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Poster Sessions

Poster Session 1 – A. Basic Science

PA-01

Effect of an ototoxic agent on cupular morphology – a comparison with semicircular canal pathology

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Objectives: To observe the morphological changes of the cupula after injecting gentamicin (GM) in the frog inner ear and to compare the changes of the cupula with those of the ampullary sensory cells.
Methods: We injected 300 μg (7.5 μl) of GM into the inner ear of 30 bullfrogs using a microsyringe under ether anesthesia. The same amount of saline was injected into the other ear as control. The posterior cupula were observed at 3, 7, and 14 days after GM injection by stereoscopic microscope after being stained with India ink. We classified cupula changes into Grades 1 $\sim$ 4 according to the degree of cupula shrinkage. Grade 1 is normal or slight change of the cupula such as the dip of the apex. Grade 2 is under 50%, and Grade 3 is 51$\sim$ 80% of cupula shrinkage. Grade 4 is more than 80% of shrinkage or absence of the cupula. After removing the cupula, the sensory epithelia of the posterior canal were immediately fixed with 2.5% glutaraldehyde solution and were assessed using a scanning electron microscope (SEM). We classified the sensory cell changes into Grades 1 $\sim$ 4 according to the extent of sensory cell damage. Grade 1 is damaged sensory cell area smaller than 20% of the total area. Grade 2 is damage of 21 $\sim$ 50%, Grade 3, 51 $\sim$ 80% and Grade 4, more than 80%. he correlation between the changes in the cupula and sensory cells was evaluated.
Results: 1. Changes at 3 days after GM injection
Normal or slightly changed cupula (grade 1) were seen in 7 out of 10 cases. Grade 4 change, disappearance of the cupula was found in 3 cases. In these cases, the sensory cell change was also severe. Sensory cell changes were Grade 2 or more in 7 cases.
2. Changes at 7 days after GM injection
The cupula showed mild changes of grade 2 or less in 5 of 10 cases. The sensory cells also showed mild changes of grade 2 or less. In the other 5 cases, the degree of cupula change was not associated with the sensory cell change. In this group, the sensory cell change was no more severe than that in the 3-day group.
3. Changes at 14 days after GM injection
The cupula showed Grade 2 or more severe changes in 7 of 10 cases. There were only 2 cases in which the cupula and sensory cell changes were both Grade 2 or milder. In 3 cases, both the cupula and sensory cells had damages Grade 3 or more. The other 4 cases showed no correlation between the cupula and the sensory cell change.
4. The control group
The cupula and sensory cells were normal in all 6 cases.
Conclusions: The cupula shows various degrees of changes after GM injection into the inner ear, with or without damage of the sensory cells. This cupula change may be a part of the etiology of peripheral vertigo, and is also potentially one of the mechanisms of reduced caloric response.

PA-02

Using an artificial vestibular system and robot simulations to mimic human postural responses to support surface translational accelerations

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Objectives: Human reactive balancing of biped stance is multisensory, even if visual cues are excluded. It involves proprioceptive and vestibular signals and joint torque/ force cues. Its multisensory nature makes the control redundant and hampers system identification. Therefore, hypothetical control schemes are required (e.g. derived from psychophysics). In a corresponding model from this laboratory, four external disturbances are considered relevant for stance, are estimat-

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ed through online sensory interactions, and are compensated for by using a 'disturbance injection' control method (disturbance estimation and compensation, DEC, model). In previous studies, we found that the model correctly described compensation of three of these disturbances (support surface rotation, contact force through body-pull stimuli, and effect of field force gravity in 'body sway referenced platform' situations). Not yet included was the fourth disturbance, which is support surface translational acceleration (SSTA). It may occur frequently in human life (e.g. during bus rides) and several laboratories have studied its postural responses. Our model simulations predicted that identification of the SSTA compensation likely is difficult since, if omitted, its function is taken over by the other compensations. We therefore sought for novel ways that may help its identification.

Methods: Healthy human subjects were standing on a motion platform with eyes closed. They were presented with forth-back SSTA stimuli using smoothed ramp, sinusoid, and pseudo-random waveforms. Responses were evaluated in terms of center of mass, COM, excursions (calculated from optoelectronic kinematic data) and of center of pressure, COP, shifts (force transducing platform). In addition to the humans, a biped robot ('PostuRob') was tested, which carried human-inspired sensors including an artificial vestibular system (Mergner et al. 2009; J. Physiol. Paris, 130: 178). PostuRob used the DEC model for stance control. Two model versions were used. In an 'old' version, STTA compensation was omitted (as before), whereas it was included in a 'new' version. STTA estimation involved a vestibular signal of translational acceleration from the artificial vestibular sensor. Human and robot data were compared with each other and with computer simulations to explore into possible expansions of the identification approach.

Results: PostuRob's responses resembled the humans' responses (including those previously reported in literature). The responses obtained with PosturRob's new model resembled those with the old model, apart from marginal differences, as expected. An exception, i.e. present only in the human data, was a balancing improvement over time during the sinusoidal stimulation (COM and COM excursions became smaller). We attributed it to a human STTA prediction, this although only a weak 'wrong prediction' effect was observed upon abrupt stimulation end. When we added a STTA prediction mechanism to PostuRob's DEC model (based on a Smith Predictor method), it successfully mimicked the corresponding human findings.

Conclusions: Complementation of the DEC model with SSTA estimation and compensation is possible and is compatible with the human data. The performance benefit for purely reactive balancing is marginal, though, because of the system's inherent redundancy. The redundancy hinders the identification of the SSTA estimation and compensation by simple straightforward 'experimental proofs'. We therefore plead to judge the value of the DEC model and other complex adaptive models on the basis of their overall describing and predictive power. We show here that the DEC model is very versatile in that it lends itself easily to the prediction of the external disturbances, and this with human-like outcome. Since the SSTA estimation involves vestibular input, we hope to learn more about the human control principles by including in future vestibular-loss subjects who, in the absence of visual orientation cues, are able to partially substitute the vestibular cues by force cues.

PA-03

Membrane excitability of Purkinje neuron in vestibulocerebellum

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Cerebellum underlies the control of posture and balance, fine coordination of motor movement, and working memory. Cerebellar Purkinje cells (PCs) are key to a variety of motor- and learning-related behavior by integrating multimodal afferent inputs and taking up the sole output of the cerebellar cortex. PCs are known to generate high-frequency action potentials. The pattern and rate of firing are under the control of both synaptic input and intrinsic ion channels that allow the neurons to fire spontaneously in the absence of synaptic input. Intrinsic membrane excitability determines the input-output relationship of neurons and therefore governs the functions of neural circuits.

Cerebellar vermis consists of ten lobules (lobule I-X), and each lobule has different function. However, lobule-specific difference of electrophysiological properties of PC is incompletely understood. To address this problem we performed a systematic study of PC spiking patterns from different lobes (lobules III, IV, V vs. X). Using patch clamp technique, passive and active properties of PC were evaluated in slices prepared from rats (P22-24). Two types of firing patterns were identified in response to depolarizing current in-

jections in PCs of lobules III, IV, and V; Tonic-firing showing Na+ spikes at regular intervals throughout the current pulse (71.4%), and Complex-bursting showing both Na+ spikes and Ca2+-Na+ spikes (28.6%). In contrast PCs in vestibulocerebellum (lobule X) exhibited four types of firing patterns; Tonic-firing (37.9%), Complex-bursting (6.9%), delayed-firing showing a delayed onset of firing in response to current injections (27.6%), and initial bursting showing short firing of a few action potentials (27.6%). This difference in firing patterns probably contributes to lobule-specific processing of input-output relationship.

PA-04

Bone-conducted vibration combined with real-time triaxial accelerometry in eliciting ocular and cervical vestibular evoked myogenic potentials

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Objective: This study utilized bone-conducted vibration (BCV) stimulation combined with real-time triaxial accelerometry to elicit ocular vestibular-evoked myogenic potentials (oVEMPs) and cervical VEMPs (cVEMPs). Our final goal was to optimize the acceleration magnitude of BCV stimuli in eliciting VEMPs
Methods: Fourteen healthy volunteers underwent oVEMP and cVEMP tests via BCV stimuli combined with real-time analysis of triaxial acceleration.
Results: All (100%) subjects showed clear oVEMPs and cVEMPs via BCV stimuli from a vibrator at the voltage of 8.0 V. Under BCV stimulation at the Fz or inion, the acceleration magnitude in y-axis revealed the largest one, as compared with that in x-axis or z-axis. Significantly positive correlations were noted between the acceleration magnitude of each axis and oVEMP/cVEMP amplitude. The optimal cutoff values of acceleration magnitude in x-, y- and z-axis were 0.05 g, 0.12 g, and 0.04 g for eliciting oVEMPs, and 0.03 g, 0.06 g and 0.03 g for evoking cVEMPs, respectively. To achieve these values, the driving voltage of the vibrator may be simply adjusted at 8.0V and 4.5V for oVEMP and cVEMP tests, respectively.
Conclusion: For eliciting oVEMPs and cVEMPs via BCV stimuli, the acceleration magnitude should exceed 0.12 g and 0.06 g in y-axis, which could be achieved by adjusting the driving voltages of the vibrator at 8.0V and 4.5 V, respectively.

PA-05

Galvanic vestibular-evoked myogenic potentials in humans and guinea pigs

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Objectives: This study applied galvanic vestibular stimulation (GVS) with various intensities and durations to elicit vestibular-evoked myogenic potentials (VEMPs) in humans. In addition, GVS-VEMPs were also carried out in guinea pigs to study the relation between GVS-VEMPs and the vestibular afferents.
Methods: Fourteen male volunteers underwent VEMP test using GVS mode with various intensities (1, 2, 3 and 5 mA) and durations (0.1, 0.2, 0.5 and 1.0 ms). The characteristic parameters (latencies and amplitude) were compared. In guinea pigs, 0.05 mL of gentamicin (40 mg/mL) was dropped on the round window membrane of the left ear. Four weeks after surgery, each animal underwent VEMP test using GVS mode (5 mA/1.0 ms), then animals were sacrificed for morphological study.
Results: In humans, galvanic stimulation at 3 mA/1.0 ms, 5 mA/0.5 ms or 5 mA/1.0 ms had high prevalence (89–100%) of GVS-VEMPs. However, the p13–n23 amplitude in group of 5 mA/1.0 ms was significantly larger than those in groups of 3 mA/1.0 ms and 5 mA/0.5 ms. In guinea pigs, all animals (100%) displayed absent click-VEMPs and GVS-VEMPs. Substantial loss of hair cells in saccular macula is consistent with absent click-VEMPs; while absent GVS-VEMPs were correlated with significantly lower percentage of voltage-gated sodium channel Nav1.8-like immunoreactive (Nav1.8-LI) neurons (38.9 ± 0.7), when compared with the control ones (53.6 ± 3.2).
Conclusions: In humans, using 5 mA in intensity and 1.0 ms in duration may be the optimal GVS mode for eliciting VEMPs. In guinea pigs, absent GVS-VEMPs are attributable to the damage of the vestibular afferents.

PA-06

Gaba b receptors contribute to the restoration of balance during vestibular compensation in mice

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Following unilateral vestibular damage (UVD), vestibular compensation restores both static and dynamic vestibular reflexes. The cerebellar cortex provides powerful GABAergic inhibitory input to the vestibular nuclei which is necessary for compensation. Metabotropic GABA type B (GABAB) receptors in the vestibular nuclei are thought to be involved. Both GABA levels in the vestibular nuclei and sensitivity of vestibular neurons to GABA are altered during compensation. GABAB receptors are also abundantly expressed in the vestibulocerebellum. GABAB antagonists, administered following compensation, can cause signs of imbalance to reappear. However, the contribution of GABAB receptors to compensation has not been demonstrated directly.
Static compensation is more rapid than dynamic compensation, and is thought to rely on different mechanisms. The exact role of GABAB receptors may differ between static and dynamic compensation. In addition, there may be a critical period for compensation. Interference with compensation during the critical period has been proposed to reduce its long-term effectiveness. We tested static and dynamic postural reflexes and gait in young mice, while they compensated for UVD caused by injection of air into the vestibular labyrinth. The air injection caused impairment of the static and dynamic vestibular reflexes that are involved in normal posture and locomotion. The effects of an agonist (baclofen), an antagonist (CGP56433A) and a positive allosteric modulator (CGP7930) of the GABAB receptor were administered to groups of mice during compensation. Multiple doses of the test substance were injected s.c. both before and shortly after UVD.
Static postural reflexes recovered very rapidly, and baclofen slightly accelerated recovery. CGP56433A significantly impaired static compensation. Dynamic reflexes were evaluated by balance-beam performance and by gait; both showed significant decrements following UVD and performance improved over the next 2 days. Both CGP56433A and baclofen temporarily impaired the ability to walk on a balance beam after UVD. Two days later, there were no longer any significant effects of drug treatments on balance-beam performance.
Baclofen slightly accelerated the recovery of stride length on a flat surface, but CGP7930 worsened the gait impairment following UVD.
Using immunohistochemistry, we confirmed that GABAB receptors are abundantly expressed on the vestibulospinal neurons of Deiters and in the descending vestibular nucleus in mice.
Our results suggest that GABAB receptors contribute to the compensation of static vestibular reflexes. GABAB receptors also appear to be involved in the recovery of gait following UVD. However, the observation that balance beam performance returned to normal in all groups suggested that impairment of static compensation does not necessarily result in an impairment of dynamic compensation in the long term.

PA-07

Vestibulo-ocular reflex thresholds match perceptual thresholds above 1 Hz

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How the brain processes signals in the presence of noise impacts much of behavioral neuroscience. Recent studies have shown that variations in smooth pursuit are predominantly due to sensory, not motor, contributions. Analyses of smooth pursuit noise/variability (e.g. [4]) and comparisons of perceptual and motor thresholds (e.g. [6]) support this conclusion. We set out to generalize these findings to another sensorimotor system – the vestibulo-ocular reflex (VOR). Specifically, we set out to determine if horizontal VOR thresholds evoked by yaw rotation match perceptual thresholds across a broad frequency range.
Only one paper [5] has previously quantified VOR thresholds – reporting VOR thresholds of 0.5°/s/s that were significantly less than perceptual thresholds (1.2°/s/s) evoked by the same angular velocity ramp stimuli. Other studies using single cycle sinusoidal accelerations have shown that yaw angular velocity perceptual thresholds are roughly constant between about 0.5 and 5.0 Hz [3] but increase substantially as frequency decreases below 0.5 Hz [1,3]. These dynamic effects can be modeled with a high-pass filter having a cut-off frequency of 0.3 Hz that is substantially above the cut-off frequency of the semicircular canals ($\sim$ 0.0 5Hz, e.g. [2]). This finding does not match VOR "velocity storage" findings that show that the VOR can be mimicked by a high-pass filter having a cut-off frequency ($\sim$ 0.01 Hz) substantially below the canal cut-off frequency.
In this study, we measured the VOR using search coils in rhesus monkeys. Single cycles of sinusoidal angular acceleration were applied over a broad range of frequencies (0.2, 0.3, 0.5, 1, 2, and 3 Hz) with the stimuli amplitude near-threshold. The direction of eye move-

ment (left or right) was determined. A psychometric function was fit for each animal at each frequency with a Gaussian cumulative distribution function. The fit parameters gave a measure of the standard deviation of the underlying noise, which is directly related to threshold.

At 2 Hz and 3 Hz, we found VOR thresholds that averaged about 0.5°/s, which matched perceptual thresholds at these frequencies, which is consistent with the hypothesis that sensory noise determines both VOR and perceptual thresholds. However, we also show that VOR thresholds diverge dramatically from perceptual thresholds at frequencies below 0.5 Hz. This demonstrates that the bandwidth over which the VOR can be used to directly assay sensory noise is restricted to frequencies above 0.5 Hz. The dramatic difference between VOR thresholds and perceptual thresholds at frequencies below 0.5 Hz suggests that different mechanisms apply to perception than to the VOR.

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PA-08

A primate model for pendular nystagmus

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Objective: Several forms of pendular nystagmus are recognized, but animal models for them are lacking. We have reported that, during early pursuit training, juvenile monkeys exhibited transient oscillatory eye movements that looked very similar to pendular nystagmus. We hypothesized that these transient oscillatory eye movements, which appeared in normal juvenile monkeys, could become an animal model. In the present study, we analyzed the characteristics of the oscillatory eye movements, recorded neuronal activity correlated with the oscillations in the cerebellar flocculus, and tested the effects of gabapentin on the oscillations.

Methods: Four monkeys were trained for horizontal and vertical smooth pursuit; in two, saccades were also tested. Three of them were aged 4 and one was 5.5 years old. Each monkey was seated in a primate chair in darkness with the head firmly restrained in the stereotaxic plane, facing a 22-inch computer display placed 65 cm away from the eyes. A red spot of 0.5° angular size was used as the target. During the initial training, our monkeys were trained only in horizontal pursuit at 0.2 Hz (± 10°). If the monkeys' gaze was within the error window of ± 5° for 0.5 s, a drop of apple juice was automatically delivered to the monkeys. Once the gain of horizontal pursuit reached 0.7, we started training the monkeys in vertical pursuit for ∼ 2–3 weeks at 0.2 Hz (± 10°), ∼ 30 min per day, 5 days per week. We measured frequency, peak-to-peak eye velocity, and amplitude of the ocular oscillations. In one monkey, oscillation-related neuronal discharge was recorded in the cerebellar floccular region. To analyze neuronal discharge during oscillatory eye movements and/or corrective saccades, all traces were aligned with peak eye velocity obtained by differentiating eye position traces on the computer using a 6 ms differentiation time. In one monkey, the effect of gabapentin on the oscillations was measured.

Results: Ocular oscillations, with features of pendular nystagmus, appeared early during training of both horizontal and vertical pursuit in all 4 monkeys. Although these oscillations were observed both in the direction of pursuit and orthogonally, the velocity and amplitude of oscillation were larger in the direction of pursuit, implicating pursuit mechanisms in their generation. The mean frequencies of vertical oscillatory eye movements were significantly higher than those of horizontal oscillatory eye movements during both horizontal pursuit

and vertical pursuit. Corrective saccades were often superimposed on the oscillations during pursuit and fixation, but exhibited clearly different velocity-amplitude relationships from those of oscillation. Recordings in the floccular region revealed that groups of neurons discharged during both the pendular oscillations and corrective saccades. Many neurons exhibited burst-tonic discharge during visually guided saccades, similar to discharge of brainstem burst-tonic neurons, suggesting contributions of the neural integrator to the oscillation. Gabapentin suppressed oscillations in the monkey tested.
Conclusions: The transient ocular oscillations occurring in monkeys during pursuit training could provide an animal model for pendular nystagmus. Both smooth pursuit and neural integrator may contribute to these ocular oscillations.

PA-09
Dose deficit in hippocampal function affect equilibrium function?
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Perception of spatial orientation and self-motion can benefit from integration of multiple sensory cues including vestibular signals. There are two types of neurons related spatial orientation in the hippocampus. Place cells were found in hippocampal areas CA1 and CA3, correlates of head orientation collectively map spatial locations, Head-direction cells are strongly selective for the direction of the head in its environment. Recently grid cells were found in entorhinal cortex (EC). They also exhibit conjunctive representations of position and orientation. Stackman showed that temporary inactivation of the vestibular system led to disruption of location-specific firing in hippocampal place cells and direction-specific discharge of postsubicular HD cells, without altering motor function. Vestibular signals have important effects in expression of hippocampal spatial representations.
Dose deficit in hippocampal function affect vestibular function? To determine whether it does, we examined the equilibrium function in patients with hippocampal sclerosis and temporal lobe epilepsy.
Subjects and methods: Data were obtained from 16 patients with hippocampal sclerosis and temporal lobe epilepsy. Eleven patients were also investigated after the amygdalohippocampectomy. They were examined by equilibrium tests (caloric test, posturograhy, step test, and modified step test). We also investigated sound lateralization test. Sound lateralization test is one of the examination of auditory space maps. Space-specific neurons in the auditory space map gain spatial selectivity as a result of tuning to combinations of the interaural time difference (ITD) and interaural level difference (ILD).
Results: We detected dysfunction of equilibrium in some patients with deficit of hippocampal function. ITD was longer than in healthy subjects.

PA-10
Cortical response concerned with circular vection detected by functional near infrared spectroscopy (fNIRS)
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To investigate brain activity during horizontal self-motion perception (circular vection :CV), hemodynamic responses by near infrared spectroscopy (NIRS) were recorded simultaneously while the subjects received optokinetic (OK) stimulation.
Six healthy subjects were enrolled (mean age 27.4 yrs old; 6 males; all right-handed). The subjects were seated on a chair in a shielded room. A head cap for NIRS (FLASH-PLUS; Shimadzu Co. Ltd., Japan) was set to the subject. There were 62 NIRS probes in the head cap, so that hemodynamic data was recorded from 103 fNIRS channels. Visual pattern of the OK stimulation projected on a hemispheric screen in front of the subject, resulting that visual pattern was applied to the whole visual field of the subjects. In the OK stimulation, visual pattern was rotated clockwise at the constant angular velocity of 180 degree/sec for 60 sec. All subjects felt CV in response to the OK stimulation. As for the control, subjects looked at the stationary same visual pattern for 60 sec. Differences of the changes in Oxy-Hb concentration between OK stimulation and control were evaluated in each probes.
Statistical analyses revealed that the widespread brain regions correlated with self motion perception, which comprised the right inferior frontal gyrus, bilateral superior temporal gyrus, bilateral angular gyri and supramarginal gyri, right medial temporal gyrus, right precuneus and bilateral superior frontal lobe. These data revealed a cortical network involving visual motion sensation corresponding to previous functional imaging studies.

PA-11

Evidence of re-weighting to plantar sensation at 0.06% and 0.10% blood alcohol intoxication in human postural control and adaptation

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Background: Acute alcohol intoxication is the cause of many accidental falls needing medical aid at emergency units and alcohol intoxication affects both the sensory and motor systems. The risk of falling at various conditions can be measured by assessing the stability especially when it is perturbed. Standing postural stability relies on input from visual, vestibular and somatosensory receptors. The somatosensory system of the feet has both rapidly and slowly adapting mechanoreceptors. When balance is perturbed through disrupted information from one of the sensory systems, appropriate postural stability can partly be restored by putting a higher reliance on information from the remaining properly working sensory sources, a procedure termed sensory re-weighting.

Aim: To assess how mechanoreceptive information contribute to stability under quiet stance and under balance perturbations at 0.06% and 0.10% blood alcohol concentration (BAC).

Method: 25 healthy subjects (mean age 25.1 years) were assessed while sober and under alcohol intoxication by a force platform during quiet standing and pseudorandom pulses of calf muscle vibration for 200-s with eyes closed or open. The plantar cutaneous sensation was assessed as tactile sensitivity (slowly adapting) and vibration perception (rapidly adapting). The correlation between individual body sway and plantar cutaneous sensation was calculated to assess the contribution of plantar sensation to the stability during each test condition.

Results: Body sway was significantly increased by alcohol intoxication and the increase was substantially larger at 0.10% BAC than at 0.06% BAC. There was an increased association between the subject's plantar sensation and the subject's body sway when intoxicated by alcohol, particularly at 0.10% BAC and in the fast corrective movements of balance when perturbed.

Conclusion: The study shows that when intoxicated by alcohol, the recorded stability becomes significantly stronger related to the individual's plantar sensation in the feet. This finding evidences that the central nervous system use sensory re-weighting to enhance the stability during alcohol intoxication. Moreover, the findings also show that under alcohol intoxication, CNS give information from the mechanoreceptive sensation from the feet higher priority than usual under normal sober conditions.

Table 1
Effects of alcohol intoxication, vision, stimulation period and local vibration sensation on total, low frequency (< 0.1 Hz) and high frequency (> 0.1 Hz) torque variance values during posturography using the GLM univariate ANOVA method, "NS" signifies no significant difference. The notation "< 0.001" means that the p-value is smaller than 0.001. The interaction combinations not presented in the table contained no statistical significant findings.

Torque variance	Vibration Perception	Alcohol	Vision	Period	Sensation	Alcohol * Period	Alcohol* Sensation	Vision* Sensation
Total	Big toe	<0.001	<0.001	<0.001	<0.001	NS	<0.001	0.007
	Little toe	<0.001	<0.001	<0.001	<0.001	NS	<0.001	<0.001
	Base of big toe	<0.001	<0.001	<0.001	<0.001	NS	<0.001	NS
	Base of little toe	<0.001	<0.001	<0.001	<0.001	NS	<0.001	NS
	Heel	<0.001	<0.001	<0.001	<0.001	NS	<0.001	NS
Low Frequency	Big toe	<0.001	<0.001	<0.001	<0.001	NS	<0.001	NS
	Little toe	<0.001	<0.001	<0.001	<0.001	NS	<0.001	0.020
	Base of big toe	<0.001	0.001	<0.001	<0.001	0.042	0.003	NS
	Base of little toe	<0.001	0.001	<0.001	<0.001	NS	<0.001	NS
	Heel	<0.001	0.001	<0.001	<0.001	NS	<0.001	NS
High Frequency	Big toe	<0.001	<0.001	NS	<0.001	NS	<0.001	0.001
	Little toe	<0.001	<0.001	0.009	<0.001	NS	<0.001	<0.001
	Base of big toe	<0.001	<0.001	NS	<0.001	NS	<0.001	0.005
	Base of little toe	<0.001	<0.001	NS	<0.001	NS	<0.001	0.006
	Heel	<0.001	<0.001	NS	<0.001	NS	<0.001	0.017

PA-12

Morphological changes in stria vascularis in experimental animal modes administered arginine vasopressin

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Objectives: A number of clinical and experimental animal studies suggest that arginine-vasopressin (AVP) is closely related to the development of endolymphatic hydrops which was a histopathological finding in the inner ear in Meniere's disease (MD) by acting as a related factor. Takeda et al. and Kumagami et al. induced experimental endolymphatic hydrops by the chronic administration of AVP for 1 week and also at a single large dose of AVP in the guinea pig, respectively.

In previous experimental models, Mori et al. reported that a perilymphatic perfusion of AVP produced an increase in the electrical resistance of the scala media concomitant with the endocochlear potential (EP) decrease and suggested that the main action site of AVP in the cochlear was the stria vascularis. The mechanism of it might be related to the dysfunction in the stria vascularis.

In the present study, to elucidate the mechanism regarding decrease in EP induced by administering AVP, the morphological change was investigated. We conducted a qualitative analysis in the morphological change in the stria vascularis by administering AVP.

Methods: Ten wistar rats weighing 100–200 g were used in following experiments. In the control group ($n = 10$, 5 animals) the same volume amount of normal saline solution as the volume amount of AVP (0.02 units /g) in the AVP group (see below) was administered by intraperitoneally injection. In AVP group ($n = 10$, 5 animals), AVP (0.02 units/g, pitressin; Arg-vasopressin, Daiichi-Sankyo, Japan) was given intraperitoneally, respectively. One hour after each injection of physical saline in the control group and AVP in the AVP group, all animals were sacrificed under deep anesthesia by an intraperitoneal injection of pentobarbital sodium and temporal bones were removed.
Ultrathin sections of stria vascularis for transmission election microscopy (TEM) were made in the conventional methods. The stria vascularis faced to the tympanic cavity at the second turn in mid-modiolar section of the cochlea was selected to observed because the condition of specimens of the stria vascularis was the most stable.
In the AVP group, the area where the organella was not in the intermediate cell (so called "vacuole") was observed. The whole of stria vascularis was observed and photographed particularly at the magnification of 2000X under TEM. The films were scanned in 400 dpi and saved in a personal computer. The images were merged with a soft ware and then the whole of the stria vascularis was saved in an image. The total area of the each vacuole whose long diameter was larger than 1 μm in the whole of the stria vascularis was measured with using measuring software of image-J. The total area of the each vacuole was compared among the control group, the AVP group. The ratios between the whole area of the stria vascularis and the total area of all the vacuoles were also calculated and compared between the control group and the AVP group.
Results: The total area of the vacuoles in the intermediate cells were 30.7Å@ $\pm$ 16.1 and 91.0 $\pm$ 49.2 μm^2 in the control and the AVP group, respectively. The areas in AVP groups were significantly increased in comparison with one in the control group ($p < 0.01$). The ratios between the total area of the vacuoles in the intermediate cells and the whole area of the stria vascularis in the AVP group (0.031 $\pm$ 0.014) was also significantly increased in comparison with one in the control group (0.011 $\pm$ 0.006) ($p < 0.01$).
Conclusions: The vacuoles in the intermediate cell were caused by the administering AVP. These morphological changes would impair the oxygen diffusion in the stria vascularis.

PA-13
Expression of aryl hydrocarbon receptor in the inner ear of rodents
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Background: Many medical drugs such as aminoglycosides and cisplatin are known to impair the inner ear. Some environmental pollutants also induce the impairment of inner ear. Especially, polychlorinated biphenyls (PCB) are well known as a representative artificial chemical substance to cause the lesion in the inner ear. Perinatal exposure to PCB produces the permanent hearing loss at a low-tone frequency as a result of reduced serum level of thyroid hormones during the critical period for the development of the inner ear. In the hypothyroid rats exposed to propiothiouracil, the formation of tectorial membrane was incomplete. In contrast, the outer hair cells near the apical turn were damaged in the PCB-exposed rats. Therefore, the decrease of thyroid hormone level does not explain the mechanism of hearing loss in the PCB-exposed rats. The dioxin-like compounds including PCB bind aryl hydrocarbon receptor (AhR) directly. However, the distribution of AhR is unclear in the inner ear.
Objectives: The aim of this study is to elucidate the distribution of AhR in the inner ear of rodents.
Methods: Wistar rats and A/J mice were used in this experiment. The immunohistochemical staining was carried using Histofine Simple Stain MAX-PO system (Nichirei Biosciences Inc., Japan) according to the manufacturer's instructions. The rodents were trascardially perfused by 4% paraformaldehyde. The brains were removed from the skull and immersed in 20% sucrose. Frozen sections were cut at 7 μm. After quenching the endogenous peroxidase activity by 3% H_2O_2 in methanol for 30 min, each sections were incubated in 10mM phosphate buffered saline with 1% bovine serum albumin and anti-AhR rabbit polyclonal antibodies (diluted at 1:150, sc-5579; Santa Cruz Biotechnology, USA) overnight at 4°C. The sections were subsequently treated with Simple Stain MAX-PO solution for an hour at room temperature. Aminoethylcarbazol (AEC) was used as a peroxidase substrate. There was no staining in the negative control slides prepared without primary antibodies.
Results: The distribution of AhR in rats were similar to that of mice. In the cochlea, outer hair cells, spiral ligament and spiral ganglion cells were immunopositive

in rats and mice. Tectorial membrane also expressed AhR in both types of rodents. The ampula of the semicircular canal expressed AhR, although the utricle did not express that receptor.
Conclusions: These results suggest that ligands of AhR may affect both auditory and vestibular function. The cochlear AhR expressed in the outer hair cells and the fibrocytes in the spiral ligament both of which play an important role in the potassium cycle to maintain the homeostasis in the inner ear. Therefore, the activation of AhR may change the concentration of potassium in the endolymph.

PA-14
Influence of galvanic and air-caloric vestibular stimulation on self-attribution of body parts and tactile perception
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A contribution of vestibular signals to bodily self-consciousness is suggested by neurological observations. Stimulation of the peripheral vestibular system may modify self-attribution of body parts in brain-damaged patients suffering from somatoparaphrenia and may improve tactile perception in patients with hemianesthesia. Yet, the underlying mechanisms remain to be precisely determined. It is not clear, for example, whether vestibular stimulation restores awareness for one body part or changes tactile sensitivity for this body part. The present study aimed at investigating the influence of galvanic and caloric vestibular stimulation on conscious bodily experiences.
In a first experiment ($n = 16$ healthy participants), we investigated whether galvanic vestibular stimulation (GVS) interfered with the mechanisms underlying self-attribution of the hand using the so-called 'rubber hand illusion' (Lopez et al., 2010 Consciousness and Cognition). The (unseen) left hand and a left rubber hand in front of them were stroked synchronously or asynchronously for the duration of 1 minute. As classically reported, synchronous stroking of the participant's hand and the rubber hand induced an illusory self-attribution of the rubber hand. We compared whether this illusory self-attribution was influenced by binaural GVS (anode left/cathode right, 'exciting' the right ear vs. anode right/cathode left, 'exciting' the left ear) applied during 1 minute stroking and compared the results with a baseline without GVS and sham stimulation (electrical stimulation on the neck). Immediately after the stroking, self-attribution of the rubber hand was assessed by means of questionnaires. The results showed that left anodal/right cathodal GVS significantly increased illusory ownership of the rubber hand and illusory location of touch (as if the touch participants felt was caused by the paintbrush touching the rubber hand). We propose that these changes might be due to a spatial or temporal modification of visual-tactile integration, leading to an enhancement of visual capture. Such changes were found selectively for left anodal/right cathodal GVS and we speculate that this finding is due to an interference with activity in the right posterior insula and right temporo-parietal junction, regions integrating vestibular, visual and tactile signals, and their integrity is required for normal sense of body part ownership.
In a follow-up experiment, we investigated whether air caloric vestibular stimulation (CVS) influenced conscious tactile perception of hands. We measured tactile two-point discrimination thresholds for the right and left hand using pairs of plastic rods separated by 7 distances (from 2–14 mm). A 0 mm distance was produced with a single rod. Each distance was tested 10 times in a randomized order. Participants reported verbally whether they experienced one touch or two touches. They performed this task while they received either cold CVS (air temperature 20°), or sham CVS (air temperature 37°), in their left ear. The two-point discrimination task was performed in darkness. Our preliminary data indicate that left cold CVS tended to increase the threshold for detecting two points, thus disturbing tactile perception. We propose that this could be due to interfering effects of left cold CVS (relative activation of the right ear) with processing in multisensory cortical vestibular areas (mostly in the right cerebral hemisphere). Important candidates are the posterior insula, temporo-parietal junction, primary and secondary somatosensory cortex and intraparietal sulcus, where vestibular-tactile integration has been described in animal and human studies.
Altogether, the results from these two studies suggest that vestibular signals are involved in conscious experience of ownership for hands and discrimination of touch, thus demonstrating the mechanisms revealed in brain-damaged patients in healthy participants. The present results also indicate the possibility to manipulate important bodily experiences for human self-consciousness by using vestibular stimulation (GVS and CVS) in healthy participants.

