

Three week results of transforaminal epidural steroid injection in patients with chronic unilateral low back related leg pain: The relation to MRI findings and clinical features

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Abstract.

BACKGROUND: Transforaminal epidural steroid injection (TESI) is a frequently used intervention for lumbar radicular pain.

OBJECTIVE: To evaluate the value of MRI findings, neurologic assessment and the Slump test (neurodynamic test) as predictors of treatment response to TESI.

METHOD: One hundred subjects (mean age 58 [SD13], 54% females) were included in this trial. The sample was stratified by location of disc herniation, grade of nerve root compression, clinically assessed neurologic deficit and positive Slump test.

Treatment response was primarily evaluated by Visual Analogue Scale for leg pain after three weeks. Predictive value for each stratum was analyzed using logistic regression after the sample was dichotomized into definite treatment response ($\geq 50\%$ reduction of pain) and negative response ($\leq 0\%$ reduction) to TESI (the 1–49% reduction group was excluded).

RESULTS: The overall definite treatment response rate was 27%. The Slump test was the only predictor of the response to TESI ($p = 0.031$). The definite treatment response rates for subjects with positive and negative Slump test were 33% and 15%, respectively.

CONCLUSION: In patients with chronic low back related leg pain, MRI findings and neurologic assessment results failed to predict treatment response, whereas a positive Slump test predicted the best 3-week response to TESI.

Keywords: Lumbar radicular pain, transforaminal epidural steroid injection, predictive value of tests

1. Introduction

Transforaminal epidural steroid injection (TESI) is a frequently used intervention for lumbar radicular pain, a syndrome commonly caused by disc herniation (DH) or foraminal stenosis [1]. Effectiveness of TESI in reducing leg pain has been determined with a maximum effect within one month after injection and then a gradual deterioration of outcome [2]. The ra-

tionale for TESI is to reduce the inflammation around the nerve root and subsequently reduce pain. It was shown that inflammatory cells are frequently present in the granulation tissue surrounding a DH [3] and that biomarkers of inflammatory disc degeneration obtained from epidural lavage could predict the response to TESI [4]. Radicular pain caused by DH with a frequently coexisting inflammation [5] is characterized by positive neurodynamic tests, such as straight leg raising (SLR) [6–8] and the Slump test [7,8], and also decreased forward bending [9].

This seems to suggest that a painful elongation of the neural structures reflects an inflammatory reac-

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tion to disc material and thus, a positive neurodynamic test might predict favorable outcome to an anti-inflammatory treatment such as TESI.

The treatment success rate for TESI was reported to be between 35–75% with the highest rates for subjects with acute symptoms [2]. For these subjects, foraminal DH [10], low-grade nerve compression [11] and neurologic deficit predicted treatment success in three reports [12] but failed to predict outcome in other reports [10,11,13]. For subjects with chronic symptoms the response rate was reported as significantly lower [2] and for those subjects, MRI verified DH at any location in contrast to non-discogenic foraminal nerve compression predicted favorable response to TESI [14]. These conflicting results may be due to the fact that MRI and neurologic examination fail to assess pain or low-grade inflammation and thus, additional tests (such as neurodynamic tests or an additional clinical assessment immediately post TESI) may play an important role in predicting the outcome of TESI.

The aim of this study was to compare effects of TESI between stratification groups according to MRI finding and clinical test results rather than evaluating the overall treatment effect. We evaluated the predictive value of MRI findings, neurologic assessment and the Slump test as predictors of the 3-week response to TESI and compared sub-group differences in reduction of leg pain (primary), self-reported disability (co-primary), forward bending and SLR (secondary).

2. Method

2.1. Hypotheses

We hypothesized that foraminal DH (in contrast to central/subarticular DH, MRI), low-grade compression of the nerve root (in contrast to high-grade, MRI), neurologic deficit (in contrast to no deficit, clinical), and positive (in contrast to negative, clinical) Slump test were better predictors of a definite short-term (3 weeks) treatment response to TESI. We also hypothesized that an immediate (30 min-post-TESI) improvement compared to baseline in self-reported leg pain, forward bending and SLR were predictors of a short-term (3 weeks) treatment response.

