syndrome

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Purpose: Hearing of eyeball movements has been reported in superior semicircular canal dehiscence (SSCD), but, not hearing of eyelid movements. Our

main objective was to report the hearing of eyeball and/or eyelid movements in unilateral SSCD. Our secondary objective was to access its specificity to SSCD and discuss the underlying mechanism.

Methods: Six patients with SSCD who could hear their eyeball and/or eyelid movements were retrospectively reviewed. With the aim of comparisons, eight patients with an enlarged vestibular aqueduct (EVA) were questioned on their ability to hear their eyeball and/or eyelid movements.

Results: Three patients with SSCD could hear both their eyeball and eyelid movements as a soft low-pitch friction sound. Two patients with SSCD could hear only their eyelid movements, one of whom after the surgery of a chronic subdural hematoma. The latter remarked that every gently tapping on the skin covering the burr-hole was heard in his dehiscent ear as the sound produced when banging on a drum, in keeping with a direct transmission of the sound to the inner ear via the cerebrospinal fluid. One patient with SSCD, who could hear only his eyeball movements, had other disabling symptoms deserving operation through a middle fossa approach with an immediate relief of his symptoms. None of the eight patients with EVA could hear his/her eyeball or eyelid movements.

Conclusions: Hearing of eyeball and/or eyelid movements is highly suggestive of a SSCD and do not seem to occur in EVA. The underlying mechanism is discussed particularly the role of a cerebrospinal fluid transmission.

PP2-72 - Improving the Specificity of VEMP testing in Superior Canal Dehiscence: Trial by oVEMP

19. Superior Canal Dehiscence Syndrome

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Purpose: The recording of oVEMP amplitudes to air-conducted (AC) sound is a sensitive screening test for Superior Semicircular Canal Dehiscence

(SCD). However, not all patients with large AC oVEMPs have SCD on CT imaging. This study sought to identify alternate diagnoses also producing large AC oVEMPs, and investigated outcome measures that would help differentiate between these cases and SCD.

Methods: In this study we reviewed the clinical records and BC oVEMP results of 42 clinic patients (53 ears) who underwent CT imaging due to enlarged AC oVEMP amplitudes. All patients were tested with BC oVEMPs to two different stimuli (1 ms square-wave pulse and 8 ms 125 Hz sine wave). Receiver Operating Characteristic (ROC) analysis was used to determine the diagnostic efficacy of BC oVEMP amplitude and latency outcome measures.

Results: Thirty-two ears were identified as having SCD; 21 had alternate diagnoses that included thinning of the bone covering (Near Dehiscence), Vestibular Migraine, Large Vestibular Aqueduct Syndrome and Ménière's disease. BC oVEMP amplitudes to 1 ms pulses and 125 Hz sine waves were not helpful in discriminating between SCD and non-SCD patient ears ($p>0.05$). In contrast, oVEMP latencies to both BC stimuli were powerful discriminators ($p<0.001$). Sensitivity of the 125 Hz stimulus was higher than for the 1 ms pulse.

Conclusions: A two-step protocol that includes AC oVEMP amplitudes and low frequency (125 Hz) BC oVEMP latencies is recommended for optimizing the sensitivity and specificity of VEMP testing in SCD.

PP2-73 - Management of Dehiscences Involving Superior Canal and Tegmen

19. Superior Canal Dehiscence Syndrome

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Purpose: Superior semicircular canal syndrome can be complicated by tegmen dehiscence of the same ear. Diagnostic criteria and treatment are still in discussion.

Methods: A series of 10 patients (40-73 y, 4m, 6f) with ipsilateral SCDS and honeycomb tegmen were

diagnosed and treated. 2 of them had residual complaints after occlusion in other centers. All had combined hearing loss, 5 had pathological middle ear compliance in addition to SCDS typical findings. Treatment was done via transtemporal approach with canal occlusion in 6 cases with open dehiscence and resurfacing of tegmen and canal with bioceramic (Bioverit) in all patients. 4 of the 10 patients had near dehiscence findings intraoperatively. Eustachian tube dysfunction in 6 patients was treated with ventilation tubes in addition to occlusion and resurfacing. Postoperative findings were compared with preoperative in all 10 cases.

Results: The air-bone gap was improved in 7 patients, bone conduction in 3 patients, VEMP thresholds were normalized in 8 cases, VEMP amplitudes and complaints (DHI) were improved in all patients. No correlation between radiologic size of dehiscences and pre-/postoperative findings was observed. The maximum of improvement in audiologic and neurotologic findings and complaints was observed in patients with preoperative Eustachian tube dysfunction in addition to the dehiscence findings.

Conclusions: Pathological pressure exposure of the superior semicircular canal can be increased by simultaneous pressure impact via middle ear and tegmen dehiscence. Therefore, the simultaneous investigation of SCDS, tegmen dehiscence and Eustachian tube dysfunction and the combined treatment in selected cases has to be considered.

PP2-74 - New issues within the third windows spectrum abnormalities impacting diagnosis and treatment

19. Superior Canal Dehiscence Syndrome

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Purpose: In patients with superior semicircular canal dehiscence (SSCD), surface of bony defect correlates to the severity of symptoms. The objectives were to: (1) report a novel entity of the third windows spectrum; (2) present an innovative treatment for SSCD by the superior petrous sinus (SPS).

Methods: Two patients with particular forms of SSCD were retrospectively reviewed. The first showed brutal Tullio phenomenon (TP). The second complained of invalidating pulsatile tinnitus and dizziness aggravated by physical exercise.

Results: First patient showed moderate hearing loss without a conductive component in both ears. Tullio phenomenon (TP) was systematically observed when 2, 3 and 4 kHz pure tones were delivered at 110dB in the left ear. Tomodensitometry revealed a sub-millimeter dehiscence located on the ampullar region of the left superior semicircular canal. As the nystagmus was undoubtedly generated by an utriculo-fugal flow, it was hypothesized that mastoidien cells system acts as a Helmholtz resonator transferring acoustic energy directly to the vestibular end organ. In second patient, symptoms were caused by a SSCD in the right ear by SPS erosion. The treatment consisted in rigidifying the wall of the SPS (1.5 mm² third window). Two stents were introduced by endo vascular approach in the SPS under general anesthesia. The patient reported immediate relief of his tinnitus, result still maintained three months after procedure.

Conclusions: (1) Limited ampullar dehiscence may explain some TP cases with "normal" petrous bone tomodensitometry. (2) In selected cases, endovascular treatment for SSCD by SPS is a safe and effective procedure.

PP2-75 - Ocular Vestibular Evoked Myogenic Potential Waveform Morphology: Signs of Superior Canal Dehiscence

19. Superior Canal Dehiscence Syndrome

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Purpose: To determine if the morphology of bone-conduction ocular vestibular evoked myogenic potentials (oVEMP) waveforms predicts the presence of superior canal dehiscence syndrome (SCDS) and if the characteristics of additional peaks predict the size and/or location of the dehiscence.

Methods: The charts of 38 patients (43 ears) with SCDS were reviewed, along with 43 age and gender matched controls. SCDS was diagnosed based on symptoms (sound and/or pressure related vertigo, autophony and/or conductive hyperacusis) and a positive CT or MRI scan. oVEMPs were evaluated for their asymmetry ratio (AR) and the amplitude of additional peaks between N1 and P1. The Additional Peak Amplitude Ratio (APAR) was calculated as the ratio of the largest additional peak amplitude to the N1 amplitude. Correlation co-efficients were used to identify the relationship between the amplitude of the peaks and the size/location of the dehiscence.

Results: 79% of the 43 SCDS ears but only one control had an APAR over 1%. The AR was highly specific (all 43 control subjects had an AR < 30%); however, the sensitivity was low (67%). When both measures were considered together the sensitivity and specificity were 95% and 98% respectively. There was no significant relationship between the size and location of the dehiscence on CT scans and the oVEMP measures.

Conclusions: Bone-conduction oVEMP morphology is a useful tool in diagnosing SCDS. oVEMP morphology markers are not dependent on the size or location of the dehiscence.

PP2-76 - Outcome of surgical plugging in superior canal dehiscence syndrome

19. Superior Canal Dehiscence Syndrome

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Purpose: Superior canal dehiscence (SCD) syndromes are characterized by tinnitus, noise- and pressure- induced vertigo, and autophony. Middle cranial fossa approach (MFA) is one of the surgery technique for SCD repair. In this study, we evaluate the outcome of MFA for SCD repair treatment.

Methods: Ten patients who underwent SCD repair via MFA were recruited. Median age of patients was 45 years (37-61) and median follow-up duration after surgery was 26.2 months (6-97.2). Clinical symptoms (autophony, aural fullness, hearing loss, imbalance, sound, pressure induced vertigo, and tinnitus), audiometry, vestibular evoked myogenic potential (VEMP), and electrocochleography (ECoG) were evaluated before and after surgery.

Results: Sensorineural hearing loss was developed after surgery in 1 patient. In the remaining 9 patients, preoperative bone conduction (BC) threshold (5.7 ± 4.8 dB) increased after surgery (11.8 ± 8.2 dB) ($p=0.018$). VEMP threshold was significantly improved after surgery (preoperative: 54.3 dB, postoperative: 82.3 dB, $p=0.018$). SP/AP ratio of ECoG was also significantly improved after surgery (preoperative: 0.51, postoperative: 0.30, $p=0.028$).

Conclusions: Most of subjective symptoms were relieved after SCD repair via MFA. Hypersensitive bone conduction threshold, air-bone gap, VEMP threshold and SP/AP ratio of ECoG were normalized after successful repair of SCD.

PP2-77 - Vestibular suppression of normal bodily sounds

19. Superior Canal Dehiscence Syndrome

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Purpose: we propose that cochlear and vestibular efferents assist the stapedius reflex in suppressing ascending masking for bodily sounds, chewing and vocalizing. The human voice is extremely loud. Why do opera singers not have noise induced hearing loss. As vegetarian animals eat up to 80% of daylight hours, it is essential for them to hear predators approaching while chewing. The evolutionary advantage of this is clear. Despite chewing at a dinner party, hearing is relatively normal.

Methods: We measured the sound in the external auditory canal in response to chewing (celery, carrots) and also to singing loudly and demonstrated extremely loud sounds 30 cm in front of the mouth in the external auditory canal. We measured bone vibration to the head with resultant sound in the ear canal during chewing and singing.

Results: The stapedius reflex causes suppression of ascending masking of high frequency sounds by low frequency sounds.

Conclusions: There is equivocal evidence that cochlear efferents assist stapedius. Superior semicircular canal dehiscence is associated with autophony and dizziness during chewing because the compensatory process for internal sound is inadequate. It is hypothesized that the vestibular efferents suppress the sound stimulus from the external canal by air and vibratory responses by bone conduction, preventing these strong stimuli from inducing dizzy symptoms. The main purpose of the vestibular efferent system may be to suppress sound and vibration causing dizziness. Dizziness occurs in superior semicircular canal dehiscence syndrome because the stimulus is too great for intrinsic suppression mechanisms to be effective.

PP2-78 - VOG and VEMPs in Superior Semicircular Canal Dehiscence and Perilymphatic Fistula

19. Superior Canal Dehiscence Syndrome

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Purpose: The aim of the literature review and our cases report were to evaluate the best examination tool for diagnosing the perilymphatic fistula (PF) and superior semicircular canal dehiscence (SSCD).

Methods: Literature search, retrospective study of 11 cases with diagnosis of semicircular canal dehiscence and perilymphatic fistula, ocular and cervical vestibular evoked myogenic potentials (oVEMP, cVEMP), videonystagmography (VOG) and video head impulse test (VHIT).

Results: There are some differences in „third window“ diagnoses. One of the main difference is integrity of the perilymphatic sac, next is a leak of perilymphatic fluid. In SSCD there is no hole in a perilymphatic sac, while in perilymphatic fistula is permanent or temporary hole, with an intermittent or continual leak of the perilymphatic fluid. In these diagnoses we can do nystagmus provocation tests on videonystagmography (Valsalva, exercising, loud sound, tympanometry), perform also VHITs. One of the most beneficial tests are VEMPs. SSCD has a lower threshold and larger amplitude of oVEMP and cVEMP anytime. According to location, oVEMP is more significant for SSCD. Contra to these findings, in perilymphatic fistulas, the VEMPs are fluctuating in results. Sometimes there are similar results to SSCD (lateral canal fistula in cholesteatoma), but sometimes we can also find normal or reduced VEMPs. We explain these fluctuating findings in perilymphatic fistulas due to fluctuant leak of perilymphatic fluid, which is not in SSCD.

Conclusions: Our experience corresponds with a literature search. Videonystagmography with VEMPs seem to be very good examination tools for to diagnose superior canal dehiscence and perilymphatic fistula for sure.

PP2-79 - Mild blast wave leads intensity-dependent sequential changes in MMP2 expression in rat brains

20. Traumatic Brain Injury

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Purpose: The prevalence of improvised explosive devices in warfare and terrorism has created unprecedented levels of blast-related traumatic brain injury (TBI). Mild TBI can sustain various symptoms, such as tinnitus, hearing loss, post-traumatic balance disorders, and migrainous disorders without overt histological and radiological findings. Matrix metalloproteinase 2 (MMP2) is a gelatinase with multiple functions at the neurovascular interface, including local modification of the glia limitations to facilitate access of immune cells into the brain amyloid-beta degradation during responses to injury or disease.

Methods: The present study examines regional changes in MMP2 immunoreactivity in the rat brain after a single mild (2.7-7.9 PSI peak) or moderate (13-17.5 PSI peak) blast overpressure (BOP) exposure through the expression isolated to patchy deposits in brain parenchyma surrounding blood vessels. MMP2 expression was examined quantitatively in histological sections of decalcified rat heads as a marker at 2, 24 and 72 hours after BOP exposure. Separate analyses were conducted for the cerebellum, brainstem and the cerebrum.

Results: The deposits varied in number, size, staining homogeneity (standard deviation of immunopositive region), and a cumulative measure, the product of size, average intensity and number, as a function of blast intensity and time. The sequences of changes in MMP2 deposits from sham control animals suggested that the mild BOP exposure differences was normalized within 72 hours in the subtentorial brainstem and cerebrum, but not the cerebellum.

Conclusions: Hence, local MMP2 responses may be a contextual biomarker for locally regulated responses to widely distributed brain injury foci.

PP2-80 - Temporal bone fracture in acute traumatic brain injury: Vestibular consequences

20. Traumatic Brain Injury

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Purpose: Traumatic brain injury (TBI) is the most common cause of death and disability in young adults with 1.4 million TBIs in the USA each year. Post-traumatic debilitating, long-lasting dizziness and chronic vestibular syndromes have been reported in up to half of patients in a 5-year follow-up study. Vestibular dysfunction and syndromes after TBI however have been recognised as an independent predictor of failure to return to work. Although many authors talk about acute injury to the vestibular apparatus and nerve, such reports are typically non-acute and retrospective.

Methods: As part of a routine clinical service at our Major Trauma Unit, we found that out of 49 TBI patients examined, 10 had clinical evidence of an acute peripheral unilateral vestibular injury (positive head-impulse-test and vestibular nystagmus). Cranial-CT scans depicted temporal bone fracture in 7 patients and no bone injury was apparent in 3.

Results: We report on a clinical follow up in 5 of these patients at least 2 years after acute TBI, 3 of whom having shown no temporal bone fracture on CT scan, clinical-neurologically, quantifying peripheral vestibular deficit using the video-head-impulse-test.

Conclusions: Possible causes include a vestibular nerve transection, compression of the vestibular nerve by haematoma, or physical damage to the labyrinth. We present this, to our knowledge, the first case series following acute peripheral vestibular loss in patients with acute TBI.

PP2-81 - The utility of the Sports Concussion Assessment Tool in hospitalized traumatic brain injury patients

20. Traumatic Brain Injury

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Purpose: The Sports Concussion Assessment Tool 3rd version (SCAT3) is a sports screening tool used to support return to play decisions following a head injury. The SCAT3 is presumed to identify brain dysfunction (implying a degree of brain injury), however the SCAT3 has never been validated with patients with definite acute traumatic brain injury.

Methods: 11 patients with Traumatic Brain Injury (TBI), abnormal acute neuroimaging, and over 18-years-old, were recruited from an acute major trauma centre, St Mary's Hospital London. TBI patients and healthy controls were assessed with the SCAT3. This assessment tool includes a symptom evaluation and severity scale, a standardized cognitive assessment, and a clinical assessment of balance.

Results: We found that all three SCAT3 domains - symptoms, cognitive and balance assessments - TBI patients scored significantly worse than healthy controls. A correlation matrix (Bonferroni corrected) found no correlation between all subjective-objective SCAT3 assessment pairs (e.g. feeling unbalanced and balance examination). Removing Bonferroni correction revealed that the SCAT3 symptom of 'pressure in the head' had the largest number of co-correlations (including affective symptoms) overwhelmingly in a pattern indicating migraine.

Conclusions: The SCAT3 is sensitive in identifying patients with moderate-to-severe acute TBI compared to healthy controls. The lack of correspondence between objective and subjective assessments indicates an uncoupling of symptoms from signs - e.g. objective measures of imbalance may be a more

reliable marker of brain injury than symptoms of feeling unbalanced. Subjective symptoms may additionally be modulated by non-brain injury mechanisms including migraine and psychosomatic inputs.

PP2-82 - Vestibular and optokinetic responses in post-concussive syndrome

20. Traumatic Brain Injury

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Purpose: Post-concussive syndrome (PCS) is a medical condition occurring in patients presenting a constellation of non-specific post-traumatic symptoms that persist beyond the expected time-frame for clinical recovery after a head trauma (i.e. 10-14 days). Reports of dizziness and nausea are common in PCS and may have different origins. Often patients specifically report increased predisposition to visually-induced motion sickness. In this study, we focus on the central processing of visual and vestibular stimuli, evaluating whether rotatory chair testing can provide objective measures related to the reported symptoms.