PA-15

The relationship between the superior canal dehiscence syndrome and human evolution: Does human evolution cause vertigo?

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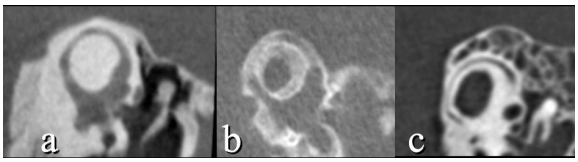
Objectives: The superior canal dehiscence syndrome (SCDS) is a relatively new disorder which causes noise-induced vertigo or dizziness and a cause of this bone defect is still unclear. In this paper, we discuss the etiology for this bone defect observed in SCDS from the view points of ontogeny and phylogeny.
Methods: Skull base computed tomography (CT) of adult human, fetus and primates (chimpansees, gibbons, macaques and baboons) were enrolled for this study. After obtaining the voxel data (minimum 0.125 mm^3), coronal image was reconstructed including superior semicircular canal. Anatomical relationships between the inner ear and skull base were estimated, especially the distance from the superior semicircular canal (SSC) to middle cranial fossa (MCF) was measured on the CT.
Results: In adult human, the position of the SSC varies, however, is situated below the surface of the MCF in the most of cases (a). On the other hand, all SSCs showed apparent protrusion into the MCF in the fetus specimens (b), whereas those of primates were far beneath the MCF (c).
Conclusions: From the pylogenic aspects, the SCDS is occurred only in the human and is the results of evolution, especially development of cerebrum, that is the brain. One possible explanation for the cause of SCDS is as follows: the defect has been already seen from the birth as an fatal defect. A certain episode like sudden pressure to the inner ear and/ or cerebrospinal fluid causes detachment of bone and dura mater. It might represent the fragility to the loud noise or changes of pressure.



Caption 1: SSC and middle cranial fossa

PA-16

Effects of 0.06% and 0.10% blood alcohol intoxication on human postural control

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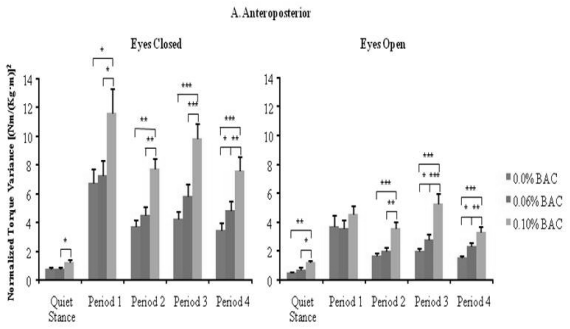
Background: Standing postural control is the physiological ability to maintain equilibrium and orientation in a gravitational environmental. Since information, which helps postural control, from the various senses alters and is not always accurate or available, postural control must also be able to adapt its properties to maintain a stable stance. Such a quality is necessary to avoid falls. Alcohol intoxication is known to cause postural instability which may lead to accidental falls. However, previous studies on alcohol intoxication and human balance have not in detail investigated the dose-dependent changes in stability and alcohol's influence on the adaptation capacity.
Aim: The aim was to investigate how postural stability and adaptation is affected by alcohol intoxication at 0.0%, 0.06% and 0.1% Blood Alcohol Concentration (BAC).
Method: 25 healthy subjects (mean age 25.1years) were intoxicated at three preset levels of BAC. Alcohol levels were measured and controlled by using a real-time breath analyzer. Stance stability, either unperturbed or when proprioceptively perturbed by calf vibration, were tested with a force platform, with either eyes open (EO) or closed (EC).
Results: Postural stability was significantly decreased by alcohol intoxication of 0.06% and 0.10% BAC with both EO and EC, particularly when subjects were perturbed. The balance worsening was strongly related to BAC, the effects increasing in a non-linear manner. The alcohol effects on postural control increased also with the duration of the sensorimotor challenge. Vision generally reduced body sway both while sober and intoxicated and counteracted perturbations. This reduction was more pronounced in anteroposterior direction. However, the destabilizing effects of alcohol could not be fully compensated with eyes opened. Intoxication also decreased the subjects adaptive capabilities, which in lateral direction sometimes was completely abolish or strikingly counteractive.
Conclusion: New insights were achieved about the effects of alcohol on balance and postural adaptation. Alcohol has complex effects on the human postural control which are dose dependent, time dependent and

direction specific. This may explain why rather low levels (here 0.06 % and 0.1% BAC) of alcohol still are associated with an increased risk of falls and accidents.



Normalized torque variance values for anteroposterior torque (mean and standard error of mean (SEM)) during tests with Eyes Closed and Eyes Open. In the figures, *denotes P<0.0167, ** denotes P<0.01 and *** denotes P<0.001.

PA-17

Predicting change of vestibular direction detection thresholds from acceleration profile differences

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In the absence of vision, the perceived direction of translational self motion is largely governed by signals originating from the otoliths. Although it has been shown that direction detection thresholds depend on the frequency of the motion stimulus, the influence of the actual time course of the motion has not been thoroughly investigated. The goal of our study was to measure, model and predict vestibular direction detection thresholds for different motion profiles in the horizontal plane.

Detection thresholds for three acceleration profiles, one sinusoidal and two non-sinusoidal (Fig. 1A), with three different durations were measured for six human participants. An anthropomorphic robot arm, the Max Planck CyberMotion Simulator, was used to provide the motion stimuli. The experiment was designed as a four-alternative forced-choice task, where blindfolded participants judged the direction of motion from four possibilities: forward, backward, left or right. Stimulus intensity (peak acceleration of the motion profile) was varied based on a Bayesian adaptive method, and a psychometric function fit to the measurements determined the sensory threshold.

For modeling, a 2nd order linear dynamical system with two poles and one zero, originally proposed by Young and Meiry (1968), was used to describe the data. The parameters of this model have been previously identified with sinusoidal motion stimuli over a broad frequency range for similar tasks, but predictions concerning perceptual thresholds for general motion profiles are unknown. In our study, the thresholds obtained from the three sinusoidal acceleration profiles were used to identify the static gain of the model by fitting the system gain to the inverted thresholds. The other parameters were derived from the literature.

Predicting the thresholds for general motion profiles was based on the assumption that the output of the model can be interpreted as the signal intensity coming from the otoliths and that if this intensity overcomes a certain value the correct direction of motion can be perceived. In order to predict the threshold, the peak acceleration of the input profile must be selected so that that the corresponding maximum model output is equal to one (Fig. 1B).

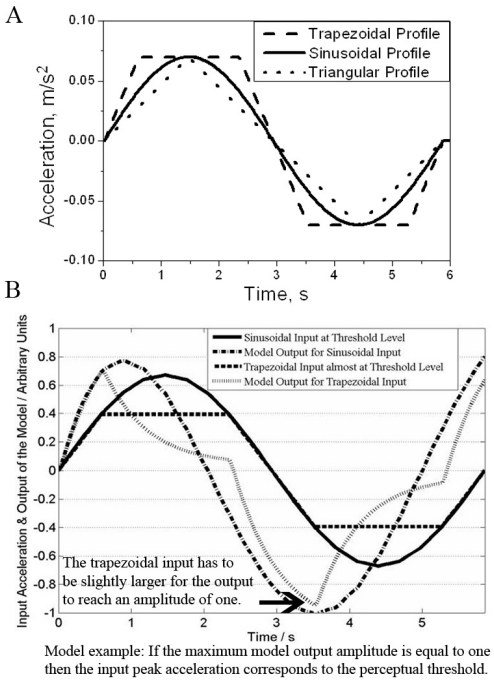
Predictions for the remaining six non-sinusoidal profiles showed that they were in good agreement with the measured data, with the average error being smaller than 20% of the average detection threshold. This is a promising result, as just the static gain of the model was identified from only three data points.

Accepting the linear model as a method to predict thresholds, it is also possible to fit the model to the non-sinusoidal profile data and identify the whole parameter set. Instead of fitting the system gain to the inverted sinusoidal thresholds, we computed the predictions for all profiles given a certain set of model parameters and iteratively varied the parameters to minimize the error between measurements and predictions. Two of the three identified model parameters agreed with the values given in the literature, while the third was found to be different. This difference suggested a phase lead for lower frequencies, which corresponds to sensitivity to jerk (the time derivative of acceleration).

Comparing threshold predictions between models with different jerk sensitivities reveal distinct differences between the predictions at low frequencies. The predictions for a model with higher jerk sensitivity appear more appropriate and could be tested in future experiments.

To summarize, we have shown that a linear model approach is able to predict vestibular perceptual direction detection thresholds. This allows the model parameters to be identified while resorting to non-sinusoidal stimuli, and helps to better understand vestibular linear mo-

tion perception. Future studies will extend these measurements to lower frequencies and assess this modeling approach for rotational movements.



Model example: If the maximum model output amplitude is equal to one then the input peak acceleration corresponds to the perceptual threshold.

PA-18

The vertical component of caloric nystagmus and the orientation of the semicircular canals

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Objective: The origin of the vertical component of caloric nystagmus remains unknown. We tried to explain the direction of the vertical component of caloric nystagmus by angular orientation of the semicircular canals in the head. We attempted to compare the vertical component of caloric nystagmus and the angular orientation of semicircular canals measured by MR imaging in each patients.

Subjects and Methods: We retrospectively examined the ears of patients who underwent MR examination of the labyrinths and caloric testing with ENG recording. We selected the data of ears with normal caloric responses that could be precisely measured by 3-dimensional MR imaging. The data of 50 ears were qualified for the analysis. We divided the ears into 3 groups from the direction of vertical component of caloric nystagmus: 10 ears with downbeating vertical component (down group), 30 with none (none group) and 10 with upbeating (up group).

Firstly, we measured the superior open angle between the horizontal canal plane and the head sagittal plane (HC), because we thought the tilt of the horizontal canal plane with respect to the head sagittal plane may determine the vertical component of caloric nystagmus, as the eye rotation is reported to occur along the plane of the stimulated canal.

We further measured the anterior open angle between the anterior canal plane and the head sagittal plane (AC) and the posterior open angle between the posterior canal plane and the head sagittal plane (PC) and calculated the difference between PC and AC (PC-AC), because we thought when the angle of one vertical canal to the head sagittal plane was narrower than that of the other, the influence of the former canal would be stronger, as the head sagittal plane aligns with gravitational vertical at standard caloric position and the 2 vertical canals produce vertical component toward the opposite directions under caloric stimulus. From this idea, we compared HC and PC – AC among the 3 groups.

Results: In the 3 groups of ears, HC was 87.9 deg in down group, 90.1 deg in none group and 93.2 deg in up group; the differences for PC-AC were 14.6 deg (down group), 13.8 deg (none group), and 20.4 deg (up group). Contrary to our expectation, neither angle measurement showed significant difference among the 3 groups.

Conclusions: We could not explain the direction of the vertical component of caloric nystagmus from the angular orientation of the semicircular canals using our current measurement technique. We concluded the vertical component of caloric nystagmus could not be determined only by the spatial orientation of semicircular canals.

PA-19

The effect of morphological cupula change on caloric response

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Objective: We had reported that the cupula sustains various degrees of changes under some conditions, and the response to the endolymphatic flow was decreased in the half-sized cupula model. In this study, we investigated the caloric response in the half-sized cupula model.

Methods: Bullfrogs were heavily anesthetized with diethyl ether. After decapitation, the posterior semicircular canals (PSCs) were removed in Ringer solution. The PSCs were placed so that the whole canal became in the vertical plane. Compound action potentials (CAPs) of the PSC nerve evoked by a cooling stimulus were recorded. A copper thermal probe with a tip diameter of 1 mm was dipped in liquid nitrogen for 10 seconds and was used to give cooling stimulus. At first, the CAPs were recorded before removing the cupula. Next, the cupula was removed from the crista with gentle flush of Ringer solution. In one group, the removed cupula was replaced on the crista and the CAPs were recorded. In another group, the removed cupula was sectioned in half using fine scissors and the half cupula was replaced on the crista. Then, the CAPs were recorded. Finally, the CAPs were recorded after removing the entire or half cupula from the crista.
Results: The CAPs after replacing the entire cupula were smaller than those before removing the cupula, and they tended to be greater than those after replacing the half cupula. The CAPs after replacing the half cupula were close to those after removing the cupula. There were only negligible CAPs after removing the cupula.
Conclusions: Thermal stimulus hardly activates CAP when the cupula is half sized. The morphological change of the cupula, such as shrinkage, is potentially one of the mechanisms of reduced caloric response.

PA-20

The mammalian saccule: transduction and transmission

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The mammalian saccule is sensitive to linear accelerations and changes in the gravity vector ($<$ 30 Hz) as well as auditory stimuli ($<$ 1500 Hz). We hypothesize that specializations in the striolar zone make it more sensitive to high-frequency stimuli. To investigate frequency filtering, we record with the whole-cell patch clamp method from hair cells and afferent terminals in semi-intact preparations of the rat saccule (postnatal days 1–8). We are focusing on striolar type I (SI) cells, which have wide bundles and are innervated by simple or complex calyceal afferent terminals. We have also begun recording from postsynaptic afferent terminals, chiefly calyx endings in the striolar zone. We use a rigid probe to deflect hair bundles with sinusoidal or step waveforms and rhodamine to label the cells we record from.
Transduction data are, on average, comparable to results from the immature mouse utricle (Vollrath and Eatock 2003). However, comparison of SI transduction currents with data from extrastriolar type II (ESII) cells indicates possible differences in transducer adaptation and operating range. Transduction currents evoked by step bundle deflections decayed with two time constants. SI cells had significantly faster ($p < 0.05$) τ fast values: 8 ± 2 ms (SEM; $n = 11$) vs. 15 ± 3 ms (5); and greater extent of adaptation: $86 \pm 3\%$ (11) vs. $70 \pm 5\%$ (7). τslow was not significantly different: 98 ± 17 ms (11) vs. 142 ± 40 ms (5). Similar results were obtained with sinusoidal stimulation (usually 2–100 Hz). Plots of peak-to-peak amplitude against stimulus frequency often showed two corner frequencies (f_c) for high-pass filtering, as expected from the adaptation time course: the lower f_c was the same (4 ± 1 Hz) for 12 SI and 5 ESII hair cells; the higher f_c was higher for SI cells: 60 ± 10 Hz (9) vs. 29 ± 3 Hz (4). The 10–90% operating range was significantly smaller for SI cells: 1.1 ± 0.2 μm (8) vs. 1.7 ± 0.1 μm (5).
As in immature hair cells from the rodent cochlea and utricle, voltage-gated currents included both Na+ currents (I_{Na}) and large outwardly rectifying K+ currents (I_K). The inactivation midpoint of I_{Na} was very negative in SI cells: -93 ± 1 mV (19) vs. -74 ± 2 mV (6) in ESII cells, showing that the currents correspond to $\mathrm{I}_{Na,1}$ and $\mathrm{I}_{Na,2}$ in immature rat utricular hair cells (Wooltorton et al. 2007). I_K had a more negative activation midpoint in SI cells than ESII cells at P4, and by P7 some SI cells had acquired $\mathrm{I}_{K,L}$, the very negative current typical of mature type I cells. In current clamp, SI cells fired spikes in response to depolarizing steps. Comparison of transduction currents and receptor potentials evoked by sinusoidal bundle deflections shows that voltage-gated currents affected rectification and produced slow spikes at the onset of depolarizing responses to low-frequency stimuli. Peak-to-peak receptor potentials tend to show more high-pass filtering than transduction currents, which, together with low-pass filtering by the membrane capacitance, produced bandpass tuning with best frequencies between 10 and 30 Hz.
Voltage-gated currents from striolar calyces belonging to calyx-only afferents ($n = 7$) revealed low-voltage-activated currents (I_{LV}) similar to those observed in some vestibular ganglion somata (Kalluri et al., ARO 2010). Like the somata and other neurons, calyces with I_{LV} responded to current steps with a transient firing

pattern (single onset spike). They also produced single spikes to positive bundle deflections of type I cells enclosed within the calyx. Three dimorphic fibers from the extrastriola lacked I_{LV} and, as seen with ganglion somata, had more sustained firing patterns. Based on comparisons of sinusoidally-evoked transduction currents, receptor potentials, EPSPs and spikes, it appears that additional filtering is added at each stage. Supported by NSBRI through NASA NCC 9–58 (JES) and NIDCD RO1 DC02290.

PA-21

Path iIntegration in the third dimension

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Path integration, the ability to update the position and orientation of external locations predominantly on the basis of internal cues, is an effective strategy for spatial navigation. While extensive work has been done on evaluating path integration in the horizontal plane, little is known for movements in the vertical (third) dimension. Here we assess whether pointing to the origin of translational movement in vertical planes is similar to that found for movement in the horizontal plane alone. 15 observers sat upright in a racecar seat that was mounted to the flange of a modified KUKA© anthropomorphic robot arm (**Fig. 1a**). An LCD display was 50cm in front of the observers who were otherwise tested in the dark. Sensory information was manipulated by providing visual (optic flow, limited lifetime star field), vestibular-kinesthetic (passive self motion with eyes closed), or visual and vestibular-kinesthetic motion cues. Movement trajectories consisted of two segment lengths (1st: 0.4 m, 2 nd: 1 m; $\pm$ 0.24 m/s^2 peak acceleration). Movements in the horizontal, sagittal and frontal planes consisted of: forward-rightward (FR) or rightward-forward (RF), downward-forward (DF) or forward-downward (FD), and downward-rightward (DR) or rightward-downward (RD) movements respectively. The angle of the two segments was either 45° or 90°. A 15 s pause preceded each trajectory. Observers pointed back to their origin by moving an arrow that was superimposed on an avatar presented on the screen (**Fig. 1b**). Movement of the arrow was constrained to the trajectory's plane and controlled by a joystick. The avatar was presented from frontal, sagittal and horizontal viewpoints. Observers were allowed to use any or all viewpoints to answer. The starting orientation of the arrow was randomized across trials. Each condition was repeated 3 times and presented in random order. Signed error and response time were analyzed as dependent variables.

Observers were more likely to underestimate angle size (average data less than 0°; **Fig. 1c**) for movement in the horizontal plane compared to the vertical planes. In the frontal plane observers were more likely on average to overestimate angle size (average data more than 0°), while there was no such bias in the sagittal plane. Another discrepancy between horizontal and vertical planes was that responses in the vertical planes were more closely related to a response bias suggesting that the path segments were of equal length (solid grey line). Finally, observers responded slower (**Fig. 1d**) when answering based on vestibular-kinesthetic information alone.

These results suggest that human path integration based on vestibular-kinesthetic information alone takes longer than when visual information is present. Path integration has been well established as a means used to resolve where an observer originated but is prone to underestimates of the angle one has moved through. Our results show this for translational movement but only within the horizontal plane. In the vertical planes pointing may have been directed in accordance with an assumption of equal path lengths. This result suggests that alternative strategies for determining one's origin may be adopted when moving in the third dimension which may relate to the fact that humans experience movement mostly within the horizontal plane.

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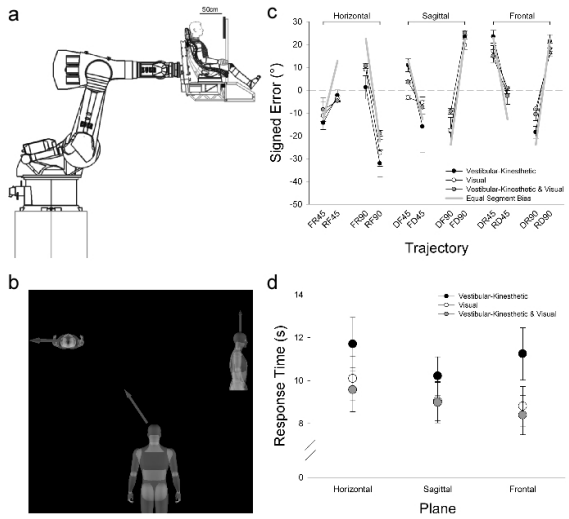

Figure 1a: Max Planck modified KUKA© anthropomorphic robot. b: Avatar viewpoints used for pointing task. c: Average signed pointing errors in the horizontal (left series), sagittal (middle series) and frontal (right series) planes for each trajectory type (see text) tested with vestibular-kinesthetic cues, visual cues, and vestibular-kinesthetic & visual cues combined. The solid grey line represents the prediction for signed errors when falsely assuming equal segment trajectory lengths (see text). d: Average response time collapsed within each plane. Error bars indicate ± 1 S.E.M.

PA-22

The use of nanotechnology for cochlear regeneration

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Following the loss of sensory cells of the inner ear, the de-afferented peripheral processes of the auditory nerve will degenerate. In time the spiral ganglion cells (SGCs) of the nerve and central projections also die. The death appears to be due to apoptosis from loss of survival factors (largely neurotrophins) provided by the normal inner ear. The primary obstacles of inner ear drug/gene therapy is the lack of vectors that are safe, efficacious, cell/tissue-selective and able to enter the nucleus to activate the repair mechanisms. Data from animal and human studies now unanimously support the view that neurotrophin treatment extends the survival and excitability of the remaining auditory nerve following deafness.

It has been recently documented that Math-1 gene also in mammalian inner ear can transform the supporting cells to outer hair cells which act as sensory receptors. The normal development of an organism is the result of an integrated network of differentiation programs and signaling pathways that control cell cycle exit. The timely ordered expression of tissue-specific genes is executed by transcription factors of the basic helix-loop-helix (bHLH) family. The bHLH transcription factor math1 is both necessary and sufficient for hair cell differentiation in the cochlea. Following binding to Id (Inhibitors of DNA binding and differentiation) proteins, bHLH cannot contact DNA, and the result is loss of transcriptional activity and inhibition of differentiation. Thus, the Id-induced negative regulation of hair cell differentiation can be decreased by Id shRNA.

The cell entry and membrane trafficking is one limiting factor in drug/gene incorporation process. At present it seems that the nano-carriers are capable of using caveolin and integrin mediated clathrin pathways in addition to non-specific macro-pinocytosis to pass round window membrane and in cell entry. These processes can be facilitated by using viral TAT-protein for enhancing the incorporation process. The critical size for cellular trafficking seems to be 80 nm of particle size but for nuclear entry it must be smaller and causes challenges for gene delivery.

In the Nanoear project we have incorporated the Math-1 plasmid, and Id-shRNA plasmid into lipid core nanocapsules, silica, polylycin, lipoplexes and chitosan nanoparticles and in hydrogel. The preliminary results indicate that the transfected cells are expressing the reporter gene (GFP) and math-1 gene. Furthermore we have demonstrated that in the cochlear nerve precursor cells can be stimulated to differentiate with BDNF and they form new SGCs. We have studied the passage of nano-carriers through the rat and human round window membrane. For cellular targeting and in inoculation process, the transfection rate is in vivo experiments still relatively low, and more efforts have to be made to improve the transfection with synthetic vectors by enhancing the inefficient migration of DNA through cellular membrane and translocation across nuclear pore complexes. The application of the nano-carriers on the round window membrane indicates that depending on type of nanoparticle different migration pathways are employed and optimal carriers can be designed depending on cargo. The use of nanoparticle as drug/gene carrier is especially attractive in conjunction with cochlear implantation or even included in the implant as a drug/gene reservoir.

www.nanoear.org. NANOEAR; 3g-Nanotechnology based targeted drug delivery using the inner ear as a model target organ. EU-Contract number:026556-2.

PA-23

Self-motion perception evoked by vestibular, visual, and combined stimulation at threshold levels

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Objectives: Our perception of self-motion may arise not only from vestibular input, but also from other sensory cues such as visual cues that signal relative motion between the self and the surroundings. The visual cues may cause self-motion illusions, which in everyday life are rare and short-lived, however. Illusion prevention owes to a visual-vestibular fusion mechanism that, optimized by evolution, rather reliably reconstructs physical reality, thereby involving cognition. The fusion and the cognitive mechanisms are still not well understood. We therefore studied perception of self-motion and motion of a visual surround pattern under experimental conditions where probability of illusion occurrence is high and cognitive influences are strong. To this end, we applied body and pattern rotations in the earth-horizontal plane (where the vestibular gain decreases at low stimulus frequency due to canal low pass transfer characteristics). Furthermore, the stimulus intensities used were low, i.e. at detection threshold, hampering subjects in their stimulus interpretation (signal-from-noise detection) and possibly emphasizing cognitive mechanisms. This study extends a previous one in which we used a visual pattern that consisted of a single light spot, replacing it here by a full-field optokinetic pattern.
Methods: Subjects were seated on a Barany rotation chair with their heads chair-fixed through bite boards. The visual pattern, projected onto a surrounding screen (radius, 0.9 m), was rotated about the same axis as the chair. Three stimuli were used: (1) 'Vestibular only' (VEST); chair and pattern were rotated, pattern 'fixed' with respect to chair (head). (2) 'Visual only' (VIS); pattern rotation, chair stationary. (3) 'Synergistic combination' (VEST + VIS); chair rotation, pattern stationary. The rotations were applied as sinusoids at 0.025, 0.05, 0.1, 0.2, and 0.4 Hz. Motion detection thresholds were evaluated using the method of 'upper and lower limits' (thresholds were approached from both, subthreshold and suprathreshold values; measure, peak angular velocity). Stimulus presentations were in runs, in which subjects were instructed to attend to and indicate rotation of (a) self or (b) visual pattern. Frequency of occurrence of the instructed (or insinuated) motion perception was noted. Subjects indicated instance and pattern of perceived motion using a joystick (only trials with correctly indicated pattern were taken).
Results: VEST: Subjects experienced rotation of self and pattern (both veridical) with almost equal probability. The two threshold curves were clearly above $1\,^{\circ}$/s at 0.025 Hz and showed essentially the same frequency dependency, decreasing with increasing frequency (henceforth: 'canal signal' characteristics). However, the curve of pattern motion showed lower thresholds than that of self-motion. VIS: Indication of pattern motion (veridical) was 100%, while that of self-motion (illusion, often called circular vection) decreased with stimulus frequency from 100% at 0.025 Hz to 12% at 0.4 Hz. Yet, the detection curves were similar for both, self and pattern being close to $0.5\,^{\circ}$/s across the whole frequency range ('visual motion signal' characteristics). VEST + VIS: Frequency of self-motion (veridical) was 100% and that of pattern motion (illusion) clearly lower. Both threshold curves showed the 'visual motion signal' characteristics. But the pattern motion illusion showed higher thresholds than the self-motion perception.
Conclusion: The main finding is that the self-motion threshold curve shows 'canal signal' characteristics upon VEST and 'visual motion signal' characteristics upon both VIS and VEST + VIS. This finding was predicted by a visual-vestibular fusion model of the Freiburg lab. Not predicted were the pattern motion illusion with VEST + VIS and the observed differences in threshold levels between self and pattern motion. The latter were not observed in our previous study in which a single spot instead of the optokinetic pattern was used. The model is to be extended or revised such as to also cover the present findings.

PA-24

Idiopathic scoliosis is linked to an anatomical asymmetry in the peripheral vestibular system

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Idiopathic scoliosis (IS) is defined as progressive structural curvature of the spine and deformity of rib cage and pelvis which can have severe consequences in adults (respiratory difficulties and spinal pain). Adolescent idiopathic scoliosis develops during pubertal

growth in an otherwise healthy child, for which no recognizable cause exists. Girls are more at risk than boys for severe progression. The scoliosis curvature tends to increase with time. The deformity is conventionally measured on standing coronal plane radiographs using the Cobb technique. Management of IS is generally carried out during growth period and a surgical correction and stabilization by orthopedic surgery can be done, only for progressive and severe cases.

Despite many years of extensive research into the field of IS, the cause of this disorder has not been resolved. Several approaches have been considered: genetic, hormonal, neurophysiological (Letellier et al., 2007). Patients with SI have postural and oculomotor abnormalities; these observations suggest that this syndrome could be in relation with vestibular dysfunction. It is well-known that a unilabyrithectomy induces a vestibular asymmetry that leads to an asymmetry in tonic activity in paravertebral and postural muscles. It is possible that, in children, a small vestibular asymmetry could induce an asymmetry in tonic paravertebral muscle activity which could progressively lead to a curvature of the spine; this phenomenon has been demonstrated in vestibular lesioned animals (Lambert et al., 2009). Moreover, we have recently shown that a vestibular dysfunction has a direct effect on bone mineralization (Levasseur et al., 2004).

The scientific literature dealing with vestibular function and IS is incomplete and heterogeneous. Some studies explored the canalar function, such as the study of Sahlstrand et Petruson (1979) who showed a right/left asymmetry during a caloric test in patients with a SI. This result was not in accordance with the study of Kapetanos et al. (2002). Only one study focused on otolithic function and SI (Wiener-Vacher et Mazda, 1998): they found an asymmetry of some otolithic parameters but the semicircular canals function was not evaluated. Finally, only one study explored the bony and lymphatic canals abnormality via a modeling procedure using CT scans or MRI (Rousie et al., 2009) and found abnormalities in IS patients.

The goal of this study is to explore a possible link between vestibular asymmetry and IS by combining an anatomical and a functional approach.

The anatomical approach is a measure of orientation of the peripheral vestibular organs symmetry by MRI. The functional approach is a canaliculo and otolitho ocular reflexes test (rotatory and tilting chair). This approach is completed by a rod and frame test (RFT) which evaluates indirectly the way the vestibular informations are integrated. The experimental group is made up of 13 patients with a IS, Cobb's angle between 10 et 50°, without surgery, boys and girls, between 10 and 18 years old. The control group is made up of age paired healthy subjects.

The first data show a significant difference between SI patients and control subjects concerning the orientation of the peripheral vestibular organs symmetry: the mean angle between the right and left lateral semi circular canals is $9.5 \pm 5.5°$ in IS patients and $4.2 \pm 3.2°$ in control subjects (t test, $p = 0.008$; see figure 1 for individual data). There is no difference in RFT scores between IS patients and control subjects suggesting that vestibular informations are correctly integrated. The data of the vestibulo ocular reflexes are in process, they will be presented and discussed at the meeting.

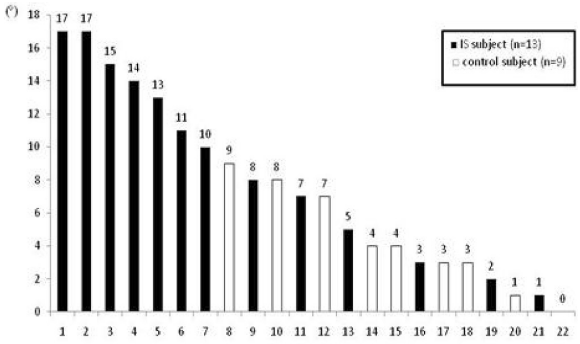

Figure 1 - Individual data :asymmetry between the plane of the two lateral semi circular canals measured on anatomical MRI. Asymmetry is defined as the angle between the plane of the two lateral semi circular canals.

PA-25

In vitro whole-cell conductances recorded from developing human cristae

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Background: Almost all the information we have about the development and function of the vestibular periphery has come from animal models. While they have provided us with invaluable data and allowed us to infer much about our own peripheral vestibular development and function, we know very little about how these animal models compare with humans. Here we describe our preliminary results from physiological and anatomical studies of vestibular hair cells and afferent terminals using in vitro human fetal tissue. Given the temporal differences in vestibular organ maturity between humans and common laboratory animals, it is important to establish a developmental timeline comparing their respective physiology and anatomy. We

have begun to record whole cell conductances in developing human vestibular hair cells and calyx terminals. Our goal is to compare these results with those from mice at various developmental stages. This basic information is important if we are to establish models using wildtype and genetically modified mice that adequately represent normal and abnormal human vestibular development and function.

Methods: Human tissue was collected and prepared according to State legislation and regulatory requirements of the University of Newcastle Human Research Ethics Committee. *Physiology:* Inner ears from terminated human fetuses (12 to 18 weeks gestation) were excised and semicircular canal cristae isolated in ice-cold glycerol-based Ringers' solution. Cristae preparations were then transferred to a recording chamber perfused with oxygenated L15 cell culture media. Whole-cell patch-clamp recordings were made from hair cells and calyx afferent terminals that were embedded within the intact cristae. Ionic currents were recorded using glass pipettes filled with potassium fluoride internal solution. In some cases the fluorescent dextran, Alexa 594, was added to the internal solution. *Anatomy:* Human tissue (8 to 18 weeks gestation) was fixed in 4% paraformaldehyde for one hour. The tissue was then sectioned and processed for immunohistochemical staining. Initially, we chose to study the distribution of calcium-binding proteins within the human vestibular epithelium.

Results: In our patch clamp studies we have successfully recorded and labeled a number of human vestibular hair cells that display a variety of inward and outward rectifying conductances. In one example at 14 weeks gestation, an amphora-shaped hair cell (as revealed by intracellular fluorescence), displayed conductances similar to those seen in postnatal mice and rats. This cell however, did not exhibit the negatively activating delayed outward rectifier potassium conductance, $g_{K,L}$, characteristic of mature type I hair cells. However, it did possess a transient current similar to sodium conductances that are typical of immature mouse and rat hair cells. In cristae aged 15 and 16 weeks gestation, we have recorded from four hair cells, that would be classified as type II due to their delayed inward and outward rectifier conductances. In contrast to the earlier hair cell, recorded at 14 weeks gestation, none of these cells showed evidence of transient sodium channel activation. Interestingly, in some type II hair cells there appears to be a "collapsing" tail current that is consistent with a transitory accumulation of potassium around the hair cell.

Summary: In this study we provide data on whole cell conductances in developing human cristae. Our preliminary results show evidence that ionic currents in human fetal hair cells are comparable to those recorded in postnatal mouse and rat. At 14 weeks gestation, our results suggest human hair cells are still functionally immature and may undergo distinct changes between 15 and 16 weeks gestational age. Further study will determine whether human vestibular tissue is physiologically mature by 18 weeks gestation.