3. Subjects

Patients with low back related leg pain, referred to TESI from the orthopedic clinic at one single hospital

in the south of Sweden, were consecutively invited to participate in this prospective clinical trial. The decision to treat with TESI (level and side) was made in the normal clinical setting by an experienced orthopedic surgeon where the signs and symptoms were consistent with the MRI findings of nerve root involvement secondary to either DH or foraminal nerve root compression. Clinical indications for treatment were persistent low back related leg pain in spite of at least 3 months of conservative treatment (pharmacological treatment and physical therapy) in patients where surgery initially was disregarded due to predicted good prognosis without surgery, diagnostic uncertainty, long symptom duration or unwillingness to undergo surgery. All patients above 18 years of age, referred to TESI over a 19 month period (2011–2012) due to low back related leg pain, were eligible for inclusion in this study ($n = 151$). Exclusion criteria were: TESI within last year, bilateral leg pain, previous lumbar fusion surgery, neurological disease, cancer, pregnancy, autoimmune disease, and any known allergy to treatment agents. From those eligible, 46 were excluded (15 due to having TESI in the previous 12 months; 10 had bilateral radicular pain; 7 had lumbar fusion surgery; 12 had a history of chronic neurological disease; 1 had cancer; 1 had rheumatoid arthritis) and 5 patients declined participation due to unwillingness to participate in a scientific trial. Consequently, 100 patients with unilateral low back related leg pain were included in this study (Table 1). Prior to inclusion, the sample size was determined using power analysis. The minimal clinically important change of VAS was suggested to be 15 mm [15]. Using a standard deviation of 10 mm, a significance level (α) at 5% (type I error) and (β) at 10% (type II error), 27 patients per group were needed to detect a between group difference at 80% power.

All subjects provided signed informed consent and the study was not registered but approved by the ethics committee, Lund University, Sweden.

3.1. Treatment

All patients received a single TESI under fluoroscopic guidance. Each subject was placed in a prone position according to well established procedure [16]. After sterile preparation, a 3.5-inch spinal needle was gently advanced under fluoroscopic guidance to the triangular space formed cranially by the underside of the pedicle and a line to the lateral border of the vertebral, laterally by the border of the vertebral body and medially by the spinal nerve root (as the tangential

Table 1
Baseline characteristics before and after stratification according to hypotheses. All values are mean (95% CI) except when explicitly stated

Variable	All (<i>n</i> = 100)	DH location F/EF (<i>n</i> = 24)	High-grade subarticular nerve compression (<i>n</i> = 14)	High-grade foraminal nerve compression (<i>n</i> = 25)	Neurologic deficit (<i>n</i> = 70)	Positive slump (<i>n</i> = 67)
Age (years)	58(55–61)	61(56–65)	53(44–62)	61(56–66)	58(55–61)	57(53–60)
Gender (men) [n (%)]	46(46)	12(50)	6(43)	15(60)	34(49)	29(43)
BMI	27(26–28)	27(25–28)	26(24–28)	28(26–30)	27(26–28)	27(26–28)
Smoker (yes) [n (%)]	14(14)	4(17)	0(0)	2(8)	10(14)	11(16)
Duration of leg pain (months)	34(28–39)	32(20–44)	24(11–35)	38(26–49)	34(27–40)	31(24–37)
Lumbar surgery [n(%)]	17(17)	5(21)	2(14)	6(24)	12(17)	7(11)
Level of TESI L2-3/L4/L5/S1 (n)	7/12/68/13	2/7/15/0	1/0/9/4	3/3/19/0	4/6/47/13	3/5/46/13
Type of DH No/Protr/Extr (n)†	15/57/27	0/11/13	0/5/9	4/12/9	5/46/18	9/37/21
VAS leg pain (mm)	50(46–53)	45(38–52)	57(49–65)	43(37–49)	51(47–55)	53(49–56)
ODI (points)	44(39–49)	40(34–45)	44(39–49)	39(34–45)	44(41–47)	45(42–47)
FTF (cm)	26(22–29)	18(10–26)	30(20–41)	22(16–28)	29(24–33)	30(26–35)
SLR (°)	55(52–59)	58(50–65)	49(41–58)	58(52–64)	51(47–55)	50(46–54)

†Type of DH stratified as no, protrusion and extrusion. Abbreviations: DH, disc herniation; F/EF, foraminal or extraforaminal; BMI, body mass index; TESI, transforaminal epidural steroid injection; VAS leg pain, visual analogue scale for leg pain; ODI, Oswestry disability index; FTF, fingertip-to-floor test; SLR, Straight leg raise.

base of the triangle) for the lumbar nerve roots [16]. For S1 nerve root the needle was advanced under fluoroscopic guidance to the root through the posterior S1 sacral foramen. Proper perineural needle placement was determined by posterior and lateral fluoroscopic projections and was confirmed/not confirmed by the patient reporting radiating symptoms (yes/no). After proper needle placement, a mixture of bupivacaine hydrochloride (0.5 ml, Marcaine Spinal 0.5% Heavy) and methylprednisolone acetate 40 mg (1 ml Depo Medrol) was injected into the epidural space.