Methods: Using a rotating chair surrounded by a horizontally rotating full-field optokinetic drum, 49 PCS patients were exposed to: angular velocity steps in darkness (60°/s for 90s) to quantify gain and time constant of the vestibulo-ocular reflex (VOR); sustained optokinetic stimulations (50°/s for 30s) to evaluate gain and time constant of the optokinetic afternystagmus (OKAN). Two repetitions of both tests were performed, changing the stimulus direction. Eye movements were recorded with video-oculography.

Results: OKAN time constants in PCS patients (median[MAD]: 16.7[5.1]s) were significantly larger ($p < 0.01$) than in healthy subjects from published normative databases (10.5[2.5]s). No differences were observed for the other parameters.

Conclusions: An increase in the OKAN time constant is observed in PCS patients. The emerging evi-

dence of a correlation between visual motion sensitivity and OKAN time constant in healthy subjects suggests a similarity between PCS and visual motion-sensitive individuals. Our findings, therefore, propose a novel way to objectify visual-induced motion sickness in PCS patients and support possible therapeutic approaches derived from motion sickness desensitization research.

Support: Schulthess Foundation.

PP2-83 - Why is routine vestibular screening not undertaken by trauma ward staff? A qualitative study

20. Traumatic Brain Injury

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Purpose: Vestibular disorders are a burdensome consequence of traumatic brain injury (TBI). There is growing data supporting the importance of routine vestibular screening, especially for common conditions such as benign paroxysmal positional vertigo (BPPV). However, a clinical audit completed at a major trauma centre (St Mary's Hospital, London) demonstrated no formalised routine vestibular screening or assessment. We aimed to qualitatively explore the staff-related reasons for this.

Methods: This study employed a qualitative approach using semi structured interviews. The theoretical domains framework was used to ensure questions covered psychological and organisational theory relevant to behaviour change. Ward staff whose role include assessing patients with dizziness and/or imbalance (therapists, junior and senior doctors) were purposively sampled. Data was analysed using a Framework analysis approach.

Results: 12 ward staff participated (Mean age 31 years; 10 females). Interviews lasted on average 38 minutes. Data from interviews supported previous findings that no routine, formalised vestibular screening or assessment is undertaken in TBI patients. Prominent themes surrounding reasons for

this lack of screening included insufficient skills and training, a responsibility gap between staff and low confidence in knowledge.

Conclusions: This study demonstrates a variety of knowledge and role-associated factors to be linked to a lack of routine vestibular screening following TBI. The clinical implications of this work are that patients with common vestibular conditions such as BPPV may be missed or poorly managed, leading to heightened and long-lasting physical, psychological and socioeconomic difficulties. Focused multidisciplinary theoretical and practical education is recommended.

PP2-84 - Acute dizziness/vertigo in the telestroke network TEMPiS: frequency and telemedical decision making

21. Vascular Vertigo

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Purpose: Acute dizziness/vertigo (AV) is a challenging symptom in the emergency department. Stroke has to be differentiated from peripheral vestibular and systemic disease. In telestroke the telemedical consultation determines the need for time critical stroke treatment. The aim of the study is to assess the frequency of AV in the teleconsultation service of a stroke network and the quality of its telemedical work up.

Methods: In the telestroke network TEMPiS two stroke centers provide care for 21 hospitals in rural Bavaria/Germany. Teleconsultants document the principal symptom of each consultation. In all cases of AV the teleconsultation report was reviewed and classified in predefined categories: **peripheral cause:** AV with contralesional horizontal nystagmus and ipsilesional positive head impulse test (HIT), without new focal neurological deficit (FND); **central cause:** new FND which also includes skew deviation and central nystagmus, or nystagmus and negative HIT; **unclassified:** all other cases.

Results: 407 (6.4%; of those 52.1% female, mean age 66.1 years) of 6.356 patients presented in our teleconsultation service in 2016 had the principal symptom AV. 10 cases (2.5%) met the classification criteria for a peripheral and 170 cases (41.8%) for a central cause, leaving 227 cases (55.8%) unclassified by the means of telemedicine. An informative HIT was available only in 37 cases (9.1%). 41 cases (10.0%) met the definition of acute vestibular syndrome.

Conclusions: AV is a frequent presentation in a stroke network, but the telemedical work up remains unsatisfactory as more than half remain unclassified. Measures to improve diagnostic quality are necessary.

PP2-85 - Canal and otolith test characteristics in vestibular neuritis and posterior circulation stroke

21. Vascular Vertigo

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Purpose: Vestibular neuritis (VN) and posterior-circulation stroke (PCS) are the two most common causes of acute vestibular syndrome (AVS). Study aims to compare characteristics of semicircular-canal and otolith-function tests in PCS and VN

Methods: Cervical and ocular-vestibular evoked myogenic potentials (c-and oVEMP), subjective visual horizontal (SVH), and video-head impulse (v-HIT) tests were undertaken in 20 patients with acute VN and 16 with acute PCS. VEMP amplitude asymmetry-ratios (AR), ipsilesional horizontal v-HIT gains and catch-up saccade parameters were compared against healthy controls.

Results: The mean age was 55.5 for VN, 65.2 for PCS. Mean time to test was 5.7 days for VN, 8.1 days for stroke. Abnormality rates for AC cVEMP, BC oVEMP and SVH were 42%, 55% and 90% for VN, 46.7%, 6% and 71% for stroke.

For ipsilesional VN, PCS and healthy controls, horizontal v-HIT gains were 0.41, 0.89 and 0.96, cumulative amplitude was 3.44, 1.67 and 0.94, mean first saccade amplitude was 5.03°, 2.05° and 1.0° and first saccade onset latencies, 179.5ms, 277.6ms and 301.3ms. For VN, all four measures differed significantly from controls ($p < 0.05$). In PCS patients, cumulative amplitude and first saccade amplitude were different ($p < 0.05$).

Conclusions: A higher prevalence of oVEMP asymmetry, lower v-HIT gains and a higher cumulative amplitude of catch-up saccades help separate VN from PCS. Detailed saccade analysis is likely to complement existing vestibular tests.

PP2-86 - Diagnosing dizziness of vascular origin: are there safer options than arteriography?

21. Vascular Vertigo

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Purpose: To evaluate the sensitivity and specificity of the magnetic resonance angiography (MRA) and transcranial Doppler ultrasound in the diagnosis of vertebrobasilar insufficiency (VBI).

Methods: We performed a cross-sectional study. We selected two groups: a control group (healthy subjects) and a group of patients who had clinical diagnosis of VBI. Each group included 12 patients, who were age- and sex-matched.

Results: The MRA results did not demonstrate significant differences in the findings of diseased and

control groups. The transcranial Doppler demonstrated that the systolic pulse velocity of the right middle cerebral artery (sensitivity=0.83, specificity=0.75; $p=0.028$), final diastolic velocity of the basilar artery (sensitivity=0.66; specificity=0.66; $p=0.028$), pulsatility index (PI) of the left middle cerebral artery (sensitivity=0.83; specificity=0.75; $p=0.005$), PI of the right middle cerebral artery (sensitivity=0.75; specificity=0.75; $p=0.010$), and the PI of the basilar artery (sensitivity=0.91; specificity=0.91; $p < 0.001$) were significantly higher in the diseased group compared to controls.

Conclusions: The MRA did not demonstrate significant changes in patients with VBI compared to controls. The PI of the basilar artery, measured using the transcranial Doppler, demonstrated high sensitivity (91%) and specificity (91%) levels in the diagnosis of VBI when the PI is higher than 1.01.

PP2-87 - Eye movements and vestibular function in patients with posterior circulation infarction

21. Vascular Vertigo

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Purpose: To evaluate the diagnostic values of eye movement and vestibular function tests in posterior circulation infarction (PCI).

Methods: 38 PCI patients and 34 patients with unilateral peripheral vestibular dysfunction (UPVD) were enrolled. All subjects were diagnosed with brain MRI and underwent eye movements and vestibular function tests, including spontaneous nystagmus (SN) and head-shaking nystagmus (HSN).

Results: The abnormal rate of eye movements was 78.9% in PCI group and 11.7% in UPVD group ($P < 0.05$). The positive rate of SN and HSN were 41.2% (7/17) and 43.8% (7/16) in cerebellar infarction patients, respectively, and the horizontal direction of SN and HSN coincided with the affected side in 85.7% (6/7) and 83.3% (5/6) patients, respectively.

The positive rate of SN and HSN were 33.3% (2/6) and 66.7% (4/6) in medullary infarction patients, respectively, and the horizontal direction of SN coincided with the healthy side in 100% (2/2) and the horizontal direction of HSN coincided with the affected side in 75% (3/4) patients. The positive rate of SN and HSN were 20.6% (7/34) and 82.4% (28/34) in UPVD patients, respectively, and the horizontal direction of SN and HSN coincided with the healthy side in 100.0% (7/7) and 78.6% (22/28) patients, respectively.

Conclusions: Eye movement and vestibular function tests contribute to the early diagnosis of PCI. The horizontal direction of SN and HSN are consistent, toward the affected side in cerebellar infarction and the healthy side in UPVD. The horizontal directions of SN and HSN are contradictory in medullary infarction, which deserves further investigations.

PP2-88 - HINTS vs ABCD2 to predict cerebrovascular cause in acute vestibular syndrome patients at the ED

21. Vascular Vertigo

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Purpose: Posterior circulation stroke may be distinguished from peripheral vestibular disease among patients with acute vestibular syndrome (AVS) using the HINTS oculomotor examination battery (Head Impulse/Nystagmus/Test-of-skew). Previous studies are based on selected materials and/or lack quantitative vestibulo-ocular reflex (VOR) assessment. We sought to compare the accuracy of HINTS to a risk stratification tool (ABCD2) in an unselected population of AVS patients presenting to the ED using delayed magnetic resonance imaging (MRI) with diffusion weighted images (DWI) to define stroke.

Methods: Prospective two year study of AVS (defined as acute, persistent vertigo lasting > 24 h with nystagmus, and nausea/vomiting, head motion intolerance, or new gait unsteadiness) at a single academic center. All patients underwent admission, neurootologic examination, neuroimaging and

follow-up. Eye movements were recorded by video-oculography and quantitative testing of the VOR by video HIT. The accuracy of HINTS was compared with ABCD2 risk scores to predict stroke using sensitivity, specificity and positive and negative likelihood ratios.

Results: Data collection runs until april 2018, and data processing has started. As of November 2017, n=175 patients had been included in the study, of which n= 21 (12%) had a cerebrovascular cause. We will further present the accuracy of HINTS in predicting cerebrovascular cause and compare this with ABCD2.

Conclusions: The patient management algorithm has performed well and data collection, including the video frenzel and vHIT systems, have worked well during the study period. Frequencies of cerebrovascular causes of AVS are as expected.

PP2-89 - Transient vertigo preceding vestibular neuritis

21. Vascular Vertigo

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Purpose: Transient vertigo may precede vestibular neuritis (VN), suggestive of TIA. We aimed to compare VN patients with and without transient premonitory vertigo to explore an age difference or VOR gain reduction difference between the two groups.

Methods: Consecutive patients with VN with onset in the previous 48 hours were enrolled. Following a detailed history and examination ICS Impulse video oculography (GN Otometrics) was performed.

Results: Amongst 32 patients with VN four had transient vertigo preceding. One man had two episodes lasting a few minutes in the preceding 30 days, and two more brief attacks on the day of presentation. Another had a single 30 minute episode four days before presentation. One had two attacks up to 10 seconds duration, one while riding a bicycle 4

days before VN. One woman had three brief attacks in the week prior to VN. The mean age was 49 (range 33-68), v mean age 63 (NS) for the remainder (range 33-88). None of the men had vascular risk factors. The mean VOR gain on the affected side was 0.52 v 0.65 (NS) in those without transient premonitory symptoms. All had normal brain MRI.

Conclusions: Transient premonitory vertigo may precede an attack of presumed VN by several days or more. More than one attack can occur. Transient premonitory vertigo may not be TIA, and may support a viral rather than a vascular mechanism for the acute vestibular syndrome. Greater numbers of patients will need to be recruited to explore this possibility further.

PP2-90 - A novel study on the relationship between dizziness or vertigo symptoms and nystagmus intensity

22. Vestibular and Inner Ear Physiology

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Purpose: To explore the vestibule mechanism of dizziness and vertigo, defined and classified as the vestibule symptoms by ICVD.

Methods: 30 patients with peripheral vestibule disease accepted the caloric test, the change of the slow phase velocity (SPV) of nystagmus and recorded SPV threshold peak value induced dizziness or vertigo, and calculate the UW value were recorded. Comparing the SPV value of dizziness and vertigo occurred in patients under different conditions of caloric test (cold and hot air stimulation for each ear).

Results: The SPV values of patients with vertigo were higher than those of the dizziness. Among all the 30 patients, 19 had normal UW values and 11 cases were abnormal. There was no significant difference in the SPV peak value between the normal group and the abnormal group. There was no significant difference in the SPV value between the two groups when there was dizziness or vertigo.

Conclusions: Dizziness and vertigo have the same mechanism, which depend on the different intensity of vestibular stimulation.

PP2-91 - Efficiency of non-invasive cooling of the vestibular system

22. Vestibular and Inner Ear Physiology

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Purpose: To investigate the efficiency of non-invasive cooling of the vestibular system.

Methods: Two cadaveric temporal bones were implanted with thermocouplers at the external auditory canal (EAC), middle ear, lateral semicircular canal (LSCC) and cochlea. Good thermocoupler position was confirmed with thin-slice temporal bone CT. The temperature measurements were performed on each temporal bone when subjected to standardized temperature modulated irrigant instilled at the level of the EAC and middle ear, respectively. Air and water were used as irrigants.

Results: The temperature variation at the LSCC exhibited a linear change prior to reaching steady state. Both air and water irrigation succeeded in cooling of LSCC, with water irrigation resulting in a more efficacious temperature transfer. Direct water irrigation of the middle ear led to a more prominent temperature change compared with irrigation at the level of the EAC. Both air flow rate and input temperature showed positive correlation with degree of temperature change of the LSCC.

Conclusions: The results of this study demonstrate the efficiency of labyrinthine cooling with water or air irrigation of the external canal (EAC) or middle

ear. Previous studies have demonstrated an anti-inflammatory effect of mild hypothermia after traumatic, toxic and ischemic organ injury. Future studies may evaluate for potential neuroprotective cooling in Meniere's disease, labyrinthitis and other labyrinthine diseases.

PP2-92 - Impact of visual stimuli on cervical vestibular evoked myogenic potentials (cVEMPs)

22. Vestibular and Inner Ear Physiology

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Purpose: cervical vestibular evoked myogenic potentials (cVEMPs) represent a measure of vestibulocollic reflex output, however little is known about how this reflex is modulated by other sensory inputs. Here we aimed to assess the impact of a simple, simultaneously presented visual stimulus on the Sternocleidomastoid (SCM) and Splenius Capitis (SPL) cVEMPs in healthy young individuals.

Methods: All procedures were done with approval from the University of Sydney Human Ethics committee. 23 healthy subjects were simultaneously exposed to a loud 4 ms, 500 Hz tone burst and one of five different visual motion conditions (vertical and horizontal drifting sinusoidal gratings; 4 cycles/degree spatial frequency. 1 cycle/degree temporal frequency). cVEMPs were measured from the SCM and SPL muscles using surface electromyography.

Results: cVEMPs were reliably recorded in both muscles during sound and visual stimulation. In general SPL cVEMPs across all conditions had shorter latencies to p13, with significant differences observed between SCM and SPL for vertical gratings drifting left and horizontal gratings drifting up ($p < 0.05$ for both). Similarly, SPL cVEMP amplitude was smaller for all visual motion conditions and reached significance for vertical gratings drifting left and horizontal gratings drifting down ($p < 0.05$ for both). Visual stimuli did not alter the incidence of cVEMPs with both muscles showing present cVEMPs in more than 80% of trials.

Conclusions: These data suggest that the addition of a visual stimuli does not alter the vestibulocollic reflex overtly. The subtle changes observed here may be further unmasked with more optimized visual stimuli.

PP2-93 - Is there any difference between clockwise and counter clockwise dynamic subjective visual vertical?

22. Vestibular and Inner Ear Physiology

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Purpose: Analysis of dynamic unilateral centrifugation subjective visual vertical(SVV) deviations from normal young volunteers to understand the physiological characteristics of utricle.

Methods: In this study,39 young volunteers participated in SVV test and dynamic unilateral centrifugation SVV test with Neuro Kinetics Inc I-portal Video nystagmus recording system and NOTC rotating chair system.Rotate vertical axis at 300 deg/sec until horizontal canal VOR response subsides.Then linear translated to the right 3.85 cm.Then to center axis and then linier translated to the left 3.85 cm. Subjects stay at each position for 1 minutes and each one needs two dynamic SVV tests: counterclockwise rotation firstly and then clockwise rotation.The interval between the two rotation tests is 5 minutesWe record SVV data from three position and parameters such as mean value, standard deviation and so on will be calculated.

Results: There is no significant difference of SVV deviation between volunteers motionless and in the center position on rotating chair.In the process of counterclockwise rotation, there are statistical differences between the three positions in the left, middle and right positions of the SVV.The value is minimal at the right side, and the middle and left positions are increasing gradually.But in clockwise rotation, there is no statistical difference between the three positions.

Conclusions: The chair moves to the right, the right utricle responds right utricle is stimulated by Gravity Inertial Acceleration (GIA) forces. When the chair moves to the left the left utricle responds. But this rule appears only during the first counter clockwise rotation.

PP2-94 - Pulsed infrared vestibular stimulation: evoked eye movement and cardiovascular responses

22. Vestibular and Inner Ear Physiology

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Purpose: Over the last decade, a number of new techniques have been developed utilizing light to trigger neural activity that may overcome limitations of contemporary techniques used to probe and control neural function. With the present study, we demonstrate potential applications of pulsed infrared stimulation focused on the vestibular endorgans.