PA-26

Inhibitory synaptic transmission in the lateral vestibular nucleus

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Background: The lateral vestibular nucleus (LVN) has an important role in the activation of vestibulocollic and vestibulospinal reflexes (VCR and VSR). LVN neurons in mice can be divided into two groups, smaller diameter neurons ($<$ 30 microns), and larger primary projection neurons ($>$ 30 microns). These large neurons are called Deiters' neurons and are topographically organised according to their spinal cord projection site. Dorso-caudally located Deiters' neurons project to lumbosacral regions whereas rostro-ventral cells innervate cervical regions. Within the spinal cord, axons of Deiters' neurons contact interneurons and motor neurons that activate axial and limb muscles that contribute to VCR and VSR.

Physiological evidence suggests an important source of excitatory input to Deiters' neurons comes from primary vestibular afferents and is glutamatergic. In contrast, inhibitory inputs arise from cerebellar Purkinje cells and is GABAergic. In addition, a recent study has shown the projection from cerebellar fastigial nucleus to LVN is glycinergic (Bagnall et al., 2009). The present study investigates inhibition of large Deiters' and smaller, presumed interneurons, of the LVN.

Methods: Mice (approx. 2–3 weeks old) were anaesthetised with Ketamine (100 mg/kg) and decapitated. The brainstem was isolated and the region containing the LVN was sectioned (250 μm) and placed in an oxygenated chamber of Ringers solution. Whole cell recordings in current- and voltage-clamp modes used KCH_3SO_4 and CsCl internal solutions, respectively. All values are expressed as mean $\pm$ S.E.

Results: Current-clamp recordings show that approximately 73% of Deiters' neurons are tonically active,

and have comparable discharge rates (12.6 $\pm$ 2.8 Hz, $n = 12$) to nearby medial vestibular nucleus (MVN) neurons (9.7 $\pm$ 1.6 Hz, $n = 27$). Approximately 85% of smaller LVN neurons are also tonically active but have a significantly lower mean discharge rate than Deiters' neurons (5.9 $\pm$ 0.9 Hz, $n = 26$; $p < 0.05$).
To characterise the effect of inhibition on discharge rate, we injected a 1 second hyperpolarizing current step to lower the membrane voltage by 30 mV. MVN neurons have been shown to exhibit post-inhibitory rebound firing (PRF; Sekirnjak and du Lac, 2002). Our results indicate Deiters' neurons and MVN neurons have similar PRF values (8.4 $\pm$ 2.9, $n = 8$; 6.9 $\pm$ 1.7, $n = 20$, respectively), whereas smaller LVN neurons have significantly higher PRF values (37.3 $\pm$ 12.8, $n = 17$; $p < 0.05$).
To investigate synaptic inhibition in LVN, we recorded quantal synaptic currents in Deiters' neurons and smaller LVN neurons in the presence of 1 μM tetrodotoxin and 10 μM CNQX. $GABA_A$ ergic miniature inhibitory postsynaptic currents (mIPSCs) were isolated by the addition of 1μM strychnine to block glycine receptors, and glycine receptor-mediated mIPSCs were isolated in the presence of $GABA_A$ receptor antagonist bicuculline (10 μM). Properties of mIPSCs, such as frequency, amplitude, rise time, and decay time constant were measured. Our results show that Deiters' $GABA_A$ergic mIPSCs were significantly different, for all measures, compared to those from smaller LVN neurons (all $p <$ 0.01). Most notable was the difference in the frequency of $GABA_A$ergic mIPSCs (Deiters' neurons = 13.25 $\pm$ 1.1 Hz; smaller neurons = 1.23 $\pm$ 0.3 Hz). We also report a difference in glycinergic inhibition to both LVN neuronal groups (Deiters' neurons = 0.2 $\pm$ 0.1 Hz; smaller neurons = 0.5 $\pm$ 0.1 Hz).
Summary: We conclude Deiters' and smaller LVN neurons not only differ in their background rate but also have different discharge responses to hyperpolarizing inhibitory current injections. In addition, we determined that there was differential $GABA_A$ ergic and glycinergic inhibitory input to the two groups of LVN neurons. Deiters' neurons received more $GABA_A$ ergic and less glycinergic input than their smaller LVN counterparts.

PA-27

Thresholds for self-motion perception in roll about earth-verical and earth-horizontal axes with and without fixation targets

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Background: Earlier studies on self-motion perception thresholds in yaw have shown that when healthy human subjects are sinusoidally rotated with a fixation spot kept in fixed alignment with their head, the threshold is lower than the threshold in total darkness. In this condition the horizontal canals are predominant.
Objectives: The purpose of the present study was to investigate: a) if there is a similar effect for self-motion perception thresholds when subjects are rotated sinusoidally in roll in the supine position about an earth-vertical axis with a fixation target kept in fixed alignment with their head, and b) how a canal-otolith interaction will influence the threshold when subjects are rotated in roll about an earth-horizontal axis while in an upright seated position.
Methods: Six subjects were tested. Subjects were supine (in a seated-like posture) and were rotated in roll about a naso-occipital earth-vertical axis, while they fixated their gaze on an LED cross (10° of visual angle) that rotated with the chair. Stimuli were single cycles of sinusoidal acceleration at four frequencies: 0.1, 0.2, 0.5, and 1 Hz. The second experiment was similar to the first except subjects were upright and were rotated about a naso-occipital earth-horizontal axis. Thresholds were measured using a 3-down, 1-up staircase paradigm. A MOOG motion platform (MOOG 6DOF2000E) was used to generate the motion.
Results: The results showed that thresholds for self-motion perception were significantly lower when subjects were rotated about an earth vertical axis while supine with gaze fixed on the cross LEDs than in total darkness. However when the rotation axis was earth-horizontal, there was no significant change in the detection threshold between roll tilt self-motion thresholds in total darkness and with visual fixation of the cross LEDs.
Conclusions: Fixation targets influence self-motion perception thresholds in roll rotation about an earth vertical axis but not for identical rotations about an earth-horizontal axis. Otolith-ocular reflexes and/or somatosensory influences acting during roll tilts about an earth horizontal axis may eliminate the fixation effect measured for earth-vertical axis rotations.
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PA-28

Response of the angular vestibulo-ocular reflex (aVOR) to high acclerations in three dimensions after lateral semiciruclar canal nerve section

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We previously demonstrated that canal plugging does not completely inactivate the plugged canals but rather reduces its dominant time constant from 4 s to 0.070 s. A model-based analysis predicts that in canal plugged animals, the spatial gain curves of the responses would be different from normal animals at low accelerations, but responses to high acceleration steps of velocity would be similar to that of normal animals. To test these predictions, animals with all 6 canals plugged were rotated about a spatial vertical axis while upright (0°) or statically tilted for-aft up to 90°, using 60°/s steps of velocity (acceleration ≈300°/s^2) and thrusts of acceleration (≈ 3000°/s^2). Temporal gains of the yaw, pitch and roll components of the aVOR were computed at every head orientation, plotted as a function of the head tilt, and fit with a cosine function to obtain the spatial gains and phases. Spatial gains peaked at ≈ 0° for yaw and ≈ 90° for roll components of eye velocity in normal animals under all stimulus conditions. Vertical aVOR gain was negligible in all the fore-aft head orientations. Consistent with the model predictions, aVOR gains of the 6-canal plugged cynomolgus monkey were indistinguishable from those of normal animals (≈ 0.6 for roll and ≈ 1.0 for yaw) for these high acceleration rotations. Gains obtained with steps of velocity with lower accelerations were significantly smaller than gains of the normal animals (≈ 0.4 and 0.5, respectively). Bilateral lateral canal nerve section had a substantially more profound effect on aVOR responses. The yaw and pitch gains were markedly reduced at all tested frequencies as well as when tested with the steps and thrusts of accelerations. The spatial yaw and roll gains also peaked with the animals tilted back ≈ 50°, in a position where the intact vertical canals were in the plane of rotation. This shows that while plugging eliminates the responses at low to midband frequencies, canal nerve section eliminates the response over a much higher bandwidth, extending to frequencies equivalent to thrusts of ≈ 3000°/s^2. The results also are consistent with the fact that canal-pairs contribute to the overall aVOR gain according to their orientation to the axis of rotation and that there is no spatial adaptation of the response planes after canal injury (Yakushin et al., 1998).

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PA-29

Self-motion perception parallels the angular vestibulo-ocular reflex during earth-vertical yaw and pitch rotations in patients with midline cerebellar dysfunction

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The velocity-storage mechanism (VSM) prolongs the angular vestibulo-ocular reflex (aVOR) at low frequencies. The vestibulo-cerebellum, specifically the nodulus and ventral uvula, modify the time constant (TC) of the aVOR via the velocity-storage network. In healthy human subjects, it has been suggested that self-motion perception of angular velocity steps about the earth-vertical axis depends on the VSM in a similar way as reflexive eye movements. We therefore hypothesized that, in patients with signs and symptoms of midline cerebellar dysfunction, changes of self-motion perception and aVOR would also go in parallel.

Perceived angular velocity (PAV; reported by hand-wheel turning) and reflexive eye movements (search-coil method) were simultaneously recorded in 9 cerebellar patients (34–81y) and in 9 age-matched healthy subjects (hS; 35–71y) after the sudden deceleration (a = 100°/s^2) from constant-velocity (v = 90°/s) counter-clockwise rotations about the earth-vertical yaw (upright position) and earth-vertical pitch axes (90° left-ear down position, upward rotation relative to the head).

PAV and aVOR data were analyzed using a two-exponential model with a direct pathway, representing semicircular canal (SCC) activity, and an indirect pathway, implementing the VSM (Raphan et al., 1979). For both PAV and aVOR, model parameters were constraint by requiring equal TCs of SCC in gain optimization procedures (parameters optimized with nonlinear least-squares algorithm).

According to our prediction, simulations with equal VSM-TCs for PAV and aVOR accurately fitted the data in both cerebellar patients (median aVOR $R^2 = 0.88$: range 0.53–0.95; median PAV $R^2 = 0.91$ [0.50–0.95])

and hS (median aVOR $R^2 = 0.94$ [0.41–0.97]; median PAV $R^2 = 0.89$ [0.75–0.97]). No significant improvement of the quality of the fit was found when we used separate VSM-TCs for PAV and aVOR ($p > 0.8$) in both populations. Overall, the median estimate of velocity-storage TC (VSM-TC) in patients was comparable to hS for yaw (median $\pm$ 1SD: 16 $\pm$ 4s and 15 $\pm$ 4s, respectively) and pitch (9 $\pm$ 5s and 5 $\pm$ 3s, respectively) rotations. For pitch rotations, however, a bimodal distribution of the cerebellar patients VSM-TC was observed, suggesting a non-homogeneous population. This observation was confirmed by hierarchical cluster analysis, which split the patients into two groups (G_1: N = 4; G_2: N = 5). A significantly longer VSM-TC was found in G_1 (15 $\pm$ 3s) compared to hS (5 $\pm$ 3s; Mann-Whitney Test: $p = 0.005$) and to G_2 (6 $\pm$ 3s; $p = 0.03$). VSM-TC in G_2, on the other hand, was similar to hS ($p = 0.8$). For yaw rotations, no significant differences were found between G_1 (16 $\pm$ 2s) and G_2 (13 $\pm$ 4s, $p = 0.05$) and between both cerebellar groups and hS (15 $\pm$ 4s; $p > 0.1$).
We conclude that (1) self-motion perception in response to angular velocity-steps is most likely controlled by the same VSM than reflexive eye movements. (2) We speculate that the short VSM-TC of pitch rotations in healthy subjects is due to suppressive adaptation by the vestibulo-cerebellum, specifically the nodulus, using signals from the otoliths. As a consequence, a prolonged VSM-TC in pitch rotations would reflect a major involvement of the vestibulo-cerebellum in patients with signs and symptoms of midline cerebellar lesions.
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PA-30

The anatomy of the utricular and saccular maculae in relation to the footplate of the stapes. An Xray MicroCT study

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Background: Stapedotomy is a frequently performed operation in an otologist's practice. Anatomy of the membranous labyrinth in relation to the stapes footplate is a difficult area to study and the placement of the piston and its depth are crucial for successful stapedotomy operations. A few studies have been conducted measuring distances from the footplate of the stapes to the maculae but there are large differences in results between studies. Usually the measurements have been derived from two dimensional information derived from histological sectioning of preserved bones, which may be affected by shrinkage artifact as well as perspective distortion in the two dimensional plane.
Objective: To undertake an analysis of the three dimensional spatial relation of the stapes to the utricle and saccule using Xray MicroCT technology.
Methods: Eleven temporal bones were fixed with Karnovsky's fixative, soaked in 2% Osmium tetroxide and scanned in a Skyscan X-ray MicroCT scanner. All specimens had an intact otic capsule to exclude sectioning artefact and no alcohol was used, to avoid tissue shrinkage. Measurements were taken in a vertical plane to measure distances from the utricle and saccule to the footplate of the stapes. Three dimensional reconstruction provided new graphical evidence of the spatial relationship of these structures and the footplate. The relationship to the vestibular end organs to the placement of a stapes piston was also studied. The 3-d reconstructions allowed realistic computer simulations of the effect of varying piston depth, angle of insertion and location of piston placement on footplate. Safety was able to be verified in three dimensions.
Results: Distance measurements varied significantly depending on the vector drawn, emphasising perspective distortion of a purely two dimensional study. MicroCT allowed analysis in coronal, sagittal and axial planes. Three dimensional reconstructions were attained of the utricle and saccular membrane as well as the respective maculae in relation to the stapes footplate. It was evident that the safest area of piston placement was the mid third of the footplate in the inferior half. It was safe to insert the piston to 0.5 mm depth at all areas except postero-superiorly where the utricular maculae is an average distance of 0.61 mm away from the footplate. The angle of insertion of the piston, also influenced the end result.
Conclusion: The safest area of manipulation is the inferior half of the footplate in the mid third region.

PA-31

Utricular function in normal subjects and patients with vestibular dysfunction

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Objective: To measure utricular function, using the unilateral centrifugation technique, in normal subjects and patients with vestibular dysfunction.
Methods: Subjects were securely seated on a rotating chair (Neuro Kinetics Inc, Pittsburgh) which slowly accelerated in darkness about a vertical axis to reach a constant velocity of 400°/s. During the constant velocity rotation, the subject was shifted slowly sideways relative to the rotation axis, up to 4.2 cm to the right and left. The subject was held for 30s in the three test positions (Right, Centre and Left). Centripetal acceleration of the utricles modifies the perceived gravitational vertical, and so changes in the subject's position relative to the rotation axis will generally induce sensations of roll tilt. This roll tilt was measured using a chair-fixed subjective visual vertical (SVV). The subject used a rotating knob to orientate a randomly offset laser line to the perceived gravitational vertical; approximately 8 settings were made in each test position and the median value was taken to indicate the subjective roll tilt. Subjects also performed the SVV task when the chair was stationary (Static value). In each extreme chair position, the net acceleration on the head (gravitational and centripetal) was equivalent to a roll tilt of 11.7°, in opposite directions for the Right and Left chair positions. The 'SVV gain' was defined as the difference between the SVV tilts in the Right and Left positions, divided by 23.3°. Utricular 'asymmetry' was defined by comparing the mean SVV tilt in the three test positions (relative to the Static value) to the difference between the Right and Left SVV settings. A complete unilateral loss would be expected to produce zero SVV tilts when the remaining functioning utricle was positioned on the rotation axis. In this case, the mean SVV tilt would be equal to half the maximum range (100% asymmetry).
We tested 28 normal subjects (age 17 to 67 years) and 42 vestibular patients (29 Ménière's, 8 bilateral vestibular loss and 5 unilateral canal pareses of different aetiology). All patients had one or more additional vestibular function tests (calorics, VEMPs or conventional rotational testing). The total caloric response was defined by summing the peak slow phase eye velocities induced by 30°C and 44°C irrigations of each ear; unilateral caloric weakness was calculated using Jongkee's formula.
Results: SVV gain and asymmetry were normally distributed in the normal subject group (mean SVV gain $= 0.55 \pm$ SD 0.25; mean asymmetry $= -6\% \pm$ SD 35%).
The patients with bilateral loss (e.g. total caloric response $\leqslant 20°$/s) had significantly reduced SVV gains (mean $= 0.23 \pm$ SD 0.14). Combining all the patients with calorics ($n = 37$) there was a significant positive correlation between SVV gain and total caloric response ($R^2 = 0.14$, $p < 0.03$).
SVV gain for the Ménière's group (mean $= 0.49 \pm$ SD 0.24) was not significantly different to the normal controls. However, in the Ménière's patient group there was a significant correlation between utricular asymmetry and caloric weakness ($R^2 = 0.26$, $p < 0.01$).
3/5 patients with unilateral loss (caloric weakness $>$ 60%) had strong asymmetries ($>$ 60%) indicating ipsilaterally reduced utricular function. However, one other patient had a large SVV gain (1.3) and only 15% utricular asymmetry (VEMPs were also preserved in this patient); the final patient in the group had a very low SVV gain (0.02).
Conclusions: Unilateral centrifugation with SVV measurements gives additional, potentially useful information about utricular function. Bilateral vestibular loss produces low SVV gains and unilateral deficits produce asymmetric SVV responses.

PA-32
Population responses of floccular purkinje cells during vergence pursuit
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Objectives: Previous studies showed that, during frontal smooth pursuit, the majority of Purkinje cells (P-cells) in the cerebellar floccular region are sensitive to position, velocity and acceleration of eye motion. As to depth pursuit it is only known that P-cells discharge depends on viewing distance (Miles et al., 1980). In this study we tried to reconstruct P-cells firing rate during vergence pursuit using position, velocity and acceleration of vergence eye motion.
Methods: We recorded simple spike discharge of floccular P-cells in four Japanese monkeys during 10° stepwise (28 cells) and sinusoidal (120 cells) target motion in depth that required vergence angle of 10°. 3D virtual stimuli were generated using images viewed alternatively by the right and left eye through polarized shutter glasses switching at 120 Hz, and the refresh rate of the computer monitor was synchronized with the shutter glasses. Simple spike discharge of P-cells represented by spike density function was fit with time shifted

linear combination of vergence eye position, velocity and acceleration, with vergence velocity being split into convergence and divergence components that was dictated by the asymmetry of the vergence step responses during on- and off- stimulus direction.

Results: About 75% of vergence cells were sensitive both to eye position and eye velocity, most of other 25% cells were sensitive to position only and only a few cells had pure vergence velocity sensitivity. Majority of P-cells showed an asymmetry in vergence step responses during on- and off- stimulus direction. In most cases the on-responses were higher in amplitude, than off-responses. Off-response gain was poorly correlated with amplitude of on-response (correlation coefficient of 0.42 with slope 0.53, N = 28). In 6 of 28 cells firing rate increased during both convergence and divergence step. In most cells vergence acceleration only insignificantly contributed to fit goodness. 82% of P-cells had the same preferred directions for vergence position and vergence velocity. The same model fitted vergence step responses and sinusoidal responses. The best-fit parameters computed for vergence step response also fitted well the sinusoidal responses of the same P-cell at different frequencies, suggesting the same neural mechanism is controlling smooth vergence pursuit and fast changes of eye vergence angle. The average responses of convergence and divergence cell populations were very similar except for the preferred directions. Both population responses started with a transient activity component centered at eye velocity peak followed by sustained activity during fixation in newly achieved position. During off-phase, the transient decrease of activity was much smaller than on-transient peak, and population response coded mainly eye position in this area. Acceleration component was unable to significantly increase a fit goodness of the group responses. Therefore each population coded vergence velocity only in preferred direction. The sum of the responses of convergence and divergence populations coded the amplitude of vergence eye velocity, whereas response position dependence was canceled as result of summation.

Conclusions: Vergence pursuit cells fire for both eye position and eye velocity. Vergence eye acceleration contributes minimally to P-cell response. Population responses of floccular Purkinje cells code vergence eye position and either convergence or divergence eye velocity.

PA-33

Sensorimotor noise in the vestibulo-ocular reflex exhibits low-dimensional structure

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Like all systems, sensorimotor networks are affected by noise which limits the accuracy of motor tasks. Noise levels determine the relative reliability of different sensory modalities, and the brain has been shown to perform sensory fusion by optimally relying on reliable cues more than degraded ones (Ernst and Banks, Nature, 2002).

Characterizing noise and attributing it to a particular part of the sensorimotor network is important from the standpoint of basic science – understanding sensory estimation and fusion – and for clinical care – being able to localize damage to a particular pathway and to either sensory, central or motor sources. Osborne et al. (Nature 2005) provide evidence that 92% of the variability in smooth pursuit can be attributed to errors in sensory estimation of target motion. Others have characterized the dimensionality of noise, the number of parameters required to describe trial-to-trial variability in multi-axis systems. These studies (e.g. Sanger TD, J Neurosci 2000) show that the dimensionality of sensorimotor noise is usually lower than the number of degrees of freedom, implying that the brain may plan in a simplified coordinate system. Most of these studies employ Principal Component Analysis (PCA) to decompose trajectories into "eigentrajectories"- time series vectors that can be used to reconstruct all of the original trajectories using linear superposition. Typically a few key eigentrajectories explain most variability.

In this study, we measured noise in the vestibulo-ocular reflex (VOR). Our goal was to use the VOR as a simple way to gain a window into vestibular noise, in the same way that another oculomotor system, smooth pursuit, has been used to provide a window into visual sensory processing. Like the earlier studies, we decomposed the variability of many repetitions of VOR responses into eigentrajectories using PCA.

Horizontal and vertical eye positions were recorded in Rhesus monkeys during rotation that was purely yaw, as well as with small pitch rotations added so that the vector direction was $\pm$ 3,6,9°. Motions consisted of a single-cycle of sinusoidal angular acceleration yielding a sigmoid-like displacement (peak velocity 20°/s, frequency 2 Hz). Motion in darkness commenced after the animal held fixation. Analysis was conducted on eye velocity for the first 125 ms of motion, which was

compared to 125 ms of "background" variability with no motion and a fixation target present. Absolute noise was calculated using standard deviation. In addition to eigentrajectories, we fit the noise to models in which we assumed that noise could be explained by two basis trajectories proportional to the mean eye velocity, in either polar or Cartesian coordinates.

In a representative session (321 trials), the absolute noise was 0.33°/s during fixation and 0.67°/s in the latter half of motion. The first five eigentrajectories computed by PCA accounted for 44%, 9%, 7%, 6% and 4% of the variation. In absolute terms, the first accounted for 0.29°/s, and the second 0.0°°/s. After removing variation described by these two eigentrajectories, the remaining noise was 0.31°/s, close to that of fixation noise. This suggests that one or two eigentrajectories are sufficient to explain most of the variance above background noise. Fitting noise to models showed that two basis trajectories were sufficient to explain the variation above the background, regardless of the coordinate system – the residual was 0.28°/s for a polar fit and 0.33°/s for a Cartesian fit.

These results suggest that the time-course of the VOR exhibits low-dimensional structure, which is consistent with other studies. In addition, one or two eigentrajectories are sufficient to explain all the variance above fixation noise suggesting that they capture all the variability related to motion.

PA-34

Perceptual roll tilt thresholds demonstrate visual-vestibular fusion

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Stable motor control relies on accurate sensory estimation, which is performed by sensory fusion of incomplete, noisy, ambiguous cues. Previously [2], we measured vestibular thresholds of humans in the dark during roll tilt (to the left and right) using a range of frequencies; we measured thresholds for the semicircular canal (SCC) and otolith organs individually and for simultaneous stimulation and found that the brain combines information from these two sensory systems. Other studies have found similar cross-modality fusion of information, such as tactile and vision [1].

This study examined visual-vestibular fusion during roll tilt using 3 conditions to separate the potential visual cues of motion, absolute orientation and relative orientation:

1. NO VISION: subjects in the dark throughout.
2. FULL VISION: lights on during, before and after motion, providing natural visual motion cues and absolute & relative orientation cues.
3. STATIC VISION ONLY: as above except lights off during motion, providing only absolute & relative visual orientation cues, and not visual motion cues.

Subjects (3 F, 4 M, mean age 41, range 31–61) were pre-screened for normal vestibular function. We measured thresholds using an adaptive staircase (3-down 1-up) in which subjects tilted left or right and indicated perceived tilt direction. A range of frequencies (DC, .1, .2, .5, 1, 2, 5 Hz) allowed us to use differences between dynamic properties of each cue to separate their contribution (canal, otolith, visual motion & orientation). Dynamic motions consisted of a single-cycle of sinusoidal angular acceleration yielding a sigmoid-like displacement. Quasi-static (DC) tilt stimuli utilized subthreshold constant velocity ramps with smooth subthreshold acceleration/deceleration.

In the figure showing recognition thresholds in the three conditions, the abscissa is the frequency of motion and the ordinate is the threshold angle of roll tilt; error bars show standard error across subjects. With NO VISION (solid line), gravitational tilt measured by the otoliths dominated at low frequencies while the SCC contribution increased at higher frequencies. At DC the average threshold was 1.32°. As frequency increased, threshold velocity was reached with smaller tilt angles, dropping to 0.05° at 5 Hz. With FULL VISION (dash-dot), thresholds between 0.1–1 Hz were reduced by 48% compared to NO VISION (ANOVA; $p < 0.005$). At DC and at higher frequencies (2 & 5 Hz) there were no significant differences. This suggests that vision provides predominantly motion and/or relative orientation cues, but not absolute orientation, cues. It suggests these visual cues are less sensitive than the otoliths at low frequencies, less sensitive than the SCC at high frequencies, but more sensitive at intermediate frequencies. Thresholds for STATIC VISION ONLY (dotted line) were not significantly different from NO VISION, suggesting that absolute visual orientation cues do not improve thresholds.

We developed an optimal Bayesian weighting model to estimate vision-only thresholds using measured vestibular-only thresholds and combined visual-vestibular thresholds. The slope of the vision-only thresholds was -11 dB/decade suggesting a contribution of both visual motion and orientation cues. These thresholds match qualitatively with those measured using random dot patterns [3].

Our results demonstrate that visual-vestibular fusion improves roll-tilt direction recognition thresholds. The results suggest that visual cues provide primarily motion and relative orientation information.

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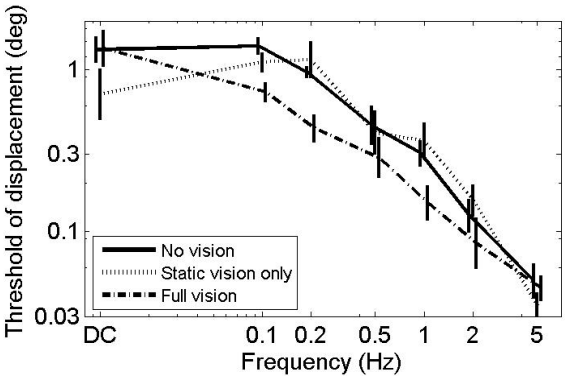

PA-35

Effects of cinnarizine on isolated vestibular hair cells of guinea pigs

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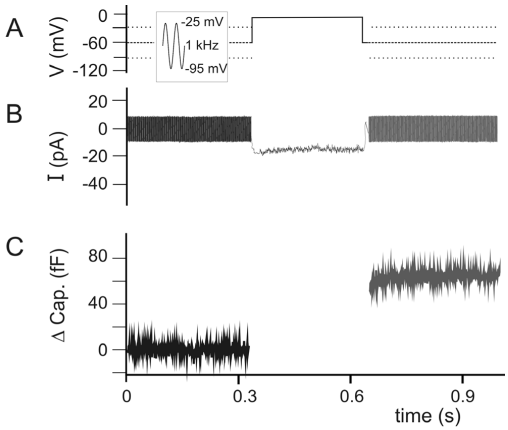
Objectives: The pathogenesis of the Meniere's disease and its histopathological correlate, the endolymphatic hydrops, is not well understood. There is no convincing answer which explains the cellular pathomechanisms on vestibular hair cells in case of the Meniere's disease. Therapeutic effects of various pharmaceutics on these cells are also unclear. Cinnarizine is a calcium antagonist, which is used in the treatment of the Meniere's disease. In our studies we analysed the effects of cinnarizine on ion currents in guinea pig vestibular hair cells.

Methods: Vestibular hair cells from guinea pigs were isolated by mechanical and enzymatical dissection. They were studied using the whole-cell patch-clamp technique. In current clamp, voltage responses to trains of stimulating currents were recorded. In voltage clamp, transmitter release was assessed from changes in the cell capacitance, as calculated from the phase shift during application of sine waves (Fig. 1).

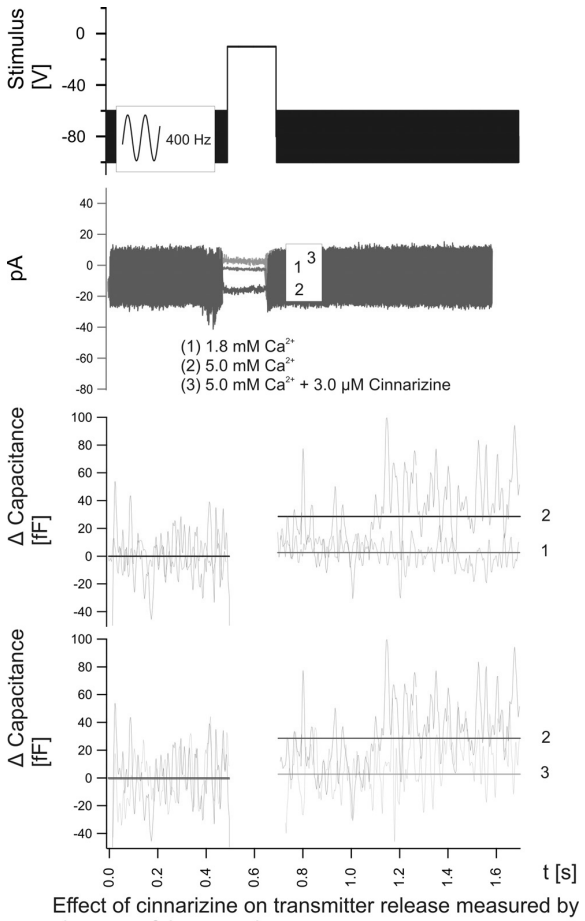
Results: We found out, that cinnarizine, beside its quality as a calcium antagonist, also has an effect on the calcium dependent K^+ outward currents, which are responsible for the repolarisation of the vestibular hair cells. Cinnarizine abrogated increases of K^+ currents induced by increases in the hydrostatic pressure. The pressure dependent K^+ currents may play an important role according to the endolymphatic hydrops. We demonstrated that cinnarizine may modulate transmitter release in vestibular hair cells by two divergent mechanisms that affect the release in opposite directions. As expected, cinnarizine inhibited transmitter release when applied at concentrations sufficient for a block of voltage-gated Ca^{2+} currents (Fig. 2). More importantly, we provide evidence that cinnarizine, at far lower concentrations, reverses the inhibiting effects of enhanced hydrostatic pressure on transmitter release.

Conclusions: Electrophysiological experiments on vestibular hair cell are essential for an all over understanding of the pathophysiology of the Meniere's disease. An elevated hydrostatic pressure in the endolymphatic space of the inner ear is discussed as pathophysiological factor in hydrops-related diseases of the inner ear. The influence of cinnarizine on the ion currents on guinea pig vestibular hair cells we showed attests the positive effects of this drug in the treatment of the Meniere's disease. The concentrations of cinnarizine required for inhibition of K^+ currents are similar to the free plasma concentrations in clinical conditions. Therefore, the induction of K^+ currents by hydrostatic pressure appears to be a possible and plausible pathological mechanism in vestibular vertigo, and the pharmacological modification of these K^+ currents may be a promising therapeutic principle that should be considered in further developments of drugs, especially for the local application for the treatment of Meniere's disease.



Effect of cinnarizine on transmitter release measured as increase of the capacitance:

A.Protocol
B.Calcium inward current
C.Capacitance measurement



Effect of cinnarizine on transmitter release measured by changes of the capacitance

PA-36

Histological analysis of a pygmy killer whale (feresa attenuata) inner ear

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Cetacean strandings are sometimes related to anthropogenic underwater noise. Histological analyses of cetacean inner ears are rare due to the scarcity of the specimens and poor preservation of inner ear tissue. We were interested in obtaining histological data from a stranded animal to evaluate it for evidence of acoustic inner trauma. We were able to obtain temporal bones from a pygmy killer whale (*Feresa attenuata*) that stranded live but died approximately ten weeks later during rehabilitation. Necropsy revealed the immediate cause of death was likely to be pneumonia. With a standard H&E stain on celloidin-embedded decalcified tissue, spiral and vestibular ganglion cells and afferents are well preserved. Pillar cells are also well preserved, but hair cells are not in evidence. Vestibular endorgans are small, compared to the cochlea, and disproportional with the size of the animal. Stereological (disector) methods are used to obtain ganglion cell counts. These histological data should give us more insight into the allometric relationship between sensory organ size and body size in the inner ear.