3.2. MR imaging

All MR acquisitions were made using a 1.5-Tesla imager (80% using one single Siemens Avanto scanner) and images were obtained at the level of the nerve root involvement. The imaging protocol included T2-weighted turbo spin-echo sequences obtained in the sagittal and axial plane and a T1-weighted spin-echo sequence obtained in the sagittal plane. All sequences had a maximum of a 4 mm slice thickness.

3.3. Image analysis

There was internal loss of MRI data in one subject due to poor quality of MR images. Consequently, 99 subjects were analyzed using MRI. MR images were analyzed by a well experienced radiologist (MA) using previously published classification systems [1,11,17,18]. The radiologist, who was blinded to all clinical information but the level of TESI, firstly, analyzed if DH existed, secondly, the type of DH (protrusion or ex-

trusion), thirdly, the location of DH (central, subarticular, foraminal and extraforaminal) according to Fardon and Milette [19] and finally, the grade of nerve compression according to Pfirmann et al. [1,11,18]. The subjects were classified as: no DH (*n* = 15), protrusion (*n* = 57) and extrusion (*n* = 27), and as: central (*n* = 15), subarticular (*n* = 45), foraminal (*n* = 18) and extraforaminal (*n* = 6) DH. The latter groups were collapsed into two groups (no DH was disregarded): central/subarticular (C/S) DH (*n* = 60) and foraminal/extraforaminal (F/EF) DH (*n* = 24), and were used to stratify the sample according to hypotheses.

3.4. Nerve compression

The grade of nerve compression, subarticular and foraminal, was assessed on axial T2-weighted images and sagittal T1-weighted images, respectively.

Subarticular nerve compression was assessed using the modification of a system described by Pfirmann et al. [11,18]. Grade I applied when the disc simply contacted the nerve root, Grade II when the nerve root was displaced but with preservation of periradicular cerebrospinal fluid (CSF) or fat, Grade III when the periradicular CSF or fat was obliterated, and Grade IV when the nerve root was morphologically distorted. Grade III + IV were considered as high-grade nerve compression [11]. The subjects were classified as: low (*n* = 85)/high (*n* = 14) grade subarticular nerve compression.

Foraminal nerve compression was assessed using a system introduced by Lee et al. [1]. Grade I applied when perineural fat was obliterated in two opposing

directions (vertical or transverse), Grade II when perineural fat was obliterated in four directions without morphologic distortion of the nerve root, and Grade III when distortion or other morphologic change in the nerve root was evident. Grade II + III were considered as high grade nerve compression. The subjects were classified as: low ($n = 74$)/high ($n = 25$) grade foraminal nerve compression.

Three groups of nerve compression were used for stratification in analysis: low-grade nerve compression ($n = 61$), high-grade subarticular nerve compression ($n = 14$) and high-grade foraminal nerve compression ($n = 25$). One subject was included in both of the latter groups.

3.5. Outcome measures

Clinical assessment was performed by the same experienced physical therapist specialized in manual therapy (HE) using an identical structure, at baseline (BL), within 30 minutes post TESI (30 min-post-TESI) and after three weeks. First, the fingertip-to-floor test was performed followed by neurological assessment, the Slump test, the SLR and the Slump knee bend. After clinical assessment, pain measures and demographic history were reported by the patient and last the self-reported disability questionnaire was filled out. The order of the assessments was pre-defined to minimize bias of the examiner due to information from the self-reports. Pain was reported at all three time points while disability was reported at the first and last visit.

Fingertip-to-floor test (FTF), a validated and responsive test with a minimal detectable change of 4.5 cm [20,21], performed in standing with lumbar and hip flexion according to the published instructions. The minimal vertical distance between the tip of the index finger and the floor was measured in centimeters [20].

The Slump test, a validated test to assess the presence/absence of lumbosacral neural mechanosensitivity [22,23] (Fig. 1). The test was performed in sitting through a combination of thoracolumbar flexion, cervical flexion, ankle dorsiflexion and knee extension, performed in this order. Using sensitizing maneuvers, beginning with the ankle and continuing with the neck, the test was considered positive if one of the maneuvers reproduced the symptoms and the symptoms were different from the contralateral side [22].

Slump knee bend, a validated test performed in side-lying on the non-affected side that assesses the presence/absence of neural mechanosensitivity (L2-L4) using knee flexion, hip extension and cervical flexion [24].



Fig. 1. The Slump test.