Methods: In a rat model, a surgical approach was developed to target pulsed infrared at individual semicircular canals and/or otolith organs. We measured evoked bilateral eye movements as a measure of activation of vestibulo-ocular reflex and changes in blood pressure and heart rate as a measure of activation of the vestibulo-sympathetic reflex pathways.

Results: The activation of vestibulo-ocular motor pathways by infrared stimulation targeted either at the vertical semicircular canals or utricular macula evoked significant, characteristic bilateral eye movements which remained consistent through several hours of repeated stimulation. These physiological responses could be maintained with 30+ minutes of continuous, frequency-modulated infrared stimulation. Simultaneously, we observed significant changes in blood pressure and heart rate with low frequency sinusoidal pulsed infrared activation of the posterior canal, whereas stimulation of utricular

macula did not result in similar responses. The infrared activation of specific endorgans was reflected in the number and location of the central vestibular neurons and confirmed with micro-CT imaging of the inner ear.

Conclusions: Our results demonstrate a novel strategy for direct optical stimulation of the vestibular pathway in rodents and lays the groundwork for future applications of optical neural stimulation in inner ear research and therapeutic applications. Funding: R01 DC01379801, R01 DC008846.

PP2-95 - The Activity of Vestibular Purkinje Cells is Attenuated During Self-Generated Head Movements

22. Vestibular and Inner Ear Physiology

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Purpose: The cerebellum, a structure that is well-conserved across vertebrates, has been suggested to drive sensory-prediction error-based motor learning. Neurons in the most medial of the deep cerebellar nuclei - the rostral fastigial nucleus (rFN) - are significantly more sensitive to passively-applied compared to self-generated head movements. Further, during motor learning, the sensitivity of rFN neurons is modulated in a manner consistent with the computation of vestibular sensory prediction error. Here, to investigate the neuronal basis of these computations, we recorded from Purkinje cells, which project to the rFN neurons.

Methods: Single unit extracellular recording were made from Purkinje cells in the cerebellar cortex (Nodulus/Uvula) from rhesus monkeys, during active and passive head movements. Simple and complex spikes from Purkinje cells were detected via an automated clustering algorithm and sensitivity of each neuron to the head movement was computed using linear regression method.

Results: Analysis of neuronal responses during passive motion first revealed robust simple spike responses to head motion that were either bi or unidirectional. In comparison, simple spike

responses during comparable active head motion were markedly attenuated. Moreover, analysis of the complex spike activity during passive and active head movement conditions showed the complex spikes are phase-locked with the onset of passive head movement, while fewer complex spikes were present during active head movements and phase locking was less evident.

Conclusions: Taken together, we conclude that the simple and complex spike responses of Purkinje cells are less robust during active than passive head movements.

PP2-96 - Case study: benefits of integrated vestibular rehabilitation in neurosarcoidosis

23. Vestibular Compensation and Rehabilitation

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Purpose: To describe quantitative and qualitative effects of vestibular, oculomotor and timing exercises in a 46-year-old female diagnosed with neurosarcoidosis. Initially, she was hospitalized with function loss including left-sided hemiparesis, facial and oculomotor paralysis. High dosages of prednisone quickly reversed these findings. Three months later she still suffered from inability to walk stairs unassisted, to balance on her left leg or to make quick turns while walking despite extensive physiotherapy.

Methods: Neurological evaluation demonstrated severe balance issues. Oculomotor evaluation (videonystagmography) demonstrated saccadic intrusions on smooth pursuit testing. Saccadometric evaluation demonstrated biphasic velocity curves. Timing and coordination capacity were severely reduced for the left lower extremity. Based on these findings a specific vestibular, oculomotor and timing training (Interactive Metronome) program was developed and administered in clinic and as home exercises.

Results: Saccadometric findings normalized completely. Timing and coordination errors reduced by 75 % for the left leg, and balance performance strongly improved. Within 4 sessions she was able to balance on a perturbed surface with her eyes closed

and within two months of care she was able to walk the stairs unassisted and she returned to horseback riding and part-time work.

Conclusions: Residual brainstem symptoms post-neurosarcoidosis strongly improved after a specific training program implementing vestibular oculomotor and timing training and improved quality of living and ease of performing activities of daily living.

PP2-97 - Case study: Reduction of intercranial hypertension-induced vestibular symptoms

23. Vestibular Compensation and Rehabilitation

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Purpose: To describe the benefits of vestibular and sensorimotor rehabilitation for a 28-year-old female patient with idiopathic intracranial hypertension suffering from severe unsteadiness. She used acetazolamide to reduce the increased pressure. Even though pressure subsided to near normal levels her symptoms persisted, and she had to use a walker for walking and suffered from double vision and subjective sensory changes for five months.

Methods: Based on a comprehensive neurological evaluation a working hypothesis of diminished vestibular-proprioceptive-oculomotor integration with resulting coordination and timing issues and distorted awareness of body in space relationships was established. Vestibular findings were semi-circular canal specific in the LARP diagonal. A tailor-made vestibular and sensorimotor rehabilitation program was implemented including gaze stability exercises, hemisphere specific saccade-pursuit training, vergence training en coordination and timing training using Interactive Metronome®.

Results: The patient was trained for 6 full days within a 10-day time frame and left the clinic being able to walk without assistance. She continued with home exercises for the next three months after which she was able to return to work, sports and driving.

Conclusions: Intracranial hypertension can give rise to vestibular and visual symptoms without explicit

pathology. The dysfunctional integration of vestibular, visual and proprioceptive signalling can be addressed by reweighting and training of these three sensory systems and their central integration leading to resolution of symptoms.

PP2-98 - Case study: Resolution of centrally maintained vestibular symptoms secondary to BBPV

23. Vestibular Compensation and Rehabilitation

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Purpose: To describe the effects of vestibular rehabilitation exercises for resolution of BPPV symptoms unresponsive to Epley's manoeuvres. This case study describes positive effects of vestibular rehabilitation strategies in a patient with persistent positional vertigo for 1 year.

Methods: Prior to presentation this patient was diagnosed with BPPV by his ENT specialist. Epley's manoeuvre was performed and Dix Hallpike testing post repositioning was negative. However, symptoms did not resolve. Pathology was excluded based on CT-scan, bloodwork, CSF evaluation, ECG and urine testing.

Bedside vestibular and oculomotor evaluation were performed as well as a videonystagmography evaluation. Vestibular rehabilitation exercises to recalibrate and reweight vestibular input with proprioception and vision were provided both in clinic and as home exercises.

Results: Videonystagmography showed persistent left beating nystagmus in dark when head was in right posterior canal position. This is opposite to the nystagmus expected for right posterior canal positioning according to Ewald's second law. Anterior and horizontal canal positioning did not result in nystagmus. This finding was interpreted as central compensation for initial peripheral vestibular pathology. After two sessions of vestibular and gaze stability exercises specific for the right posterior canal position symptoms resolved completely and videonystagmography findings were normal.

Conclusions: Positional vertigo in the direction of a specific semi-circular canal in which the direction of nystagmus is opposite to what is expected might be due to central vestibular compensation for initial BPPV. Targeted vestibular rehabilitation strategies might address this central compensation and provide a tool for recalibration of centrally maintained vestibular symptoms.

PP2-99 - Do sinusoidal gaze stabilising exercises result in adaptation of the transient (head impulse) VOR?

23. Vestibular Compensation and Rehabilitation

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Purpose: The vestibulo-ocular reflex (VOR) maintains stable vision during rapid transient head rotations. Vestibular rehabilitation includes active head rotation gaze stabilising exercises to improve postural control and possibly VOR adaptation. Currently, these consist of sinusoidal head rotations while looking at a space-fixed target. We sought to determine whether sinusoidal training leads to changes in the transient VOR.

Methods: We tested 6 normal subjects over 2 sessions. For protocol 1, subjects performed sinusoidal head rotations at 1.3 Hz while tracking a laser target whose velocity incrementally increased relative to head velocity so that the VOR gain (eye/head velocity) required to stabilise the target went from 1 to 2 over 15 minutes. For protocol 2, head rotation frequency incrementally increased from 0.5 to 2 Hz over 15 minutes, while the VOR gain required to stabilise the target was fixed at 2. We measured the active and passive, transient and sinusoidal (1.3Hz), VOR gains before and after each protocol.

Results: Sinusoidal and transient VOR gains increased due to the training, however, the sinusoidal gain increase was significantly larger (18.1%±2.3 vs 9.7%±1.4, P<0.0001). Protocol 1 training

affected the active VOR more than the passive, whereas protocol 2 affected both (interaction, $P < 0.03$). The transient VOR increase was smaller than in studies where the training consisted of head impulses (16.2% \pm 5.3) rather than sinusoidal rotations.

Conclusions: Sinusoidal adaptation training is not as optimal as head impulse training to increase the VOR during rapid head movements where its function is most important.

PP2-100 - Efficacy of vestibular rehabilitation exercises in acute unilateral peripheral vestibulopathy

23. Vestibular Compensation and Rehabilitation

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Purpose: The proper rehabilitation protocol for acute unilateral peripheral vestibulopathy (aUPV) has not been fully established to date. The objective of this study is to evaluate the effectiveness of 3 different vestibular rehabilitation exercises in patients with aUPV.

Methods: A prospective, randomized controlled study was conducted on 20 patients with vestibular neuritis and 3 patients of labyrinthitis. They were randomly assigned to a customized exercise (n=11), Cawthorn-Cooksey exercise (n=6) or simple VOR adaptation exercise (n=6) group. Balance performance and subjective disability were assessed with clinical and objective measurements before and after 4 weeks of training.

Results: Balance performance and subjective disability scores were significantly improved in all three exercise groups ($p < 0.05$). However, there was no significant difference in the therapeutic effect among three exercise groups in terms of post-treatment values ($p > 0.05$).

Conclusions: Customized and generic programs were equally effective in the improvement of

dizziness and balance performance in short term follow up period in aUPV.

PP2-101 - HTC Vive to improve balance and dizziness in unilateral peripheral hypofunction: 2 case reports

23. Vestibular Compensation and Rehabilitation

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Purpose: Patients with vestibular dysfunction typically complain of dizziness and imbalance in busy and complex environments. We created a clinical app using the HTC Vive headset to provide a graded way for patients to experience these environments in a functional context and a safe manner. We describe the application of this novel intervention in 2 patients with unilateral peripheral vestibular hypofunction.

Methods: Within our app, patients explore a virtual street, airport or subway. The clinician controls direction, amount and speed of virtual people (5 levels each, starting empty). Two patients ages 72 and 75 performed 8 individualized sessions using the app, 5-7 scenes per session. Level of difficulty was gradually increased by: visual complexity, task duration (60-120 seconds) and movement (gait, head turns etc.). Progression was guided by symptoms.

Results: From baseline to post-intervention, Functional Gait Analysis improved from 20 to 26 (patient 1) and 17 to 20 (patient 2). Four Step Square Test has not changed for patient 1 (9 seconds) but improved from 15 to 8 seconds in patient 2. Both patients improved their Activities-Specific Balance Confidence (52% to 70% and 41% to 59%); their Visual Vertigo Analog Scale (284mm to 211mm and 640mm to 234mm) and their State (S) / Trait (T) Anxiety (from 46(S)/37(T) to 22(S)/27(T) and from 32(S)/25(T) to 21(S)/21(T)).

Conclusions: Our Vive app enables patients to engage in safe yet challenging environments that are not easily reproducible in traditional rehabilitation.

Using this platform could improve balance and reduce anxiety in patients with vestibular hypofunction, especially in busy environments.

PP2-102 - Impact of Vestibular Rehabilitation on Patients with Chronic Vestibular Hypofunction

23. Vestibular Compensation and Rehabilitation

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Purpose: The goal of the study was to show the impact of vestibular rehabilitation in patients with chronic unilateral vestibular hypofunction (CUVH) and bilateral vestibular hypofunction (BVH) on reducing the symptoms and reducing the risk of falling.

Methods: In this study, we analysed the data of 30 patients with CUVH and 20 with BVH treated with vestibular rehabilitation. Inclusion criteria were as follows: symptoms persisting more than three months, the bi-caloric tests results showing the uncompensated weakness of one or both labyrinths, with Dizziness Handicap Inventory (DHI) ≥ 40 and the Activities-specific Balance Confidence (ABC) Scale $\leq 66\%$. Adaptational, substitutional and habituation exercises were customised to CUVH patients, while BVH patients performed substitution and adaptation exercises.

Results: In both groups of patients, there was significantly less disablement as a result of the disease between the initial and final DHI scores (from 59-20 in CUVH and 74-41 in BVH group). There was a significant increase in the balance confidence between the initial and final ABC Scale in both groups of patients (from 49,5-90% in CUVH and 42-73% in BVH group).

Conclusions: Both patient groups demonstrated a significantly better result in the DHI and ABC scores after vestibular rehabilitation. The results of ABC

were inferior, and the treatment duration was longer in the BVH group. According to the state of impairment, disability and functional performance, physiotherapist performed carefully selected and individually tailored exercises. Responsible implementation of vestibular rehabilitation can lead to significant results in the treatment of patients with CUVH and BVH.

PP2-103 - Is Static Acuity Pre-requisite for Dynamic Visual Acuity: Case Series Failed Vestibular Rehab

23. Vestibular Compensation and Rehabilitation

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Purpose: To describe the impact of unrecognized pre-existing ocular misalignment of 3 patients with acquired unilateral peripheral vestibular deficits who underwent a course of vestibular rehabilitation resulting in partial resolution of oscillopsia.

Methods: A retrospective case series of 3 patients diagnosed with unilateral peripheral vestibular hypofunction or post-concussion dizziness, who were unsuccessfully treated with gaze stability exercises, and then referred to out patient vestibular rehabilitation clinic. Two complained of a pre-existing vertical diplopia, 1 gaze right and the other with gaze up and towards left. The cover-uncover test was performed in the 9 diagnostic positions of gaze with neutralization of deviation with prism bars. The Park's 3 step test was performed to identify isolated cranial nerve palsies. All received vision therapy prior to 2nd episode of vestibular rehabilitation.

Results: All patients had a pre-existing tropia or phoria. Neutralization of deviation in 1 patient in the gaze right position was 8 diopter base up and the other patient in the gaze up and left position was 8 diopters base up. The third patient had an 12 diopter right exophoria. Following vision therapy and vestibular rehabilitation, all were able to maintain a stable gaze at minimal to moderate frequencies of head movements. None were able to maintain a stable gaze at high frequency.

Conclusions: Pre-existing ocular misalignment may be associated with failure to compensate for a new vestibular hypofunction. Static visual acuity should be optimized prior to gaze stability exercises.

PP2-104 - Manifestation and Prognostic Factors of Dizziness due to Long-Term Use of Vestibular Suppressant

23. Vestibular Compensation and Rehabilitation

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Purpose: The objective of this study was to investigate the clinical manifestation and prognostic factors of long term use of vestibular suppressants which elicit various atypical vestibular symptoms.

Methods: Serial follow up of 32 patients who were diagnosed as vestibular suppressant drug associated dizziness (DAD) was performed. The numeric rating scale (NRS) on dizziness symptom, vestibular function test outcome, compliance to treatment, and prognosis were evaluated. The duration of illness was 44.4 ± 47.3 months and the duration of vestibular suppressant drug intake was 20.0 ± 20.9 months. The prognosis was categorized as good (improvement in $NRS \geq 50\%$) or unsatisfactory (improvement in $NRS < 50\%$).

Results: Most of the patients (65.6%) complained of spinning vertigo. The severity of the DAD symptom was dependent on the preceding vestibular disorder: it was most severe when the preceding vestibular disorder was vestibular neuritis. Unilateral vestibulopathy was identified in 42.9-52.0%, regardless of which vestibular function test was performed. Atypical vestibular function test findings that cannot be fully explained by known vestibular disorders were frequently found: direction changing positional nystagmus (25.0%), direction changing VIN (9.4%), and HIT corrective saccades that did not correlate with caloric test (22.2-42.9%). Old age, non-compliance to VRT, and vestibular neuritis as the preceding vestibular disorder were bad prognostic factors.

Conclusions: Frequent atypical vestibular function test findings in DAD should not be confused for

central signs. Vestibular neuritis as the preceding cause of DAD and old age may hamper the recovery, due to combined peripheral and central deficit. But active vestibular rehabilitation may be an effective solution.

PP2-105 - Noisy galvanic stimulation improves vestibular perception

23. Vestibular Compensation and Rehabilitation

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Purpose: Noise can enhance information processing in sensory systems via stochastic resonance. It has recently been demonstrated that noisy galvanic vestibular stimulation (nGVS) improves balance control in healthy subjects and in patients with bilateral vestibular hypofunction, both during standing and during walking. It affects vestibulospinal reflex thresholds. It is not known whether there is a simultaneous enhancement of vestibular perception.

Methods: Fifteen healthy subjects (mean age 25.1 ± 1.7 years) performed quiet-stance tasks on foam with eyes closed at eight different nGVS amplitudes ranging from 0 mA (baseline) to 0.5 mA. The nGVS amplitude that improved balance performance most compared to baseline was assigned as the optimal nGVS amplitude. The effect of nGVS delivered at the determined optimal intensity on perception was examined using direction-recognition tasks on a motion-platform, testing roll rotations and translations at 0.2, 0.5 and 1.0Hz.

Results: nGVS significantly reduced direction recognition thresholds compared to the sham condition at 0.5Hz (ANOVA $p=0.045$; $F=5.006$; mean threshold reduction: $14.1 \pm 0.5\%$) and 1.0Hz (ANOVA $p=0.013$; $F=8.455$; mean threshold reduction: $20.1 \pm 0.5\%$). No correlation was found between nGVS-induced improvements in balance control and vestibular motion perception at 0.5 and 1Hz, which may suggest different mechanisms by which nGVS affects both modalities.

Conclusions: We show that nGVS can enhance vestibular motion perception. The outcomes of this study

are likely to be relevant for the potential therapeutic use of nGVS in patients with balance problems.