Poster Session 1 – B. Diagnosis

PB-37

Non-invasive evaluation of endolymphatic hydrops and normal value of endolymphatic space using magnetic resonance imaging

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Background: In 1861, Prosper Meniere first described the symptom complex of the disease and proposed the pathologic site to be in the labyrinth. Despite this well-known symptom complex, Meniere's disease remains a controversial and often difficult disease. The contributing factors include that the etiology remains unknown,

the natural course is highly unpredictable, moreover, it is impossible to demonstrate the dilated endolymphatic network histologically in temporal bones of living patients with clinical Meniere's disease and there is no test that makes the diagnosis of Meniere's disease.
Recently, several reports indicate that endolymphatic hydrops can be visualized and graded using three-dimensional fluid-attenuated inversion recovery (3D-FLAIR) magnetic resonance imaging (MRI) after invasive transtympanic gadolinium (Gd) injection through tympanic membrane in patients with inner ear diseases but there was still no the range of normal values of endolymphatic space to diagnose "endolymphatic hydrops" and estimate its degrees in Meniere's disease. Our purpose is to standardize the evaluation of endolymphatic hydrops and normal value of endolymphatic space in both the cochlea and the vestibule by applying for non-invasive intratympanic Gd perfusion through eustachian tube and 3D-FLAIR MRI.
Study Design: Prospective study. With a 3 Tesla MRI unit, 3D-FLAIR MR imaging was performed 24 hours after intratympanic Gd through eustachian tube in seven patients with Meniere's disease and sixteen health volunteers. Pure tone test and tympanometry were performed 24 h before and after administered Gd, moreover, tympanometry was performed 1 month after administered Gd.
Results: The gadolinium could appear in the perilymph inside inner ear, moreover, the border between the perilymph and the endolymph was visible so that endolymphatic space was clearly shown on 3D-FLAIR MRI. In health, the ranges of normal value of endolymphatic space in the cochlea and the vestibule were $\leqslant$ 28% and $\leqslant$ 40%, respectively. According to the normal value of endolymphatic space, all of 7 patients had a ratio of more than 28% in the cochlea, moreover, three of 7 patients had a ratio of more than 40% in vestibule. No significant changes in pure tone test and tympanometry were noted.
Conclusions: The non-invasive evaluation of endolymphatic hydrops and normal value of endolymphatic space using magnetic resonance imaging is indicated.

PB-38
OVEMP findings to air-conducted tones are independent of CVEMP findings?
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Background: Vestibular evoked myogenic potentials in the cervical muscles (cVEMP) have been used as a clinical test of the vestibulo-collic reflex, predominantly sacculo-collic reflex. Recently, myogenic potentials around the eyes (oVEMP) have also been recorded. However, significance of oVEMP remains unclear.
Objectives: To clarify if oVEMP findings to air-conducted tones in patients with unilateral peripheral vestibular disorders are independent of cVEMP findings.
Subjects and Methods: Clinical records of patients with unilateral peripheral vestibular disorders were reviewed. Among the patients, patients that underwent both of oVEMP testing and cVEMP testing were selected. Methods for recording of oVEMP and cVEMP were as follow. Electrodes for recording were placed just beneath the lower eye lid (active) and 2 cm below the active electrode (reference) for oVEMP, and on the upper half of the sternocleidomastoid muscle (active) and on the lateral end of the upper sternum (reference) for cVEMP. Five hundred Hz short tone bursts (rise/fall time $=$ 1 msec, plateau time $=$ 2 msec, 125 dB SPL) were presented. Signals were amplified, bandpass-filtered (20–2000 Hz), and 100 responses were averaged twice. Responses beneath the contralateral eye to the stimulated ear were studied for oVEMP and those of the ipsilateral sternocleidomastoid muscle were studied for cVEMP. [Results] Some patients showed abnormal results only in oVEMP testing, while some did only in cVEMP testing. Two tests were independent statistically. In patients who also underwent caloric tests, relations of caloric test results to VEMP results were studied. Caloric test results were not dependent on cVEMP or oVEMP results.
Conclusions: These results suggested that oVEMP should reflect functions of different peripheral vestibular populations from cVEMP or caloric testing.

PB-39
Diagnostic value of rotational test in peripheral vertigo patients
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Objective: to explore the clinical value of different parameters of rotational test in the diagnosis of peripheral vertigo.
Material and Methods: 176 peripheral vertigo patients were analyzed in this study. All the patients underwent the rotational test and caloric test. The patients were divided into the different groups according to the value of unilateral weakness (UW) or directional preponderance (DP) in caloric test, and the results of different four parameters of rotational test among the different groups were evaluated.
Results: The abnormal rate of gain, phase, directional preponderance, and time constant of rotational test was 6.8%, 38.6%, 31.8%, and 32.4% respectively in 176 patients. The combination of four parameters was 62.5%. There existed a statistically significant difference in value of phase and directional preponderance between peripheral vertigo and control group ($p < 0.05$). There were significant difference in phase, preponderance and time constant between the groups of normal and abnormal value of DP group in caloric test ($p < 0.05$). However, there were no differences in all kinds of parameters between the groups of normal and abnormal value of UW in caloric test ($p > 0.05$).
Conclusions: Individual rotational test parameters showed lower sensitivity in identifying peripheral vertigo. The combination of rotational test parameters improved predictive capabilities. Phase has the greatest clinical significance in its ability to find peripheral vestibular system injury. The DP value had important influence on the results of rotational test, which indicated that rotational test could reflect the compensation status of peripheral vertigo.

PB-40
Digitalization of paper-based electronystagmography
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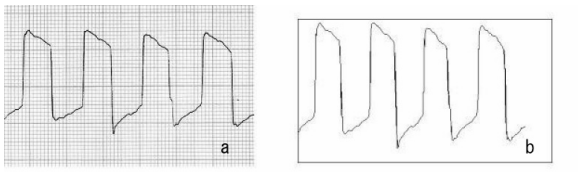
Objective: Electronystagmography (ENG) is the most readily available system for recording eye movements and it is widely used to evaluate eye movements of patients with vertigo as a routine clinical test. Since the development of ENG, eye movements were recorded on polygraph recorders with a long strip of graph paper. Development of computerized eye movement analysis procedure commenced in the late 1960s. During the 1980s, computerized ENG recording became available for clinical use. Digital ENGs have several evident advantages over paper-based ENGs. They are easy to store, easy to retrieve, can be transmitted electronically, and do not deteriorate. However, it is difficult to compare the recent recordings with computerized ENGs with previous paper-based ones. No report showed a method to digitalize and utilize valuable paper data of one's forefathers. The aim of this study is preservation, rescue and re-analysis of paper-based ENG using ImageJ.
Methods: A color scanner is used to scan ECG paper records and those images of ENG signals are fed into a personal computer. Then, we used ImageJ (NIH, open-source image-processing software written in Java) for the following process. First, the image containing eye movements was opened and a 8-bit binary image was created. Secondly, thresholding tool was applied. A suitable threshold selection can remove the background, e.g. gridlines of ENG papers. If thresholding of ImageJ did not well remove the background, GIMP2 (free software raster graphic editor) was used for thresholding. After thinning or sharpening, we finally used "Analyze>Tools>Analyze Line Graph" which providing the XY co-ordinates and the extracted image. To evaluate how accurately paper-based ENG was digitalized, we differentiated the extracted data of eye position and compared with differentiated waves of ENG tracings. We used Matlab (Mathworks) for differentiation and re-generation of the ENG signals.
Results: ENG tracings recorded at 5 mm/sec (saccade, smooth pursuit eye movement and caloric nystagmus) were largely well converted to digital forms. Differentiated data largely corresponds with eye velocity data in paper ENG. However, ENG tracing recorded at 1 mm/sec, e.g. optokinetic patten test, and differentiated wave did not correspond with paper ones.
Conclusion: We could recover numeric coordinate data from scanned paper-based ENG using ImageJ. Our method is very low cost by using open-source software. Clinicians and researchers can easily compare past paper-based ENG data with recent digital ones in patients who have prolonged courses of vertigo and abnormal eye movements.



a: Paper saccade tracing; b: Digitalization

PB-41

The prevalence of vestibulo ocular reflex (vor) deficit and postural sway in children with intellectual disability: preliminary results

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Background: It had been demonsatred that among elderly people with intellectual disability (ID) there is higher prevalence a deficit of the Vestibulo Ocular Reflex (VOR) as compared to a normal population but who 20 years older. As of today, the disturbances of vestibular development on children with ID were not published. In this study we examined whether deficit in vestibular functioning occurs already at childhood, or in fact, is a result of pre mature aging. The information is important in order to consider early intervention and rehabilitation.
Goals: 1) To investigate the prevalence of vestibular deficit among children with ID. 2) To analyze the correlation between vestibular deficit and the ability to maintain postural stability while standing with eyes open and close.
Methods: Eighteen ID children, ages 8–22, live at residential care centers for children with special needs and were authorized to participate in the study by the Helsinki ethics committee. Vestibular function was assessed using two clinical tests: the Head Impulse Test (HIT), and the Dynamic Visual Acuity (DVA). Equilibrium functions were assessed using two postural stability procedures: open and closed eyes, while standing on a force plate.
Results: Out of the 18 participants, one participant was not tested in neither the vestibular nor the postural control examinations and 4 participants were not tested in the two vestibular tests due to communication and understanding difficulties. Thus, out of the 14 remained participants, deficit of VOR was found in 8 participants (57%). At the postural control tests, there was a lack of understanding and cooperation with most participants and therefore, the tests were not addressed.
Conclusions: There is a high prevalence of VOR deficits among children with ID. In order to examine static balance for 30 seconds, force plate may not be an effective tool for this population and other examination tools should be considered.

PB-42

Subjective visual vertical in vestibular neuritis and unilateral sudden deafness

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Introduction and Purpose: The measurement of subjective visual vertical (SVV) is used to assess the degree of dysfunction in the otolith, primary vestibular nerves, and central graviceptive pathways. We measured the SVV in patients with vestibular neuritis (VN) and unilateral sudden deafness (uSD). The purpose of this study is to demonstrate the characteristics of the SVV in patients of VN and uSD, and to determine the relation between the SVV and other neuro-otological examinations, including vestibular evoked myogenic potentials (VEMP) and caloric test.
Subject and Methods: The SVV was measured by means of a small rotatable luminous line in the upright body position in a completely darkened room at the acute phase of their disease. The SVV was measured in 36 VN patients (20 men and 16 women, aged from 25 to 76 years) and 80 uSD patients (43 men and 37 women aged from 21 to 83). We defined the normal range of SVV as -2° to $+2^\circ$. VEMP was tested for all VN patients and 60 uSD patients.
Results: The SVV was tilted more than 2° in VN 69.4% of VN and in 26.3% of uSD patients. Among the abnormal SVV, the SVV tilt was directed toward the affected ear in 96.0% of VN patients and in 47.6% of uSD patients. Among VN, VEMP was normal in 21, and was abnormal in 15 patients. There was no significant relation in the results of SVV and VEMP in VN. In uSD patients, 18 patients showed abnormal VEMP and 50 showed normal SVV. There was a significant relationship between the percentages of abnormal SVV and the result of VEMP.
Conclusion: The percentage of abnormal SVV was higher in VN than in uSD, and there was a significant relationship between the abnormal SVV and abnormal

VEMP in uSD. Our results suggest that the shift of the SVV was strongly affected with superior vestibular nerve lesion, but also with inferior vestibular lesion.

PB-43

The n10 of the ocular vestibular evoked myogenic potential to 500Hz Fz bone conducted vibration is a valuable new indicator of semicircular canal dehiscence.

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Objective: Semicircular canal dehiscences (SCD) is a clinical entity characterized by vestibular and cochlear symptoms induced by enhanced sensitivity of labyrinthine receptors due to a bone defect of the otic capsule usually located on the semicircular canal bony roof. Diagnosis of SCD may be suspected with some combination of:

- history of sound and / or pressure – induced vertigo or symptoms of mixed hearing loss (peculiar low frequencies conductive hearing loss)
- bed side examination that reveal eye movements evoked by stimuli such as pressure of the external ear (Hennebert sign) and Valsalva maneuver aligned in the plane of the affected semicircular canal

Confirmation by clinical studies:

(i) Audiometry with Air Bone Gap
(ii) Cervical VEMPs: Increased amplitude p13 n23 complex and low threshold to Air Conducted Sound (ACS)
(iii) Ocular VEMPs: Increased n10 amplitude for Air Conducted Sound and Bone Conducted Vibration
(iv) And at the end positive CT scan confirming suspicion

But while ACS cVEMPs have taken an important role in diagnosing SCD, they do not always distinguish between dehiscent and non-dehiscent vestibular labyrinth, or above all between symptomatic and non-symptomatic dehiscences. They may be not be typical as was described above for several reason. The objective of the presented case report is to demonstrate the need for the clinician to be highly suspicious of the associations between auditory and vestibular symptoms and to perform both air conducted sound (ACS) and bone conducted vibration (BCV) Fz Cervical VEMPs and Ocular VEMPs.

Methods: A 63 years old woman was referred to our tertiary referral neurotological center (MSA ENT Academy Center – Cassino, Italy) with vestibular (recurrent Tullio Phenomenon or sound induced vertigo) and cochlear symptoms (persistent aural fullness) plus mixed hearing loss associated with disabling pulsatile tinnitus, hyperacusis and oscillopsia. Suspecting on the basis of symptoms and history a superior semicircular canal syndrome (SCDS), the patient was then submitted to ACS and BCV Fz ocular and cervical VEMPs carried out with a very short tone burst of 500 Hz lasting 7 milliseconds (5 millisecond plateau) with a repetition rate of 4 Hz for 50 times.

Results: Surprisingly, contrary to expectations, only the n10 potential of the ocular VEMPs to ACS and BCV Fz showed enhanced responses indicating utricular function in terms of amplitude and low threshold. The p13 potential of the cVEMP indicating saccular function to ACS and similarly to BCV was evocable with normal threshold and normal amplitude.

Conclusion: The case shows the need to add air conducted sound and bone conducted vibration ocular VEMPs to the test battery useful to improve diagnostic protocol for SCDS.

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PB-44

Ocular vestibular evoked myogenic potentials to air-conducted sound and bone-conducted vibration in superior vestibular neuritis

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Background: Recently, vestibular evoked myogenic potentials in response to air-conducted sound (ACS) and bone-conducted vibration (BCV) have been recorded from extraocular muscles (oVEMPs) as well as from

cervical muscles (cVEMPs). The oVEMPs are considered to represent vestibular function mediated by crossed vestibulo-ocular pathways, because they are present in patients without hearing, but absent on the contralateral side in those with unilateral vestibular loss [2].

The oVEMPs in response to BCV have been suggested to reflect the function of the otolith organs, especially the utricle. Physiological studies using guinea pigs showed that moderate BCV selectively activates irregular otolithic primary vestibular neurons including some that originate in the utricular maculae [1]. Clinically, oVEMPs to BCV are reduced or absent in patients with unilateral superior vestibular neuritis, affecting the nerves from the horizontal and anterior canals and the utricular macula, but sparing the saccule and inferior vestibular function [3].

On the other hand, the origin of the oVEMPs to ACS is still unclear, while several studies suggested that oVEMPs to ACS are saccular in origin.

Objective: To compare the oVEMPs to ACS and BCV in patients with superior vestibular neuritis, to determine the role of the saccule in generating oVEMPs.

Methods: The n10 component of the oVEMP to BCV and ACS was measured in 12 patients (age 23–70 years) with unilateral superior vestibular neuritis.

For measuring oVEMPs, the active EMG electrodes were placed just below the eyelid and the reference electrodes were placed 3 cm below the active electrode. The ACS stimuli were 500 Hz tone bust (95 dBnHL, 4 ms in duration) delivered monaurally by a calibrated headphone. BCV stimuli were 6ms 500 Hz tone bursts delivered by a stimulator (Bruel and Kjaer minishaker 4810) to the midline forehead of the patient at the hairline (Fz).

Asymmetry ratio (AR) for n10 amplitude of the oVEMP was calculated using a following formula: Asymmetry Ratio (AR) = ((larger n10 – smaller n10) / (larger n10 + smaller n10))* 100

Results: All patients had normal cVEMPs on both sides. The average AR for cVEMPs to ACS was 9.1 $\pm$ 1.1% (SE here and below). In most patients with superior vestibular neuritis, the contralateral oVEMPs in response to ACS of the affected ear were reduced or absent. The average AR for oVEMPs to BCV was 65.2 $\pm$ 8.9%, and that for oVEMPs to ACS was 61.4 $\pm$ 11.5%. There was no significant difference between the mean value of the oVEMPs to BCV and ACS.

There was a very close relationship between the size of AR for oVEMPs to ACS and that for oVEMPs to BCV ($r = 0.87, p < 0.001$).

Conclusion: The n10 component of the oVEMP to ACS is probably mediated predominantly by the contralteral superior vestibular nerve and so most likely by the utricular receptors and afferents.

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PB-45

About correlation between centre of pressure, trunk, and head sways during quiet upright stance

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In order to better understand the mechanisms of orthostatic balance, centre of pressure (CoP), trunk, and head sways were simultaneously measured during quiet upright stance, and compared to each other, looking for possible correlation.

Methods: A total of 16 healthy young adults served as subjects. They were asked to keep orthostatic position for 120 s, once with open and once with closed eyes. COP sway was measured by force platform, trunk oscillation by inclinometers placed at the sternum level, trunk and head angular velocities by miniature gyroscopes, placed at the sternum and the skull vertex, respectively. Cross-correlation functions were used to compare sways measured at different levels to each other. In particular, antero-posterior (AP) and mediolateral (ML) components of CoP sway were correlated to the homologous components of trunk oscillation, and AP and ML trunk oscillation velocities to the homologous head oscillation velocities.

Results: Clear and consistent positive correlation was found between trunk and head sways. In 83% of cases, cross-correlation functions presented one sharp

peak near the origin, and much lower values elsewhere. Mean correlation delays in the different conditions (open or closed eyes) and directions (AP and ML) ranged 17 to 47 ms, and weren't significantly different from 0 at $p = 0.05$ (t-test). Cross-correlation functions computed inside a 20 s sliding window showed that sharp and steady correlation was kept all along the test duration (120s).

CoP-trunk correlation was much less clear. Cross-correlation peaks as sharp as those observed between trunk and head velocities could never be observed. However, in many instances the two sways did show almost parallel time courses. This could either extend to almost the whole test duration or be limited to more or less shorter periods, and was much more frequent in ML than in AP plane, where, in general, the two sways appeared to be uncorrelated. However, in a few instances, in the AP plane they semed to be phase opposed.

Discussion: Sharp cross-correlation peaks with almost no delay show that trunk and head moved almost synchronously, like one rigid body. This was consistent with the fact that in either plane (AP or ML) and vision condition (eyes open or closed) the sway velocity distributions of trunk and head were similar to each other, and the corresponding average velocity ranges (5th to 95th percentile of sway velocity distribution) were not significantly different from one another at $p = 0.05$ (t-test).

Poorer correlation between CoP and trunk sways is a likely consequence of the presence of the hip joint, and the inertia of the trunk-arms-head system, linked to this joint. This makes the trunk over the hip intrinsically less steady, and more moveable, than the head over the neck. Interestingly enough, CoP-trunk correlation was better in ML plane, meaning a stronger tendency to move together in this plane, than in AP one, and this may easily be explained by the different stiffness of the hip joint in the two planes, due to the different geometry.

Different degrees and modes of correlation between CoP and trunk sway, from almost parallel patterns throughout the whole test to seemingly phase opposed patterns, suggest the use of different balance strategies, that further investigation might possibly elucidate. It is also possible that the two sways convey different, maybe complementary, information about balance control, and it could possibly make sense to consider also trunk movements in the diagnostic approach to balance control. This conclusion is consistent with previous suggestions by different authors (e.g.: Kamen et al. 1998; Allum et al. 2001; Mayagoitia et al. 2002; Moe-Nilssen and Helbostad 2002).

PB-46

3D analysis of benign positional nystagmus due to cupulolithiais in posterior semicircular canal

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Objective: Recently, it is recognized that the pathophysiology of benign paroxysmal positional vertigo (BPPV) is cupulolithiasis or canalolithiasis in either posterior semicircular canal (PSCC) or horizontal semicircular canal (HSCC). Patients with cupulolithiasis in HSCC show apogeotropic positional nystagmus, while those with canalolithiasis in HSCC show geotropic positional nystagmus. Thus, the differential diagnosis of cupulolithiasis from canalolithiasis can be made by the direction of the positional nystagmus in patients with the HSCC type of BPPV (H-BPPV). On the other hand, in patients with the PSCC type of BPPV (P-BPPV), cupulolithiasis in PSCC induced the vertical-torsional positional nystagmus, of which direction is the same as that induced by canalolithiasis. In the present study, an attempt was made to diagnose cupulolithiasis in patients with the posterior semicircular canal (PSCC) type of benign paroxysmal positional vertigo (P-BPPV). Methods and Results: We first, three-dimensionally analyzed the vertical-torsional positional nystagmus in 111 patients with P-BPPV and evaluated its time constant. This parameter showed a wide variation that could be divided into two groups: one lasting more than 40 sec in 8 patients and another below 20 sec in 103 patients. Since the time constant of the positional nystagmus induced by cupulolithiasis was much longer than that induced by canalolithiasis, this finding suggests that cupulolithiasis in the PSCC induced the vertical-torsional positional nystagmus with a long time constant in the group of 8 patients. We also found that the vertical-torsional positional nystagmus disappeared in these patients at the neutral head position, where the axis of the cupula of affected PSCC

aligned with gravity. Conclusions: In the present study, we diagnosed P-BPPV in 111 patients and found in 8 of them a vertical-torsional positional nystagmus with a long time constant ($>$ 40 sec). This nystagmus disappeared at the neutral head position. They also showed a direction-changing vertical-torsional positional nystagmus in left and right head positions in supine, which was suppressed by the neutral head position. Finally, the axis angles of their positional nystagmus were in line with ipsilateral PSCC and contralateral ASCC. All these findings suggest that the development of a cupulolithiasis in the PSCC may be the underlying cause of BPPV in a small portion of patients with this condition.

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PB-47

Localization and prevalence of hydrops formation in Meniere's disease using a test battery

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Objective: This study investigated the localization and prevalence of hydrops formation in patients with unilateral Meniere's disease.
Method: Twenty patients with unilateral Meniere's disease underwent a battery of tests including audiometry, and caloric, ocular vestibular evoked myogenic potential (oVEMP) and cervical VEMP (cVEMP) tests. The latter two tests used air-conducted sound (ACS) and bone-conducted vibration (BCV) as stimuli.
Results: Thirteen patients (65%) had abnormal hearing with a four-tone average $>$ 26 dBHL. In the caloric test, 4 patients (20%) had abnormal responses, including canal paresis in three and caloric areflexia in one. The percentages of patients with abnormal ACS-oVEMP, BCV-oVEMP, ACS-cVEMP and BCV-cVEMP tests were 65%, 25%, 45%, and 25% in affected ears, and 40%, 0%, 15%, and 0% in unaffected ears, respectively. Although ACS- and BCV-oVEMP results significantly differed, ACS- and BCV-cVEMP results did not, regardless of the affected or unaffected ears. Thus, the abnormal rates for hearing, ACS-cVEMP, BCV-oVEMP, and caloric tests in affected ears were 65%, 45%, 25%, and 20%, respectively. This decreasing order of abnormal percentages in function of the cochlea, saccule, utricle and semicircular canals mimics the declining sequence of hydrops formation in temporal bone studies.
Conclusion: An inner ear test battery comprising audiometry, and caloric, oVEMP and cVEMP tests may provide further insight into the localization and prevalence of hydrops formation in Meniere's disease.

PB-48

Ocular vestibular evoked myogentic potentials in response to vertex bone

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Objective: To explore whether testing ocular vestibular evoked myogenic potentials (oVEMPs) in response to vertex bone vibration is capable of identifying unilateral peripheral vestibular lesions.
There is an ongoing discussion as to whether testing oVEMPs in response to skull vibration might reflect "crossed" utriculo-ocular reflexes. Animal experience has shown that irregular otolithic primary neurons are selectively activated by bone-conducted stimulation and many of these neurons originate from the utricular macula. Recent studies in humans also support a utricular origin for the oVEMPs to skull vibration. However, data are still lacking on both optimal stimulus site and on optimal stimulus configuration for testing oVEMPs in response to bone-conducted stimulation.
Theoretically, a vertex stimulus site has advantages over forehead and lateral stimulus sites: it is easy to apply repeatable static pressure to the skull with the "Minishaker" bone conductor on a sitting test subject with the head/utricle in a "neutral" position, i.e. the 1.1 kg "Minishaker" is simply supported side-ways without adding further static pressure to the skull.
Methods: oVEMPs in response to bone-conducted vibration applied at the vertex were tested in healthy controls ($n = 18$) and in patients with unilateral loss of vestibular function ($n = 10$). The hand-supported "Minishaker" was used. Stimulus frequencies tested were 125 Hz, 250 Hz and 500 Hz. Stimulus intensities tested were 130, 135 and 140 dB force level.
Results: oVEMP amplitude was dependent on stimulus frequencies. It was weak in response to 500 Hz, but present in response to 125 and 250 Hz stimulation for all three stimulus intensities. The 125 Hz stimulus caused larger oVEMPs compared with the 250 Hz stim-

ulus. In patients, although stimulating with 125 Hz and using the highest stimulus intensity (140 dB), "crossed" oVEMP was absent from the lesioned side, but normal from the healthy side.
Conclusions: The present data suggest vertex bone vibration to generate oVEMPs in normals. Testing oVEMPs to vertex bone vibration can also distinguish peripheral vestibular lesions. Hence, although vertex might not be the site that generates the most prominent oVEMPs to bone-conducted stimulation, it should still be considered a potential site for evaluating labyrinthine/utricular function.

PB-49
Impaired sacculocollic reflex in anterior inferior cerebellar artery infarction
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Background: Cervical vestibular-evoked myogenic potential (cVEMP) refers to inhibitory potentials recorded in the contracting muscles, usually in the sternocleidomastoids (SCM), when loud click or short tone burst sound was applied. cVEMP seems to be generated via a rapidly conducting disynaptic pathway, originating in the saccule and proceeding along the vestibular afferent fibers to the vestibular nuclei, and then through rapidly conducting projections that synapse with SCM nuclei. The AICA is important for vascular supply to the peripheral and central vestibular structures. It usually supplies the inner ear, lateral pons, middle cerebellar peduncle (MCP), and anterior inferior cerebellum including the flocculus. As a result, AICA infarction usually damages both the peripheral labyrinth and central vestibular apparatus. To determine saccular dysfunction by measuring cervical vestibular-evoked myogenic potentials (cVEMP) in infarction involving the territory of anterior inferior cerebellar artery (AICA).
Methods: We recorded cVEMP in 12 patients with AICA infarction documented on MRI. Patients also underwent other audiovestibular function tests. The patients included seven men and the ages ranged from 46 to 76 years (mean $\pm$ SD $=$ 65.4 $\pm$ 9, median $=$ 70). cVEMP was induced by a short tone burst and was recorded in contracting sternocleidomastoid muscle while patients turned their heads forcefully to the contralateral side against resistance. A short alternating tone bursts (110 dB nHL; 500 Hz; ramp $=$ 2 ms; plateau $=$ 3 ms) were given at 2.1 Hz monaurally using a headphone. The analysis time for each stimulus was 50 ms and responses for up to 200 stimuli were averaged for each test. The signal was filtered at a bandpass of 30–1500 Hz, and the mean values of at least two trials were obtained from each ear. The absolute cVEMP amplitude was then normalized against mean tonic activation of SCM during the recording. Patients also underwent video-oculographic recording of spontaneous, gaze-evoked and head-shaking (HSN), ocular lateropulsion, ocular tilt reaction (OTR), measurement of the subjective visual vertical (SVV) tilt, audiometry, and bithermal caloric tests. Normative data of cVEMP were obtained from 47 healthy volunteers.
Results: Eight patients (67%) showed abnormal cVEMP, unilateral in six and bilateral in two. The cVEMP abnormalities included absent responses in three, decreased p13–n23 amplitude in five, and delayed p13/n23 responses in three. cVEMP was abnormal mostly in the side of MRI lesions. However, one patient showed decreased amplitude in the contralesional side and two with unilateral lesion exhibited bilateral cVEMP abnormalities. In contrast, one patient with bilateral lesions involving the middle cerebellar peduncles had unilateral cVEMP abnormality. The side of abnormal cVEMP was correlated with the side of canal paresis and hearing loss. However, the proportion of canal paresis, hearing loss, ocular tilt reaction and abnormal SVV tilt, and distribution of the MRI lesions did not differ between the abnormal and normal cVEMP groups.
Conclusion: Our patients with AICA infarction showed various combinations of audiovestibular loss. The associations and dissociations of the audiovestibular dysfunction suggest differential involvements of the vestibulocochlear structures in AICA infarction.

PB-50
Emergency department referrals for acute vestibular neuritis are more commonly due to BPPV
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Objectives: To compare the clinical diagnosis of emergency department doctors of vestibular neuritis with a neuro-otologist diagnosis
Methods: Patients with acute vestibular neuritis were recruited from the emergency department of an academic tertiary London hospital. Emergency de-

partment junior doctors were taught vestibular clinical assessment, including head-impulse testing and Hallpike's, at regular intervals to co-incide with new staff rotated to the department. Cases were referred to the academic neuro-otology team thought to be probable vestibular neuritis. The actual diagnosis reached by a neuro-otologist was recorded.

Results: Over a twelve month period, from a single emergency department, 90 referrals were made for 'acute vestibular neuritis'. The neuro-otologist diagnoses were: vestibular neuritis $n = 14$, posterior canal BPPV 29, horizontal canal BPPV 2, history of resolved acute vestibulopathy but no diagnosis reached (normal assessment including caloric irrigation) 14, vestibular migraine 12, stroke 4, pre-syncope 4, anxiety 11, Meniere's 0.

Conclusions: BPPV was found to be the diagnosis twice as commonly as vestibular neuritis, when the latter was the initial diagnosis. This was despite attempts to train junior medical staff to correctly differentiate between the two. Further training of front line Emergency doctors is desirable to identify and terminate bouts of BPPV, reducing community morbidity. Presentations with other acute vestibular conditions such as Meniere's disease were better identified (probably because of the associated auditory symptoms) and not referred as 'vestibular neuritis'. Vestibular research groups must use extreme caution in retrospectively using clinical diagnoses made by doctors who do not have adequate vestibular training.

PB-51

Dissociation between cVEMP and oVEMP projections activated by sound in vestibular neuritis.

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Introduction and Objectives: Stimulation of the vestibular apparatus by air-conducted (AC) sound or bone-conducted (BC) vibration evokes short latency electromyographic potentials which assess the integrity of vestibulo-collic (cVEMP) and vestibulo-ocular (oVEMP) reflex pathways. In humans, afferent specificity for both modes of stimulation remains controversial. Emerging clinical evidence using 500Hz BC vibration has been suggested to imply that cVEMPs reflect predominately saccular function and oVEMPs predominately utricular function regardless of stimulus modality [3]. However, tuning experiments suggest that similar profiles of vestibular afferents project to both reflex pathways [6], and cVEMPs evoked by BC stimuli such as taps and lateral pulses have been suggested to excite utricular projections to the neck muscles [1,5]. Thus, the purpose of this study was to investigate the possible selectivity of different stimuli for utricular or saccular afferents by testing patients with vestibular neuritis (VN), a condition which commonly results in selective impairment of superior vestibular nerve function.

Methods: cVEMPs and oVEMPs were measured to AC (500 Hz short tone bursts) and BC (forehead tap and lateral pulse) stimuli in 23 patients diagnosed with VN (58 ± 13 years). We compared their responses to 40 normal controls (60 ± 12 yrs) to determine rates of abnormality. For cVEMPs, we recorded responses from the ipsilateral sternocleidomastoid muscle. oVEMPs were recorded from beneath the contralateral eye during upwards gaze. Responses were recorded bilaterally following forehead taps.

Results: AC cVEMPs were generally preserved and showed significantly fewer abnormalities when compared to AC oVEMPs (cVEMP: 22% vs oVEMP: 68%; $P < 0.001$). When stimulus intensity was matched at the same level above AC cVEMP threshold for both ears, oVEMPs were often absent from the affected ear. AC cVEMPs were also associated with fewer abnormalities than lateral pulses for both cVEMPs and oVEMPs ($P < 0.001$), which were similar to each other (74% vs 70%; $P = 0.862$). Forehead taps showed no significant difference in rates of abnormalities between reflexes (33% vs 13%; $P = 0.195$), and produced significantly fewer abnormalities than lateral pulses ($P < 0.03$).

Conclusion: Our results are consistent with AC cVEMPs often being preserved in VN, and that they reflect saccular (inferior nerve) activation. BC stimuli results suggest that reflexes evoked by lateral pulses are mediated by the superior nerve (possibly utricular fibres), as they were often abnormal. As such, these results identify a similar contribution of utricular input to both cVEMPs and oVEMPs. Forehead taps were not as successful as lateral pulse stimulation, possibly due to the variability of taps in normal subjects. Our findings also suggest a dependence of AC oVEMPs upon the integrity of the superior vestibular nerve, which may be due to saccular afferents in the superior vestibular nerve [4] or a dependence of the response on utricular function, possibly via afferent convergence [2].

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PB-52
Analysis of vestibular function in patients with otosclerosis

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Objectives: Some patients with otosclerosis might suffer from not only hearing impairment but also equilibrium disorder, but its pathogenesis otosclerosis remains unknown. This study retrospectively analyzed the vestibular function in patients with otosclerosis.
Methods: Between June 2009 and April 2010, we performed stapes surgery on 8 patients with otosclerosis at Hyogo College of Medicine. All patients were female, with a mean age of 49 years old (36–66 years). Diagnosis of otosclerosis was based on surgical findings as well as preoperative audiograms and radiological findings. To evaluate the vestibular function of the patients, the duration of hearing impairment, presence of neuro-otological symptoms (dizziness or vertigo), audiograms, vestibular evoked myogenic potential (VEMP) using bone-conducted tone burst stimulation (Miyamoto et al. Otol Neurotol, 2006), and caloric tests, were investigated preoperatively. The patients were divided into two groups: with (group A) and without (group B) dizziness or vertigo, and compared statistically.
Results: Four patients presented with dizziness or vertigo (group A), whereas the other four patients did not (group B). In group A, dizziness was observed in three patients and vertigo was in one patient. The mean duration of otosclerosis of 15 years in group A ($n = 4$) was significantly longer than in group B, 8 years ($n = 4$) ($p < 0.05$). Regarding the mean preoperative hearing level, air conduction in group A (70 dB, $n = 4$) and group B (60dB, $n = 4$) did not show a significant difference. Consequently, there was no significant difference in the mean air-bone gap between group A (27dB, $n = 4$) and group B (32dB, $n = 4$). For vestibular function, only one patient in group A (25%) and two patients in group B (50%) showed canal paresis (CP) by the caloric test. In the VEMP test, three patients with dizziness in group A (75%) did not show a small amplitude, these was one patient in group B (25%).
Conclusion: Patients with a longer duration of otosclerosis might easily suffer from an equilibrium disorder. Impairments of the hearing level and semicircle canals (CP) might not etiologically correlate with equilibrium disorder. It was suggested that patients with otosclerosis, especially presenting with dizziness, might have saccule dysfunction. Further studies on equilibrium disorders are required to elucidate the pathogenesis.