Straight leg raising test (SLR), a validated measure with a minimal detectable change of 6° [6,21], was performed on the affected leg according to the published instructions. The test was performed without ankle dorsiflexion. Range of motion angle between the tibial crest and the horizontal plane was measured using a goniometer in (non-rounded) degrees [25].

Neurologic deficit was determined by testing the patellar reflex, Achilles reflex, strength of large toe in dorsiflexion (additional muscle testing was disregarded in order to minimize the risk of aggravating pain) and sensibility (light touch and pinprick) in a specific dermatome. A positive sign was considered when one of the above deficits was present and differed from the unaffected side.

Leg pain was self-reported using the horizontal Visual Analogue Scale (VAS), a validated and responsive measure for pain (0–100, best to worst) with a minimal detectable change of 15 mm [26,27]. VAS was obtained for three different measures: present leg pain and minimum and maximum leg pain during the last four days. From these three measures an average pain score (VAS leg pain) was calculated.

Self-reported disability was measured using the Oswestry Disability Index (ODI), a widely used and valid instrument with a minimal detectable change of 9 points [27,28]. ODI consists of 10 self-reported items addressing different aspects of function. Each item is scored from 0 to 5, with higher values representing

greater disability. The total score is multiplied by 2 and expressed in points.

All MRI assessments, clinical tests and self-reported outcomes have shown adequate reliability previously [1,11,18,26,28,29]. Thus, an inter-rater reliability evaluation was not performed in this study.

3.6. Stratification

The sample was stratified, firstly, by location of DH (C/S and F/EF DH); secondly, by low-grade nerve compression, high-grade subarticular nerve compression and high-grade foraminal nerve compression; thirdly, by presence/absence of neurologic deficit and finally, by positive/negative Slump test. The Slump knee bend was excluded as a variable as only two subjects with negative Slump test results had positive Slump knee bend results.

3.7. Statistical analysis

Statistical analyses were made using SPSS (21.0). The relationship between the baseline values and the 3-week follow-up values of the primary outcomes were assessed graphically (Figs 2a+2b). A parametric analysis was performed for the entire sample and for each stratum (MRI and clinical), where change in VAS leg pain over three weeks (primary outcome), change in ODI over three weeks (co-primary outcome), change in FTF and change in SLR (secondary outcomes) were utilized to measure improvement from BL to three weeks after treatment using Student's T-test. The effect sizes were calculated for the primary outcomes [30].

Predictive value was first analyzed using chi-square for the variables according to hypotheses. Then a stepwise multiple logistic regression was performed for all explanatory variables (BL characteristics [Table 1], BL values of primary and secondary outcomes and for the results from 30 min-post-TESI assessments [Table 2]) that were significantly related to the dependent variables ($p < 0.05$). Two dichotomous dependent variables were constructed of the two primary outcomes after 3 weeks according to previously published cut-off points (definite treatment response, VAS leg pain $\geq 50\%$ reduction of pain and ODI ≥ 10 points reduction of disability; non-definite improvement, VAS leg pain 1–49% reduction and ODI 1–9 points reduction; negative response, VAS leg pain $\leq 0\%$ reduction and ODI ≤ 0 points reduction) [2,15,31]. The definite treatment response results and the negative results constructed the dichotomous dependent variables and non-definite