PP2-106 - Pediatric vestibular rehabilitation: A case study

23. Vestibular Compensation and Rehabilitation

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Purpose: A nine-year-old child with a 9-month history of complaints of dizziness, headache, and motion sensitivity presented to physical therapy. The patient complained of difficulties playing on a playground, running, being a passenger in a car, watching “action movies”, sitting under fluorescent lights, and making quick head movements.

Methods: An initial evaluation consisting of a clinical oculomotor exam, vergence testing, static and dynamic visual acuity testing, head impulse testing, subjective visual vertical, balance testing, functional reach, the pediatric vestibular symptom questionnaire (PVSQ), the Dizziness Handicap Inventory-patient caregivers version (DHI-PC) and a visual vertigo analog scale (VVAS). The use of virtual reality with x-box games, adaptation, habituation and balance exercises were prescribed. She was seen once/week and was told to perform her exercises 2-3 time a day.

Results: After 10 sessions (approximately 11 weeks) she reported that playing was easier, headaches had reduced, she could travel as a passenger in a car in long distances without complaints and that she could watch 3-D action movies without symptoms. Her PVSQ scores had reduced from 0.7 to 0.1 and her VVAS scores were improved. The DHI-PC has decreased from 22 to 12 points .

Conclusions: Vestibular rehabilitation improved this child’s quality of the life. She was able to return to her daily living activities with less symptoms.

PP2-107 - Prognosis after Acute Unilateral Vestibulopathy: the importance of video Head Impulse Test.

23. Vestibular Compensation and Rehabilitation

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Purpose: To describe the relationships among the main instrumental features characterizing an acute unilateral vestibulopathy and to clarify the role of the video head impulse test in predicting the development of chronic vestibular insufficiency.

Methods: Sixty patients suffering from acute unilateral vestibulopathy were retrospectively analyzed: 30 who recovered spontaneously (group 1) and 30 who needed a vestibular rehabilitation program (group 2). The main outcome measures included Dizziness Handicap Inventory score, canal paresis, high-velocity vestibulo-oculomotor reflex gain, and catch-up saccade parameters. The tests were all performed between 4 and 8 weeks from the onset of symptoms.

Results: The high-velocity vestibulo-oculomotor reflex gain correlated with the Dizziness Handicap Inventory score ($P = .004$), with the amplitude of covert and overt saccades ($P \leq .001$), and with the prevalence of overt saccades ($P \leq .001$). Patients in need for vestibular rehabilitation programs had a significantly lower gain ($P \leq .001$) and a higher prevalence and amplitude of overt saccades ($P = .002$ and $P = .008$, respectively). Conversely, we found no differences in terms of response to the caloric test ($P = .359$).

Conclusions: Lower values of high-velocity vestibulo-oculomotor reflex gain and a high prevalence of overt saccades are related to a worse prognosis after acute unilateral vestibulopathy. This is of great interest to clinicians in identifying which patients are less likely to recover and more likely to need a vestibular rehabilitation program.

PP2-108 - Smartphone-based Virtual Reality Vestibular Therapy App for Motion Sickness

23. Vestibular Compensation and Rehabilitation

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Purpose: Demonstrate the clinical effectiveness of virtual reality (VR) vestibular therapy delivered via a portable VR smartphone-based application (app) for motion sickness.

Methods: Four subjects who suffered from motion sickness were enrolled in a pilot study of the researcher-developed VR smartphone-based app. Subjects were asked to complete thirty VR vestibular therapy sessions over a six week time period. The primary outcome measure was a change in the Dizziness Handicap Index (DHI) score to determine the improvement in motion sickness symptoms. Vestibular therapy compliance data was automatically recorded via a backend SQL database.

Results: Three of the four subjects had a >15 point DHI score reduction (19-28), indicating a clinically significant improvement. One subject had a 12 point improvement in DHI. The database-generated compliance data were examined. Three of the four subjects participated in fewer sessions than originally directed (10-32). The subject who did not show a clinically significant change in DHI completed the fewest number of sessions (10).

Conclusions: VR vestibular therapy via smartphone-based app resulted in DHI score improvement for all users. There was poor compliance with the recommended number of sessions. The portable smartphone-based app has exciting potential for cost-effective therapies that can be widely distributed. The automatic data collection facilitates analysis for research and therapeutic purposes.

PP2-109 - Subsensory Neuromodulation Improves Vestibular Function in Bilateral or Unilateral Hypofunction

23. Vestibular Compensation and Rehabilitation

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Purpose: Loss of vestibular function can be debilitating and greatly affect quality of life. Our group has been developing a novel subsensory neuromodulation device to enhance vestibular function and balance. The goal of the current work was to determine if this stimulus would be effective in patients with either bilateral or unilateral vestibular hypofunction.

Methods: We measured static sway while standing on a force plate for 30 sec trials, either with eyes open or closed. During the trials we provided low levels of random bilateral electrical current to the ear lobes (mean 0 with SD<0.2 mA) to enhance vestibular function based on the principle of stochastic resonance. Three trials of sham and stim in each condition were performed. Patients were unable to feel the stimulus.

Results: While all patients were able to maintain balance well with eyes open on firm surface, upon closing their eyes there was a significant increase in sway in the bilateral (+1326%) and the two unilateral patients (+560% & +56%), as was expected since the patients have no or reduced vestibular inputs and therefore must rely on visual inputs. During stim trials the sway area reduced in all the patients with the greatest reduction in the bilateral (-53%) compared to the unilateral patients (-29% & -8%).

Conclusions: The decrease in sway in all the patients during the eyes closed trial indicates that the device was effective in enhancing balance, presumably through vestibular mechanisms. This initial work supports the concept of using neuromodulation as a treatment for vestibular loss.

PP2-110 - The effect of consolidation on human vestibulo-ocular reflex adaptation and retention.

23. Vestibular Compensation and Rehabilitation

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Purpose: The vestibulo-ocular reflex (VOR) is the main gaze stabilising system during rapid head movements. The VOR is highly plastic and its gain (eye / head velocity) can be increased via training that induces an incrementally increasing retinal image slip error signal to drive VOR adaptation. The unilateral incremental adaptation technique typically consists of one 15 minute training block. We sought to determine if separating the training into 3x5 minute blocks with 20 minutes in between, as generally recommended for other vestibular exercises, would result in consolidation leading to improved VOR adaptation and retention.

Methods: We tested 11 normal subjects, each over 6 separate sessions/days. We tested three different 5 minute training protocols. For each training protocol, we measured the active and passive VOR gains before and after: 3x5 minute training with 20 minute consolidation breaks, and 5 minutes of training only. For training with consolidation breaks, we measured retention of the VOR gain over one hour and compared results to a prior retention study.

Results: VOR gain adaptation with 1x5 minutes training was approximately one third of that observed after 3x5 minutes training, suggesting that consolidation does not affect VOR gain adaptation, i.e., there was no synergistic affect. Retention was also unaffected by the addition of the consolidation break between exercises.

Conclusions: These data have implications for vestibular rehabilitation, suggesting that optimal VOR adaptation exercises can be performed in one continuous or separated in time blocks.

PP2-111 - The role of physiotherapy in managing vestibular migraine: A critical literature review

23. Vestibular Compensation and Rehabilitation

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Purpose: Is there research supporting the use of physiotherapy in managing individuals with vestibular migraine?

Methods: A literature review of published papers in EMBASE, PEDro and Cochrane Databases between 1990 and 2017. Quality of the identified papers was assessed using the Jadad scale and PEDro scale. The studies utilised a range of heterogeneous outcome measures such as balance, gait, visual analogue scale (VAS) for pain intensity and the Dizziness Handicap Inventory.

Results: The search yielded four studies of poor quality and two case studies. Studies consisted of research evaluating the benefits of vestibular rehabilitation therapy in individuals with vestibular migraine and migrainous associated vertigo. Therapy typically consisted of gaze stability, habituation, balance and gait exercise programs delivered by a physical therapist. These treatment programs were found to be safe and moderately effective in managing vestibular migraine associated impairments such as dizziness, balance and gait disturbances. There was insufficient evidence to suggest any benefit of treatment on migraine pain intensity. Manual therapy to the cervical spine was recommended if there was any concurrent neck pain identified, however there was no quantitative data to support this.

Conclusions: From the limited number of high quality studies conducted, this review supports the existing body of evidence that vestibular rehabilitation delivered by a physiotherapist maybe an efficacious modality in managing the associated impairments of vestibular migraine. However, studies have not investigated if these interventions can reduce the frequency or severity of migrainous episodes or if manual therapy to the cervical spine may improve outcomes.

PP2-112 - Therapy of impaired upright body orientation using a 3D device

23. Vestibular Compensation and Rehabilitation

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Purpose: Pusher behavior is a disorder of verticality perception and impairs postural control. Patients actively shift their center of gravity towards the paretic body side and resist passive correction. They orient the body toward a disturbed inner reference of verticality. Pusher behavior hampers the rehabilitation process and prolongs hospitalization. The aim of this pilot study was to investigate the effectiveness of verticality training with the Spacecurl device on pusher behavior and standing balance.

Methods: Stroke patients with pusher behavior were included (Burke Lateropulsion Scale = BLS ≥ 3). Patients trained three times within one week on the Spacecurl (each session 30 minutes). Before and after the intervention the BLS and the Subjective Postural Vertical (SPV) were tested.

Results: Four patients (median BLS 5, range 3-8) were included. All patients improved pusher behavior after intervention (mean BLS pre 6.5, post 4.5). In one patient pusher behavior ceased (BLS <3). At pretest, all patients showed an altered SPV in both the roll and the pitch plane. The SPV in roll was on average 2.1° tilted to the ipsilesional side. This deviation normalized after the intervention phase (mean 0.1°). Further, the baseline SPV was tilted backwards (mean -3.4°) and slightly improved after the interventions (mean -2.9°).

Conclusions: Therapy with the Spacecurl improves pusher behavior. The device provides a unique opportunity to experience the tilted body position in space without the risk to fall. Visual feedback can be used to correct a mismatch between perceived and actual body position. This is a promising approach for treatment of severe postural imbalance.

PP2-113 - Training time affects human vestibulo-ocular reflex adaptation.

23. Vestibular Compensation and Rehabilitation

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Purpose: The vestibulo-ocular reflex (VOR) is the main gaze stabilising system during rapid head movements. The VOR is highly plastic and its gain (eye / head velocity) can be increased via training that induces an incrementally increasing retinal image slip error signal to drive VOR adaptation. Using the unilateral incremental VOR adaptation technique and horizontal active head impulses as the vestibular stimulus, we sought to determine the factors important for VOR adaptation including: the total training time, ratio and number of head impulses to each side (adapting and non-adapting sides; the adapting side was pseudo-randomized to be left or right) and exposure time to the visual target during each head impulse.

Methods: We tested 11 normal subjects, each over 5 separate sessions and training protocols. Each protocol consisted of up to 15 minutes of unilateral incremental VOR adaptation training. The training protocols were designed so that the effect of each training factor on adaptation could be determined. The active and passive VOR gains were measured before and after training.

Results: Our data suggest that the total training time (5.7% \pm 3.8 vs 9.0% \pm 4.5, $P < 0.05$) and the visual target exposure time for each head impulse (16.2% \pm 5.3, $P < 0.005$) affected adaptation, whereas the total number and repetition rate of head impulses did not.

Conclusions: These data have implications for vestibular rehabilitation, suggesting that quality, i.e. eyes open throughout each head rotation with concentrated training towards the side with vestibular hypofunction, and duration of VOR adaptation exercises are more important than rapid repetition of exercises.

PP2-114 - Changes CGRP serological parameters in patients with vestibular migraine

24. Vestibular Migraine

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Purpose: Previous studies have shown that CGRP is associated with migraine. However, the relationship between CGRP and vestibular migraines remains unclear. Nearly zero detail studies of vestibular migraine with the patient's gender, age, hormone level, and cognitive decline are relevant. The purpose of this observational cohort study was to determine if serum CGRP could be a serological marker for patients with vestibular migraine.

Methods: The study was conducted from July 2017 to December 2017. Thirty cases of migraine headaches and 30 healthy controls in the First Affiliated Hospital of Harbin Medical University were selected as the study subjects. CGRP was measured by immunoturbidimetry. The severity of the subjective symptoms of dizziness was assessed by the DHI scale and VAS was used to assess the severity of the subjective symptoms of dizziness and dizziness. Subsequently, cognitive function was assessed using Addenbrooke's Cognitive Function Test Scale (ACE-R). Finally, possible predictors of migraine (vestibular) were evaluated by binary logistic regression analysis.

Results: It can be seen that vestibular migraine mostly female, the average age (40.6 ± 9.87) years old. The levels of plasma CGRP in patients with vestibular migraine were higher than those in normal subjects ($P < 0.05$).

Conclusions: First, the vestibular migraine is highly correlated with mid-menopausal women, and the serum CGRP in patients with vestibular migraine is significantly higher than that of the healthy controls. It is an important predictor of vestibular migraine. In addition, the cognitive level of patients with vestibular migraines was significantly reduced.

PP2-115 - Clinical characteristics of vestibular migraine based on Barany diagnostic criteria

24. Vestibular Migraine

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Purpose: To investigate clinical features of vestibular migraine (VM) based on Barany diagnostic criteria.

Methods: Baseline data of 50 patients with vestibular symptoms accompanied by migraine/migraine features were collected. Videonystagmography, including head shaking nystagmus (HSN) and caloric test, and immunological examination were performed.

Results: Among 50 patients, 29 (58.0%) VM and 6 (12.0%) probable VM. In VM the mean age of onset of vestibular symptoms was 39.4 years, while that of migraine was 34.8 years. Migraine occurred earlier than vestibular symptoms in 17 patients (58.6%). Vestibular symptoms presented spontaneous vertigo in 15 (51.7%), positional vertigo in 10 (34.5%), dizziness with nausea in 5 (17.2%), visually-induced vertigo in 1 (3.4%), postural symptoms in 5 (17.2%). The duration of vertigo attacks was less than 5 minutes in 3 (10.3%), 5 minutes~24 hours in 18 (62.0%), up to 24 hours in 8 (27.6%). Patients referred accompanying migraine features: headache (13/29, 44.8%), photophobia (24/29, 82.8%), phonophobia (23/29, 79.3%) and visual aura (11/29, 37.9%). The incidence of motion sickness was 58.6% (17/29). The positive-rate of HSN was 48.3% (14/29); Peripheral vestibule was damaged in 12 (41.4%). Severe autonomic nervous symptoms after caloric test appeared in 19 (65.5%). The abnormal-rate of immunology was 20.7% (6/29), positive-rate of thyroid antibodies was 83.3% (5/6).

Conclusions: The age of onset of migraines is earlier than vestibular symptoms in VM. Patients always have a history of motion sickness and severe autonomic nervous symptoms after caloric test. Many patients of VM may be accompanied by peripheral and systemic diseases, presumably there is a diagnosis of secondary/concomitant VM.

PP2-116 - Differences between patients who have vestibular migraine and those who migraine only

24. Vestibular Migraine

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Purpose: Our hypothesis is that there are differences between patients with vestibular migraine (MV) and those who have no vestibular symptoms i.e. – that is migraine headaches only (MO).

Methods: We evaluated 35 VM and 35 MO patients on the following: (a) Migraine Disability Assessment (MIDAS); (b) Allodynia Symptom Checklist (ASC-12), (c) Beck Depression Inventory (BDI); (d) State-Trait Anxiety Inventory (STAI); (e) Health anxiety inventory (HAI); (f) World Health Organization Quality of Life Questionnaire Short Form (WHOQL-SF12); (g) Activities Specific Balance Confidence scale (ABC). Dizziness Handicap Inventory (DHI) was assessed in only VM patients.

Results: In 22 VM patients the diagnosis migraine was first made during evaluation in our Balance Disorder Clinic. Specific food triggers were noted (for both headache or vertigo) by 8 VM patients but not by any of the MO patients. Of the VM patients 17/35 had headache with the vertigo. The onset headaches was later in life in VM than in MO patients (GIVE MEAN IN YEARS p:0.038). BDI was higher in VM whereas STAI was higher in MO. On the other hand, MIDAS, HAI, ASC-12 and WHOQL-SF12 were no different. ABC Scale was low and DHI showed moderate disability (highest in functional scale) in VM patients. MIDAS score and DHI- functional part were positively correlated.

Conclusions: Migraine diagnosis is often made only after consultation in a balance disorders clinic shows that neurootologist should always take a headache history. Certain food triggers for both headache and vertigo in VM patients attracts attention to allergy. DHI confirms the need for vestibular rehabilitation.

PP2-117 - Do the inflammatory factors contribute to the pathogenesis of vestibular migraine?

24. Vestibular Migraine

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Purpose: Vestibular migraine (VM) is an under-recognized entity with substantial burden for the individual and society. The underlying mechanism of VM and its distinction from other migraine mechanisms still remained unclear. Studies revealed that inflammatory pathways contribute to migraine. We aimed to investigate the possible role of inflammation in the pathophysiology of VM compared to migraineurs without history of vertigo-migraine only (MO) and healthy controls (HC).

Methods: We recruited 25 patients with MO and 32 with VM, diagnosed according to ICHD-3beta criteria and 26 sex- and age-matched HC. Blood samples could be obtained only from 12 patients during the attack, whereas the remaining samples were taken in headache-free periods. Plasma levels of CGRP, NKA, Substance P (SP), NLPR-1, NLPR-2, CASP-1, IL-1b, IL-6, IL-8, IL-10, TNF- α , IF- γ , NF κ B were measured with the commercial kits by following the manufacture's instructions.

Results: Inflammatory cytokines were found positively correlated with inflammasome pathway in

both VM and migraine groups. TNF- α and IL-6 were both suppressed in VM and MO while SP was reduced only in MO patients when compared to HC. Furthermore, inflammasome pathway factors were correlated with allodynia in patients with VM. Prophylactic treatment had no effect on cytokine levels.