PB-53
Accurate VOR gain measurement in the video head impulse test

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Background: Recent advances in small, light-weight, high-resolution, high-speed video cameras have allowed the development of head mounted systems that record eye movement responses during the head impulse test (the video head impulse (vHIT) test; Macdougall et al. [1]). However many challenges remain with: noise levels, and lower spatial and temporal resolution when compared with existing search coil systems. Another significant problem is the "bump artifact", that is the relative movement between the camera and the head during the initial thrust of the head impulse delivered by the clinician. The use of this system on many subjects and the direct comparison of video data with coils data has highlighted the problems in the standard measure; calculation of VOR gain as simple eye velocity/head velocity.
Objective: We sought to use regularization techniques to accurately separate the vestibular ocular reflex (VOR) component from the net eye signal and thereupon provide more accurate measures of VOR gain. Our strategy was to use simultaneous search coil recordings as a "ground truth" comparison to aid in system design and permit direct evaluation.
Methods: Subjects wore tight fitting goggles which contain the video camera and inertial sensors which

measure linear acceleration and angular velocity in three dimensions. Video frames and inertial measurements were acquired at 250 Hz. Subjects simultaneously wore a search coil in the same eye measured by video. The data were obtained during repeated horizontal head impulse test trials for 10 patients and 10 normals. We developed a procedure which simultaneously performs signal restoration and separation of the constituent components that form the overall eye response, that is, the slow phase eye movement (the VOR), the saccadic eye movements, noise and "bump artifact". The regularization was constructed in the form of a cost function minimization problem, which exploits the differing spatial and frequency characteristics of the individual components. The system also allowed testing of different ways of measuring VOR gain: it implements three different measures of VOR Gain 1) Gain in velocity at peak head acceleration, 2) Area under the eye velocity curve or position at zero crossing of head velocity and 3) Average low frequency amplitude response of the least transfer function between the head and VOR signals. The software used for data acquisition, imaging and signal processing is written in LabVIEW 9.0 (National Instruments).

Results: We applied the regularization to each data-set and measured the VOR using four separate paradigms. As expected the standard method of measuring gain at peak head acceleration was most affected by the "bump artifact". The performance of the other indicators will be described.

Conclusion: The application of regularization achieves a significant improvement over traditional methods of measuring VOR gain.

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PB-54

Difference of vestibuloauditory findings in patients with tumor of cerebellopontine angle: vestibular schwannoma vs meningioma

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Background: Vestibular schwannoma is a most common tumor in the cerebellopontine angle (CPA). Additionally, other types of tumors also arise at the CPA. For instance, meningioma is second common tumor in that area. The differential diagnosis is based on the patten of imaging such as computed tomography and magnetic resonance imaging (MRI). However, there is little information about the difference of neurotological examination between the vestibular schwannoma and meningioma in the CPA, although each tumor was well documented about the vestibuloauditory function.

Objectives: The aim of this study is to elucidate the functional difference in the neurotological examination in patients with vestibular schwannoma and meningioma in CPA.

Methods: We collected the patients with vestibular schwannoma and meningioma in CPA who visited our department of otorhinolaryngology in Kyushu University Hospital. The electronystagmography, caloric test, vestibular evoked myogenic potentials (VEMP) and statokinesigraphy were tested to evaluate the vestibular function, and pure-tone audiometry (PTA), distortion product otoacoustic emission (DPOAE), speech discrimination score, and auditory brainstem response were performed to evaluate the auditory function. In addition, taste was tested using electric stimulation as a function of facial nerve. We measured the location and size of tumor with MRI. Finally we compared the functional difference between vestibular schwannoma and meningioma.

Results: The caloric response revealed that maximum slow phase velocity of patients with vestibular schwannoma tended to be less than that with meningioma. VEMP and statokinesigraphy did not show the statistical difference. The hearing threshold in PTA and the amplitude of DPOAE were different between two tumors. Other examinations did not show the statistically significant difference.

Conclusions: The patients with vestibular schwannoma showed worse function in the vestibuloauditory tests than those of meningioma. These results suggest that functional difference may exist among several types of tumors in the CPA.

PB-55

The clinical utility of Romberg's test

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'Romberg's test, whose name is perhaps taken in vain more often than any other in medicine'. "'C. H. Ed-

wards ('Neurology of Ear, Nose, and Throat Disease' 1973).
Marshall Hall, Moritz Romberg, and Bernardus Brach first described this sign in the early 19th century. But, other 19th-century clinicians were pivotal to its interpretation, and these included William Osler, Jean-Martin Charcot and William Gowers.
Early in its history, the sign was linked to the specific diagnosis of tabes dorsalis or progressive locomotor ataxia, later known to be caused by syphilis. The current understanding allows for a much broader range of underlying pathologies, including vestibular, cerebellar and proprioceptive dysfunction.
A central issue in interpreting the Romberg's test is whether its application is that of a binary clinical sign (i.e. it is either present or absent), or whether it finds utility as a form of posturography, whereby the result is interpreted in the context of a continuum (wherein normal values are set according to age).
In 2009 we surveyed 48 neurologists at the Australian and New Zealand Association of Neurologist's Annual Scientific Meeting and the members of a division of General Practice in Melbourne, Australia, regarding their understanding, method and interpretation of the Romberg's test. There was little consistency in the responses to the eight item written survey, both within and between, the two groups surveyed. We proffer some tentative recommendations on nomenclature.

PB-56

Ocular vestibular-evoked myogenic potentials to bone conducted vibrations in superior vestibular neuritis show utricular function

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Objective: The n10 component (n10), a negative component at around 10 ms latency, of the ocular vestibular-evoked myogenic potential (oVEMP) in response to bone-conducted vibration (BCV) delivered to the midline of the forehead at the hairline (a location called Fz), is a crossed vestibulo-ocular response which is probably caused by the vibration selectively activating vestibular otolithic receptors. We wished to determine whether n10 is due primarily to activation of the utricular macula. If the n10 is due primarily to utricular activation then diseases which affect only the superior division of the vestibular nerve (i.e. superior vestibular neuritis, SVN) in which all utricular afferents course, should reduce or eliminate n10 beneath the contralesional eye, whilst the n10 beneath the ipsilesional eye and the sacculo-collic cVEMP on the ipsilesional side should be preserved.
Patients and Methods: The oVEMP was recorded by surface electrodes beneath both eyes, as the patient looked up, in response to brief repeated bursts of 500 Hz BCV at Fz (50 bursts of 7ms at a repetition rate of 3/s). The n10 component of the oVEMP was measured in 133 patients with unilateral SVN but with inferior vestibular nerve function preserved, as shown by ipsilesional cVEMPs. In addition 50 normal subjects were tested.
Results: The n10 to Fz BCV of 133 SVN patients was reduced or absent beneath the contralesional eye relative to the ipsilesional eye, so that there was an n10 asymmetry which was significantly greater than the n10 asymmetry in the 50 healthy subjects. The diagnostic accuracy of the n10 asymmetry ratio (n10 AR) in determining the affected side in patients was assessed in relation to the "gold standard"- canal paresis (CP) score using STARD procedures. In terms of predicting the affected side, using a cut-off n10 asymmetry ratio of 46.5% the n10 AR has a sensitivity of 0.9, a specificity of 0.8 and a diagnostic accuracy of 94%.
Conclusion: We conclude that the n10 component of the oVEMP to BCV is probably mediated by the superior vestibular nerve and probably due to activation of mainly utricular receptors. This simple new response is almost as good as the caloric test in identifying the affected side in patients.

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PB-57

Bedside diagnosis of vestibular neuritis in a patient with congenital nystagmus

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The discrimination between central and peripheral lesions in patients suffering from acute vertigo is not always clear-cut and requires a general good comprehension of neurological and neuro-otological examination procedures. Here we present a case with acute vertigo where the diagnostic procedures were complicated by the presence of congenital nystagmus. The familiarity with bed-side clinical tests, such as the head-thrust test and tests of the subjective visual horizontal and vertical, helped in this case to establish the diagnosis of vestibular neuritis. Without this knowledge the exclusion of a central lesion would have been impossible to make despite the 'golden standards' of caloric irrigation and radiologic imaging techniques.

PB-58

High VOR gain and prolonged time constant in rotation chair test can induce motion intolerance in dizzy patients

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Background and Objective: The vestibular function tests are helpful to diagnose the dizzy patients. Among them, bithermal caloric test is most commonly used for localizing the permanent vestibular loss. However, normal caloric response does not indicate that the functional status of vestibular system is normal. Prolonged time constant in VOR can be caused by abnormal velocity storage mechanism. We tried to evaluate the clinical features of the patients who showed normal caloric response, but high gain in low frequency and prolonged time constant in rotation chair test.
Materials and Methods: A retrospective review of clinical records was performed in 69 dizzy patients who showed abnormal vestibular function test with normal caloric response. We defined normal caloric response as canal paresis was below 30%. The vestibular function tests include bithermal caloric test, rotary chair test (slow harmonic acceleration(SHA) test, visual fixation(VFX) test, visual vestibulo-ocular reflex(VVOR) test), electronystagmography and posturography. Among them, 7 patients showed high gain in low frequency and prolonged time constant in step velocity test with rotation chair. These patients were evaluated for clinical features and possible diagnosis.
Results: Seven patients were complaining of symptoms, such as positional dizziness, motion intolerance, disequilibrium and lightheadedness. There were 1 male and 6 females with a mean age of 51.7 years (range: 25 to 75 years). The gain of VOR is 0.52 ± 0.14 at 0.01 Hz, 0.56 ± 0.06 at 0.02 Hz, 0.57 ± 0.05 at 0.04 Hz, 0.62 ± 0.03 at 0.08 Hz, 0.64 ± 0.03 at 0.16 Hz, 0.64 ± 0.05 at 0.32 Hz, and 0.70 ± 0.04 at 0.64Hz. Time constant of VOR with step velocity (100 deg/sec) is 24.8 ± 2.34 sec (After CW rotation and after stopping CCW rotation) and 27.8 ± 4.2 sec (After CCW rotation and after stopping CW rotation). Slow phase velocity of caloric response in each stimulus was increased (29.1 ± 7.3 deg/sec). Most patients (6 out of 7) had headache. Most patients were diagnosed as migraine associated dizziness ($n = 5$). Others are unknown (Visual-vesibular mismatch).
Conclusion: High gain at low frequency VOR and abnormally prolonged time constant may imply vestibular hyperexcitability induced by abnormal velocity storage mechanism. Those patients with these findings were complaining of positional dizziness and visually evoked disequilibrium in addition to motion sickness. Migraine associated dizziness usually have these symptoms and VFT findings. Maybe, these VOR change are essential diagnostic criteria for migraine associated dizziness.

PB-59

A vestibular evoked myogenic potential (VEMP) metric that estimates the EMG inhibition depth produced by the saccular response

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Objective: To develop a metric of the sensitivity of the saccule to air-conducted sound stimuli using vestibular evoked myogenic potential (VEMP) measurements.
Methods: (i) Experiment: VEMPs evoked by 500 Hz tone-burst stimuli were measured from 5 normal human subjects. On each subject, 12 recordings of 500 stimulus presentations each were made at 5 stimulus levels between 70 and 90 dB HL, and post-stimulus EMG waveforms (*traces*) in response to all individual tone-bursts were recorded. (ii) Model: Electromyograms (EMGs) from the sternocleidomastoid muscle were simulated using a computational model of skeletal muscle physiology. The muscle was modeled as a collection of motor units, with independent motor unit action potential (MUAP) sequences evoked by the cortical motor drive. Sets of EMG waveforms were syn-

thesized by convolving the simulated spike trains with the surface response to single MUAPs. Model parameters such as numbers and sizes of the motor units, firing thresholds and rates were determined using existing anatomical and physiological data, and by matching statistics of the model outputs to experimental EMG.
Synthetic VEMP traces corresponding to different amounts of vestibular-induced inhibition were created by modulating the motor unit spiking in the EMG model, simulating the vestibulocollic reflex. The modulation was described by a single parameter, the inhibition depth (ID) or percentage decrease in spike rate, representing the sensitivity of the saccule to the stimulus. The motor drive parameter was varied to follow the experimentally measured changes in contraction effort.
(iii) Analysis: A metric of response amplitude (denoted TC, and defined as the correlation of a trace with a subject-specific template) was computed for ensembles of traces synthesized using different values of ID. The dependence of the statistics of TC on inhibition depth and other model parameters was examined.
The results were used to define an estimator of ID. This estimator was then applied to experimentally recorded VEMP traces, and the variation of the ID estimate with stimulus level was studied.
Results: The peak-to-peak amplitude of the experimentally measured VEMP average waveform increased with stimulus intensity. However, the amplitude varied with contraction effort and the waveform shape varied between normal subjects, and between sessions within each subject.
Model VEMPs synthesized with inhibition depth of 12%, had mean TCs and TC variances equal to experimental VEMPs evoked by the largest stimuli used.
The mean TC of synthetic VEMP varied linearly with inhibition depth. The slope of this relationship, as well as the variance of TC, varied with non-vestibular model parameters such as motor drive and MUAP response shape.
The mean-to-standard-deviation ratio of TC was proportional to the ID parameter of the model, and therefore formed an estimator (VEMP_{ID}) of the inhibition depth. The slope of VEMP_{ID} vs. ID was largely independent of other model parameters.
For each of the five subjects studied, the VEMP_{ID} computed from 200-trace ensembles of experimentally recorded VEMP showed greater sensitivity to changes in stimulus intensity than the peak-to-peak amplitude of the VEMP average from the same ensembles.
Conclusions: The key idea of the study is that the motor unit inhibition depth (ID) induced by a fixed stimulus is a measure of the sensitivity of the saccule. We therefore sought to estimate the ID from the VEMP measurements.
The variability of the experimental and model VEMP average waveforms suggest that the peak-to-peak amplitude of the average waveform is a poor estimator of ID. However, the VEMP_{ID} appears to be an estimator that is strongly dependent on ID, while having smaller within-subject variability. In summary, we have identified a simple statistic that can be computed from a set of VEMP measurements to yield a robust measure of saccular sensitivity.

PB-60

The Vestibular Dysfunction Index (VDI): a method to assess the degree of vestibular dysfunction in patients with vertigo

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Objectives: The purpose of the present study was to establish a vestibular dysfunction index, capable of determining the degree of vestibular dysfunction in patients complaining of vertigo, apart from the vestibular pathology and based on objective measuring techniques.
Methods: A group of 132 adults (64 men and 68 women, aged 17.7 to 79.4 yrs, with a mean age of 49.4 yrs) participated. They were clinically divided into two different categories: 90 subjects had no vertigo complaints, and 42 subjects suffered from severe vertigo. The objective test battery consisted of a single sinusoidal rotation at 0.05 Hz, a binaural bithermal water caloric test, and the examination of spontaneous nystagmus (SN), with the presence of a SN classified as 1 and the absence of a SN classified as 0. For the rotatory test, gain, phase, and the absolute values of the asymmetry parameter were calculated, whereas for the caloric test, the sum of the slow component velocity values of the four irrigations, as well as the absolute values of the unilateral weakness (UW abs) and directional preponderance (DP abs) parameters were determined. The VDI was calculated using a binary backward logistic regression model. From all input parameters, only a specific combination of variables appeared sufficient to discriminate between the subjects with no vertigo and those with severe vertigo.
Results: The vestibular dysfunction index composed of the following combination of response parameters:

VDI = 0.074 DP abs + 0.2307 UW abs + 3.7 SN + 0.0729 gain −2.1347.

Conclusions: The vestibular dysfunction index or VDI is a tool to estimate a subject's degree of vestibular dysfunction, with 0 presenting normal vestibular function, and 10 indicating severe vestibular dysfunction. Because this is a continuous scale, higher values than 10 are possible, suggesting a higher defective vestibular function than the average of the group of subjects with severe vertigo. Likewise, scores below 0 indicate a better vestibular function than average. The VDI indicates the degree of vesibular dysfunction, regardless of the pathology. But is appears clearly that patients with vestibular neuritis have a higher VDI than patients with for example superior canal dehiscence. The VDI is not meant to classify a subject into a specific disease category, but to assess the degree of dysfunction, similar to for example the Body Mass Index (BMI). The VDI can be used in follow-up studies, to examine central and/or peripheral recovery, and the effect of certain medications or rehabilitation programs.

PB-61

Impaired sacculocollic reflex in lateral medullary infarction: correlation of cervical vestibular evoked myogenic potential with other vestibular function tests

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Background: Cervical vestibular-evoked myogenic potential (cVEMP) refers to inhibitory potentials recorded in the contracting muscles, usually in the sternocleidomastoids (SCM), when loud click or short tone burst sound was applied. cVEMP seems to be generated via a rapidly conducting disynaptic pathway, originating in the saccule and proceeding along the vestibular afferent fibers to the vestibular nuclei, and then through rapidly conducting projections that synapse with SCM nuclei. Due to damage of the vestibular fascicles, vestibular nucleus, or vestibular efferents from the nuclei that are involved in relaying and central processing of peripheral vestibular inputs, lateral medullary infarction (Wallenberg syndrome, LMI) may provide a good anatomical substrate for studying abnormal cVEMP in central vestibulopathies. We measured cVEMP in 21 patients with LMI to determine saccular dysfunction and to correlate abnormality of cVEMP with results of other vestibular function tests in lateral medullary infarction (LMI).

Methods: Of the 50 patients who underwent cVEMP with confirmed diagnosis of LMI at Seoul National University Bundang Hospital from April 2007 to January 2010, 21 patients were included in this study after excluding 29 patients. The patients included 16 men and the ages ranged from 30 to 76 years (mean ± SD = 56.4 ± 12, median = 60). cVEMP was induced by a short tone burst and was recorded in contracting sternocleidomastoid muscle while patients turned their heads forcefully to the contralateral side against resistance. A short alternating tone bursts (110 dB nHL; 500 Hz; ramp = 2 ms; plateau = 3 ms) were given at 2.1 Hz monaurally using a headphone. The absolute cVEMP amplitude was then normalized against mean tonic activation of SCM during the recording. Patients also underwent video-oculographic recording of spontaneous, gaze-evoked and head-shaking (HSN), ocular lateropulsion, ocular tilt reaction (OTR), measurement of the subjective visual vertical (SVV) tilt, audiometry, and bithermal caloric tests. Normative data of cVEMP were obtained from 47 healthy volunteers.

Results: All patients suffered from vertigo/dizziness, veering to ipsilesional side of MRI lesions in 15, dysphagia in five, hoarseness in two, diplopia in one, ipsilesional face numbness in nine, and contralesional extremities numbness in 11 patients. Honer syndrome was detected in 11, ipsilesional truncal lateropulsion in 11, ipsilateral facial palsy in one patient. There was no difference of these findings between normal and abnormal cVEMP groups ($p > 0.05$). Nine patients (43%) showed abnormal cVEMP, unilateral in seven and bilateral in two. The cVEMP abnormalities included decreased p13–n23 amplitude in four patients, delayed p13/n23 responses in five patients, and both decreased and delayed response in two patients. There was no significant correlation between rostral or caudal distribution of MRI lesions and cVEMP abnormality. Furthermore, the prevalence of OTR, SVV tilt, spontaneous nystagmus, HSN and ocular lateropulsion did not differ between the patients with normal and abnormal cVEMP. The direction of abnormal cVEMP was ipsilesional side of MRI lesions in five patients, contralesional side in two patients, and bilateral abnormal response with unilateral MRI lesion in two patients. However, the direction of OTR/SVV tilt was mostly ipsilesional side of MRI lesions except one patient. The horizontal directions of spontaneous nystagmus and HSN did not differ between the patients with normal and abnormal cVEMP.

Conclusion: Abnormal cVEMP response in LMI is not uncommon. The direction of abnormal cVEMP was mostly ipsilesional, but contralesional and bilateral abnormal responses also occur. The possible mechanism of contralesional or bilateral abnormal cVEMP was disruption of commissural effect of facilitation between bilateral vestibular nucleuses which received input from saccule. Furthermore, the dissociation of abnormalities between cVEMP and OTR/SVV tilt suggests differential involvements of otolithic pathways in central vestibular mechanisms.

PB-62

Furosemide loading VEMP testing can detect occult endolymphatic hydrops in silent ears.

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Introduction: We previously reported that furosemid-loading vestibular evoked myogenic potential (F-VEMP) testing indicated positive results in 40% of the affected ear of unilateral Meniere's disease. Positive results were also showed in 25% of the unaffected ear. The results were not thought to be false positive but attribute to latent endolymphatic hydrops, however this hypothesis has not been confirmed. The purpose of this study was to clarify whether positive results of F-VEMP on silent ears showed occult endolymphatic hydrops or not.

Study 1. Contralateral involvements in patients with unilateral Menierse's disease

Subjects and Methods 1: Twenty-five patients with unilateral Menierse's disease. Positive group consisted of 6 patients with positive results of F-VEMP testing on the contralateral ear, while negative group consisted of 19 patients with negative results. Incidences of contralateral involvements were compared between both groups with Kaplan-Meier method.

Results 1: Contralateral involvement was shown in 3 cases (50%) of the positive group (elapsed period were 2, 12 and 26 months) and 3 cases (16%) of the negative group (27, 56 and 78 months). The positive group had a higher incidence of contralateral involvement than the negative group ($p = 0.0017$, log rank test).

Study 2. Developing definite Meniere's disease of in patients with so called vestibular Meniere's disease.

Subjects and Methods 2: Subjects were 14 patients with vestibular Meniere's disease. They included 5 males and 9 females, and their ages ranged from 18 to 66 years (mean, 43.5 years). Positive group consisted of 4 patients with positive results of F-VEMP testing, while negative group consisted of 8 patients with negative results. Incidences of definite Meniere's disease were compared between the two groups. Subjects were followed up from 2 to 50 months (mean 8.2 months).

Results 2: Four cases (29%) developed the definite Meniere's disease. The developing rate was 75% (3 of 4 cases) in the positive group (elapsed period were 15, 15 and 50 months) and 10% (one of 10 cases) in the negative group (21 months). The rate was significantly different between the two groups (Fisher's exact test, $p = 0.04$).

Conclusions: Our results indicate positive results of F-VEMP are related to development of endolymphatic hydrops in the unaffected ear of Meniere's disease, and so-called vestibular Meniere's disease. Therefore, positive results suggested latent hydrops in silent ears.

PB-63

Video Head Impulse Tests (vHIT) of individual lateral, posterior and anterior semicircular canal function

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Background: In the traditional clinical head impulse test of the vestibulo-ocular reflex (VOR) (Halmagyi and Curthoys, 1988) the patent fixates a stationary point while the clinician passively rotates their head through a small angle (15–30°) with a peak velocity of 150–300°/s and acceleration of 2000–4000 °/s^2. The clinician then tries to detect, by visual observation, the corrective 'catch up' saccades that the patient uses to compensate for vestibular dysfunction. Objective assessment of VOR gain using scleral search coil measures of head and eye velocity are used in research but are too complex for the clinic.

Recently we have shown that the video head impulse test (vHIT) exhibits many of the advantages of objective measures without the complexity, cost, and discomfort of search coils. Simultaneous video and search coil measurement during horizontal head impulse tests showed a high concordance and similar diagnostic utility (MacDougall and Weber et al., 2009).

Subjective (clinical) and objective (search coil) head impulse tests have also been extended to the assessment of individual lateral, posterior and anterior semicircular canal function by delivering head rotations in the direction and plane that maximises the stimulus to one canal while minimising the stimuli to the others. Rotating the patient's head in the horizontal plane largely targets the lateral canals, while rotating the head in a diagonal plane, midway between the frontal (roll) and sagittal (pitch) planes targets the right anterior and left posterior canals (the RALP plane) or the left anterior and right posterior canals (the LARP plane).
Aim: In this project we aimed to validate the accuracy and utility of vHIT measures during LARP and RALP tests, again by comparison with simultaneous scleral search coil measures.
Methods: Head rotations in the LARP and RALP planes usually produce compensatory eye movement response with vertical and torsional components and the vHIT system cannot yet measure torsion reliably at 250 Hz. To avoid this problem we used modified LARP and RALP tests in which the subject's head is offset towards one shoulder while their gaze is directed into the plane of the canal that is being tested – i.e. they look diagonally at the fixation point. With this arrangement the compensatory eye movement response to LARP and RALP head movements becomes predominantly vertical. We delivered horizontal, modified LARP and modified RALP head impulses while simultaneously recording eye movement responses with both scleral search coils (1000 Hz) and vHIT (250 Hz). We compared measures subjectively (overlaid traces) and objectively (concordance correlation coefficients and significance of VOR gain differences).
Results: Simultaneous data showed a high concordance between the two recording methods and the interpretation of data (patient diagnosis) was similarly clear for the two methods.
Conclusion: Assessing the function of individual lateral, posterior and anterior semicircular canals can be achieved using the vHIT test. Modified LARP and RALP head impulses are a little more difficult for the clinician to deliver. Learning this skill is faster with online feedback of head velocity, acceleration and rotation axis.
Support: The Garnett Passe and Rodney Williams Memorial Foundation, the National Health and Medical Research Council Australia, and the Australian Research Council.
Disclosure: GN Otometrics provides funding for further development of the video system. [None of the authors received personal compensations from GN Otometrics].

PB-64
Inerior labyrinth compromise in Fabry's disease
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We studied with Vestibular Myogenic Evoked Potential (VEMP's) the prevalence of the compromise of the inferior labyrinth in patient with confirmed Fabry's Disease (FD).
Material and Methods: We performed VEMP's with click stimulus at 105 db SPL in both ears in 82 patients. The average age was 49 y.o... 49 women and 33 men. Diagnosis of FD was confirmed by genetic studies in women and by enzymatic assay in men.
We defined abnormality for VEMP's in terms of latency and side to side amplitudes.
Results: VEMP's were abnormal in 30 subjects; in 10 the abnormality was bilateral.
Discussion: Compromise of the inferior labyrinth in vestibular diseases is not common except in acoustics neuromas (80%). In previous papers has been proven that inner ear compromise has no pattern in FD (Palla et al., 2007, Carmona et al., 2008) and can explain the high prevalence of this finding in patients affected of FD. The early treatment with enzyme replacement improve the inner ear compromise in those patients (Palla et al., 2007).
Conclusions: VEMP's are useful in the study of FD patients since the replacement therapy could improve those patients conditions an early diagnose has relevant consequences.

PB-65
Ocular vestibular evoked myogenic potentials in response to skull vibration: dependency on stimulus configuration and stimulus site
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Objective: To study skull vibration induced ocular vestibular evoked myogenic potentials (oVEMPs), and more specifically, its dependency on two different stimulus factors: 1. stimulus configuration (rarefaction versus condensation) and 2. stimulus site (vertex versus lateral).

Recent studies support a utricular origin for oVEMPs to skull vibration. However, it is not yet apparent how skull vibration activates the labyrinth/utricle and generates oVEMPs. We were interested in studying dependency on direction of the initial stimulus component.
Methods: oVEMPs in response to bone-conducted vibration were tested in normals ($n = 12$). The subjects were sitting with their head slightly pitched forward. A hand-held bone-conduction vibrator (Bruel and Kjaer "Minishaker" 4810) was used for stimulation. The stimulus sites compared were vertex and behind each ear (approximately 2 cm posterior to the external acoustic meatus). A load cell was used to ascertain that the static force was the same (10 N) for each stimulus site. The stimulus used was a single-cycle, 125 Hz tone-burst at 135 dB force level (re 1 μN). The directions for stimulus onset compared were condensation and rarefaction.
Results: For vertex stimulation, the oVEMP peaks to rarefaction stimulus occurred earlier compared with those to condensation. The oVEMPs from the contra-lateral eye to lateral condensation stimulation were very similar to the response to rarefaction vertex stimulation. The oVEMPs from the contra-lateral eye to lateral rarefaction stimulation was very similar to the vertex condensation response.
Conclusions: The present data suggest that oVEMPs in response to skull vibration are critically dependent on both stimulus site and stimulus configuration. One possible explanation for the present findings would be that the direction of the stimulus generated displacement that first reaches the labyrinth is crucial for oVEMP in response to low-frequency tone-bursts.

PB-66
Prediction of abnormalities of Postural Evoked Responses (PER) with Motor Control Test (MCT) results
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Background: Postural Evoked Responses (PER), surface electrode recordings from selected muscles of the lower limbs in response to sudden toe up tilts is available. In 1993 normative data for clinical the use of this test was established. In 1994 a pilot study suggested that PER had a specificity of 87% and sensitivity of 68% for the identification of spinal or other central nervous system abnormalities. In that work a loose relationship was noted between PER and the Motor Control Test (MCT) performed on the EquiTest® platform. That relationship was used for criteria as to when to proceed with PER testing. A specific study to better define the relationship between MCT and PER testing to establish criteria for use of PER based on MCT has not been reported.
Objectives: The primary objective was to determine the strength of correlation between MCT and PER and the sensitivity and specificity of MCT to predict abnormal results of the PER test. The secondary objective was to develop criteria for when to proceed with PER testing based on MCT results and clinical characteristics of the patient.
Methods: A cohort of 100 consecutive patients, 35 from the Ft Wayne and 65 from Mayo, had PER testing by the protocol defined in the 1993 normative range work as part of their work up for complaints of balance and dizziness. These patients were seen over a 6 month interval. An IRB approved retrospective review of the patient files was used to collect the following data for each patient.
MCT latency to onset of active recovery from induced forward and backward sway.
PER abnormality (yes / no) and the pattern of the abnormality.
Sensory Organization test (SOT) pattern.
Presence or absence of a history of chronic or episodic imbalance.
History of 2 or more unexplained falls within the last year.
Age and gender of the patient.
Indications from caloric water irrigations of peripheral hypofunction (asymmetry of $> 24\%$).
Indications of central system involvement as determined by abnormal pursuit tracking and / or individual eye random saccade testing.
History of pain or joint disorder that interferes with mobility.
To achieve the primary objective correlation coefficients and linear regression analysis between MCT latency and PER abnormality were developed. ROC curve analysis was used to determine the cut point for sensitivity and specificity of MCT latency to predict PER abnormality. For the secondary objective correlation coefficient and linear regression analysis along with cluster analysis were used to establish relationships between clinical characteristics of the patient and MCT results for determining criteria for when PER testing would be most beneficial.
Results: Preliminary analysis of the first 33 patients suggests sensitivity for identification of abnormal PER

by MCT latency of 43% and specificity of 89%. However, this is based on a simple MCT normal or abnormal. When the magnitude of the latency abnormality of the MCT is used sensitivity increases to the 60% range without significant impact on the specificity. The optimal value of latency for best performance of sensitivity and specificity in predicting PER abnormality will be presented based on the ROC analysis. On a preliminary basis the SOT pattern, age, gender, caloric results, mobility restrictions and falls history do not significantly correlate with PER abnormalities.

Conclusions: The preliminary results suggest that the magnitude of the MCT latency response may be a reasonable predictor of PER abnormality and that the other symptom data of falls history or mobility restrictions do not have a significant relationship.

PB-67

HITs for kids: the video-based head-impulse test in children and adolescents

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Vertigo is a common complaint in children and adolescents [1]. Surprisingly however, there is no quantitative test to assess peripheral 0vestibular function at the bedside in this age-group [2]. In adults, clinical [3] and now also video-based head-impulses [4,5] are used for this purpose. Here we validate the video-based head-impulse test (HIT) in children.

We assessed healthy children and adolescents aged 3-18 years with no history or clinical signs of balance and posture disorders. Horizontal head impulses were performed as previously described [6]. Eye movements were recorded with a video-camera with a sampling rate of 256 Hz; head movements were measured with inertial sensors.

We find that the gain of the vestibular-ocular reflex and thus peripheral vestibular function can be readily assessed with the video-based head-impulse test in children. Gains are comparable to those documented for adults [7].

Head-impulses recorded with video-oculography and inertial sensors are a quick and reliable way to assess peripheral vestibular function in children and adolescents not only at the bedside.

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PB-68

Psychophysical responses to earth-vertical rotations in normal and vestibulopathic subjects

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Psychophysical techniques have shown to be extraordinarily sensitive in detecting pathology in the auditory and other sensory systems. These techniques have not been explored as methods for evaluating vestibular function in subjects with imbalance. We constructed a two-interval, two-alternative forced-choice paradigm to determine detection and discrimination thresholds for responses of the horizontal semicircular canals. The paradigm consisted of sinusoidal rotations about an earth-vertical axis adjusted to avoid the effect of the velocity storage mechanism. We measured thresholds at reference velocities over the range from 0 to 150 deg/sec peak velocity in a control group of normal young subjects and an experimental group of unilaterally vestibular-deficient subjects. Thresholds did not distinguish between the two groups at peak velocities of 0 and 20 deg/sec but were clearly different at higher velocities. Binaural summation appears to contribute to vestibular perception of angular rotation, except at very low velocities. Discrimination thresholds can be a sensitive method for identifying subjects with vestibular loss.

PB-69

Head-tilt thermal test in patients with unilateral vestibular disorders

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Objectives: The function of vertical semicircular canal is difficult to evaluate. Aoki reported that caloric test with head-tilt can be used as a tool for assessing vertical canal function. Vertical canal function is investigated by detecting vertical component of nystagmus during caloric testing in position which posterior semicircular canal or anterior semicircular canal seems to be vertical. Vertical semicircular canal function is not usually investigated in patients with unilateral vestibular disorders. We examined head-tilt thermal test in patients with unilateral vestibular disorders.
Methods: We enrolled patients with unilateral vestibular disorders. These patients were diagnosed as vestibular neuritis, Meniere's disease, sudden deafness with vertigo, Ramsay Hunt syndrome, perilymph fistula, benign paroxysmal positional vertigo, acoustic neuroma, ipsilateral delayed endolymphatic hydrops etc. Head-tilt thermal test was performed with the posture that their posterior semicircular canals or anterior semicircular canals seemed to be vertical during thermal test. Concretely, after we irrigated cold water into their ears, their heads in spine position were anteflexed by 30 degree to place their lateral semicircular canals to vertical. Next, sagittal plane of their heads was rotated from front toward the irrigated ear by 45 degree to become their head position that their posterior semicircular canals seemed to be vertical. After that, sagittal plane of their heads was rotated from front toward the opposite direction to irrigated ear by 45 degree to become their heads position that their anterior semicircular canals seemed to be vertical. Ocular movements were monitored under infrared CCD camera (ET-60, NEWOPTO Co.). Ocular movements were analyzed using a computer. In addition, head-shaking nystagmus and VEMP (vestibular evoked myogenic potential) were also examined.
Results: Vertical component of nystagmus increased during head-tilt thermal test in many cases of unaffected ears. Downward component increased or appeared in position that their posterior semicircular canals seemed to be vertical during cold water stimulation. On the other hand, vertical component changed in position that their anterior semicircular canals seemed to be vertical. Upward component of nystagmus increased or appeared during cold water stimulation. Cold water stimulation to affected ears less evoked vertical component of nystagmus than stimulation to unaffected ears.
Conclusions: Head-tilt thermal test is useful to evaluate vertical semicircular canal function.

PB-70

Inferior vestibular neuritis: absence of vestibular evoked myogenic potentials in the presence of normal caloric responses

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Objective: To report the clinical features of patients diagnosed with cases of inferior vestibular neuritis based on abnormal VEMP responses with normal caloric test results. Methods: We retrospectively reviewed 62 patients presenting with dizziness. All patients underwent a battery of audiovestibular testing, including hearing tests, caloric test and VEMP test.
Results: Six patients were diagnosed as inferior vestibular neuritis. The pure tone audiograms and caloric test results were normal. VEMP response was absent unilaterally, and normal in the contralateral ear. Conclusion: Inferior vestibular neuritis should be considered in patients presenting with similar symptoms as vestibular neuritis. Comprehensive vestibular testing including VEMP is necessary.

Poster Session 2 – C. Disorders

PC-71

Physical activity as a contributing factor for onset of idiopathic benign paroxysmal positional vertigo

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Background: The vast majority of BPPV (benign paroxysmal positional vertigo) cases are idiopathic. Some patients report prolonged bed rest due to an unrelated cause that precedes an attack of BPPV. Others feel that their vertigo was provoked by strenuous physical work or exercise. Mechanical factors might thus play a role in the onset of the idiopathic form of BPPV.

We performed a structured questionnaire study about physical activity in patients with BPPV and controls.
Patients and Methods: Sixty-three consecutive patients with idiopathic BPPV who were diagnosed and treated at an outpatient clinic participated in the study. Their mean age was 59.2 $\pm$ 14.5 years, 14 were men and 49 were women. Fifty two patients had posterior canal type BPPV while horizontal canal or anterior canal BPPV was diagnosed in 11 patients. Sixty-four age and sex matched generally healthy individuals served as controls.
Levels of physical activity were assessed by the PASE questionnaire, which consists of 12 items quantifying physical activity during leisure, household and occupational activities over seven day- period.
Results: We found that physical activity was significantly lower in patients with idiopathic BPPV over 60 years old than in controls, regardless to gender. Differences were found mainly in household and leisure activity while occupational activity was similar in both groups.
An inverse correlation was found between total physical activity and age of patients and controls. No differences were found either between physical activity scores and type of BPPV or between patients with a first or recurrent attack of vertigo.
Patients who had only one treatment of their condition did not differ in physical activity from patients who required multiple repositioning maneuvers.
Discussion: Despite the limitations arising from a questionnaire-performed study, it seems that nonspecific physical activity can protect from BPPV and, on the contrary, physical inactivity predisposes to BPPV. We propose a hypothetical explanation for our finding.

PC-72

Vestibular and psychiatric manifestations during the first 3 months after vestibular neuritis

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Objective: To assess the correlation between vestibular dysfunction and psychiatric symptoms during the first three months after vestibular neuritis.
Methods: Nine patients with acute vestibular neuritis and no history of systemic or neurological or psychiatric disease accepted to participate. At the beginning of the study and at the 1st and 3rd months of follow-up, we recorded the static visual vertical (VV), the estimation error of reorientation in the yaw plane and the responses to the following 7 questionnaires: a standardized questionnaire of balance symptoms (Jáuregui-Renaud, 2003), the Dizziness Handicap Inventory by Jacobson (DHI), the depersonalisation/derealisation inventory by Cox and Swinson (DD), the Dissociative Experiences Scale by Bernstein (TD), the 12 item General Health Questionnaire by Goldberg (GHQ-12), the Zung Instrument for Anxiety Disorders and the Hamilton Depression Rating Scale. At the same intervals, 7 healthy subjects accepted to perform the tests and to reply to the questionnaires; within this reference group, the responses were always similar ($p > 0.05$).
Results: At day 1, all the patients showed a VV $>2^\circ$ and failed to reorient themselves effectively; they reported several balance symptoms and handicap, as well as dissociative experiences, particularly DD symptoms; 8 patients had a Hamilton score $\geqslant 8$. At this time the balance symptom score correlated with the DHI, while the Hamilton score correlated with the reorientation error. However, no correlation was observed between the DD or the TD scores and any of the other measurements. At the 3rd month, all the patients showed a VV $<2^\circ$, a reorientation error similar to healthy subjects, a balance symptom score $\leqslant 4$ and a decrease on the DHI score of at least 18 point. Although all the scores decreased, the multiple regression analysis of the differences from baseline showed that the DD score difference (but not the TD score difference) was related to the decrease on the balance score and the reorientation error ($p < 0.01$); however, no correlation was observed between the DD or TD score differences and the differences on the DHI, GHQ12, Hamilton scale or Zung instrument ($p > 0.5$).
Conclusion: During the acute phase of vestibular neuritis, patients may be depressed and they may report dissociative experiences, particularly DD symptoms; after 3 months, their DD symptom score may decrease as much as their vestibular function improves.

PC-73

Vestibular paroxysmia with paroxysmal pulsatile tinnitus

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Introduction: Vestibular paroxysmia is defined as paroxysmal and brief vertigo that is carbamazepine-responsive. Neurovascular cross-compression (NVCC) of a vessel and the vestibulocochlear nerve is thought

to be the cause, although it is difficult to prove directly. We describe herein a man with NVCC presenting with paroxysmal vertigo combined with paroxysmal pulsatile tinnitus. The pulsatile feature supports the theory of vascular compression.

Case Report: A 68-year-old man presented to our dizzy clinic after a 1-month history of paroxysmal vertigo. The vertigo occurred daily with a frequency of 1 to 5 times per day. Each paroxysm lasted for a few seconds to 1 minute. Tinnitus in the right ear appeared simultaneously with the vertigo. When these paroxysms lasted longer, the tinnitus was noted to be pulsatile, and was synchronized with the patient's heartbeat. When the vertigo was more severe, the pulsatile tinnitus became louder. These episodes were often induced by positional change, but also occurred at rest. Vestibular suppressants improved the vertigo partially, but were unable to stop the vertigo and tinnitus totally. During the interictal periods, the patient complained of mild disequilibrium.

The findings of otoscopy and neuro-ophthalmologic test were unremarkable. Dix-Hallpike test showed normal result. Pure-tone audiometry revealed bilateral symmetric high-frequency sensori-neural hearing loss. Caloric test showed 16% unilateral weakness in the right ear, which was within the normal range in our laboratory. In posturography, vestibular dysfunction was noticed in the sensory organization test. His center of gravity deviated to the right.

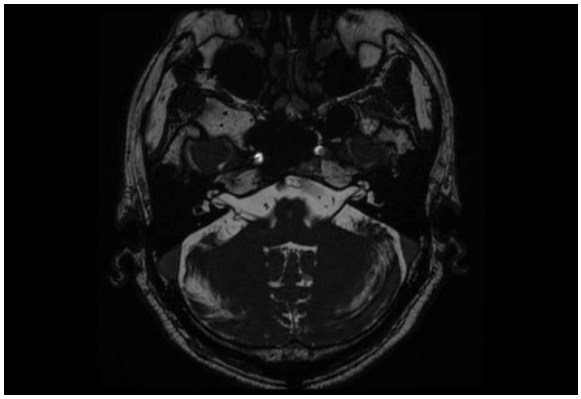
HRCT of the temporal bone was performed for pulsatile tinnitus; however, the results were unremarkable. Brain MRI was performed for possible vertebrobasilar insufficiency. No structural lesions were found in the brainstem or cerebellum. In MR angiography, there was no stenosis or apparent atherosclerosis in the vertebrobasilar arteries. However, the right anterior inferior cerebellar artery (AICA) apparently compressed and displaced the right vestibulocochlear nerve on T2WI (FIESTA) (Figure).

On the basis of the image findings, the patient was treated for vestibular paroxysmia with carbamazepine. One day after the treatment, his tandem gait had almost returned to normal. At the 1-week follow-up, the paroxysmal vertigo and pulsatile tinnitus had been completely eliminated. Only a mild floating sensation remained.

Discussion: NVCC of the vestibulocochlear nerve was first reported by Jannetta in 1975 and named as disabling positional vertigo. The clinical diagnosis is made mainly by excluding other established vestibulopathies, such as benign paroxysmal positional vertigo, Meniere's disease, and vestibular neuritis.

In 1994, Brandt et al. described an entity, vestibular paroxysmia, defined as paroxysmal and brief vertigo, which was responsive to carbamazepine. The clinical manifestations, including disease onset, duration, and frequency, were similar to trigeminal neuralgia and hemifacial spasm. A high incidence of NVCC has been reported in MRI studies, and the effectiveness of carbamazepine also implied the presence of NVCC. However, according to a review of 100 MRI scans from patients with no complaints of vertigo, a large number of NVCC are asymptomatic. It is possible that vestibular paroxysmia and NVCC in the image are coincident. More evidence is needed to establish the pathophysiology from NVCC to paroxysmal vertigo.

The patient we describe presented not only with paroxysmal vertigo but also with paroxysmal pulsatile tinnitus. The paroxysmal characteristic is compatible with the feature of nerve compression, and the pulsatile tinnitus further indicates that the auditory nerve was compressed by a pulsating artery. It is believed that these unique clinical features support a relationship between vestibular paroxysmia and NVCC rather than their coincidence.



PC-74

A case of mumps virus related opsoclonus myoclonus syndrome

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Background: Opsoclonus-myoclonus syndrome (OMS) is a rare but distinctive neuro-ophthalmologic disorder, characteristically presented by involuntary chaotic eye movements and generalized myoclonus. OMS has been associated with many etiologies, but most commonly occurs as a paraneoplastic, parainfectious, toxic, drug related, systemic, or idiopathic caus-

es. Definite pathophysiology of OMS are not demonstrated.
Case Report: A 19-year-old male was admitted to our hospital with involuntary multi directional eye movements and four-extremities myoclonic movement. He was diagnosed as OMS because of the typical clinical manifestations. There was no history of drug and toxin. Initial laboratory studies, cerebrospinal fluid (CSF), positron emission tomography- computed tomography (PET-CT) and brain Magnetic Resonance Imaging (MRI) were normal. The serum IgM antibody titer to mumps virus was checked to 1.20 positive and the follow up titer of IgG antibody (2-week interval) was 1.40 positive. These findings suggest mumps virus related parainfectious OMS. His symptoms were aggravated and acute renal failure was developed due to rhabdomyolysis. We started midazolam-coma therapy and administered IVIG. The patient was fully recovered after two months of therapies.
Conclusion: OMS is a rare disorder and there is no standard regimen of treatment. Although the exact pathogenesis of OMS is not known, OMS may be well responded to immunomodulatory agents such as IVIG, corticosteroid, low dose cyclophosphamide and rituximab. This case is the first report of mumps virus related OMS in Korea and has shown excellent recovery after IVIG administration.

PC-75

Dynamic posturography: the clinical value in finding balance abnormity of patients with benign paroxysmal positional vertigo

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Objective: To explore the clinical value of dynamic posturography in finding the imbalance of patients with benign paroxysmal positional vertigo (BPPV).
Material and Methods: 23 patients with BPPV were subjected to caloric test, static posturography, and dynamic posturography. The vestibular tests were performed at two different time points: 1) the onset when the patients had typical nystagmus provoked by the Dix-Hallpike maneuver before treatment, and 2) one week after treatment with the canalith repositioning maneuver (CRM) as their nystagmus disappeared.
Results: Among 23 cases of BPPV, the abnormal rates of caloric test, static posturography, and dynamic posturography were 26.1%, 34.8% and 73.9% respectively before CRM. The abnormal rate of dynamic posturography was much higher than that of caloric test or static posturography. After CRM, the abnormal rates of caloric test, static posturography, and dynamic posturography were 17.4%, 8.7% and 21.7% respectively. After CRM the abnormal rate of static and dynamic posturography showed signi?cant reduction, however, the results of caloric test showed no significant change.
Conclusions: Dynamic posturography has clinical value in confirming the presence of impaired balance in patients with BPPV. Treatment of BPPV using CRM results in improved postural stability in dynamic posturography.

PC-76

Assessment of postural stability using a foam posturography in idiopathic bilateral vestibulopathy.

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Objectives: Idiopathic bilateral vestibulopathy (IBV) is an acquired bilateral vestibulopathy of unknown cause. The main clinical symptoms are persistent imbalance. Recent studies suggested that IBV affects not only the superior vestibular nerve (SVN) system but also the inferior vestibular nerve (IVN) system. Our purpose of this study was to assess the postural stability in patients with IBV involving SVN, IVN, and both vestibular nerve systems.
Methods: A total of 19 consecutive patients with IBV who fulfilled the diagnostic criteria of IBV [1] were enrolled after vestibular examination including caloric test and cVEMP test. All of the included patients could participate in the posturgraphic study [9 men, 10 women, mean ($\pm$ SD) age, 64.9 ($\pm$ 9.6) years, range, 41–80]. We categorized IBV into three subgroups: (1) vestibulopathy in bilateral SVN systems, sparing at least unilateral IVN system (superior type), (2) vestibulopathy in bilateral IVN systems, sparing at least unilateral SVN system (inferior type), (3) bilateral vestibulopathy in both IVN and SVN systems (total type). Out of the 19 patients, 7 [2 men, 5 women, age, 65.7 ($\pm$ 4.5) years, range, 60–71], 6 [3 men, 3 women, age, 58.8 ($\pm$ 13.1) years, range, 41–80] and 6 [4 men, 2 women, age, 70.0 ($\pm$ 7.9) years, range, 62–80] were classified into the superior type, the inferior type and

the total type, respectively. Two-legged stance tasks were performed on patients with IBV ($n = 19$) in four conditions; with eyes open in using and without the foam rubber, and with eyes closed in using and without the foam rubber [2]. We adopted six variables; the velocity of movement of the center of pressure (COP) and envelopment area tracing by the movement of the COP in eyes closed/foam rubber, the Romberg's ratios of velocity and area with foam rubber, and the foam ratios (ratios of a measured variable with to without the foam rubber), of velocity and area in eyes closed.
Results: Three of 19 patients (16%) with IBV required assistance in eyes closed/foam rubber condition. The values of the velocity and area in eyes closed/foam rubber, the Romberg's ratio of the velocity and area with foam rubber, were significantly higher in patients with IBV than those in the control group ($p < 0.05$). There were no significant differences between patients with IBV and the control group in the values of the foam ratio of the area and velocity in eyes closed. The posturographic findings for total type tended to be more severe.
Conclusions: IBV could significantly affect the postural stability and might enhance the visual dependence. Residual function of spared vestibular nerve system might affect the postural stability, even though bilateral peripheral vestibular functions were reduced.

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PC-77

Episodic upbeat nystagmus: a new phenotype of episodic ataxia?

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Background: Episodic ataxia (EA) is an autosomal dominant ion channel disorder characterized by paroxysmal attacks of incoordination. The number of identified EA phenotypes and genotypes is expanding, now up to EA 7 and growing. During an acute episode of ataxia or between episodes, most patients typically exhibit a gaze-evoked nystagmus or downbeat nystagmus. We report a family with recurrent vertigo and postural imbalance, who showed spontaneous upbeat nystagmus during episodes.
Case report: A 22-year-old man presented with recurrent attack of oscillopsia, vertigo, and gait ataxia since childhood. The attack lasted several hours and occurred 2-3 times per month, which were provoked by excessive exercise, cold temperature or strong light stimuli. His grandfather, father, uncles, and cousins also had similar episodes. Between the attacks the general medical and neurological examinations were normal. Sustained upward gaze for one minute or walking for 30 minutes produced upbeat nystagmus in the primary position following alexander's law and postural imbalance, which lasted for several hours. Results of routine chemical analyses and brain MRI were normal. No mutation was found in CACNA1A gene.
Conclusion: The present family may be a new phenotype of episodic ataxia, which has not been previously described, characterised clinically by episodic upbeat nystagmus. Linkage analysis of this family await to document a new subtype of episodic ataxia syndrome.

PC-78

Ictal downbeat nystagmus in cardiogenic vertigo

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Background: Rotatory vertigo mostly develops in vestibular disorders while presyncopal dizziness usually reflects generalized cerebral ischemia due to a cardiovascular cause. Nevertheless, contrary to established wisdom, patients with cardiovascular disorders frequently report vertigo. However, the mechanism of so-called cardiogenic vertigo remains unknown. Furthermore, no study has explored vestibular dysfunction during a spontaneous episode in a patient with cardiogenic vertigo. The previous studies of induced syncope suggest that the vertigo may result from cerebellar ischemia and vestibular function was in fact assessed in one of these studies. We observed downbeat nystagmus during the presyncopal attack with vertigo in a patient with recurrent asystole due to sick sinus syndrome.
Case Report: A 67-year-old woman presented with recurrent rotatory vertigo, nausea and palpitation for three months. The patient reported that the vertigo had

lasted for 5–10 seconds, and occurred 2–3 times per week, which became more frequent for the previous several days. She had a history of mitral valve replacement 10 years before. Between the episodes, the general medical and neurological examinations were unremarkable, and electrocardiogram (ECG) was normal. During a spontaneous vertiginous attack, the patient showed pure downbeat nystagmus without fixation lasting several seconds. After admission, the patient developed abrupt loss of consciousness following rotatory vertigo for about 10 seconds. During the syncopal attack, ECG monitoring exhibited a sinus pause for several seconds. ECG returned to normal sinus rhythm with regain of her consciousness. The patient underwent emergent implantation of a permanent pacemaker without further attacks of vertigo or syncope. CT angiography obtained after the pacemaker implantation showed patent intra- and extracranial arteries except for mild stenosis of the left distal vertebral artery. Transthoracic echocardiography was unremarkable without any evidence for a cardiac source of embolism.

Conclusion: In view of the recurrent isolated vertigo without any other neurological symptoms and pure downbeat nystagmus during the episode, the cardiogenic vertigo in our patient was more likely to result from cerebellar rather than labyrinthine or brainstem ischemia. Considering downbeat nystagmus in the present case with recurrent asystole and both downbeat nystagmus and increased VOR gain during induced syncope, it appears that frequent vertigo in patients with cardiovascular disorders or syncope may result from cerebellar dysfunction due to hypoperfusion.

PC-79

Walking to the toilet in inpatient with vertigo (**2nd report**)

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At the 25th Barany Society Meeting in 2008, we reported that it took 3 days before patients hospitalized to our department on the day of onset of vertigo became able to walk to the toilet without the assistance of medical staff. In this paper we report on our investigation of the influence of Atarax P, an anti-allergic, anti-anxiety drug, on the ability to walk to the toilet. The study population comprised 100 patients who were admitted to our department on the day of onset of vertigo between January 1, 2008 and March 31, 2010. They were divided into two groups: those with use of Atarax P and those without. The items investigated were the number of days taken before restoration of the ability to walk to the toilet, the number of days taken before disappearance of each of fixation nystagmus and voluntary nystagmus, and the number of days before disappearance of vertigo at rest, upon moving the head, and upon moving the body. Although differences were statistically insignificant in all items, the ratio of patients who took 4 days or more before becoming able to walk to the toilet was slightly higher in the group of patients not receiving Atarax P than in the group receiving the drug. In both groups, some patients took a relatively long time before their vertigo upon moving their body disappeared. The ability to walk to the toilet may be involved by mental factors such as anxiety about falling or exacerbation of nausea and vertigo. In the patients who persistently experienced vertigo upon moving the body, Atarax P might have been more effective than required, in addition to the mental factors. Hence, it is desirable that the duration of treatment with Atarax P be about 3 days.

PC-80

Vestibular neuritis with dissociation between cVEMP and oVEMP responses is consistent with utricular origin of oVEMPs and saccular origin of cVEMPs

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Objective: Recently two important tests of otolith function have been reported – firstly the cervical vestibular evoked myogenic potential (cVEMP) from contracted sternocleidomastoid (SCM) muscles to an air-conducted sound (ACS) or bone-conducted vibration (BCV). Secondly the ocular vestibular-evoked myogenic potential (oVEMP) to BCV and ACS from contracted extrocular muscles (Inferior Recti and Inferior Oblique muscles). These potentials have an important role in diagnosing vestibular disease. Evidence shows that in response to Short Tone Burst (7 millisecond) 500 Hz BCV delivered to the midline of the forehead at the hairline (a location called Fz) or ACS stimulation, the early negative n10 potential of the oVEMP indicates crossed utricular function and the early positive p13 potential of the cVEMP indicates uncrossed saccular function (reviewed in Curthoys [1]). The objective of the present case report is to present further ev-

idence confirming the origin of cVEMPs and oVEMPs to air conducted sound (ACS) and bone conducted vibration (BCV) at Fz.

Methods: A 29 year old woman was referred to our tertiary referral neurotological center (MSA ENT Academy Center – Cassino, Italy) with acute vertigo, pallor, vomiting, but no cochlear symptoms. Suspecting on the basis of symptoms and history an acute onset of Vestibular Neuritis, the patient was then submitted to the following: caloric testing; Bed Side examination; both ACS and BCV Fz ocular and cervical VEMPs carried out with a very short tone burst of 500 Hz lasting 7 milliseconds (5 millisecond plateau) with a repetition rate of 4 Hz for 50 times.

Results: The Audiological investigation (Pure Tone Audiometry) revealed a Mixed Hearing Loss with preserved stapedial reflexes and normal tympanometry and auditory brainstem responses. Vestibular tests showed: absent spontaneous nystagmus; no head shaking nystagmus; positional nystagmus (Dix-Hallpike manoeuvre) with downbeating nystagmus when the head was positioned to the left. Caloric tests showed a normal pattern (Fitzgerald-Hallpike stimulation). For air conducted sound (ACS) and bone conducted vibration (BCV) stimuli the cervical Vestibular Evoked Myogenic Potentials (cVEMPs) showed a clearly detectable response only from the right SCM. While air conducted sound (ACS) and bone conducted vibration (BCV) ocular Vestibular Evoked Myogenic Potentials (oVEMPs) showed both a normal n10 beneath the left eye. After the aforementioned series of diagnostic procedures, she was diagnosed as having Inferior Vestibular Neuritis on the right side.

Conclusion: cVEMPs to ACS and BCV at Fz test primarily saccular and inferior vestibular nerve function whereas oVEMPs to ACS and BCV at Fz test primarily utricular and superior vestibular nerve function. The case confirms that the n10 potential of the ocular VEMPs to ACS and BCV Fz is related to utricular function. Conversely the p13 potential of the ACS and BCV Fz cVEMP indicates saccular function. However these two indicators, combined with other standard tests of peripheral vestibular function such as the head impulse test allow clinical testing of all of the vestibular end-organs in each inner ear.

Reference

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PC-81

Treatment of apogeotropic horizontal canal benign paroxysmal positional vertigo; comparison of gufoni and head-shaking maneuver

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Background: Several methods of physiotherapy have been advanced for apogeotropic type of benign paroxysmal positional vertigo involving the horizontal semicircular canal (HC-BPPV). However, head-to-head comparison using a randomized controlled trial is unavailable.

Objective: The aim of this study was to determine the immediate and long-term therapeutic efficacies of the Gufoni and head-shaking maneuvers in apogeotropic HC-BPPV compared with sham maneuver.

Design: A randomized double blind prospective controlled study.

Methods: In nationwide 10 Dizziness Clinics of Korea, 157 consecutive patients (95 women, age range: 18–89 years, mean age $\pm$ SD $=$ 59.9 $\pm$ 13.6) with apogeotropic HC-BPPV were randomized to Gufoni's maneuver ($n = 52$), head-shaking ($n = 54$) or sham maneuver ($n = 51$) group. Immediate response was determined within one hour after each maneuver based on resolution of vertigo and nystagmus during the positioning maneuvers. The repositioning maneuver was repeated once more when the symptom and signs persisted. The patients also had weekly follow-ups for one month after the initial maneuver.

Statistics: X2 and ANOVA tests were used to compare the clinical characteristics and therapeutic efficacy of each maneuver among the groups. Cox proportional hazards regression analysis was used to determine the effect of independent variables on the outcome. We performed Kaplan-Meier survival analysis to determine the long-term effect, and the log rank test for a statistical comparison among the groups. A two-tailed p value of less than 0.05 was considered significant.

Results: After single treatment maneuver, head-shaking (25/53, 47.2%) and Gufoni maneuver (31/52,

59.6%) showed better immediate results than sham maneuver (11/49, 22.0%, $p = 0.001$). The Kaplan-Meier survival curve for the long-term effects also showed a better outcome in the head-shaking ($p = 0.026$) and Gufoni ($p = 0.000$) groups compared with the sham group. However, therapeutic efficacy of head-shaking and Gufoni's maneuver did not differ in terms of both immediate ($p = 0.129$) and long-term ($p = 0.239$) outcomes.

Conclusion: Using a prospective randomized trial, we demonstrated that the Gufoni's and head-shaking maneuvers are effective and superior to the sham maneuver in treating apogeotropic HC-BPPV.

PC-82

Partial labyrinthine injury in severe decompression illness: a vascular embolic explanation?

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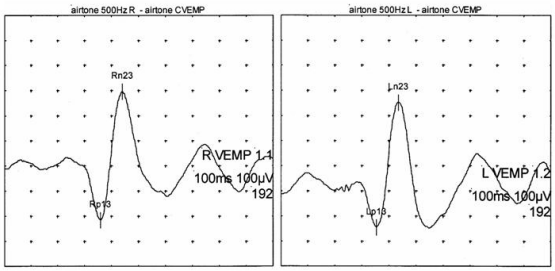
Objective: We present a case report suggesting N2 bubble embolization as the cause of peripheral vestibular dysfunction in decompression accidents.

A selective vulnerability of the inner ear to decompression illness has been suggested. A few observational studies have demonstrated the inner ear to be the only injured site following decompression accidents. However, there is no full agreement about the patophysiological basis for the inner ear damage; whereas some argue for a relation to the selective difficulty of inner ear tissues to wash out the N2, others argue for N2 vascular embolization as the cause. The present patient had a severe decompression illness with a partial vestibular lesion that minutely traced the inner ear vascular supply, affecting only the territory of the anterior vestibular artery.

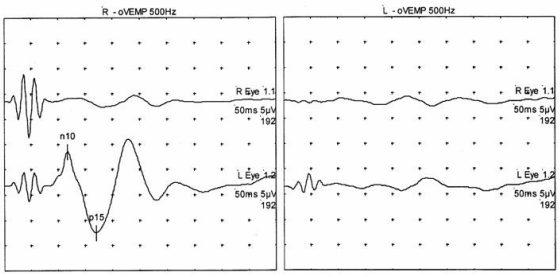
Methods: A 48-year-old male dive master was neuro-otologically evaluated one month after an episode with severe decompression illness that also involved the left inner ear. Twenty minutes after a dive, the patient suffered a rapidly increasing intense abdominal pain and after a few more minutes he became unconscious. He was treated in a hyperbaric chamber with a standard program for hyperbaric oxygen administration. After 14 hours he regained consciousness, but for the next three days he was still confused and disoriented. Cerebral images revealed diffuse micro-embolization in the supra-tentorial white matter. In addition to the cerebral symptoms the patient complained of continuous vertigo. After a few days of further hospital attendance he was dismissed with diminishing subjective vertigo and no other neurological symptoms. A few weeks later, the patient was seen for the neuro-otological evaluation.

Results: The examination suggested a left partial vestibular deficit without auditory involvement. There was no caloric response from the affected left ear. Head impulse test for the left lateral and the left anterior semicircular canal was also impaired. Testing vestibular evoked myogenic potentials (VEMPs) showed divergent results. Ocular VEMPs in response to left ear stimulation were absent, whereas the cervical VEMPs were completely symmetrical and normal. Thus, the lesion profile suggested a left partial vestibular loss of the kind that would be suspected following a left anterior vestibular artery embolus.

Conclusion: Clinical reports have described cases of inner-ear decompression illness without other neurological findings, pointing to a selective vulnerability of inner ear tissues in decompression accidents. Recent physiological models have suggested that the specific inner ear vulnerability is related to the prolonged half-time of N2 elimination from inner ear tissue. Inner ear involvement has also been demonstrated to occur more often in patients with a right-left shunt, suggesting vascular embolization to be the cause for inner ear decompression illness (and the nitrogen bubbles would also tend to grow once they enter a supersaturated territory).The present case report consists of a well documented decompression illness with a partial labyrinthine damage that mirrors the vascular supply of the anterior vestibular artery. The enrolment of so distinct vestibular functional subunits represents, in our opinion, a demonstration that inner ear decompression illness is related to an embolic mechanism.



Caption 1: cVEMPs. Simmetrical and normal



Caption 2: cVEMPs. No response to left stimulation

PC-83
Audiovestibular sarcoidosis
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We report two patients with biopsy proven audiovestibular sarcoidosis who presented with hearing loss, vertigo and gait ataxia. The clinical findings were confirmed by formal oto-neurology testing, which revealed sensorineural hearing loss with poor speech discrimination, vestibular hypofunction and abnormal auditory brainstem responses. MRI scans of the brain revealed enhancement of the vestibulocochlear nerves. Both patients responded to high dose oral corticosteroid treatment.

PC-84
Vertigo and disequilibrium of SLE patients
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Objectives: Collagen disease induce various neurological symptoms that range from central nervous system to peripheral nerve. Therefore, some of patients with them complain vertigo and disequilibrium. But there are little reports about the detail of them.
As systemic lupus erythematosus (SLE) is representative disease of collagen disease, we studied about neuro-otological observations of SLE patieuts who had complained vertigo and diseruilibrium and came to Department of Neurotology, Kitasato University Hospital.
Methods: The subjects of our study are 25 SLE patients who came from January 1985 to December 2009. They consisted of 1 male and 24 females. Their age were ranged from 14 to 68 years old and mean age was 41.8 ± 12.8.
We examined gaze nystagmus test, positional nystagmus test, positioning nystagmus test, eye tracking test (ETT), optokinetic pattern test (OKP) and pure- tone audiometry as neuro-otological examination.
Results: We diagnosed 5 patients as central vestibular disturbances for reasons of vertical nystagmus, saccadic and ataxic ETT, hypofunction of OKP and so on.We did 2 patients as Meniere's disease and 5 patients as benign paroxysmal positional vertigo for reasons of pathognomonic pure- tone audiogram, nystagmus and so on.
Conclusions: As to the mechanism of central vestibular disturbances of SLE, there are possibility of transmigration of lymphocytotoxin with microvascular disorder and deposition of immune complex at blood- brain barrier. In a similar way, in the inner ear, there are possibility of inner ear disturbance that transmigration of lymphocytotoxin with microvascular disorder and dysfunction of blood- inner ear barrier. As to vertigo and disequilibrium of SLE patients, our study showed that various factor are intermingled about their pathophysiology and disordered part.

PC-85
Characterization of presbyequilbrium among institutionalized elderly persons
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Background: Dizziness, vertigo, poor maintenance of posture, and black-outs are common symptoms (called presbyvertigo) in the elderly and make them at risk for falls, and social isolation. These problems are ubiquitous and become increasingly prevalent with aging such that significant symptoms often go unrecognized, being attributed to natural degeneration. Although the aetiology of presbyvertigo remains largely uncertain, acute or rapid deterioration of balance may be due to a treatable medical disorder. Rehabilitation may be effective when medical therapy has reached its limits. The aim of this study was to characterize presbyvertigo among institutionalized elderly to identify the treatable causes.
Methods: We examined 72 out of 156 institutionalized elderly persons from a single residential facility in a cross sectional study and followed them for 3 years. In order to define their presbyvertigo, a standardized questionnaire was administered that consisted of 98 questions about the subjects' symptoms, medical history

and medication. A general health related quality of life measure (QoL-15D) and mini mental status examination (MMSE) were completed. Additionally, records were made of falls and scoring was done for anxiety, and physical activity. Factorial analysis was carried out to determine the components of presbyvertigo.

Results: 54 % of the elderly subjects reported some kind of vertigo, dizziness, syncope or balance problems. The most common complaint was postural instability, with a tendency to fall. "Spinning" vertigo and "floating" sensation had strong inter-correlation ($p < 0.001$) and correlated with habitual falls. The symptoms often occurred in combinations with the most common combination being poor postural stability and gait problems followed by poor postural stability and spinning vertigo. Attacks of syncope never occurred alone but always in combination with spinning vertigo or tendency to fall. In factorial analysis, presbyvertigo could be divided into six categories. "Poor vestibular coping" (factor 1) correlated significantly with reduction of general measure of quality of life ($p = 0.037$) and with anxiety ($p = 0.050$). The "vestibular frail-syndrome"(Factor 2) correlated significantly with loss of vigilance ($r = 0.332$, $p = 0.021$), mobility ($p > 0.001$), vision ($p = 0.003$), subjective impairment in memory ($p = 0.014$) and with habitual falls ($p = 0.010$). "Vestibular failure" (Factor 3) correlated significantly with loss of energy ($p = 0.021$) and with sense of impending death ($p = 0.031$). "Positional vertigo" (Factor 4) correlated with anxiety ($r = 0.283$, $p = 0.051$). "Autonomic vertigo" (Factor 5) correlated with anxiety ($p < 0.001$), loss of energy ($p = 0.031$) and accidental falls ($p = 0.041$). Finally, "movement intolerance" (factor 6) correlated with reduction of MMSE score ($p = 0.033$).