Conclusions: Inflammatory cytokines were found positively correlated with inflammasome pathway in both VM and migraine groups. TNF- α and IL-6 were both suppressed in VM and MO while SP was reduced only in MO patients when compared to HC. Furthermore, inflammasome pathway factors were correlated with allodynia in patients with VM. Prophylactic treatment had no effect on cytokine levels.

PP2-118 - Is it possible to differentiate vestibular migraine from Meniere's disease neurophysiologically?

24. Vestibular Migraine

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Purpose: Meniere's disease (MD) and vestibular migraine (VM) are representative diseases presented with episodic vertigo attacks. Their clinical diagnoses basically depend on medical history. In this situation, objective tests which enable clinicians to differentiate two diseases using neurophysiological methods are required. For differential diagnosis of MD and VM, we studied tuning property of cervical vestibular evoked myogenic potentials (cVEMP) (Part 1) and habituation in auditory middle latency responses (MLR) (Part 2).

Methods: Subjects were patients with definite MD or VM. Part 1. To study tuning property of cVEMP, normalized cVEMP amplitudes (p13-n23) to 500Hz short tone bursts (STB) were compared with those to 1000Hz STB, 500-1000Hz cVEMP slope as an index of tuning property was calculated. Part 2. MLRs were recorded to assess habituation in MLRs. Totally, 800 responses were averaged. Recordings were divided into 4 sets according to the order of recording. Peak-to-peak amplitudes in MLR to the first 200

responses were compared with those to the 2nd, third and fourth 200 responses.

Results: Part 1. MD patients showed tendency of larger responses to 1000Hz STB than 500Hz STB although VM patients showed tendency of larger responses to 500Hz STB. Part 2. While MD patients showed reduction of Na-Pa amplitudes in the fourth set to amplitudes in the first set, VM patients rather showed augmentation of Na-Pa amplitudes in the fourth set.

Conclusions: Detection of tuning property shift using cVEMP tuning property test and detection of lack of habituation using auditory MLR might be neurophysiological methods of differentiation between MD and VM.

PP2-119 - Postural instability evoked by visual motion stimuli in patients with vestibular migraine

24. Vestibular Migraine

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Purpose: Patients with vestibular migraine are highly susceptible to motion sickness. It has been hypothesized that motion sickness occurs from instability in the control of the posture of the body or its segments. This study aimed to determine whether the severity of posture instability are related to the susceptibility to motion sickness.

Methods: This study enrolled 18 patients with vestibular migraine (16 women, age of 45.67 ± 12.55 years) who met the diagnostic criteria produced by a working group of the Barany Society. We used a visual motion paradigm with two conditions of the stimulated retinal field and the head posture to quantify postural stability while maintaining a static stance in healthy subjects and in patients with vestibular migraine. Sixteen healthy volunteers (10 women, age of 34.94 ± 10.29 years) served as the controls.

Results: In contrast to the controls, patients with vestibular migraine showed marked postural instability of the head and neck when visual stimuli were presented in the retinal periphery. However, the pseudo-Coriolis effect induced by head roll tilt was not responsible for the main differences in postural instability between patients and controls.

Conclusions: Patients with vestibular migraine had a higher visual dependency and low stability of the postural control system when maintaining quiet standing, which may be related to susceptibility to motion sickness.

PP2-120 - The differences of clinical characteristics between Vestibular migraine and Meniere's Disease

24. Vestibular Migraine

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Purpose: To distinguish VM from MD by comparing audiological and vestibular test results in patients with both.

Methods: 60 patients of VM group and 80 patients of MD group were studied. All the patients were tested with bithermal caloric test, vHIT and audiological test, some patients were tested with VEMP in acute or subacute phase.

Results: The sex ratio of VM and MD were 1:9.3 and 1:1.08. Family history of VM and MD patients were 66.67% and 7.5% respectively. Thirty-one percent of the VM patients in this study had abnormal bithermal caloric test findings, 88.33% abnormal vHIT, 50% abnormal cVEMP, 88.64% abnormal oVEMP. In the MD group, the abnormal rates of these four tests were 77.5%, 50%, 61.11% and 50% respectively. The difference of bithermal caloric test, vHIT, oVEMP between VM and MD was statistically significant, and the difference of cVEMP abnormal rate was not statistically significant. Sensorineural hearing loss was present in 63.3% of VM patients. Among them, the pattern of hearing loss was flat in 39.5% of patients, low frequency in 13.2% and high frequency in 47.4%.

Conclusions: In VM patients, there are more females than males, and sex ratio of the MD patients is basically the same. Compared with MD patients, there is an obvious family history of VM patients. Both VM and MD patients can have semicircular canal and otolith organ function abnormality. vHIT and oVEMP have higher abnormality rate in VM patients, and the bithermal caloric test has higher abnormality rate in MD patients. Both the VM patients and the MD patients have different levels of hearing loss. The hearing curve of VM is various and the hearing loss of high frequency is more serious.

PP2-121 - The Research of Cognitive Change and Imaging Features in patients with (vestibular) migraine

24. Vestibular Migraine

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Purpose: It has been demonstrated that the cognitive function changes of many patients has different performance in different regions of functional magnetic resonance imaging, the aim of this study was to examine the association between cognitive function changes in patients with migraine and migraine-associated vertigo and the corresponding functional magnetic resonance.

Methods: In total, 30 patients with migraine and migraine-associated vertigo were consecutively recruited. After admission, functional magnetic resonance imaging was performed. The ACE-R cognitive function scale was used to examine patients' cognitive function changes. A total of 10 healthy controls were also recruited and the cognitive function and functional magnetic resonance measurements were measured.

Results: 1. The metabolism of temporal-apex-island region and bilateral thalamic region in patients with vestibular migraine was more than normal people. The patient's vestibular thalamus - cortical pathway was activated, abnormalities of the thalamic functional area appeared after vestibular stimulation, and its intensity was positively correlated with the frequency of vestibular stimulation. 2. The resting fMRI study of patients with vestibular migraine during the episode showed a decrease in activation of cognitive-related occipital and frontal lobes (eg, hip-

pocampal areas responsible for spatial memory and navigation).³ Temporal gray matter volume, cingulate gyrus, dorsolateral forehead, insula, and occipital lobe cortex were all decreased in patients with vestibular migraines. All of these brain regions suggest that they are associated with cognitive decline in patients with vestibular migraine.

Conclusions: It was found that the change of cognitive function in patients with vestibular migraine was related to the functional magnetic resonance.

PP2-122 - Unique findings of video head impulse test during the ictal period of vestibular migraine

24. Vestibular Migraine

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Purpose: Vestibular migraine (VM) is a common disorder presenting recurrent episodes of vertigo and headache. There are several reports of clinical and neuro-otologic findings in VM.

Methods: A 40-year-old man with vestibular migraine visited the emergency department due to vertigo. He had nausea, vomiting and a slight imbalance, but had no auditory symptoms. His symptoms met the criteria of vestibular migraine according to the Barany Society's diagnostic criteria.

Results: He showed prominent spontaneous nystagmus with caloric canal paresis and vestibulo-ocular reflex deficit by rotatory chair test during the ictal period. In addition, a video head impulse test revealed "early acceleration and premature deceleration" during stimulation of the left posterior canal. The spontaneous nystagmus increased during leftward gaze and convergence, but decreased during rightward gaze. Positional maneuvers augmented the spontaneous nystagmus and induced a down-beating component during head bending while sitting. Two days after onset, his vertigo and the spontaneous nystagmus had disappeared, but he complained of migrainous headache lasting for 24

hours. On follow-up vHIT, the VOR gain and the peak velocity of "early acceleration and premature deceleration" were also improved.

Conclusions: Since unilateral HC dysfunction does not coexist with ipsilateral PC hyperactivity physiologically, the vHIT finding in our patient during the ictal period suggests that central and peripheral vestibular syndromes were present simultaneously. In summary, our vestibular migraine patient showed "early acceleration and premature deceleration" on vHIT during the ictal period. This response may be considered a subsidiary sign, suggesting central vestibular syndrome beyond the VOR deficits.

PP2-123 - Vestibular Migraineurs journey from symptom to diagnosis; long frustrating and often disappointing

24. Vestibular Migraine

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Purpose: To investigate Vestibular Migraineurs' experience with various healthcare professionals (HCPs) and to identify probable obstacles that once addressed, will improve patients' experience with HCPs.

Methods: Semi-structured interviews were conducted with 11 patients. Audio-recordings of the interviews were transcribed and analyzed using qualitative content analysis.

Results: Analysis resulted in six major themes; 1) Frustration by frequent misdiagnosis and numerous referrals 2) Dismissive behaviours and poor management by practitioners especially General Practitioners (GPs) 3) Patients assuming responsibility for their diagnosis/treatment due to scepticism

towards non-specialized practitioners' competency, 4) Satisfaction by Vestibular Specialists' (VSs) practice 5) Expectations from HCPs 5) Multi-faceted function of a formal diagnosis. The results indicated that most GPs either fail to recognize VM as a differential diagnosis of recurrent vertigo, lack the confidence to manage it or have uncertainty about which specialists to refer the patients to. The consequences are unnecessary lengthening of the patients' illness experience and increased burden on the health system.

Conclusions: We propose the following recommendations to address this issue: 1) improve practitioners' knowledge especially GP's on how to differentiate VM from other vestibular disorders via training courses. 2) Informing HCPs about Vestibular Specialists' scope of practice for more accurate referrals, 3) Provide online patient resources that will help HCPs to accurately evaluate the symptoms, help the patients ask the right questions from their doctor or choose their vestibular healthcare provider.

PP2-124 - VHIT in Vestibular migraine - Overt and covert saccades with increased gain.

24. Vestibular Migraine

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Purpose: Video Head Impulse Test (VHIT) was originally designed to help in the diagnosis of vestibular hypofunction. The application of VHIT in vestibular migraine patients is explored in our study.

Methods: 10 patients with clinical history consistent with Definite Vestibular Migraine according to the 2012 Consensus Diagnostic criteria agreed on by the Barany Society and International Headache Society were also investigated with VHIT and caloric.

Results: All patients underwent a thorough clinical examination including Halmagyi Head Thrust, post head shake nystagmus, Dynamic Visual Acuity, Romberg's test and Oculomotor evaluation. All patients had catch up saccades on Halmagyi Head Thrust either unilaterally or bilaterally and Dynamic Visual Acuity drop of 3 lines or more. Whilst this

may be suggestive of bilateral vestibular hypofunction, no post head shake nystagmus were elicited and they had normal foam Romberg's eyes shut examination.

All patients were found to have overt and covert saccades in multiple canals on VHIT testing with the Interacoustic VHIT equipment. However, all of them have normal or increased gain, some as high as over 2. None of them have gain less than 0.9. Caloric test in all patients also confirmed no vestibular hypofunction. The presence of catch up saccades in Vestibular Migraine is not well understood but may be related to intolerance to sudden head movement which is part of the sensory amplification phenomenon experienced by migraine patients.

Conclusions: Patients with clinical history suggestive of vestibular migraine with mixed clinical examination findings should have the VHIT to confirm there is no vestibular hypofunction.

PP2-125 - Diagnosing peripheral vestibular dysfunction by assessing 3D body tracking via Kinect v2

25. Vestibular Neuritis

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Purpose: Normal human locomotion requires a complex interaction of the visual, vestibular and proprioceptive systems together with the neural circuits coordinating locomotion. When one of these components malfunctions, gait abnormalities occur. Peripheral vestibular dysfunction (PVD) is a common disorder that affects gait and balance. Therefore, a well-tolerated, easy to operate (user-friendly) and low cost method that can diagnose peripheral vestibular dysfunction is needed so that non-experts

in the community can also use it for diagnosis. In order to achieve this goal we decided to use the low-cost Microsoft Kinect v2 sensor for tracking body movements in PVD patients.

Methods: This is an ongoing study in PVD patients and healthy controls. PVD patients worsen their performance for tasks that are vestibular-dependent if other sensory input (e.g. vision) is removed. Hence, we assess gait performance in the light vs. the dark for a simple protocol of clinical tests including the Romberg and Unterberger's tests.

Results: We predict that the worsening of gait and postural parameters measured by Kinect v2 in the dark vs. the light will be greater and easily detectable in PVD patients compared to healthy controls.

Conclusions: Gait is an important parameter and its accurate measurement in PVD patients with Microsoft Kinect v2 is likely to provide useful diagnostic information.

PP2-126 - Diplopia from skew deviation in peripheral vestibulopathy

25. Vestibular Neuritis

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Purpose: Although skew deviation is well described in brainstem lesions, the phenomenon can also result from peripheral vestibular lesions. But it rarely has been reported in the literature. The authors report the case of a 63-year-old woman with peripheral vestibulopathy who developed binocular vertical diplopia with skew deviation and incomplete OTR.

Methods: A 63-year-old female presented vertical diplopia without focal neurologic signs for 3 days. Neurologic examination showed comitant hypotropia of the left eye without nystagmus or head tilt.

Results: Fundus photography showed counter-clockwise ocular torsion and SVV tilt were shown toward the left. Caloric test showed normal response. v-HIT showed normal except low gain and corrective saccade of left PC. Amplitude of cVEMP (p13-n23) decreased in the left side. Abnormal findings

of cVEMP and v-HIT returned to normal 2 weeks later. These results mean inferior vestibular dysfunction with otolith dysfunction. Serological examinations and brain MRI including angiography were normal.

Conclusions: In this patient, skew deviation and tilt of the static visual vertical were interpreted as signs of an acute unilateral selective(inferior division) vestibular dysfunction including otolithic dysfunction. We thought that her distinct diplopia was due to no apparent nystagmus because the horizontal canal pathway was sparing.

PP2-127 - Disability and neuritis, prognostic factors

25. Vestibular Neuritis

Bernard Cohen¹

¹

Purpose:

Methods:

Results:

Conclusions:

PP2-128 - Functional MR Spectroscopy of the Primary vestibular Cortex in Patients with vestibular neuritis

25. Vestibular Neuritis

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Purpose: This study was designed to evaluate MR spectroscopic biochemical changes in patients with acute vestibular neuritis (VN) as compared with healthy volunteers. It is also designed to know metabolites concentrations changes and to evaluate the correlation between the grade of peripheral vestibular assessment and the concentration of metabolite in patients with acute unilateral VN.

Methods: Included 33 individuals who visited Kyung-Hee medical center at Gang-Dong from Mar.2016 to Mar.2017. We performed MR imaging and HMR 1 spectroscopy of the brain in VN patients. Single-voxel MR spectroscopy was used to study biochemical changes in the primary vestibular cortex and cerebellum in 13 control subjects and 20 patients with acute VN.

Results: There are no significant alteration of all brain metabolites between VN group and control group. The mi/H₂O, mi/Cr ratio was lower in the primary vestibular cortex of lesion side when comparing those of contralesional side in acute stage of VN patients. The NAA/Cr ratio was higher in the lesion side when comparing those of contralesional side in acute VN. Correlation between Caloric CP and alteration of some metabolite concentration in VN patients showed the statistically significant (Cho/Cr, Cho/H₂O, Cho/NAA, ml/Cr, ml/H₂O, NAA/Cr).

Conclusions: Myosinositol of lesion side was decreased and ratio of NAA to Cr was increased significantly when comparing those of contralesional side in VN patients. There are significant correlation between alteration of some brain metabolite like a cholin, ratio of NAA to Cr and degree of canal paresis. So we could consider these metabolites would be biologic marker of acute VN.

PP2-129 - Genome-wide Association Study in Vestibular Neuritis

25. Vestibular Neuritis

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Purpose: In order to identify genetic variants associated with vestibular neuritis, a common cause of peripheral vertigo with a potential causative link to the reactivation of herpes simplex type 1 (HSV-1), we conducted a genome-wide association study.

Methods: Association was assessed using app. 8 million single nucleotide polymorphisms after imputation in 7 batches. 131 patients with vestibular neuritis and 2609 controls of European ancestry were included.

Results: Genome-wide associations with vestibular neuritis were detected in 5 regions containing protein coding genes assignable to two functional groups: virus hypothesis and insulin metabolism. Genes of set 1 are related to viral processes: NR3C2 is a receptor for mineralocorticoids and glucocorticoids and was shown to be a host factor for HSV-1 replication. ANKRD30A is a host factor for human immunodeficiency virus-1 (HIV-1) infection. It shows rapid evolution and is induced by interferon stimulation. MED30 is an essential member of the mediator complex and has been shown to be involved in replication of HIV-1, a knockdown leading to impaired viral replication. The second set of genes (LMX1A, SLC30A8, HTR2C) is associated to insulin metabolism and resistance, a feature of some patients with type 2 diabetes as an accompanying comorbidity of vestibular neuritis.

Conclusions: Using a different approach to evaluate the etiology of vestibular neuritis these findings give another piece of evidence that it may be caused by a viral inflammation.

PP2-130 - Steroids for acute vestibular neuronitis - the earlier the treatment, the better the outcome?

25. Vestibular Neuritis

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Purpose: To present findings that suggest steroid treatment within 24 hours of onset of vestibular

neuronitis results in better restitution of vestibular function than treatment between 25 to 72 hours.

Methods: 33 consecutive patients (17 men, 16 women, mean age 57 years, range 17-85 years) with acute vestibular neuronitis and treated with steroids within 72 hours after symptom onset. Patients were divided into 2 groups depending on if they were treated within the first 24 hours or not.

Oral prednisolone 50 mg/day for 5 days with tapering of doses for the next 5 days, or combined with initial intravenous betamethasone 8 mg the first 1 to 2 days if the patient was nauseous.

Results: All 9 patients (100%) treated within 24 hours from onset of vestibular neuronitis had normal caloric test results at follow-up, as compared to 16 of 24 (66%) of the patients treated between 25-72 hours ($p < 0,05$, chi2-test).

Conclusions: The timing of steroid treatment of vestibular neuronitis may be of importance for subsequent vestibular restitution, and hence, for both time to recovery and late symptoms according to the literature.