Conclusion: Among elderly, dysfunction of the vestibular system is commonly characterized by a combination of phenomena involving emotional, perceptual, orientation, postural, and autonomic manifestations. It is often difficult to obtain an accurate history from the elderly and the presence of treatable symptoms is frequently overlooked. Taking a careful history and utilizing the classification of symptoms that emerged from the factorial analysis may give a deeper understanding of the aetiology of presbyvertigo, thereby facilitating appropriate medical treatment and rehabilitation.

PC-86

Asymmetric vestibular function in CI candidates – does it matter?

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Objective: Around 30% of patients experience vertigo or imbalance following cochlear implantation. In order to minimize the risk of post-operative vestibular disorders, it is generally recommended to implant the ear with the least functional vestibule. However, hardly any data comparing pre-operative vestibular function between the two ears in adult CI candidates have been published so far. Therefore, the present study was designed:

1. to determine the number of patients with asymmetric vestibular function among adult CI candidates.
2. to evaluate the proportion of patients where cochlear implantation is considered on the better balancing ear for audiological reasons.

Methods: In this preliminary study, 25 adult CI candidates (age: 23–84 years) underwent otoneurological examination including spontaneous and headshake nystagmus, vestibulo-ocular reflex, rotational chair testing, bithermal caloric irrigation, positional testing and computerized dynamic posturography (CDP) prior to cochlear implantation.

Results: Among the 25 CI candidates, 17 showed signs of peripheral vestibular hypofunction on vestibular testing (68%). Bilateral vestibular hypofunction (BVH) was diagnosed in 9 patients. Of these, 5 presented with symmetric BVH and 4 with asymmetric BVH. Unilateral vestibular hypofunction (UVH) was found in 8 subjects. Thus, asymmetric vestibular function was determined in 12/25 patients (48%). Cochlear implantation was considered on the better balancing ear for audiological reasons in 5 out of the 12 patients with asymmetric vestibular function (41.6%).

Conclusions: 1.) The high prevalence of CI candidates with asymmetric vestibular function (48%) in our preliminary study advocates pre-operative vestibular testing in *all* patients considered for cochlear implantation. If all other factors are equal, the ear with the least functional vestibule should be implanted.

2.) Those patients, where cochlear implantation is considered on the better balancing ear for audiological reasons (41.6% in our study), require special counselling about the risk of post-operative vertigo. Pre-operative vestibular training is particularly advisable in

these patients in order to promote central compensation of asymmetric peripheral vestibular function.

PC-87

Comparing CT methods for temporal bone imaging

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Statement of Study: The learning objective is to compare Multi Slice CT (MSCT) to Cone Beam CT (CBCT).

The main focus of this poster is to understand the role of novel cone-beam CT technology in diagnosing inner ear diseases and vestibular disorders.

CBCT is gaining popularity because its smaller radiation dose (e.g., 5 mA and 120 kV) compared to conventional MS CT (e.g., 250 mA and 135 kV) allows the technology to be deployed directly to otolaryngology and dental offices. A disadvantage of CBCT is that the use of low energy photons results in less image contrast. However, there is potentially better spatial resolution compared to MSCT when inherent tissue contrast is high.

This should be the case with superior canal dehiscence (SCD), where thin bone must be detected between low radiodensity brain and perilymph, and with delineation of the stapes and cochlear implant arrays. Data from cadaveric temporal bones scanned with CBCT and MSCT are compared. Results demonstrate better spatial resolution of CBCT in these applications.

Superior canal dehiscence syndrome (SCDS) is a syndrome of sound- and/or pressure-induced vertigo OR conductive hearing loss and/or hyperacusis caused by a thinning or complete absence of the part of the temporal bone overlying the superior semicircular canal of the labyrinth. It is probably due to a congenital defect in the bone, which may become symptomatic over time with physical trauma or dural pulsations.

Objective: The desired result is a non-biased overview of the new CT devices on the market.

Methods: Cadaveric temporal bones and a bony phantom were scanned with MSCT and CBCT, and after extracting the image information in DICOM format, they were post processed in Vitrea (Vital Images, Minnetonka, MN) to adjust windowing and rotation angle. DICOM data were finally extracted to MATLAB 7.9.0.529 (R2009b) (The MathWorks Inc., Natick, MA) for quantification of the difference of the spatial resolution between the two scan techniques.

In order to make the pictures from the two different technologies comparable, we needed to rectify them: Grayscale images (e.g., 1) were converted into black and white (2), and images were normalized to obtain equal size and center for the canal in all images. To examine the information content at the transitions from bone to surrounding tissue, we calculated the Derivative of each pair of pixels in the horizontal axis in the image. In order to determine spatial resolution, a Phantom was created from a dry temporal bone with holes drilled into the squamous portion ranging from 0.8 mm diameter in 0.05 mm steps to 0.3 mm. The centers were 1.5 mm apart, and there were 5 or 6 holes in each vertical set. The phantom was put into water in order to mimic the radiodensity of cerebrospinal fluid.

Results: MSCT had difficulty demonstrating the 5th hole (0.55 mm in diameter).

CBCT demonstrated all holes down to the 7th hole (0.45 mm in diameter) without problems.

Moreover, the MSCT did not show that the holes penetrated to the full thickness of the calvarial bone.

Conclusion: Cone Beam Scanners may be better for diagnosing SCDS because CBCT has:

More spatial resolution using an actual temporal bone phantom with water to mimic the relevant bone/fluid interface found in SCD.

Less radiation dose.

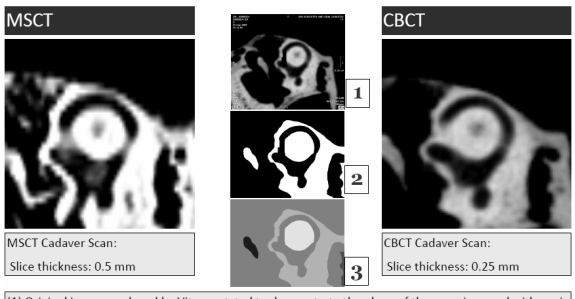
Faster image acquisition.

Volumetric coverage in one rotation.

Less motion artifacts.

Potential “turnkey” utilization.

The phantom in the MSCT | The phantom itself. | The phantom in the CBCT



MSCT Cadaver Scan: Slice thickness: 0.5 mm

CBCT Cadaver Scan: Slice thickness: 0.25 mm

(1) Original image produced by Vitrea rotated to demonstrate the plane of the superior canal with a minimum Region of Interest (ROI)

(2) Black and white image after applying *imopen* and *imclose* with MatLab

(3) Contiguous bony areas are similarly colored

PC-88

Rizatriptan reduces motion sickness in migraineurs

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Persons with migraine are known to have a higher level of motion sickness susceptibility than persons without migraine. Also, symptoms associated with migraine headache often include autonomic-type symptoms similar to those of motion sickness. In an effort to better understand these parallels between migraine and motion sickness, we evaluated the effect of the 1B/1D receptor serotonin agonist rizatriptan on motion sickness provocation. We performed a double-blind, randomized, placebo-controlled study wherein we measured motion sickness in migraineurs in response to a complex vestibular stimulus following pretreatment with either rizatriptan or a placebo. This study was motivated by two previous pilot studies that suggested that rizatriptan influenced motion sickness in migraineurs. Subjects for this study included 25 migraineurs (23 female; 2 male) aged 21 to 45 yrs (31.0 $\pm$ 7.8 yrs) with ($n = 12$) or without ($n = 13$) migraine-related dizziness. Motion sickness was induced using a rotate-then tilt constant velocity off-vertical axis rotation in darkness, which stimulates first the semicircular canals and then the otolith organs. Off-vertical axis rotation was continued for approximately 50 seconds. Following a two-minute rest, if the subject could tolerate additional stimulation, they were then exposed to a second off-vertical axis rotation in the direction opposite to that of the first off-vertical axis rotation. Motion sickness was judged using the motion sickness scale developed by Graybiel. Subjective units of distress were rated from 0-10 based on the method of Wolpe. Sinusoidal-earth vertical earth axis rotation was used to assess the vestibulo-ocular reflex (VOR) before and after ingestion of the drug or placebo. Eye movements were recorded with electro-oculography and analyzed using standard techniques. Motion sickness scores and subjective units of distress were analyzed by computing the differences between baseline (i.e., pre-earth-vertical axis rotation) and post-OVAR. Eye movement data were analyzed using standard techniques to compute gain and phase for earth-vertical axis rotations and modulation and bias components for off vertical axis rotations. Results indicated that 15 of the 25 subjects experienced vestibular-induced motion sickness when pre-treated with placebo. 13 of these 15 subjects showed a decrease in motion sickness following pretreatment with rizatriptan compared with pretreatment with placebo. This significant effect was not seen when subjects were exposed to more provocative vestibular stimulation, i.e., a second off-vertical axis rotation, although there was a trend for subjects without migrainous vertigo to show a benefit with rizatriptan as compared to placebo. Subjective units of distress were not different for rizatriptan vs. placebo. There was no consistent effect of rizatriptan on the VOR or a correlation between motion sickness and the VOR.

The results of this study corroborate the implications of our prior pilot data suggesting that rizatriptan provided protection against motion sickness induced by complex vestibular stimulation in migraineurs. The absence of an effect of pre-treatment with rizatriptan on motion sickness in response to a second off-vertical axis rotation suggests a type of dose-response mechanism. The trend for subjects without migrainous vertigo to gain benefit from rizatriptan despite a high level of motion sickness provocation suggests that subjects with migrainous vertigo may be more susceptible to motion sickness. We hypothesize that the serotonin agonist rizatriptan reduces vestibular-induced motion sickness by influencing serotonergic vestibular-autonomic projections (Figure). Rizatriptan had no apparent effect on the so called "velocity storage system" of the VOR. Our data thus do not support a connection between motion sickness and velocity storage. The ability of rizatriptan to reduce motion sickness in migraineurs suggests that migraine-related mechanisms, such as trigeminovascular reflexes and central pain pathways, may be involved in generating motion sickness.

This research was supported by Merck & Co., Inc via an investigator-initiated award.

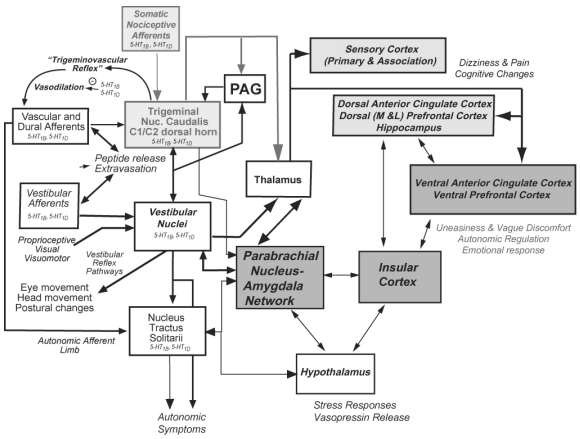

Diagram of relevant neural structures

PC-89

Lack of vestibulo-ocular reflex gain modulation by eye position signals in the post-acute phase of vestibular neuritis

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Objectives: The nystagmus of acute vestibular neuritis is characterized by slow-phase velocity augmentation as gaze moves in the direction of fast phase. This phenomenon is called Alexander's law (AL). It has been suggested that eye position signals modulate the asymmetrical vestibulo-ocular reflex. However, little is known about the persistence of AL in the post-acute phase, when no spontaneous nystagmus is present.
Methods: Head and eye movements were recorded with the search-coil method during passive head-impulses in yaw, while subjects (5 patients with unilateral vestibular neuritis in the post-acute phase, 12 controls) were asked to hold gaze at various azimuth angles in 8 deg-steps within $\pm$ 16 deg from the straight ahead reference position.
Results: In normal subjects, the gain of the VOR remained unaffected by eye-in-orbit position and this was true for leftward as well as for rightward impulses. In patients, ipsilesional head impulses were characterized by reduced VOR-gains, which did not change by eye-in-orbit position. Contralesional impulses produced slightly decreased VOR-gains, which, again, were not influenced by eye-in-orbit position.
Conclusions: The gain of the VOR during ipsilesional head-impulses did not scale up with eye-in-orbit positions towards the healthy side. This points to an absence of the AL-phenomenon in the post-acute phase of vestibular neuritis.

PC-90

Covert short latency saccades in combined vestibular and cerebellar failure

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Context: The head impulse test, introduced by Halmagyi and Curthoys in 1988, is a high frequency head rotation to detect a complete paresis of the semicircular canals. Catch up corrective saccades may be overt saccades with occurrence after the head rotation has stopped or covert saccades that occur early during the head rotation.
Objective: To assess whether early covert catch up saccades occurred in combined cerebellar and vestibular failure in the same way that they occur in isolated vestibular failure alone. It was proposed that the presence of cerebellar failure would prevent the appearance of early covert saccades because of impaired CNS processing mechanisms.
Method: Three patients with the clinical syndrome of complete bilateral vestibular failure and clinical and supportive MRI evidence of cerebellar degeneration were evaluated with a passive head impulse test, as described by other authors1. Patients were seated and asked to fixate on a target at 2 meters while the examiner made passive unpredictable horizontal head thrusts. A total of approximately 15 head thrusts were made in each direction. Bithermal caloric testing was performed to confirm the clinical observation of bilateral vestibular failure. The position signal of the VOR was recorded with infrared oculography and head movement measured by a velocity transducer.
The gain of the VOR was defined as the point on the VOR trace where this was interrupted by an initial saccadic eye movement over the total eye movement in response to a head impulse. The latency of the initial catch up saccade was defined as above and calculated in relation to the point on the velocity signal of head impulse onset.
Results: All subjects with isolated vestibular failure or when combined with cerebellar degeneration had either absent bithermal caloric tests or caloric slow phase velocity of less than 6°/s. The VOR gain of three combined cerebellar vestibular failure patients was similar to that of four patients with isolated vestibular failure with a mean VOR gain of 0.31 ± 0.19.
Covert short latency saccades at approximately 100 ms occurred in both isolated vestibular failure and combined cerebellar vestibular failure patients.
Conclusion: Patients with combined cerebellar vestibular failure can still use compensatory mechanisms to generate short latency covert saccades during a head impulse test.

Reference

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PC-91

Clinical characteristics of inferior vestibular neuritis

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Objectives: Cervical vestibular evoked myogenic potentials (cVEMPs) have been described as a useful clinical test for assessing saccular and inferior vestibular nerve function. Parallel to clinical application of cVEMPs, several cases suggestive of inferior vestibular neuritis (IVN) have been reported [1–3]. These cases presented with sudden onset of vertigo or dizziness, spontaneous nystagmus, absence of other auditory and neurological findings, reduced or absent cVEMPs on one side, but normal caloric responses on both sides. Because of the paucity of literature on IVN, clinical features of IVN are still unknown to us. We retrospectively reviewed clinical characteristics of patients with IVN and compared them with those of superior vestibular neuritis (SVN) and total (superior and inferior) vestibular neuritis (TVN).
Methods: We retrospectively reviewed clinical records of 1,777 consecutive patients visiting Balance Disorder Clinic, the University of Tokyo Hospital, from January 2005 to April 2010. Among them, we have diagnosed 104 patients as having vestibular neuritis (VN). Seventy five of the 104 patients were enrolled in this study due to full documentation. With the results of caloric testing and cVEMP testing, we classified these 75 patients into three groups; 1) The patients with IVN who showed asymmetrical cVEMP responses but symmetrical caloric responses, 2) The patients with SVN who showed asymmetrical caloric responses but symmetrical cVEMP responses, and 3) The patients with TVN who showed asymmetrical responses both in caloric and cVEMP testing. We focused on the clinical characteristics of patients with IVN and compared them with those of SVN and TVN.
Results: Of 75 patients with VN, the number of patients classified into IVN, SVN, and TVN was 13, 38, and 24 respectively. The clinical profiles of these 75 patients were summarized in the Table. The mean age of patients with IVN was significantly smaller than those of TVN. The duration between first attack and remission of patients with IVN was significantly smaller than that of TVN. There were no significant differences in other profiles among the three groups. Some patients with IVN showed spontaneous nystagmus with eyes open and/or closed. No patients with IVN showed benign paroxysmal positional vertigo (BPPV) as a sequela.

Conclusions: From the clinical symptoms of patients suggestive of vestibular neuritis, it was difficult to differentiate IVN from those of SVN and TVN. Thus, the cVEMP testing as well as caloric testing played an important role for diagnosing those patients. The prognosis of IVN was better than those of TVN and patients with IVN showed no BPPV during their recovery period.

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Table 1
Profile of 75 patients with vestibular neuritis

	N	Age	Male/Female	Right/Left	Vertigo/Dizziness	Duration of attack	Duration of hospitalization	Time to remission
IVN	13	44.2 ± 4.8	6 / 7	6 / 7	10 / 3	20.0 ± 6.2	3.8 ± 0.7	0.9 ± 0.2
SVN	38	53.1 ± 2.7	22 / 12	15 / 19	34 / 4	46.7 ± 7.2	5.5 ± 0.7	3.7 ± 0.8
TVN	24	57.3 ± 2.5	17 / 7	14 / 10	22 / 2	35.0 ± 6.2	7.1 ± 1.1	4.9 ± 1.0
		(Years)				(hours)	(days)	(months)

PC-92

The action of vestibular signals in suppressing first trial and habituated reactions in the upper body following postural perturbations

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Aim: This study examined the contribution of vestibular signals to upper body responses during the very first unexpected reaction and subsequent reactions to sudden support surface perturbations.
Background: Vestibular loss (VL) has been shown to negatively influence balance control for a series of re-

peated (habituated) toe-up tilt perturbations of the support surface by reducing leg muscle and increasing back muscle activity during automatic postural responses. However, this effect of VL on postural responses is not observed in lower-leg and neck muscle responses for the very first trial. This suggests that VL does not influence first trial responses (FTRs), rather in VL subjects FTRs have similar amplitude startle-like reactions to those of healthy subjects. FTRs in healthy subjects comprise large trunk flexion responses, leading to instability. Thus, it would seem important to determine how the amplitudes of trunk and arm muscles, and resulting trunk, neck and arm motion are influenced by VL during startle-like FTRs to balance perturbations. Studying FTRs in VL subjects, might provide important insights into the underlying sensory mechanisms contributing to FTRs and falls, especially if VL does not lead to excessive FTRs at the trunk compared to controls and the instability for the FTR is not different from that of controls.

Methods: Five subjects with bilaterally absent peripheral vestibular function and 14 age-matched controls were perturbed, while standing, first unexpectedly in the pure pitch (toe-up) direction, and then in 8 directions of pitch and roll support surface rotation 8 times in random order. Body segment movements were recorded with a motion analysis system, head accelerations with accelerometers, and muscle activity with surface EMG. We compared the 1st toe-up response with the 8 averaged toe-up responses given randomly.

Results: The characteristic increased trunk flexion of FTRs was recorded for VL and control subjects. However, the profiles of trunk pitch were different in VL and control subjects. VL subjects showed initially a greater amplitude in trunk flexion at ca 400 ms followed by a greater reduction to no flexion at 900 ms. Neck flexion was also greater in VL and control subjects for the FTR, but, unlike trunk flexion, showed no differences between test populations for FTRs or habituated responses. Arm abduction and rotation forwards were greater in VL subjects for both FTRs and adapted responses. The resultant CoM profiles showed greater instability for FTRs and habituated responses for VL subjects. However, the pelvis AP movement contributed more to the FTR instability in controls and trunk AP movement more in VL subjects. Trunk (paraspinals and gluteus medius) and arm muscle (deltoid, biceps and triceps) FTR and habituated automatic responses (measurement interval 120–250 ms) were greater in amplitude for VL subjects. Stretch reflexes in soleus (over 40–80 ms) were lower in amplitude in VL subjects. No differences in EMG response onset latencies for FTRs were observed between VL and controls. Across trunk and arm biomechanical and EMG measures, there was no population difference between the increase of FTRs compared to habituated respronse.

Conclusions: These results suggest that vestibular signals act to reduce the amplitude of FTRs and habituated responses in the trunk and arms, once these are triggered by proprioceptive signals. This reduction could act directly on muscle amplitude modulation or indirectly via the influence of VL on leg proprioceptive reflexes. Thus, in the absence of vestibular signals, trunk muscle amplitudes are greater than controls and lead to greater instability of the trunk for both FTRs and adapted responses. Evidence for vestibular triggering of FTRs was not found.

PC-93

Depersonalization and derealization symptoms in vestibular patients with and without anxiety

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Objectives: Depersonalization is an alteration in the perception or experience of the self so that one feels detached from, and as if one is an outside observer of, one's mental processes or body. Depersonalisation is usually accompanied by derealisation, the experience of the external world appearing strange or unreal.
The aim of this study was to investigate (i) is there difference in depersonalization/derealization (DD) symptoms between vestibular patients with and without anxiety, (ii) whether the underlying sensory dysfunction resulted in both anxiety and DD symptoms, or these DD symptoms were secondary to anxiety.

Subjects and Methods: Routine neurootological examination was held to evaluate the subjective and objective vestibular symptoms. All participants in the study completed: 1) The Human -Anxiety and Depression Scale (Snaith and Zigmond, 1994); 2) The 28 – item depersonalisation/derealisation inventory of Cox and Swinson (2002). According to the results from HADS test they were divided into three groups: (i) 20 healthy controls; (ii) 20 patients with peripheral vestibular disease and (iii) 28 vestibular patients with anxiety.

Results: The number of symptoms and the total score reported by patients with anxiety were higher than any other group (Figs 1 and 2). The frequency and

severity of the reported DD symptoms were significantly higher on 27 of 28 items ($p < 0.05$) compared to healthy subjects and on 10 of 28 compared to vestibular patients without anxiety ($p = 0.001$). In the group of vestibular patients with anxiety appeared symptoms which permitted discrimination between them and the other two groups – "Feel as though in a dream", "Body feels numb", "Feeling of detachment or separation from surroundings", "Numbing of emotions", "Feeling detached or separated from body", "Thoughts seem blurred", "Your emotions seem disconnected from yourself", "Feel confused or bewildered", "Feel isolated from the world".

Conclusion: Anxiety modifies depersonalization and derealization symptoms in vestibular patients.

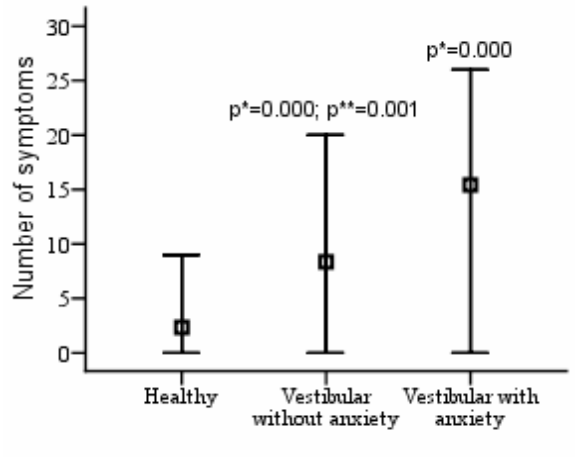

Fig. 1. Range and mean of the number of symptoms.

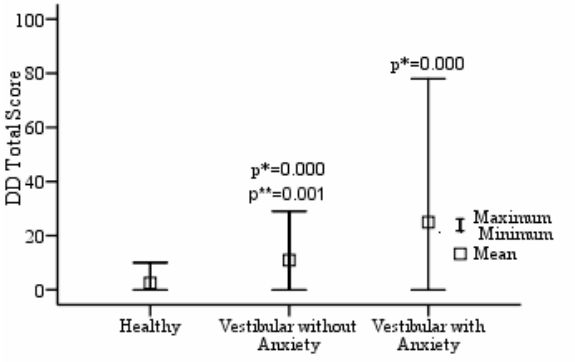

Fig. 2. The depersonalization/derealization score.

Poster Session 2 – D. Treatment

PD-94

The comparison of intratympanic steroid injection and oral steroid therapy for sudden sensorineural hearing loss

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Background and Objectives: The aim of this study was to evaluate the efficacy of intratympanic steroid injection for sudden sensorineural hearing loss (SSNHL) according to audiometric frequencies and in terms of inpatient or outpatient care setting by comparing the results with oral steroid therapy as first line treatment.

Material and Methods: We carried out a retrospective review of 441 patients with SSNHL, with oral steroid therapy(OST) or intratympanic steroid(ITS) injection and with inpatient or outpatient care setting. All cases were classified into four groups. Four groups were consisted of OST and inpatient care group (OST-in), OST and outpatient care group (OST-out), ITS and inpatient care group (ITS-in) and ITS and outpatient care group (ITS-out). In the OST group, the patients received prednisolone orally. In the ITS injection group, the patient received dexamethasone intratympanically. In the inpatient care group, the treatment included low salt diet, carbogen therapy, stellate ganglion block therapy, peripheral vasodilators, dextran and steroid. In the outpatient care group, the treatment included peripheral vasodilators and steroid.

Results: The hearing gains were significantly greater in group of OST-in (16.1 $\pm$ 19.2 dB) than in group of OST-out (11.1 $\pm$ 17.7 dB) ($P = 0.02$) and there were statistically significant improvement of more than 15% of speech discrimination score(SDS) (43.2 $\pm$ 49.9%) in ITS-in group than in ITS-out group (24.6 $\pm$ 43.4%) ($P = 0.02$). But there were no statistically significant hearing gain when comparing OST-in group to ITS-in group, OST-out group to ITS-out group or ITS-in group to ITS-out group. There were no statistically significant improvement of more than 15% of SDS when we comparing OST-in to ITS-in, OST-out to ITS-out or OST-in to OST-out. When comparing ITS group to OST group, there was no significantly different hearing gains between two groups.

Conclusion: Intratympanic steroid injections are as effective as oral steroid therapy for SSNHL. And when considering the effect of steroid on hearing gain, it

may be significant better hearing gain in inpatient care setting rather than outpatient care setting.

PD-95

4-Aminopyridine improves oculomotor and vestibular function in ataxia-telangiectasia

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Background: Eye-movement abnormalities are common in ataxia telangiectasia (A-T). These deficits include spontaneous horizontal and/or vertical nystagmus when subjects attempt to hold gaze on the target of interest, periodic alternating nystagmus (alternately changing the nystagmus direction; PAN), abnormally prolonged duration of rotation-induced nystagmus, inability to smoothly track the moving objects, and saccadic intrusions. Impaired gaze stabilization and nystagmus interfere with clear vision. Here we report that 4-aminopyridine (4-AP) – a potassium channel blocker that is also known to increase the GABA release from the cerebellar Purkinje neurons, offers a therapeutic benefit by ameliorating oculomotor phenotype in A-T.
Methods: We quantitatively investigated the effects of 4-AP on the oculomotor phenotype in four A-T patients. Specifically we measured (1) the decay time constant of the compensatory rotation-induced nystagmus in complete darkness, (2) the slow-phase eye velocity of the periodic alternating nystagmus in complete darkness, (3) spontaneous horizontal and vertical nystagmus when patients attempted to fixate gaze on a target, and (4) saccadic intrusions when subjects attempted to fixate gaze on a target. These measurements were performed before and 30 minutes after administration of one dose of 10mg 4-AP by mouth.
Results: 4-AP shortened the decay time constant of the rotational nystagmus in two of three A-T patients (ANOVA; $p < 0.05$). 4-AP significantly reduced the maximum slow-phase eye velocity of PAN from $24.7 \pm 4.6°$/sec to $13.4 \pm 2.4°$/sec (ANOVA; $p < 0.001$) in one patient and completely abolished it in the other. 4-AP significantly reduced vertical and horizontal nystagmus when these subjects attempted to fixate gaze on the target of interest (One-way ANOVA, $p < 0.05$). There was a significant reduction in the amplitude and rate of saccadic intrusions in one patient (One-way ANOVA, $p < 0.05$).
Conclusion: 4-AP ameliorates some aspects of the abnormal eye movements in A-T. The effects of 4-AP on the oculomotor phenotype in A-T could be secondary to possible increase in the GABA secretion from the residual Purkinje neurons. However, due to its presynaptic mechanism of action, 4-AP may have limited benefit in patients with profound loss of Purkinje neurons. The rapid pharmacokinetics of this drug offers an opportunity to determine quickly the usefulness of this drug on a case-by-case basis.

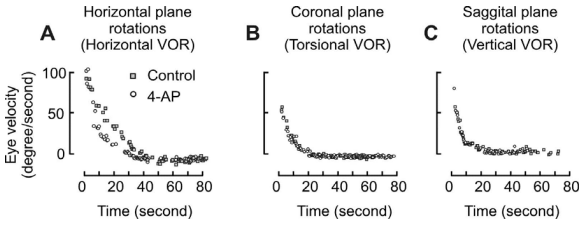

Fig. 1.

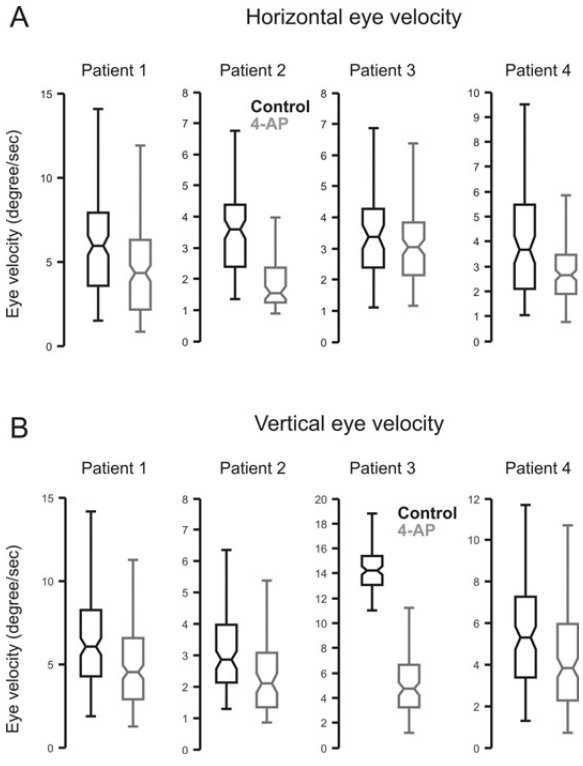

Fig. 2.

PD-96

Long-term outcome of benign paroxysmal positional vertigo

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Objectives: Benign paroxysmal positional vertigo (BPPV) is the most common inner ear disease of vertigo. Despite its familiarity, little is revealed about the long-term outcome of BPPV and the factors influencing it. The aims of this study are to elucidate the long-term recurrence rates of BPPV and to verify the factors influencing them along with the types of BPPV.
Methods: From January 1999 to June 2007, 680 BPPV patients were recruited consecutively at Dizziness Clinic of Eulji General Hospital. BPPV was defined by clinical findings of vertigo and the nystagmus evoked by Dix-Hallpike maneuver or head turning in supine position. All patients were registered with their demographic and clinical data, which included age, gender, type of BPPV, severity of vertigo, dizziness duration, and general review of potential events, and past medical history. Until 21 June 2007, all the patients recruited were either followed up at dizziness clinic. The Kaplan-Meier survaival analysis was used for evaluating the factors which affect long term prognosis, and multivariate analysis was performed by Cox regression analysis.
Results: The mean age was 55.7 year old (SD: 13.5), and female gender took 69.9%. The total recurrence rate of BPPV was 37%. The 30-day, 1-year, 2-year, 3-year, and 4-year recurrence rates for those with horizontal canal BPPV (N $=$ 295) were 4.2%, 17.5%, 21.0%, 25% and 29.7%, respectively; and 4.1%, 22.9%, 32.9%, 36.8%, and 42.8% for those with posterior canal BPPV (N $=$ 369). The patient with p-BPPV have higher recurrence rate than those with h-BPPV ($p = 0.018$ on Log rank test). Among the risk factors, female gender and history of prior BPPV history were associated with the high recurrence rate significantly ($p < 0.1$) and represented the significant hazard to the recurrence rate. In the case of head trauma history, it was correlated with low recurrence rate, but not low hazard ratio.
Conclusions: BPPV is recurrent in the substantial portion of patients and their majority was occurred within 1year. And p-BPPV was higher recurrence rate than h-BPPV. Female gender and prior BPPV history were found to be the factors raised the recurrences.

PD-97

The protective effect of resveratrol on vestibular hair cells death

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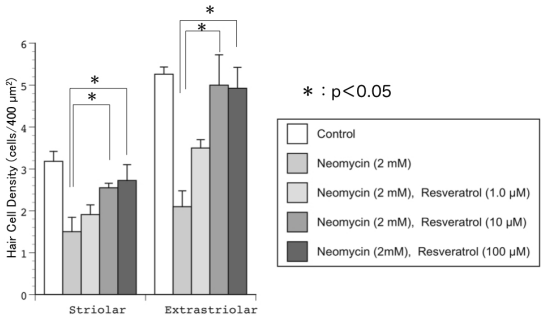
Background: Recently, the several reports elucidated the many kinds of polyphenol could protect tissue against the stress. Resveratrol is well known as the polyphenol abundant in grapes. This molecule has demonstrated reactive oxygen species (ROS) scavenger activity. In this present study, we studied the effect of resveratrol on vestibular hair cell death induced by aminoglycoside.
Objectives: CBA/N mice with normal Preyer's reflexes were used in this study.
Methods: The temporal bones were quickly removed and the individual vestibular organs were dissected in medium with sterile technique. Hair cell death was induced by neomycin. Cultured utricles were divided to three groups (Control group, Neomycin group, Neomycin $+$ Resveratrol group). In Neomycin group, utricles were cultured with neomycin (2 mM). In Neomycin $+$ Resveratrol group, utricles were cultured with neomycin and resveratrol ($100 - 1.0$ μM). Twenty-four hours after exposure to neomycin, the cultured tissues were fixed with 4% paraformaldehyde. The hair cells were labeled by immunohistochemistry using anti-calmodulin antibody, and anti-calbindin antibody. The rate of survival vestibular hair cells was evaluated with the fluorescence microscope. In addition, we investigated the production of hydroxy radical by immunohistochemical analysis of 4-hydroxy-2-nonenal.
Results: The almost hair cells survived for 24 hours in Control group, though the hair cell death was observed in Neomycin group. The hair cell death was inhibited in Neomycin $+$ Resveratrol group. The survival rate of hair cells was significantly more in Neomycin $+$ Resveratrol group than in Neomycin group. The production of ROS by the exposure to neomycin was inhibited in Neomycin $+$ Resveratrol group.
Discussion: The results indicated that resveratrol protected the sensory hair cells against neomycin-induced cell death in mammalian vestibular epithelium. Resveratrol was known as the strong anti-oxidant. In addition, the molecule is derived from a natural plant. Therefore, resveratrol can be safely used as the protective drug in the inner ear.

Conclusion: Resveratrol protected the vestibular hair cells against the hair cell death induced by aminoglycosides.



The density of survived hair cells

PD-98

A much better visual acuity could suppress the magnitude of the nystagmoid oscillation in a case of congenital nystagmus

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Introduction: Congenital nystagmus (CN) is a common disorder but its precise incidence mechanism has not been fully understood. We did cataract surgery and she subsequently showed remarkable suppress in both amplitude and frequency of the nystagmoid oscillation, and improving subjective visual activities. Here we mention underlying possible mechanism of CN. Report of a Case A 75-year-old female with CN revisited in our follow-up clinic for complaining of her feeling halos in the evening twilight by car headlamps in May 26, 2006. Immediately after referring to our ophthalmologic division, ophthalmologic findings in June 23, 2006 said as follows:Congenital nystagmus and no family history; Visual acuity: Vd = 0.09 (0.4 × + 2.5D = cyl + 0.75D Ax170°), Vs = 0.1 (0.4 ×+ 1.75D); Past history: Left-breast cancer (partial mastectomy). Cataract surgery with lens implantation was carried out under local anesthesia in August 24 and 31, 2006. After the operation, ophthalmologic findings in October 9, 2007 said as follows:Visual acuity: Vd = (0.8p × IOL) 1.2p × IOL = + 0.25D = cyl-0.75D Ax10 °) and Vs = (1.0p × IOL) (1.2 × IOL = + 0.25D = cyl-1.0D Ax85°). The magnitude of the nystagmoid oscillation was suppressed with regard to horizontal component of the nystagmus after the operation. She now much feels more confident to walk around the street and do not notice any adverse effect after the operation.

Discussion: We would like to know the mechanism why the magnitude of the nystagmoid oscillation was suppressed in this case. We discussed it and mentioned two probabilities, which are an altered proprioceptive input of the eyes and her acquired much better visual acuity, after the operation. The former was easily rejected, because the weight of the intraocular lens is lighter than that of the crystal lens. The latter is the most likely. There can be the fixation mechanism in CN. So, we tried to prove whether or not the Frenzel's glass, which can make a blurred vision and we can fixate out of focus on the retina by using it, could suppress the magnitude of the nystagmoid oscillation in this case. Wearing the Frenzel's glass and no lens were performed as the same instruction. Eye movements were recorded while the patient's left eye tried to fixate on the examiner's nose in front of her at the primary position. The patient's steady fixation of the right eye was recorded around one minute by using an infrared CCD camera. The data were analyzed by a new version of the NIH Image. Peak to peak range of the horizontal component was as the magnitude of the nystagmoid oscillation. Around ten seconds of data during fixation in the light was measured and compared with each experimental condition. The magnitude range of nystagmoid oscillation was from 8.49° (September 18, 2008) to 18.51° (July 8, 2008) with the Frenzel's glass and 3.05° (July 8) to 5.47° (September 18) with no lens. According this, the Frenzel's glass could not suppress the magnitude of the nystagmoid oscillation and we thought her acquired much better visual acuity could improve her visual activities. This case can be something special at the moment. This cataract surgery, if we have got a bold speculation, could be one of probabilities in the treatment for CN.

PD-99

Effect of furosemide in patients with Ménière's disease.

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Objective: Ménière's Disease is a clinical syndrome of the inner ear characterized by episodic vertigo, aural fullness, tinnitus and sensorineural hearing loss. Although these symptoms can be temporarily reduced by

conventional medical treatment such as salt restriction, diuretics and steroids, these symptoms recur at different intervals in patients with Ménière's Disease. For intractable patients with Ménière's Disease, intratympanic gentamicin injection is performed. Although intratympanic gentamicin injection is effective in control of vertigo with intractable Ménière's Disease, some patients refuse intratympanic gentamicin injection for reasons of the risk of sensorineural hearing loss and prolonged disequilibrium. For these patients, we use furosemide 10-20mg/day. We examined whether use of furosemide was effective in the control of vertigo and hearing level in patients with intractable Ménière's Disease.

Methods: Twenty-two patients with Ménière's Disease were studied. These patients were treated with conventional medical treatment over six months from their first visit, and switched medicine from isosorbide to furosemide for reasons of poor control of vertigo or hearing symptom. We evaluated vertigo control and hearing outcome. For evaluation of vertigo control, we compared the number of episodes of vertigo per month for 6 months before switched medicine and the number of episodes per month for 18 to 24 months after switched medicine. We also compared functional level scale according to the guidelines of the AAO-HNS Committee on Hearing and Equilibrium. Auditory examination was conducted using pure tone average at frequencies of 125 Hz, 250 Hz and 500 Hz (dB HL) for evaluation of hearing outcome. We additionally analyzed hearing at frequencies of 2 kHz, 4 kHz and 8 kHz (dB HL).

Results: Control of vertigo: Thirteen out of twenty-two patients (59.1%) had complete or substantial vertigo control, six out of twenty-two patients (27.3%) had limited or insignificant vertigo control and three out of twenty-two patients (13.6%) had worse vertigo control. Sixteen out of twenty-two patients (72.7%) were improved in the functional level scale, four out of twenty-two patients (18.2%) does not change the functional level score and the others were got worse.

Hearing outcome: Hearing levels did not improve after switched from isosorbide to furosemide in most of patients.

Conclusions: Although hearing levels were not improved, furosemide was effective in control of vertigo for the patients with intractable Ménière's Disease.

PD-100

Postural control and adaptation are influenced by preceding postural challenges

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We investigated the possible consequences of two consecutive postural tasks on adaptation. Four groups (total number of 46 healthy subjects) were perturbed on two consecutive days with vibration stimulus to Tibialis Anterior or posterior calf muscles, or both in different orders. Postural movements were recorded with a force-platform. There were three major results; 1) Tibialis anterior vibration instigated postural adaptation during exposure to the vibration, but did not induce long-term adaptation from day to day, contrary to posterior calf vibration. 2) The long-term postural adaptation from day to day when the posterior calf was vibrated was not affected by prior or subsequent tibialis anterior vibration, which contrasts to other studies on motor learning. 3) Exposure to posterior calf vibration prior Tibialis Anterior vibration, led to changes of postural strategies and larger amount of torque variance, implying that postural strategies initiated by the gastrocnemius vibration were re-employed during the subsequent tibialis anterior stimulation. This may represent the formation of an internal model, used as feedforward control of posture, possibly consisting of sensory reweighting.

Postural perturbations need to be sufficiently difficult to withstand, in order to induce long-term learning, and postural strategies may be transferred between different postural challenges if they post different demands. Clinically, this suggests that exercises designed to rehabilitate patients should be sufficiently challenging to instigate learning processes, and spaced in order to avoid development of inappropriate postural strategies.

PD-101

Prospective analysis of treatment outcomes between geotropic and apogeotropic type in HC-BPPV

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Background and Objective: In benign paroxysmal positional vertigo of horizontal canal (HC-BPPV), differences of treatment outcomes between two subtypes (geotropic and apogeotropic types) have been variably

reported. In addition, various otolithic repositioning maneuvers have been suggested for treating these types of HC-BPPV. In this prospective study, we tried to compare the treatment outcomes between two subytypes of HC-BPPV and evaluate the efficacy of single otolithic repositioning maneuver(Barbecue maneuver) using the videonystagmography (VNG).

Materials and Methods: Fourty nine patients were included in this prospective study who visited our clinic and diagnosed as HC-BPPV serially from August 2008 to July 2009. They were subdivided into geotropic and apogeotrpic types according to the direction of nystagmus induced by positional roll test. Once HC-BPPV was confirmed, every patient was treated using barbeque maneuver at the same day. After a week, patients revisited outpatient clinic and the positional roll test was performed using VNG. Treatment success was defined as maximal slow phase velocity was below 2 deg/sec without subjective symptom. If not successfully treated, another successive attempt of barbeque maneuver was performed every week.

Results: Among 49 patients, geotropic type was 23 and apogeotropic type was 26. In geotropic type, nine cases (39%) were successfully treated by single maneuver. However, three patients (13%) needed more than four times of maneuver. The average numbers of repositioning maneuver was 1.95, and the average of initial slow phase velocity of nystagmus was 30 (5–78) deg/sec. On the other hand, in apogeotropic type, 16 patients (62%) were successfully treated with single maneuver, and 3 (12%) cases needed more than four. The average numbers of maneuver was 1.78, however, there was no statistical difference ($p > 0.05$). The mean value of the first slow phase velocity was 18 (7–31) deg/sec.

Conclusion: In this prospective analysis, there were no significant differences in treatment outcomes between geotropic and apogeotropic types of HC-BPPV. In addition, Barbecue maneuver was equally effective for both types.

PD-102

Treatment of posture and gait disturbance in a patient with advanced Parkinson's disease using simultaneous PPN and STN DBS

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Objective: To report on the preliminary kinematic findings of simultaneous bilateral subthalamic nucleus (STN) and pedunculopontine nucleus (PPN) deep brain stimulation (DBS) treatment for posture and gait disturbance in a patient with advanced Parkinson's disease (PD).

Background: As PD progresses, many patients develop axial motor symptoms of postural dysfunction and gait problems which are generally drug resistant. DBS of the STN is the current surgical method of treating these patients. Stimulation of this area has been shown to improve the cardinal symptoms of PD but has been less effective in treating the axial motor symptoms [Mov Disord, 2004. 19(9): 1092–1099; Clin Neurol Neurosurg, 2006. 108(5): 461–464]. It has recently been shown however, that a combination of bilateral stimulation of the STN and PPN may improve both the cardinal symptoms of PD and the axial motor symptoms [Brain, 2007. 130(Pt 6):1596-607; Brain, 2010. 133(Pt 1): 205–14]. Unilateral PPN stimulation has also been shown to improve falls in PD [Brain, 2010. 133(Pt 1): 215–224].

Methods: A 56-year-old, right-handed man with advanced idiopathic PD of 8-years duration and history of freezing of gait, postural instability, marked "Off" akinesia and "On" dyskinesia underwent simultaneous bilateral STN and PPN DBS implantation. With the patient in half "Off"-half "On"medication state, gaze displacement and inter-segmental co-ordination during large whole body voluntary rotations [Exp Brain Res, 2009. 193(3): 323–336] were analysed during bilateral STN and PPN DBS.

Results: Successful simultaneous implantation of bilateral STN & PPN electrodes was confirmed on postoperative stereotactic imaging. On DBS of STN at 2.5 V, 130 Hz, 60 microseconds and PPN at 2.0 V, 20 Hz, 60 microseconds, the following kinematic improvements were noted: 15% & 62% reduction in trunk & feet latencies respectively, 54% & 302% increase in trunk & feet velocities respectively, 60% reduction in the number of steps needed and 93% increase in the fraction of the desired angular displacement achieved with the first step (all $p < 0.01$).

Conclusion: Simultaneous bilateral STN and PPN DBS offer the possibility of ameliorating both the cardinal and the axial motor symptoms in advanced PD. The motor paradigm adopted [Exp Brain Res, 2009. 193(3): 323–36] provides objective evidence of performance changes in the relevant axial motor segments.

PD-103

Influence of occlusal splints on equilibrium function

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We present a patient with prolonged dysequilibrium after total extraction of an acoustic tumor, whose dysequilibrium was improved by occlusal splints and physical therapy. We also discuss the influence of occlusal splints on posture and equilibrium function.
The patient was a sixty-year-old woman who had undergone total extraction of an acoustic tumor with a diameter of 18mm. After the tumorectomy, she suffered from dizziness. hough drug therapy was performed, the dizziness did not improve. No psychiatric diseases were found. She consulted us 2 years and 3 months after the operation. Her chief complaint was dizziness while walking. When she walked with someone, she unconsciously held on to a sleeve of the person she was walking with. She was diagnosed as having temporomandibular joint disorder. An occlusal splint was put on and physical therapy was simultaneously performed. Two months after the treatments her dizziness disappeared and she became able to walk without holding on to other person's. Her improvement in equilibrium function was objectively proved by posturography and gait analysis.
In conclusion, occlusal splints have an influence on postures and equilibrium function in some patients with physical dysfunction. Temporomandibular joint disorders have the possibility of preventing compensation for equilibrium dysfunction. In rehabilitation for equilibrium dysfunction medical measures to deal with the causes of decompensation are required.

PD-104

3D angular vestibulo-ocular reflex adaptation to chronic motion-modulated multichannel prosthetic stimulation of semicircular canal ampullary nerves

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We have previously demonstrated that prosthetic electrical stimuli delivered to bilaterally vestibular-deficient animals using the Johns Hopkins Multichannel Vestibular Prosthesis (MVP) can partially restore the normal 3-dimensional angular vestibulo-ocular reflex (aVOR). However, spurious stimulation of nontarget axons due to current spread distorts in the vestibular nerve activation pattern, resulting in misalignment between the actual axis of head rotation (detected by MVP sensors) and perceived axis of rotation (as indicated by the axis of the aVOR eye movement response). Optimization of electrode design, surgical technique and stimulus timing have achieved eye movement responses that are better aligned with the axis of head rotation, and vector compensation of residual 3D misalignment can further improve results (see Chiang et al.; Davidovics et al.; Fridman et al.; this conference). Nonetheless, some residual error in the vestibular nerve activation pattern is unavoidable. We hypothesized that over time, central nervous system (CNS) plasticity mechanisms that mediate cross-axis adaptation in otherwise normal animals will adapt to the distorted signals as needed to correct residual misalignment.
To test this hypothesis, we examined the changes in aVOR response misalignment over the first week of MVP use in 5 chinchillas rendered bilaterally vestibular deficient via gentamicin treatment and canal plugging prior to unilateral implantation of intralabyrinthine electrodes in each of the 3 left semicircular canals (SCC). Prosthesis circuitry was securely affixed to the top of the head of each chinchilla and connected to electrodes through a percutaneous connector. 3D aVOR responses during head rotation in darkness about each of the three SCC axes were measured on the 1st, 3rd and 7th day after MVP activation using 3D video-oculography. We used 3D aVOR axis as a proxy for perceived axis of head rotation.
On the first day after prosthesis activation, the dominant-component aVOR gain in response to 50 °/s peak sinusoidal head rotation at 2 Hz about the horizontal, left-anterior/right-posterior (LARP) and right-anterior/left-posterior (RALP) SCC axes ranged from 0.13–0.55, which agrees with the normal chinchilla aVOR gain. However, significant misalignment (range: 31–47°) was observed between the perceived (i.e., aVOR) and actual head rotation axes. After 3 days of wearing the prosthesis, gain for the desired component remained approximately constant as compared to the first day, but reduction in off-axis response components resulted in a decrease of misalignment (range: 25–33°). When the animals were tested on the 7th day, the desired component gain remained constant or slightly increased, while off-axis components and overall misalignment further decreased (range: 12–25 °).
We conclude that the CNS cross-axis adaptation mechanisms can be relied upon to improve the alignment of aVOR responses – and presumably head movement percepts – during chronic use of a multichannel vestibular

prosthesis. Topics of interest for future study include the dependence of this process on the extent of initial misalignment, long-term outcomes of axis adaptation, impact of visuo-vestibular training paradigms similar to vestibular rehabilitation exercises in clinical use, and the resolution of conflicts between head rotation axis as encoded by the two vestibular nerves.
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PD-105
The clinical features of vertigo with psychogenic origin
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Introduction: Of the 694 patients who had visited the author's outpatient clinic during two years and nine months in our university hospital, 21 patients had also visited psychiatric clinic at once. Furthermore there is a possibility that patients with vertigo with psychogenic origin might exist even in the patients suffering from vertigo whose pathogens were not clear.
Objectives: The aim of the present study is to clarify the clinical features of vertigo with psychogenic origin, and to distinguish vertigo with psychogenic origin in order to give them immediate and proper treatment.
Subjects and Methods: Out of 694 who had visited the author's vertigo clinic, 21 patients who were supposed to have psychogenic origin were analyzed of their clinical findings; 1) the features, duration, frequency of vertigo, 2) the complaints besides vertigo, 3) the outcomes of the questionnaire related to anxiety and depression, 4) the situations in which the vertigo often arise, 5) the contradiction between symptoms and examinations, and 6) the course their vertigo.
Results: The clinical ferture seen in the patients with vertigo of psychogenic origin were, 1) this disease most frequently affects females in their 20th, 30th, and 40th years. 2) this disease were frequent in patients with anxiety disorders and with depression, 3) dizzy or floating sensation were most frequent followed by rotating vertigo, 4) the patients often complained symptoms besides vertigo, especially related to digestive organ such as nausea or vomiting, loss of motivations, or numbness, 5) nystagmus were not seen even when the patients complain vertigo, 6) fainting or positional vertigo were frequent, 7) vertigo arose in the specific condition, such as always they were in the tram, 8) the patients felt better when they walked or run compared to when they sat still.
Discussion: We have to treat patients with psychiatric procedures when we see the clinical features such that were mentioned above in the vertigo patients.

PD-106
Design and performance of a multichannel vestibular prosthesis that restores semicircular canal sensation in rhesus monkey
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In normal individuals, the vestibular labyrinths sense head movement and mediate reflexes that maintain stable gaze and posture. Bilateral loss of vestibular sensation causes chronic disequilibrium, oscillopsia, and postural instability. We have previously described a multichannel vestibular prosthesis (MVP) intended to restore modulation of vestibular nerve activity with head rotation (Della Santina, Migliaccio and Patel, 2007). Although that device has been successful in partially restoring the 3-dimensional angular vestibulo-ocular reflex (3D aVOR) in chinchillas rendered bilaterally vestibular-deficient via intratympanic gentamicin and surgical plugging of semicircular canals (SCC), its relatively large thickness ($\sim$ 11 mm) and high power consumption constrained its use for chronic in vivo studies of device performance.
Here we describe a new version of the Johns Hopkins MVP, which incorporates many improvements over previous prototypes. Like the prior MVP1 design, the MVP2 comprises motion sensors to measure rotation, a microcontroller to calculate pulse timing, and stimulator units that deliver constant-current pulses to microelectrodes implanted in the labyrinth. However, the MVP2 also incorporates multiple enhancements, including: a 50% decrease in implant thickness, a 50% decrease in power consumption (and corresponding doubling of battery life), sensors for 3D gravitoinertial acceleration, a new microelectrode array design meant to simplify implantation and reliably achieve selective nerve-electrode coupling, multiple current sources that confer ability to simultaneously stimulate on multiple electrodes, and circuitry for in vivo measurement of electrode impedances.
We evaluated the performance of this device through in vitro bench-top characterization and in vivo physiological experiments with a rhesus macaque monkey. As expected, the device partially restored the normal 3D aVOR in a rhesus monkey rendered bilaterally vestibular-deficient via intratympanic gentamicin and

SCC plugging. Preliminary experiments exploring the use of a tripolar electrode configuration demonstrated improved performance (i.e., higher response amplitude for a given degree of response misalignment) over that achieved with the bipolar configurations to which the MVP was effectively limited.
While production of an MVP appropriate for clinical deployment will likely require further reduction in device size and power consumption, hermetic encapsulation, and other additional enhancements, the MVP2 provides an excellent platform for neurophysiologic and behavioral studies requiring chronic multichannel electrical stimulation of the vestibular nerve in nonhuman primates.
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PD-107

Vestibulo-ocular reflex responses to a multichannel vestibular prosthesis incorporating a 3D coordinate transformation for correction of misalignment

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We have previously shown that prosthetic electrical stimuli delivered to bilaterally vestibular-deficient animals using the Johns Hopkins Multichannel Vestibular Prosthesis (MVP) can partially restore the normal 3-dimensional angular vestibulo-ocular reflex (3D aVOR). However, spurious stimulation of nontarget axons due to current spread distorts in the vestibular nerve activation pattern, resulting in misalignment between the actual axis of head rotation (detected by MVP sensors) and perceived axis of rotation (as indicated by the axis of the aVOR eye movement response). Optimization of electrode design, surgical technique and stimulus timing has achieved eye movement responses that are better aligned with the axis of head rotation (see Chiang et al.; Davidovics et al.; this conference). Nonetheless, residual errors in the vestibular nerve activation pattern and resulting 3D aVOR response axis unavoidably occur. We hypothesized that the electrically-evoked aVOR is sufficiently linear that a standard linear algebraic orthogonalization approach can correct for residual 3D misalignment through "vector precompensation" of stimuli.
To test this hypothesis, we examined 3D aVOR responses of four chinchillas implanted unilaterally with vestibular prosthesis electrodes after intratympanic gentamicin and semicircular canal plugging resulting in bilateral vestibular areflexia. We first examined the relationship between aVOR response amplitude and stimulus intensity (SI, equal to depth of pulse frequency modulation after piecewise-linear transformation from MVP gyro sensor inputs to instantaneous pulse rate of symmetric biphasic current pulses, expressed as a percentage of the maximum expected gyro angular velocity [300/°s]). This relationship was nearly linear over the range examined, with R2 $>$0.93 for linear fits to data.
We then examined 3D aVOR responses to "raw" prosthetic stimuli (i.e., without vector precompensation) encoding 65 different head rotation axes, and found misalignment error of 27.5 $\pm$ 14.4° (mean $\pm$ SD) for 50% SI stimuli. Desired and actual 3D aVOR response axes for each of the 65 different stimulus combinations were then used to compute a precompensation matrix using QR decomposition. After vector precompensation, misalignment decreased to 16.5 $\pm$ 9.6°. The precompensation approach also effectively normalized response velocity across all axes tested. For each animal, misalignment and velocity errors were lower with precompensation than without for every SI examined. This reduction in error was more pronounced for higher SI stimuli representing faster head rotations.
Our observations confirm that the prosthetically evoked 3D aVOR exhibits linearity and vector summation to sufficient extent that a vector precompensation strategy incorporating a linear coordinate system transformation derived from desired and measured responses to a priori stimuli can significantly correct misalignment of eye movement responses (and presumably of head movement percepts) that would otherwise occur due to current spread beyond the intended nerve target. This optimal transformation, which effectively encodes both reorientation and rescaling of stimulus intensities, significantly corrected both the axis and amplitude of eye rotational velocity. Incorporating this correction allowed us to maintain 3D aVOR alignment while reliably achieving larger peak eye movement response velocities than we and others have reported previously. Responses to unilateral prosthetic stimulation exhibited excitation-inhibition asymmetry before and after precompensation, but the degree of asymmetry was similar to responses of animals with a single normal labyrinth experiencing natural head rotation stimuli.
In the work presented here, we focused on creating a single compensation matrix based on best-fit whole cycle sinusoids. It may be possible to reduce error fur-

ther by incorporating different precompensation matrices that depend on the sense and magnitude of head rotation. Whether this or other more computationally intensive strategies is necessary will depend on the degree to which central nervous system adaptive mechanisms can correct for residual 3D aVOR errors during chronic MVP use (Dai et al., this conference).
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PD-108

Effects of biphasic current pulse frequency, amplitude, duration and interphase gap on eye movement responses to prosthetic electrical stimulation of the vestibular nerve

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We have previously demonstrated that prosthetic electrical stimuli delivered to bilaterally vestibular-deficient animals using a multichannel vestibular prosthesis (MVP) can partially restore the normal 3-dimensional angular vestibulo-ocular reflex (3D aVOR). However, the optimal stimulus encoding strategy for such a device is not yet known.
We investigated effects of varying biphasic current pulse frequency, amplitude, duration and interphase gap on 3D aVOR eye movements measured using video-oculography in chinchillas. Increasing pulse frequency increased response amplitude while maintaining a relatively constant axis of rotation. Increasing pulse amplitude (tested range 0–325 μA) also increased response amplitude but spuriously shifted eye movement axis, probably due to current spread beyond the target nerve. Shorter pulse durations (tested range 28–340 μs) required less charge to elicit a given response amplitude and caused less axis shift than longer durations, apparently because shorter pulse duration stimuli result in more spatially selective excitation of the targeted ampullary nerve. Varying interphase gap had no significant effect over the range examined (25–175 μs). Although the specific values reported herein depend on microanatomy, electrode location and degree of neural survival in each case, qualitative aspects of these findings will likely hold true across species, including humans. We conclude that pulse frequency modulation (PFM) with short duration biphasic pulses should form the foundation for further optimization of stimulus encoding strategies for vestibular prostheses intended to restore sensation of head rotation. Modulation of pulse amplitude carries a greater tendency to elicit misalignment (due to current spread beyond the target ampullary nerve) but may offer benefit as an adjunct to PFM for modulating afferent activity during low velocity head rotations.
In light of experience with optimization of cochlear implant performance, restoration of stable gaze and posture in individuals disabled by loss of vestibular sensation will likely require some combination of timing optimization and other approaches, such as improvements in electrode design, multichannel vector correction of misalignment and rehabilitative paradigms that enlist central nervous system mechanisms of cross-axis adaptation (see Chiang et al.; Fridman et al.; Dai et al.; this conference). Efforts at further optimization of stimulus encoding protocols would benefit from complementing the 3D eye movement assay with direct measurement of single-unit activity in proximal vestibular nerve fibers, which might also help characterize differential effects of biphasic current pulse stimulus trains on fibers with different baseline discharge regularity.
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PD-109

Galvanic stimulation associated to vestibular rehabilitation to treat unilateral peripheral vestibular lesions

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Introduction: We studied the results of the Vestibular Rehabilitation (VR, using Susan Herdman protocol) plus Galvanic Stimulation (GS) in comparison with conventional VR.
Material and Methods: We studied 59 patients with unilateral peripheral vestibular lesions, divided in three groups: 1) 14 patients received conventional VR plus 5 sessions of GE: 1 minute stimulation 2 mAmp, in the mastoid. The direction of the stimulation was opposite of the body sway. 2) 5 patients received conventional VR and a sham protocol of GE: mastoid stimulation like the group one in two sessions and stimulation over the shoulder in three sessions, 3) 40 patients received only conventional VR.
The criteria of improvement were: a) reduction of the body sway in degrees, 2) subjective improvement through a questionnaire and 3) the total time of rehabilitation.
Results: 1) In the group 1 65% showed improvement

2) In the group 2 100% showed improve
Both group compared against the group 3 of conventional VR
Discussion: Even when the best results were obtained in the sham group and could be due to a placebo effect, the patients who received GS had a reduction of a 20% in average of the total time of VR and the highest level of subjective improvement, 90% in average.
Conclusion: GS associated to VR could be useful in reduce the time necessary to reach the goals of the VR in unilateral peripheral vestibular syndromes.

Poster Session 2 – E. Epidemiology

PE-110
The clinical characteristics and treatment outcome of post-traumatic BPPV

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Objectives: Head trauma is the most common cause of secondary form of benign paroxysmal positional vertigo (BPPV). However, little is known about clinical features and treatment outcomes of BPPV. We evaluate the clinical characteristics, response to treatment, short-term and long-term outcomes of post-traumatic BPPV.
Methods: We included 779 consecutive patients (mean age was 55.8 ± 14, female was 71%) with BPPV diagnosed by history of vertigo and positioning test. Post-traumatic BPPV was defined by onset of positional vertigo within 14 days of head trauma. 48 patients (6.1%) were diagnosed as post-traumatic BPPV. Mean age was 52.0 ± 14 years old and 67% were female. We compared site of canal involvement, head trauma type, response to canalith repositioning maneuvers and recurrence rate between idiopathic and post-traumatic BPPV groups.
Results: Although there seems to be higher proportion of bilateral involvement(4.2% vs 0.8%), younger (52 years old vs 56 years old) and lack of female dominance (67% vs 71%) in the t-BPPV group, there was no statistical difference. The most common causes of head trauma were falling down followed by car accident and blow to the head. Cure rates by 1 week were not different between two groups (91.7% vs 92.3%) All patients were treated successfully by repositioning maneuver or remitted spontaneously within 1 month. Recurrence occurred in 7 patients during the mean follow-up periods of 21.9 month. Short term recurrence rates between two groups were not different (12.0% vs 12.5%). However 3 year recurrence rates were significantly different between two groups (18.9% vs 40.3%). Factors related with recurrence were severity of head trauma.
Conclusions: Post-traumatic BPPV consist of 6.1% of all BPPV. There was no difference in response to repositioning maneuver and early recurrence rate between two groups. However, long-term outcome of post-traumatic BPPV was favorable.

PE-111
A research of disquilibrium disease at department of neurotology, Kitasato University Hospital

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Objectives: To investigate in the changes of incidence in each disequilibrium disease at Department of Neurotology, Kitasato University Hospital from 2004 to 2009.
Methods: The age, sex ratio, diagnosis, underlying disease and therapeutic methods in the patients, who were followed up in the outpatient clinic from 2004 to 2010, were evaluated.
Results: The total number of the patients in the outpatient clinic was slightly increased and the average of patient's age was obviously older than before. The number of patients having the disorders in central nervous system was decreased. However, one who has the disorders in peripheral vestibular apparatus was significantly increased. Especially, the number of the patients having Meniere's disease was significantly increased.
Conclusions: At the outpatient clinic, the number of Meniere's disease was significantly increased due to the referral of Meniere's disease patients to our outpatient clinic. By conducting hydration therapy (every day, restricted water intake 35ml/kg/day) for Meniere's disease, the result proves that the good therapeutic results are able to reduce vertigo attack and especially improve hearing in Meniere's disease.
It was considered that diagnostic imaging such as magnetic resonance imaging (MRI) was carried out in early stage of disease. The central balance disorders were diagnosed before the patients were referred to the department of neurotology. Therefore, in recent several years, the number of the disequilibrium patients with central nervous system disorder was decreased.

Poster Session 2 – F. Ageing and Balance

PF-112

Postural deficiency in intellectually disabled adult with vestibular impairment

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Background and Aims: Falls probability increases with age. Impaired balance in older adults with Intellectual Disability (ID) presents a special challenge to the health care system. Older adults generally serve as subjects of many researchers aimed to identify extrinsic and intrinsic factors related to falls. Methods: Cross-sectional study. A sample of 29 participants (age range of 34 to 57 years, mean 48.6 $\pm$, 16 males, 13 females) was chosen randomly from permanent foster home. The selected participants, excluded minimal loss of visual acuity, able to verbally communicate, lived at least 5 years in the foster home, were well familiar with their care-takers and independent with all activities of daily life (ADLs). The research included 2 phases: Phase 1 was dedicated to Vestibular Ocular Reflex (VOR) tests (Static and Dynamic Visual Test (VAT-S/D) and Head Impulse Test (HIT)) and Phase 2 was dedicated the Sensory Organisation Test (SOT) by the Computerized Dynamic Posture-Graph (CDP) system. Results: In phase one, 8 participants of the 29 (27.6%) had a positive VOR test. In phase two, 7 participants of the 8 with positive VOR (88%) had a positive SOT test. Conclusions: VOR screening tests succeeded to detect participants with balance impairment. Almost 30% of the sample population had balance deficiencies and therefore there is a strong motivation to define the source of the impairment. It will be interesting to find out if this source is age related or ID related, because if the later is true, then we will expect to find these symptoms in younger participants as well.

PF-113

Effect of vision, proprioception and the position of the vestibular organ on postural sway

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Objective: To investigate how postural sway was affected by provocation of vision, by the position of the vestibular organ and by provocation of proprioception, when measured together.

Method: There were 30 subjects in the study, 25 women and 5 men, all healthy adults between the ages of 21 and 59 (SD 12 years). They were 156 to 198 cm (SD 9.8 cm) tall. All subjects had normal range of motion in the neck, normal vestibular function and had no problems with dizziness, pain, dizziness or decreased range of motion in the lower extremities. All had normal vision, some of them after correction with glasses or lenses.

Postural sway was measured by using a force plate. On the basis of the vertical force signals from each corner of the platform, the system calculated mean speed of the movement of centre of pressure (CO) in mediolateral (ML) direction as well as in anteriorposterior (AP) direction (mm/s). Sway area (SA) (mm2/sec) was also measured. Tests were performed with eyes open and eyes closed, with head in neutral position and rotated to the right and to the left and with head maximally extended, both standing on firm surface and on foam. Mean values and standard deviations were calculated for each measure. Due to the fact that the observations are repeated measures within the same subject, there is dependence between measurements. Therefore, when comparing the different measures and to correct for this deviation from the pre-requisites for a traditional regression model, we used a multilevel approach, where a correction for dependence is built into the model.

Results: Measures of mediolateral (ML) speed (mm/sec), anteriorposterior (AP) speed (mm/sec) and sway area (SA) (mm2/sec) were analysed using multilevel approach.

This revealed a significant influence of how the postural sway was affected by closed eyes, standing on foam and by the position of the vestibular organ. Closed eyes and standing on foam both significantly prolongs the dependent measurement, irrespective if it is ML, AP or SA. However, only AP and SA were significantly affected by vestibular position, i.e. maximal head movement to the right and extension of the head.

Conclusion: It seems that vision and proprioception as well as position of the vestibular organ affect postural sway, vision the most. The position of the vestibular organ seems to affect postural sway the least.