PP2-131 - The clinical efficacy of vestibular function tests in patients with acute peripheral vestibulopathy

25. Vestibular Neuritis

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Purpose: Aim of this study is to investigate the clinical efficacy of the vestibular function tests and the predictability of lesion side of vestibular asymmetry parameters in acute peripheral vestibulopathy .

Methods: The medical records and vestibular function test results of 62 patients with acute unilateral peripheral vestibulopathy were retrospectively reviewed. The caloric, rotatory chair, posturography, bedside and video HITs were examined within 7 days after the clinical onset.

Results: For the caloric test, 79% showed significant canal paresis and the predictability of lesion side was

84%. For the sinusoidal harmonic acceleration test, 97% had low gain in at least one Hz, phase lead showed 66%, 93% showed phase asymmetry and the predictability of lesion side was 85%. For velocity step test, 66% had abnormal Tc asymmetry and the predictability of lesion side was 95%. In bedside HIT, abnormal catch up saccades were observed in 92% and the predictability of lesion side was 100%. For the video HIT, cover or overt catch-up saccades were observed in 96% and the predictability of lesion side was 100%. 100% had low gain on the video HIT, but the lesion sides were uncertain because of bilateral involvements. 91% showed vestibular dysfunction on sensory analysis of posturography.

Conclusions: The most important things about the diagnosis of acute peripheral vestibulopathy are typical clinical symptoms and spontaneous nystagmus. Only a single test has insufficient sensitivity and predictability of lesion side. Among them, head impulse test is considered the best in acute unilateral peripheral vestibulopathy.

PP2-132 - Vestibular function features and prognosis of vestibular neuritis in children

25. Vestibular Neuritis

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Purpose: Investigate the clinical characteristics, prognosis and affected branches of vestibular neuritis in children.

Methods: Twenty-five patients with vestibular neuritis in ENT department, Beijing Children's Hospital, from October 2015 to October 2016 were collected. The clinical manifestations recorded, pure tone audiometry, bithermal caloric test, cervical and ocular vestibular-evoked myogenic potential (cVEMP and oVEMP) were done for every patients. We also took the blood sample for pathogenic virus for those who had upper respiratory tract infection or intestinal infection history.

Results: Twenty-five patients were 4~14 years old (mean 9.8). There were 17 cases with vomiting and 19 cases with balance dysfunction. Twenty patients had respiratory tract or intestinal infection history. In 20 blood samples for virology, 4 cases of herpes simplex virus and 6 cases of influenza B virus were identified. Bithermal caloric test was abnormal in 18 cases. The oVEMP in 12 cases and cVEMP in 5 cases were abnormal. All patients recovered well, but the time differed. The symptoms of 21 patients were complete recovery within 1 month. 3 patients were complete recovery within 3 months (aged 8 ~ 14 years old). One patients was complete recovery within 6 months (aged 13 years old).

Conclusions: The vestibular neuritis in children may be related with respiratory tract infection. The most common affected branch was superior vestibular nerve, and two branches, superior and inferior vestibular nerve were secondly involved, which is the same as that of adults. The younger patients with VN recovered more quickly than that in the older.

PP2-133 - Video Head Impulse Test and Cervical Vestibular Evoked Myogenic Potential in Vestibular Neuritis

25. Vestibular Neuritis

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Purpose: To evaluate and compare the results of cervical vestibular evoked myogenic potential (cVEMP) and video head impulse test (p-vHIT) of posterior semicircular canal plane in acute vestibular neuritis

Methods: Seventy-nine patients with vestibular neuritis participated in this study. We analyzed the interaural amplitude difference in cVEMP with a positive rate of p-vHIT according to gain and corrective saccade in the study population. To evaluate the concordance rate of both tests, we analyzed Fleiss' Kappa value inter-test agreement of cVEMP with p-vHIT. Finally, we performed detailed analysis of the bilaterally absent response on cVEMP according to the p-vHIT results.

Results: The inter-test agreement between cVEMP and p-vHIT was 69.8% as we also considered the lesion side. This result indicated a statistically fair to good agreement in both tests. In mostly elderly patients with a bilaterally absent response (11 patients) on cVEMP, as a result of vHIT, nine patients with a bilaterally negative response on p-vHIT showed only canal paresis. Two patients showed canal paresis and a unilaterally positive response on p-vHIT.

Conclusions: Inter-test agreement between cVEMP and p-vHIT assessed in vestibular neuritis was relatively lower than we had predicted. Probably, p-vHIT can provide additional information on the differential diagnosis of dysfunction of the inferior vestibular nerve which is composed of the saccular nerve and the posterior ampullary nerve.

PP2-134 - Controlled postural responses upon electrical stimulation with a vestibular implant in humans

26. Vestibular Prosthesis

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Purpose: To investigate the possibility of evoking controlled postural responses using electrical stimulation delivered by a vestibular implant prototype in humans.

Methods: A female patient with bilateral vestibular hypofunction (71 years old) received a prototype vestibular implant providing 3 electrode branches

implanted in the ampullae of the 3 semicircular canals (left ear). Postural responses were evaluated during 20s trials of the Unterberger test without any electrical stimulation and upon electrical stimulation (charge-balanced biphasic pulse trains, 200µs/phase, 400 pulses-per-second) at different current intensities (300µA, 325µA, 375µA, 400µA) up- and down-modulated around a constant baseline current (350µA). Whole-body postural responses were recorded using a 12-camera motion capture system (Oqus7+, Qualisys AB, Göteborg, Sweden).

Results: Without electrical stimulation, the angular rotation of the patient's trunk was $3.6^\circ \pm 3.6^\circ$ (mean \pm standard deviation; clock-wise). We observed a significant negative correlation between current intensity and trunk rotation (Pearson product-moment correlation $r=-0.92$, $n=14$, $p<0.0001$), reaching values of $31.6^\circ \pm 5.8^\circ$ for maximum down-modulation and $-8.33^\circ \pm 10.8^\circ$ for maximum up-modulation. Linear body motion (distance and direction) was variable and uncorrelated to electrical stimulation. Results for head motion were practically identical, demonstrating that the patient's whole body moved "in-bloc".

Conclusions: These results demonstrate, for the first time in humans, that whole-body motion can be controlled and modulated using electrical stimulation delivered to the ampullary nerves in humans. These results are very encouraging, suggesting that vestibular implants could potentially provide useful cues to address disabling postural deficiencies (e.g., imbalance) and consequently decrease fall risks.

PP2-135 - Effects of long-term noisy vestibular stimulation on body balance in bilateral vestibulopathy

26. Vestibular Prosthesis

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Purpose: To examine the effects of long-term noisy galvanic vestibular stimulation (nGVS) on improving body balance after the cessation of the stimulus in patients with bilateral vestibulopathy (BV).

Methods: Thirteen BV patients underwent two nGVS sessions at 2-week interval. In each session, the BV patients received nGVS for 30 min and were monitored without stimuli for 6 h. Two-legged stance tasks were performed with eyes closed with and without nGVS. The velocity, area, and root mean square of the center of pressure (COP) movement were measured using posturography. The effect of nGVS on the frequency component of the COP sway were then investigated by power spectral analysis using maximum entropy method. Power spectral density (PSD) of the COP were calculated. Subjective improvement of body balance was also scored.

Results: In each session, the velocity of the COP movement was significantly improved for 6 h after the cessation of the stimulus. The mean frequency of postural movement was significantly smaller until 3 h after the cessation of the stimulus than at baseline, suggesting that the ameliorating effect of nGVS on the postural stability might have an association with the frequency shift of the COP sway to the lower frequency. The subjective symptom of imbalance was also improved during the post-stimulation effect of nGVS.

Conclusions: nGVS can lead to the improvement in body balance that lasts for several hours after the cessation of the stimulus in BV patients, especially in the velocity of the COP movement.

PP2-136 - Immediate efficacy of Gufoni maneuver for HC-BPPV: a meta-analysis

26. Vestibular Prosthesis

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Purpose: Gufoni maneuver is a very common and efficient treatment for horizontal canal benign

paroxysmal positional vertigo(HC-BPPV), with which patients with either a canalolithiasis or a cupulolithiasis can be successfully treated. However, there is no evidence-based study to reveal the immediate efficacy of this maneuver for HCBPPV. Therefore, This meta-analysis aims to systematically measure the immediate efficacy of the Gufoni maneuver for HC-BPPV.

Methods: A extensive search electronic databases, including PubMed, Embase, Web of Science, Cochrane and Chinese medical databases, were searched until to September 1, 2017 for relevant articles. we selected only randomized clinical trials studying with treatment of HC-BPPV employ by the Gufoni maneuver.

Results: Six randomized clinical trials were included in the current meta-analysis with a total of 696 HC-BPPV patients. The pooled odds ratio of efficacy (OR_e) and odds ratio of otolith switch (OR_o) were used to estimate overall therapeutic performance. The pooled OR_e were 4.00 (95% CI, 2.05-7.78, $p < 0.01$, Gufoni VS. Sham), 1.87(95% CI, 0.42-8.33, $p = 0.41$, Gufoni VS. Barbecue maneuver), while the pooled OR_o was 2.17(95% CI, 0.55-8.53, $p = 0.27$). Subgroup analyses showed that the respective pooled OR_e were 3.51(95% CI, 2.09-5.89, $p < 0.01$) and 3.23(95% CI, 1.24-8.39, $p < 0.05$) in groups of geotropic nystagmus and geonegative nystagmus.

Conclusions: Gufoni maneuver has a satisfactory immediate efficacy for HC-BPPV and doesn't increase otolith switch.

PP2-137 - A Novel Tele-Dizzy Consultation Program in the Emergency Department using Portable Video-oculography

27. Others

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Purpose: Deploy a tele-dizzy consultation service to improve diagnosis of emergency department (ED) patients with acute dizziness/vertigo.

Methods: Case study of a systems-level quality improvement intervention. Pilot program included (1) defining a new care pathway; (2) securing leadership buy-in; (3) modeling quality and cost benefits; (4) conducting training and implementing technology; and (5) identifying barriers and lessons learned.

Results: (1) Defined care pathway for evaluating ED patients with dizziness/vertigo of suspected neurologic or peripheral vestibular etiology using portable video-oculography (VOG) in the ED, with urgent clinic referrals for unclear cases. (2) Secured buy-in of ED Department Directors at 5 health system hospitals. (3) Modeled health system reduction of 50 missed strokes and ~\$1 million per year saved on unnecessary imaging and admissions. (4) Conducted training for ED technicians and implemented secure data platforms for eye movement recordings to be electronically transferred for review by clinical faculty using 'store-forward' telemedicine approach. (5) Identified need for culture change through local champions; method to sustain 'critical mass' of workforce trained; faculty and fellow staffing to sustain service availability on evenings/weekends; and novel billing mechanisms in hybrid payment system (mixed population-based budgeted and fee-for-service). Over six months at the pilot hospital site, we assessed 68 tele-dizzy consults, 43 with vestibular diagnoses. The response to the service by ED providers has been positive.

Conclusions: Bringing specialty expertise via tele-dizzy consultation using VOG based rapid triage to EDs is feasible. The next step is testing the hypotheses of improved access, higher quality, and lower costs.

PP2-138 - A Retrospective Study of a Multidisciplinary Chronic Dizziness Clinic and an Acute Dizziness Clinic

27. Others

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Purpose: Vertigo remains a diagnostic challenge for emergency physicians and specialists. We describe, for the first time in Canada, the clinical characteristics of patients presenting with chronic and acute dizziness to both a multidisciplinary dizziness clinic (MDC) and a rapid access dizziness (RAD) clinic at The Ottawa Hospital (TOH).

Methods: We performed a retrospective review of all patients presenting to the MDC and RAD clinics at TOH from July 2015 to August 2017.

Results: We found that 211 patients (median age: 61 years old) presented to the RAD clinic and 292 patients (median age: 55 years old) presented to the MDC. In the RAD clinic, 63% of patients had peripheral dizziness, of which 55% had BPPV, and only one patient had functional dizziness. Interestingly, only 25% of RAD diagnoses were concordant with the emergency diagnoses; moreover, only 33% of RAD patients had HiNTs completed, while 44% had CT scans, of which only one patient had an abnormal finding. In the MDC, 28% of patients had vestibular dizziness and 21% had functional dizziness, of which 43% had PPPD. Moreover, 12% of patients with functional dizziness also suffered from comorbid severe anxiety and depression.

Conclusions: Dizziness is a heterogeneous disorder that necessitates multidisciplinary care. RAD clinics can serve to help patients with peripheral dizziness in an acute setting, while ensuring informative diagnostic tests are utilized. MDCs can provide prolonged care for patients with PPPD while helping to alleviate the significant psychiatric burden amongst patients with chronic dizziness.

PP2-139 - Brain tissue volume changes in astronauts after six months of exposure to microgravity

27. Others

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Purpose: Long-duration spaceflight has a profound impact on human physiology. It is crucial to understand these effects as they pose a potential health risk for astronauts on long-duration missions. Only few investigations into the effect of spaceflight on the central nervous system have been conducted. We therefore performed a study using brain MRI scans of astronauts before and after spaceflight to assess brain tissue volume changes.

Methods: 10 astronauts were scanned before and after 6 months of exposure to microgravity. 10 healthy controls were scanned twice with a similar time interval. Data were acquired on a 3T GE MRI scanner by means of T1 weighted imaging and diffusion tensor imaging. SIENA analysis was performed

to assess brain and ventricular volume change. Vox-el-based morphometry was performed to assess regional changes in gray matter, white matter and CSF volumes. Diffusion tensor imaging was used to perform analysis of free-water and mean diffusivity.

Results: An increase in brain ventricular volume was noted after spaceflight compared to before. Gray matter volume decreases were observed in ventral areas of the brain, while increases were noted in dorsal areas. Opposite changes in CSF volume and mean diffusivity were noted in the same regions.

Conclusions: Our results indicate that the volume changes occur due to a redistribution of bodily fluids. This is in line with previous studies showing that microgravity causes an upward fluid shift and an upward mechanical shift of the brain. These findings might help explain the phenomenon of increased intracranial pressure in astronauts as a result of spaceflight.

PP2-140 - Central Vestibular Sensitivity affects Motion Sick Susceptibility through the Velocity Storage.

27. Others

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Purpose: To determine the effects of Central Vestibular Sensitivity (CVS) on Motion Sick Susceptibility (MSS), through the velocity storage's function of prolonging Slow-Phase Eye Velocity (SPEV) and Perceived Rotational Duration (PRD), in healthy individuals with different motion sick susceptibility.

Methods: A quantitative descriptive single blind controlled design. All participants recruited, completed the motion sick susceptibility questionnaire (short) and had no reports of neuro otologic/vestibular history or non-corrected visual problems. 25 controls and 25 highly motion sick susceptible subjects were recruited and first screened for any peripheral vestibular (Horizontal Semicircular canal and Saccular function) and central disorders, using videonystagmography, video-head impulse and cervical

vestibular myogenic potential tests. Next, participants were tested on the rotatory chair to obtain the Slow-Phase Eye Velocity Time Constant (SPEV TC) and Perceived Rotational Duration (PRD). Readings were then compared for significant differences between control and subject group.

Results: Results showed no significant difference in SPEV TC between control and subject group for slow and fast rotations. However, there was significant difference in the PRD between these two groups. Multiple regression analysis indicated that post-rotatory PRD and the number of motion sick symptoms reported were positively correlated with the degree of MSS and were hence, significantly strong predictors.

Conclusions: Highly MSS individuals were observed with elevated PRD in general, indirectly suggesting greater velocity storage efficiency, hence, greater CVS; CVS is therefore positively correlated with MSS. PRD could be a reliable clinical indicator of motion sick susceptibility and may help in the verification of therapeutic interventions at reducing susceptibility to motion sickness.

PP2-141 - Challenge and Limitation of the Emergent Care of Dizziness in a Hospital without Specialists

27. Others

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Purpose: Many patients with acute vertigo or dizziness are referred to Emergency Hospital in the world. However, all of hospitals with emergency department don't have Otorhinolaryngologist or Neurologist as specialists. Our hospital is certified by World Health Organization as a health promoting hospital and usually receives the patients with acute vestibular syndrome (AVS). The aim of this study is to extract the characteristics of those patients and to formulate more effective treatment system than a current that.

Methods: Retrospective electric records-based study was designed. The subjects with AVS were recruited from 2013 to 2016. We collected age, gender, diagnosis, admission, duration of admission, outcome etc. for descriptive statistics. This study was approved by our institutional ethics committee.

Results: We have experienced over 300 patients with AVS for four years. A half of them were admitted to soothe symptoms. Some critical disorders were examined at a first line, and we introduced them to specialists when we could not diagnose their diseases correctly. A big earthquake occurred at Kumamoto on April 16, 2016. 5.4 and 14.5 patients with AVS were referred per month before and after this catastrophe, respectively.

Conclusions: The hospitals without specialists play a great role for the management of patients with AVS because the number of specialists is limited. It may be important to cooperate with hospitals with specialists after first care in hospitals without specialist.

PP2-142 - Clinical characteristics of 26 cases with recurrent low frequency sensorineural hearing loss

27. Others

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Purpose: The etiology of recurrent low frequency sensorineural hearing loss (RLFSNHL) is unknown. It is often admitted to hospital diagnosed as sudden sensorineural hearing loss. This aimed at retrospectively analyzing the clinical data of RLFSNHL in order to providing evidence-based clues for the diagnosis and treatment of such patients.

Methods: Such 26 patients in the First Affiliated Hospital of Chongqing Medical University from August 2013 to January 2018 were recorded. All patients had experienced more than two times admissions. Statistical analysis for demography,

clinical data, audiological examination (26 cases, audiometry, ABR, DPOAE, ECoChG and glycerol test), and MRI Scan (6 cases), VNG, glycerol test.

Results: 6 male and women 20 cases (average year 32.15, 25 unilateral and 1 bilateral) presented the chief discomfort as follow, low pitch tinnitus (the first and second admission respectively 21, 20), ear fullness (13,19), vertigo (2, 4), dizziness (3,8), photophobia and phonophobia (4, 6) . The recovery rate of the first and second admission was respectively 59.26% (16/27), 51.85% , the total effective rate was 76.92%, 55.56%. The total efficiency difference between the first and second hospitalization was statistically significant. 11 cases are definitely diagnosed as Meniere's disease (4), cochlear migraine (6), paroxysmal vestibular disorder(1).

Conclusions: RLFSNHL more often attack young women and is effectively treated. However, with the increase of the number of onset, the therapeutic effect gradually decreases. RLFSNHL might be relative with Meniere's disease, cochlear migraine and other diseases which involve a similar pathological mechanism.

PP2-143 - Cobalt-induced ototoxicity from metal-on-metal hip prostheses: preliminary results

27. Others

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Purpose: This study aims to evaluate the potential cochleotoxic and vestibulotoxic effect of cobalt (Co) ions released from metal-on-metal (MoM) hip prostheses.

Methods: 10* patients with a MoM implant and 10* age- and gender-matched control subjects participated in the study. Each participant was subjected to an extensive auditory and vestibular test battery and a blood sample collection, to determine the blood Co concentration. Statistical comparison of both groups was performed using a linear mixed model. * *Data collection is ongoing; additional data will be supplemented to the existing pool.*

Results: The patients exhibited a significantly higher blood Co concentration. Within the auditory test battery, pure tone audiometry showed a non-significant trend of higher thresholds in the patient group. The Distortion Product Otoacoustic Emission (DPOAE) signal amplitude at 4 and 8 kHz was significantly lower in the patient versus control group, and a similar but non-significant trend was observed for the Transient Evoked OAEs (TEOAEs) at 4 kHz and the DPOAEs at 6 kHz. Within the vestibular test battery, the P1 latency of the cervical Vestibular Evoked Myogenic Potentials (cVEMP) was significantly longer and the caloric sum significantly lower in the patient group. The outcome parameters of the Auditory Brainstem Responses (ABR), rotatory test, video Head Impulse Test (vHIT) and ocular VEMP (oVEMP) did not reveal significant differences between groups.

Conclusions: Our preliminary results suggest that high-frequency audiometric thresholds and DPOAE signal amplitudes, and the caloric sum may be the most sensitive parameters to detect cobalt-induced ototoxicity. This largely corresponds to previous findings regarding drug-related ototoxicity.

PP2-144 - Description of otoneurological findings in peripuberal females

27. Others

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Purpose: To describe clinical and complementary studies in peripuberal females with otoneurological symptoms.

Methods: A case series was performed by a review of medical records of patients with otoneurological symptoms at Buenos Aires British Hospital, Argentina.

Results: This study included fourteen female patients, mean age was 13.1 ± 2 (9-16). Menarche mean age was 10.9 ± 0.8 . No statistically significant associations were found between comorbidities such as middle ear diseases, hypothyroidism, retinoblastoma and benign paroxysmal vertigo of childhood. Migraine was found as a significant comorbidity ($p=0.002$). Vertigo (79%) and headache (57%) were described as the most frequent consultation symptoms, only 21% of patients presented aural fullness. Only three patients presented otoneurological symptoms before menarche and seven women within 2 years after menarche. Audiometric tests (79%) and C-VEMP results (50%) were normal. No statistically significant differences were found between abnormal and normal videonystagmographies (64%); and pathological and non-pathological Video head impulse results (85%). Initial electrocochleography mean was 39 ± 13.6 and eight months follow up mean was 25.2 ± 12.2 . A significant decrease was observed eight months later ($p=0.003$) after treatment with betahistine in 80% of patients. Earlier Menarche age had a positive correlation with higher electrocochleography results ($p=0.001$).

Conclusions: Female teenagers presented vertigo and headache as the most frequent consultation symptoms. Migraine was observed as a significant comorbidity. Electrocochleography improvement was significant in patients after eight months follow-up. Earlier menarche age had a positive correlation with electrocochleography values.

PP2-145 - Direct Observational Procedural Skills in Otolaryngology Training

27. Others

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Purpose: There are a lot of procedures like wax removal, microscopic ear examination, Dix-Halpike and Epley repositioning maneuvers that a resident have to learn perfectly in the first year of training. It is important to be sure about the skills of the residents before they examine a patients independently. The aim of this study is implantation of an assessment method, Direct observation of procedural skills (DOPS), during the training process of ENT residency.

Methods: A prospective educational research was planned. In the quantitative assessment, the “construct validity” of the assessment tool were examined. In the qualitative assessment, the trainees and trainers’ experiences about the contribution of DOPS in training process were investigated.

Results: A total of 55 DOPS forms were filled in. The mean observation time was 7.14 ± 4.83 (max:20-min:1) minutes and the mean feedback time was 2.11 ± 2.01 (max:10,min:0.) minutes. A statistical difference was detected between the first year trainees and others, while no statistically difference between the thirth, fourth and fifth year trainees. A statistically significant positive correlation was found between the seniority years and the mean scores. According to qualitative assessment results, the trainees stated that they realized their some deficiencies, and it contributed positively to their residency training.

Conclusions: DOPS is a useful, valid and fair tool in assessing otolaryngology traniess. The data obtained from the DOPS forms can be used as an evidence to demonstrate the success of the training clinic and to evaluate the training program

PP2-146 - Distorted own-body representations and out-of-body experience in 350 patients with dizziness

27. Others

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Purpose: How vestibular disorders affect own-body and self representations has been overlooked, despite descriptions of depersonalisation-derealisation and cases of out-of-body experiences (OBE, the feeling that the self is located outside of the body) in patients with dizziness. This was explored in a large-scale observational, prospective study.

Methods: We measured the occurrence and severity of distorted own-body representations and OBE in the largest sample of patients with dizziness to date ($n=350$) compared to a group of age- and gender-matched healthy controls ($n=350$), using otoneurological examination, the Cambridge Depersonalization Scale, Hospital Anxiety and Depression Scale, and the Palmer’s questionnaire for OBE.

Results: Distorted own-body and self representations were more frequent and severe in patients with dizziness: 12% of the patients experienced their limbs have temporarily become larger or smaller, 37% reported abnormal sense of agency, 35% reported disownership for the body. We show a significantly higher occurrence of full-blown OBE in patients (14%) than controls (5%). Most of the patients experienced OBE only after they started having dizziness, and OBE was mainly related to peripheral vestibular disorders, never to bilateral vestibular failure. We identify depersonalization-derealization, depression and anxiety as the main predictors of OBE, as well as a contribution of migraine.

Conclusions: We propose that OBE may arise from a combination of *perceptual incoherence* evoked by the vestibular dysfunction, with psychological factors (depersonalization-derealization, depression and anxiety) and neurological factors (migraine).

This study should help understand the complex symptomatology of patients with dizziness, who present with alterations of the most fundamental aspects of their self.

PP2-147 - Dizziness related to patulous eustachian tube

27. Others

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Purpose: In 1989, Robinson et al. reported that 9 out of 13 patients with patulous eustachian tube (PET) had vestibular symptoms which improved on treatment of the PET. However, its pathogenesis remains unclear. The purpose of this study was to examine the characteristics of vestibular symptoms and function of patients with PET.

Methods: The study included 181 patients with PET. The diagnosis of PET was based on the criteria proposed by the Japan Otological Society (2016). The vestibular symptoms of all patients were recorded using a questionnaire. Furthermore, we conducted caloric test (43 patients), Schellong test (43 patients), and cervical vestibular evoked myogenic potential (cVEMP) test (27 ears of 20 patients) for patients with PET and dizziness.

Results: Vestibular symptoms were recorded in 79 of the 181 patients (44%) with PET. Seventy of the 79 patients (89%) with vestibular symptoms complained of mild dizziness and/or brief lightheadedness on standing up. Only 9 of the 79 patients (11%) experienced spinning. Canal paresis was observed in 2 of 43 patients (5%). Schellong test showed abnormal findings in 23 of 43 patients (53%). On the cVEMP test, the acoustic stimulus frequency at the largest amplitudes shifted to higher frequencies in 23 of 27 ears (85%).

Conclusions: The results indicate that 44% of the patients with PET had dizziness. The pathogenesis of dizziness related to PET is considered to be orthostatic dysregulation and/or otolith dysfunction.

PP2-148 - EEG Correlates of Postural Control and Balance

27. Others

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Purpose: Non-visual afferent cortical contributions to postural control remain unclear. Parietal areas have been implicated however localisation during balance tasks is limited with neuroimaging. Here, we use EEG to investigate cortical activity during continuous balance at single electrode positions.

Methods: Experiment I) we investigate the impact of task difficulty upon alpha (8-12Hz) and theta (4-8Hz) bands in EEG - 24 healthy, right-handed adults performed seated (SITTING) and balance tasks (FLOOR, FOAM, R FOOT FLOOR, R FOOT FOAM) with eyes closed. Task difficulty was measured and increased in the order above. C3, Cz, C4, P3, P4 spectral power was analysed.

Results: Significant differences in theta power were demonstrated between hemispheres: C3-C4, Cz-C4, Cz-P4. There was a trend towards theta power reduction during active tasks, greater in the right hemisphere. Alpha power negatively correlated with task difficulty, in C3, C4, P3, P4, again greater in right vs left areas.

Experiment II) we recorded EEGs in sitting and standing in 8 healthy young adults, 8 healthy older adults and 4 older adults with dizziness, not explained by established diagnoses (perhaps due to small vessel disease). No major differences between Young and Old were found but dizzy patients had more pronounced reductions in alpha/theta activity.

Conclusions: We show hemispheric asymmetry in cortical activity during continuous balance. Reductions in alpha/theta power were greater in right-sided areas, suggesting a role for the non-dominant hemisphere in monitoring postural control. Increased reduction in alpha/theta power on

standing in the dizzy patients suggests abnormal cortico-subcortical interaction but larger patient samples are required.

PP2-149 - Etiologic evaluation and risk factor profile of childhood hearing loss

27. Others

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Purpose: The goal was to clarify the prevalence and etiologic causes of childhood hearing loss (HL) in Swedish children and to evaluate the JCIH risk factor exposure in both bilateral hearing loss and unilateral hearing loss.

Methods: Subjects consisted of 296 infants suspected of hearing loss referred to a tertiary university hospital for further diagnosis and treatment. They belonged to the birth cohort spanning the years 2009-2013 in Stockholm County. The clinical data were collected from the electronic medical records of the Karolinska University Hospital. Age at reference, degree and type of HL were recorded. Risk factors and etiology of bilateral hearing loss (BHL) and unilateral hearing loss (UHL) were analyzed separately.

Results: 296 infants were confirmed with HL, and the prevalence of childhood HL was 2.0/ 1000 live-births, of which BHL was present in 0.15%, while another 0.05% revealed UHL. Of the infants with BHL, familial history and neonatal indicator were the two most commonly discovered risk factors (26.7%, respectively), followed by syndrome related risk in 15.0% and craniofacial anomaly in 6.3%. Mean while, craniofacial anomaly was the most commonly exposed risk in children with UHL (48.9%), followed by familial history, which was found in 21.3% of children with UHL.

Conclusions: Pediatric hearing loss can be attributed to a variety of sources with an etiology identifiable in 47% of the patient with UHL and 42% of them with BHL while ear malformations were more commonly in infants with UHL. High congenital CMV infection (cCMV) rates were identified in this population.

PP2-150 - Influence of vestibular stimulation on executive functions

27. Others

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Purpose: There is growing evidence that patients with peripheral vestibular loss show impairments in non-spatial cognitive domains like executive functioning. However, it is unclear which executive components are affected by vestibular loss and whether there is a causal link between vestibular loss and impaired executive functions. Therefore, the aim of this experiment was to investigate the effect of induced mild vestibular impairment in healthy participants on performance in tasks assessing executive functions.

Methods: Fifty-four participants solved executive tasks twice, before and during simultaneous bilateral bipolar galvanic vestibular stimulation (GVS). Suprathreshold GVS (inducing mild vestibular impairment), subthreshold GVS or sham GVS were applied. Core components of executive functions (working memory, inhibition, cognitive flexibility) were measured with two executive tasks (n-back task, Stroop task).

Results: Results indicate impaired performance in the working memory task during suprathreshold stimulation when compared to the groups receiving subthreshold or sham GVS. Performance in inhibition and cognitive flexibility showed no differences between groups. These results suggest that artificially induced mild vestibular impairment in healthy participants can lead to selective impairments in executive functions.

Conclusions: To investigate the causal influence of vestibular stimulation on the performance in executive tasks in healthy participants helps to explain executive deficits in patients with vestibular loss. Since executive functions are a composite of several distinct functions, it is important to more specifically determine the executive components which are affected by vestibular impairment. This can help to screen patients with vestibular loss, and ultimately provide cognitive training methods that are tailored to their pattern of performance.

PP2-151 - Influence of vestibular stimulation on phantom limb pain after supracondylar amputation

27. Others

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Purpose: In patients with unilateral supracondylar amputation of a lower limb, secondary to type 2 diabetes mellitus, to assess the influence of non-physiological vestibular stimulation (either angular or linear) on the intensity of phantom limb pain and symptoms of depersonalization/ derealization.

Methods: Thirty patients accepted to participate. They had phantom limb pain after at least 3 months of unilateral supracondylar amputation, without surgical complications. First, neuro-otology evaluation and assessment of symptoms of common mental disorders were performed. Then, using a cross-over design, in 2 separate sessions with one week in between, vestibular stimulation was delivered by right or left calorics (30°C or 44°C) or centrifugation (300/s, 3.5 cm). Before and after each vestibular stimulus, the intensity of pain and depersonalization/ derealization symptoms were appraised.

Results: In those who experienced phantom pain at the moment of vestibular stimulation, pain decreased in up to 91% of the patients after either right or left unilateral caloric stimulation (30°C or 44°C) or centrifugation, along with decrease of depersonalization/ derealization symptoms ($p < 0.005$). In some patients, pain decrease persisted even one day after vestibular stimulation. Multivariate analysis showed no influence of the report of symptoms of common mental disorders on pain intensity.

Conclusions: Non-physiological vestibular stimulation, either angular or linear, may have an influence on phantom limb pain. We propose that this effect could be related to an update of the immediate experience of the body.

PP2-152 - Interaction between Vestibulo Ocular Reflex and Optokinetic Nystagmus in virtual reality worlds

27. Others

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Purpose: We studied the optokinetic nystagmus (OKN) with an optokinetic stimulation (OKs) presented on virtual reality goggles were the stimulus velocity (from the subject's perspective) remains unchanged. We explored the eye movements and the perception of the OKs velocity while the head moved from side to side. If the OKN is purely dependent on the OKs, head movements should affect neither perception nor eye movements and we ought to see a classic OKN.

Methods: 10 healthy subjects (mean age 22.5, std 2.4) wore an eyetracking system (ICS, Otometrics) and over it a virtual reality viewer with a phone inside to display the optokinetic stimulation. Pace of head movements was set by a metronome (0.5Hz) and subjects were instructed to move the head from side to side (around 90 degree total movement) in a smooth and velocity-constant movement.

Results: Subjects report a change in velocity depending on whether the head moves in the same direction as the stimulation or the opposite direction. The number of the fast phase of the OKN with the same stimulus and opposite head movements, was

significantly different for both OKs Left to Right and OKs Right to Left.

Conclusions: As opposed to a purely OKN response to an OKs, we see a differential eye movement dependent upon head rotation direction. The perceptual differences of OKs velocity presented in virtual reality while the head moves, could be attributed to different eye movements and these eye movements can be explained by simultaneous activation of the VOR and OKN.

PP2-153 - Mastoid Obliteration with Middle Temporal Artery and Inferior Musculo-periosteal Flaps

27. Others

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Purpose: The aim of this study is to evaluate the surgical outcomes with the use of a combination of the middle temporal artery flap and the inferior musculo-periosteal flap for mastoid obliteration after canal wall down mastoidectomy.

Methods: A total of 55 patients who have undergone canal wall down mastoidectomy and mastoid obliteration with the middle temporal artery flap and the inferior musculo-periosteal flap were included. Surgical outcomes measured included time taken to mastoid cavity epithelisation, the creation of a dry mastoid cavity as measured by a previously developed semi-quantitative scale, and the rate of revision surgery needed.

Results: Patients were followed up for a median of 13 months. Median time to epithelisation of the mastoid cavity was 2 months (interquartile range 1-2). At 1 and 3 months, 36.2% and 69.0% of patients respectively had grade 0/1 cavities, with 1 or less episodes of mild otorrhea or sensation of wetness. 100% of patients achieved a grade 2 (more than 1 episode of otorrhea or the presence of granulation tissue that promptly resolved with simple treatment)

or better cavity at 3 months. Throughout the entire follow up period, only 1 patient had a grade 3 cavity with uncontrolled infection and daily otorrhea secondary to an attic perforation that manifested at 6 months, requiring revision surgery.

Conclusions: The use of the middle temporal artery flap and the inferior musculo-periosteal flap for mastoid obliteration is an effective adjunct to achieving a safe, dry ear after canal wall down mastoidectomy.

PP2-154 - Metabolic syndrome among patients with different type of peripheral vestibular vertigo

27. Others

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Purpose: No study has separately described and analyzed metabolic syndrome in patients with different types of peripheral vestibular vertigo. The present study investigated metabolic syndrome among patients with 4 different types of peripheral vertigo.

Methods: A total of 92 patients with 4 types of peripheral vertigo, namely, benign paroxysmal positional vertigo (BPPV, n=35), vestibular migraine (VM, n=24), Menière disease (MD, n=18), and vestibular neuronitis (VN, n=15), were included in the present study. Otological and neurootological examinations were carefully performed, and waist circumference, serum HDL level, serum triglyceride level, blood pressure and fasting glucose level were used to evaluate metabolic syndrome. In this study, metabolic syndrome was diagnosed according to standards suggested by the AHA/NHLBI ATP III 2005, and abdominal obesity (≥ 90 cm in men and ≥ 85 cm in women for Korean) was diagnosed according to standards set forth by the Korean Society for Study of Obesity.

Results: Patients were divided into 2 groups, according to the vestibular function: normal and

abnormal vestibular function. There was no significant difference in the risk of metabolic syndrome between these 2 groups. However, for patients with the 4 different vertigo types, the prevalence of metabolic syndrome (VM=40.9%, VN=50%) was significantly higher in the patients with VM or VN than those with BPPV or MD ($P<0.05$).

Conclusions: Vestibular function is not significantly associated with the risk of metabolic syndrome. Metabolic syndrome is more common in patients with VM or VN than those with BPPV or MD.

PP2-155 - Predictive capability of an iPad based medical device for the diagnosis of vertigo and dizziness

27. Others

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Purpose: Making the correct diagnosis of patients presenting with vertigo and dizziness in clinical practice is often challenging. In this study, we analyzed the usage of the iPad-based program *medx* in the prediction of different diagnoses.

Methods: The data collection was done in the outpatient clinic of the German Center of Vertigo and Balance Disorders. The “gold standard diagnosis” was confirmed by a physician there. The *medx* diagnosis was based on an algorithm using all available clinical information. The accuracy of the system was defined as the number of correctly classified patients. Moreover, sensitivity, specificity as well as positive and negative predictive values for the most common diagnoses were reported.

Results: 610 patients (mean age 58.1 ± 16.3 years, 51.2% female) were included. The accuracy for the most common diagnoses was between 82.1-96.6% with a sensitivity of 40-80.5% and a specificity of $>80\%$. When analyzing the quality of *medx* in a multiclass-problem for the six most common clinical diagnoses the sensitivity, specificity, positive and negative predictive value were as follows: Bilateral vestibulopathy (81.6%, 97.1%, 71.1%, 97.5%), Ménière's disease (77.8%, 97.6%, 87.%, 95.3%), benign paroxysmal positional vertigo (61.7%, 98.3%, 86.6%, 93.4%), downbeat nystagmus syndrome (69.6%, 97.7%, 71.1%, 97.5%), vestibular migraine (34.7%, 97.8%, 76.1%, 88.3%) and phobic postural vertigo (80.5%, 82.5%, 52.5%, 94.6%).

Conclusions: With the high specificity and high negative predictive value the *medx* system helps to rule out differential diagnoses and can therefore also lead to a cost reduction in health care system. However, in some disease the sensitivity was unexpectedly low. Therefore, this device can only be a complementary tool, in particular for non-experts in the field.

PP2-156 - Prevalence of and factors related to mild and substantial dizziness in older adults

27. Others

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Purpose: The aim of the study was to determine the prevalence of and factors related to dizziness among community-dwelling older adults in Sweden.

Methods: A sample of 305 older persons between 75 and 90 years of age (mean age 81 years) were interviewed and examined. Subjects with dizziness answered the University of California Los Angeles Dizziness Questionnaire and questions about

provoking movements. The groups with substantial, mild, or no dizziness were compared with regard to age, sex, diseases, drugs, blood pressure, physical activity, exercises, falls, fear of falling, quality of life, general health, mobility aids, and physical performance. In contrast to previous studies, the subjects with dizziness were divided into two groups, mild and substantial dizziness, according to the frequency and intensity of dizziness.

Results: In this sample, 79 subjects experienced substantial and 46 mild dizziness. Subjects with substantial dizziness were less physically active, reported more fear of falling, falls, depression/anxiety, diabetes, stroke/TIA, heart disease, a higher total number of drugs and antihypertensive drugs, lower quality of life and general health, and performed worse physically.

Conclusions: There are many and complex associations between dizziness and factors like falls, diseases, drugs, physical performance, and activity. For most of these factors, the associations are stronger in subjects with substantial dizziness compared with subjects with mild or no dizziness; therefore, it is relevant to differ between mild and substantial dizziness symptoms in research and clinical practice in the future.

PP2-157 - Recovery of Ocular and Cervical Vestibular Evoked Myogenic Potentials after Vertigo Attacks

27. Others

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Purpose: This study reports the ocular vestibular evoked myogenic potential (oVEMP) and/or cervical vestibular evoked myogenic potential (cVEMP) recovery after peripheral vertigo attack. The study aimed at assessing the clinical value of oVEMP and

cVEMP for monitoring the rehabilitation of vestibular function.

Methods: Six patients diagnosed with peripheral vertigo with no VEMP response on the affected side but exhibiting symptom alleviation and VEMP responses after therapies were enrolled. The restoration and parameters of their VEMP response were analyzed.

Results: After treatment, three patients with sudden sensorineural hearing loss showed VEMP recovery, including one on both oVEMP and cVEMP recovery, and the other two on oVEMP recovery only. One patient of Meniere's disease showed cVEMP recovery, while the other Meniere's disease patient showed oVEMP recovery. One patient of Herpes Zoster Oticus exhibited cVEMP recovery. All the patients presented normal VEMP parameters before and after treatment.

Conclusions: Combined oVEMP and cVEMP are objective tools to assess vestibular otolithic end organ function in the process of dynamic functional recovery in vestibular diseases.

PP2-158 - Sub-clinical symptoms of postural-perceptual dizziness are associated with general sensory avoidance

27. Others

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Purpose: Persistent postural-perceptual dizziness (PPPD) is a condition where certain visual environments trigger vertigo and nausea. Our interest is whether symptoms of PPPD lie on a spectrum in the general population and how these symptoms relate to more general sensory processing.

Methods: We used the Situational Characteristics Questionnaire (SCQ) and the Visual Vertigo Analogue Scale (VVAS) to examine symptoms of PPPD in 219 undergraduate students. We related these

measures to the sensory avoidance subscale of the Adult Sensory Profile (ASP).

Results: We found that PPPD symptoms were surprisingly common in this non-clinical sample, with 9% of participants within a clinically relevant range for the SCQ and 6% above a patient cohort average for the VVAS. Symptoms on both scales were associated with increased sensory avoidance across all modalities (e.g. touch, smell, audition) as measured by the ASP (R for SCQ = 0.34, R for VVAS = 0.45).

Conclusions: These results suggest that the visual-vestibular atypicalities characteristic of PPPD could generalise to other sensory modalities. Ongoing research is examining whether this relationship is influenced by psychophysical measures of sensory performance and psychiatric factors such as anxiety. We are also validating the results with members of the general population and a PPPD patient population.

PP2-159 - The central nervous system complications accompanied by Ramsay-Hunt syndrome

27. Others

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Purpose: Reactivation of the latent varicella zoster virus (VZV) in the geniculate ganglion of facial nerve causes Ramsay-Hunt syndrome (RHS). Three features of RHS are the facial palsy, inner ear disorder and auricular herpes zoster. RHS may hurt around cranial nerves and even the central nervous system (CNS).

Methods: The patient was 50-year-old female, and she had the breast cancer which was undergoing the chemotherapy in our hospital. She felt vertigo and nausea and was referred to our department.

Results: In gaze nystagmus test, the rightward nystagmus was found in all eye positions. And left au-

ricle and parotid skin were reddish without left facial palsy. Next day, she complained the double vision and the left hearing loss, and the left auricular herpes zoster appeared without any other cranial nerve complication. Moreover, the right obliquely upward nystagmus was mixed with rightward nystagmus in gaze nystagmus test, and the skew deviation was found. Then the treatment to the VZV infection was started. Two days later, fortunately, the skew deviation disappeared and there was no finding in ENG test except the left canal paresis in caloric test. Next day, the facial palsy appeared, and she was diagnosed as RHS.

Conclusions: Skew deviation is an unusual ocular deviation, most commonly due to brainstem or cerebellar stroke. Reactivation of the VZV is easy to occur in the patients with decrease of immunity, and the geniculate ganglion of facial nerve is closed to brainstem and cerebellum. Therefore, we should be concerned about CNS complication in the patient with RHS.

PP2-160 - The ototoxic effect of cisplatin on vestibular hair cells in vitro

27. Others

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Purpose: to investigate the ototoxic effect of cisplatin on vestibular hair cells of saccule and utricle in vestibular organ cultures.

Methods: The macula utriculi and macula sacculi of three- or four-day-old F344 rats was cultured and treated with various doses of cisplatin for 48 h. Vestibular hair cells were stained with immunofluorescence and were observed under confocal microscope.

Results: The in vitro culture of vestibular hair cells in the control group grew well during the 48h culture and only an occasional loss of vestibular hair cells occurred. Cis-treated vestibular tissue showed loss of hair cells at low concentration (Cis10 μ M, Cis50 μ M, Cis100 μ M). The overall vestibular hair cell loss for Cis-treated macula utriculi and macula sacculi was 30 % at 10 μ M concentration, 80 % at

50 μ M, 50% at 100 μ M. However, at high concentrations of cisplatin (Cis 400 μ M and Cis 1000 μ M), most hair cells were intact. In all groups of cisplatin, ANOVA showed that there are statistically.

Conclusions: In vitro culture, cisplatin is ototoxic to vestibular hair cells. However, cisplatin-induced ototoxicity to vestibule showed a non-dose-dependent manner. Vestibular air cells possess intrinsic resistance to high levels of extracellular cisplatin. We speculate that this may be related to intake mechanism of cisplatin and molecular autophagy mechanism.

PP2-161 - Vestibular Neuropathy in Auditory Neuropathy: Detected by Vestibular Evoked Myogenic Potentials

27. Others

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Purpose: The aim of this study is to evaluate the lesion and the extent of vestibular involvement in patients with auditory neuropathy (AN) using the vestibular test battery of ocular vestibular evoked myogenic potential (oVEMP), cervical vestibular evoked myogenic potential (cVEMP) and Caloric test.

Methods: Sixteen patients (32 ears) of AN were enrolled as the case group, and fifty age- and sex-matched normal subjects (100 ears) enrolled as the control group. All of the subjects underwent air-conducted oVEMP and cVEMP tests in bilateral ears, and 14 of the AN patients underwent Caloric test. The results were compared between the two groups.

Results: Significant differences in VEMP abnormality were found between the AN group and the control group. In the AN group, the ratio of response was 31.25% in oVEMP test and 21.88% in cVEMP test, which was lower than that in the control group

(93% and 97%, both $P < 0.01$). The parameters of VEMP test, including amplitude, n1 latency, p1 latency, n1-p1 interpeak latency, also showed significant differences between the two groups. Of the 14 AN cases underwent Caloric test, 6 cases showed unilateral semicircular canal weakness and another 3 showed bilateral caloric weakness, with an abnormal rate of 64.28%.

Conclusions: This study is among first to use the combination of oVEMP, cVEMP and Caloric test to assess the status of vestibular function in AN. Most AN patients experienced disturbance of vestibular function. The test battery of VEMPs and Caloric testing may provide valuable information for detecting vestibular abnormalities in AN.

PP2-162 - Vestibular Symptoms and Function in Veterans with Post Traumatic Stress Disorder

27. Others

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Purpose: Posttraumatic Stress Disorder (PTSD) is a complex condition that has a range of symptoms of which a commonly reported one is dizziness. Given the overlap of symptoms in veterans with PTSD and vestibular patients, the question arises if vestibular dysfunction may be under diagnosed in veterans with PTSD due to the overlap in symptoms.

Methods: In a study of 124 veterans (age 53.9 \pm 9.9 yrs) we assessed vestibular symptoms using the VSS, DHI and VDADL. We also measured vestibular function with vHITs and ocular torsion. PTSD status was determined via the PCL.

Results: 53% of the Veterans were classified as having PTSD. As was expected those with PTSD had a significantly greater incidence of severe dizziness

(48% vs 13%) and higher scores on DHI (35±30 vs 11±20), VSS (14±11 vs 4±6), VDADL (65±37 vs 38±18) and lower balance confidence (75±23 vs 91±15), all $P < 0.001$. However, they did not differ in ocular torsion or vHIT gain values. There was a correlation between Right Posterior Canal Gain and PCL score, with higher PCL scores correlated to reduced gain ($R = -0.21$, $P = 0.045$). Surprisingly this was not true for the Left Posterior canal. There was also a strong correlation between PCL score and Balance Confidence ($R = 0.50$, $P < 0.001$).

Conclusions: These data demonstrate that veterans with PTSD report significant vestibular symptoms that impair their daily activity and are associated with reduced balance confidence. However, they did not demonstrate impairments in canal or otolith measures, expect for right posterior canal gain. Further work is necessary to determine causes of the symptoms.

PP2-163 - Voluntary eye closure disrupts the vestibulo-ocular response to head rotation in man and monkey

27. Others

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Purpose: Vestibulo-ocular reflexes (VOR) produce eye movements that minimize retinal image motion during head movement; though, it does not depend on visual input and functions in darkness. The effect of eye closure, however, which similarly eliminates vision, remains unclear. Authors report decreased/absent vestibular-evoked eye movements while others describe no change. Here, we performed experiments in man and monkey to investigate modulatory effects of eye closure on the VOR.

Methods: Human (N=26) and rhesus monkeys (N=2) were exposed to whole-body sinusoidal, step or pseudorandom rotations with eyes open and

closed in darkness. Eye movements were recorded with scleral (human) or implanted (monkeys) search-coils.

Results: Across conditions, voluntary eye closure reduced VOR gains from ~0.8-1.0 to ~0.1-0.3 in humans. Gains decreased in all sinusoidal rotation directions (horizontal/vertical/torsional) during eye closure, with the largest relative decreases (~60-70%) in horizontal/vertical directions. Taping one eye shut during step rotations moderately decreased gains (~10-15%), suggesting that mechanical restriction or afferent feedback play minor roles in attenuation. In contrast, attempting to open the lids when both eyes were taped shut increased VOR gains 4-times relative to voluntary closure; suggesting VOR engagement is related to the motor command to open the eyes. Finally, parallel studies in humans and monkeys established a link between lid closure and VOR attenuation: during pseudorandom rotations, gain decreased rapidly (~60-70%), and in humans initiated with eye deviations starting 40-60ms prior to lid motion.

Conclusions: Our results show robust attenuation of the VOR during voluntary eye closure that is related to the motor command to close the lids.

PP2-164 - Walking to the Toilet in Impatient with Vertigo (5th report)-An Evaluation Using the DHI

27. Others

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Purpose: Since the 25th Barany Society Meeting, we have been studying the walking to the toilet in patient with vertigo. Hypertension and ages of 65 years or older were identified as toilet walk prolongation factors. In this study, we examined the relationship between hypertension and daily activity ratings determined using the Dizziness Handicap Inventory (DHI) questionnaire in patients with vertigo. Tendencies in the DHI ratings in daily activities were also examined.

Methods: The study population comprised 215 patients with vertigo who presented to the outpatient clinic of the Kochi Health Sciences Center between January and March 2015. Items for investigation: The patients were divided into six groups according to the number of DHI questions responded with the answer "Yes": "0", "1-5", "6-10", "11-15", "16-20", and "21-25". The proportion of hypertensive patients and the distribution of physical (P), emotional (E), and functional (F) ratings in each group were determined.

Results: The population of hypertensive patients was high at 42.9% in the "21-25" group, with no significant differences found in the other groups. In the "11-15" group, the rating E accounted for a high percentage.

Conclusions: In the "21-25" group, hypertension had may also be an influential factor in their daily activities. In the other groups, hypertension had little influence in the daily activities. Blood pressure fluctuation and hemodynamic changes in the presence of vertigo were suggested to be the reasons for the influence of hypertension in their "toilet walk" during hospitalization for vertigo. In the "11-15" group, Psychological influence may have been more closely involved in the daily activities than hypertension.

PP2-165 - When on earth a patient with congenital nystagmus experiences oscillopsia? -A case report-

27. Others

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Purpose: Patients with congenital nystagmus (CN) usually do not experience oscillopsia. There are some suggestions about this lack of oscillopsia in CN, but some patients experience oscillopsia, actually. Our purpose is to know why our CN patient experienced oscillopsia and to prove whether or not we could record strange eye movements on each eye recording when he experienced oscillopsia.

Our CN patient as follows: A PAN type patient wearing glasses who was 30-year-old software engineer man, had lots of complaints (dizziness, blurred vision and/or oscillopsia), in particular, during computing, whom he got behind in his daily living in the end, was referred and visited to our clinic.

Methods: We routinely investigate CN by using a goggle with bilateral infra-red CCD cameras, which can record each eye movement simultaneously. Eye movements are recorded under gazing onto the imaginary target, like examiner's nose, for ten seconds, in front of them at the primary position. We analyse each eye movement by use of a software named Image J.

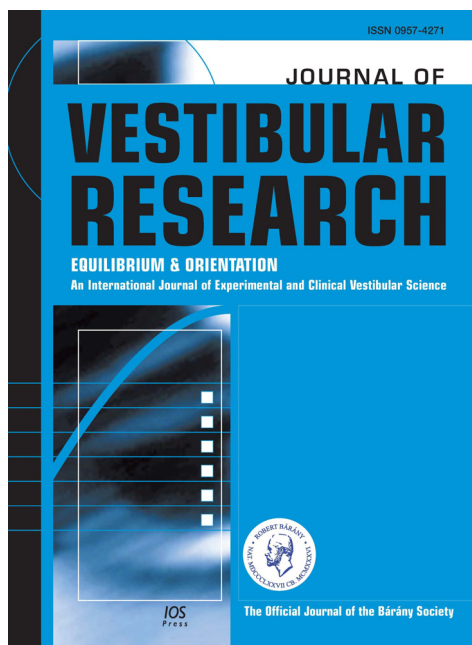
Results: At our follow-up clinic, when he wore glasses, he had lots of complaints and the analysed eye movements indicated his each eye had own eye movements, like chameleon's eye movements. After asking him not to wear glasses, and allowing him to wear contact lenses, he was gradually getting better of his symptoms and he had nothing to complain. The analysed eye movements indicated similar oscillations on both eyes.

Conclusions: We thought his workaholicism and wearing glasses could influence his visual surroundings and eye movements. He experienced oscillopsia, finally.

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