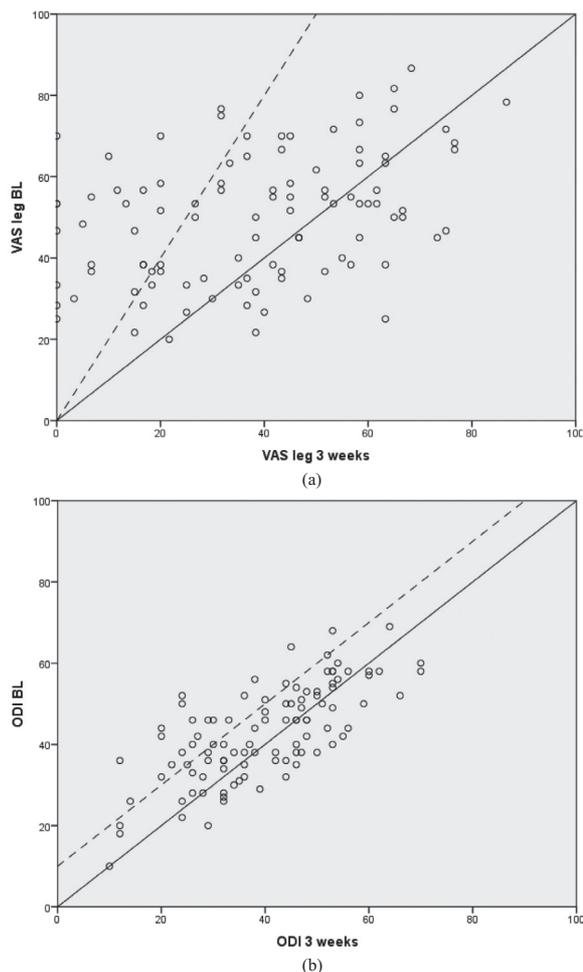


Fig. 2. (a) and (b) Relationship between VAS leg pain at baseline (BL) and at the 3-week follow-up and the respective relationship for ODI. The subjects displayed above the dotted lines had definite treatment response to TESI ($\geq 50\%$ and ≥ 10 points reduction for VAS leg pain and ODI, respectively) and the subjects displayed below the solid lines showed negative response.

improvement results were excluded from the predictive analyses. Nagelkerkes R^2 was used to describe the approximate proportion of the variation in response explained by the model.

4. Results

4.1. General

Overall, definite treatment response to TESI was found in 27 (VAS leg pain) and 24 (ODI) subjects. A non-definite improvement was found in 37 and 36 subjects, respectively, whereas the remaining subjects

Table 2

Improvement in primary and secondary outcomes obtained immediately (30 min) and 3 weeks after TESI and radiating symptoms during TESI. All values are mean (95% CI) except when explicitly stated

Variable	All (n = 100)	DH location F/EF (n = 24)	Subarticular nerve compression (n = 14)	Foraminal nerve compression (n = 25)	Neurologic deficit (n = 70)	Positive slump (n = 67)	Negative slump (n = 33)
TESI elicited radiation [n(%)]	77(77)	18(75)	13(93)	18(72)	56(80)	55(82)	22(67)
Improved VAS leg pain post TESI #	18(14–23)	12(–0.4–24)	30(20–40)	15(5.0–25)	21(16–26)	22(17–27)	12(3.0–21)
Improved FTF post TESI #	5.6(3.9–7.3)	2.8(1.1–4.6)	9.9(2.4–17)	4.1(1.6–6.6)	6.6(4.3–8.9)	7.5(5.2–9.8)	1.7(0.2–3.3)
Improved SLR post TESI#	3.0(1.0–4.9)	3.0(–0.1–6.1)	7.1(2.5–12)	1.8(–1.3–5.0)	4.1(1.5–6.7)	4.1(1.5–6.7)	0.7(–1.8–3.2)
Improved VAS leg pain 3 weeks	12(7.6–16)	6.7(–1.6–15)	14(1.4–26)	12(5.8–18)	13(8.4–18)	16(11–21)	3.6(–3.3–10)
Improved ODI 3 weeks	3.2(1.2–5.0)	2.1(–1.3–5.5)	7.7(1.1–14)	3.4(–0.5–7.3)	2.8(0.4–5.2)	4.3(1.7–6.9)	0.8(–1.5–3.0)
Improved FTF 3 weeks	4.5(2.5–6.4)	2.6(0.4–4.9)	7.0(0.0–14)	4.7(2.2–7.2)	5.4(3.1–7.6)	6.4(3.9–8.9)	0.5(–1.8–2.9)
Improved SLR 3 weeks	2.6(0.8–4.4)	3.2(–1.0–7.4)	4.5(–0.8–10)	2.2(–1.4–6.1)	3.4(1.2–5.6)	4.1(2.0–6.1)	–0.4(–4.1–3.3)

Improvement in comparison to BL in values taken 30 min-post-TESI. Significant improvements ($p < 0.05$) according to T-test in bold. Abbreviations: DH, disc herniation; F/EF, foraminal or extraforaminal; TESI, transforaminal epidural steroid injection.

(36 and 40) reported negative response to TESI after 3 weeks (Figs 2a+b). For the entire sample, a statistically significant mean change (improvement) was found in all four continuous variables: VAS leg pain (12, 95% CI 7.6–16 mm); ODI (3.2, 1.2–5.0 points); FTF (4.5, 2.5–6.4 cm); SLR (2.6, 0.8–4.4°). The corresponding effect sizes were 0.75, 0.29, 0.24, and 0.16, respectively.

4.2. MR imaging strata

Statistically significant mean improvement 3 weeks after TESI was found in VAS leg pain for all MRI findings groups except for those with foraminal/extraforaminal DH. Those with central/subarticular DH (mean [95% CI] 3.3[0.7–5.9]) and high-grade subarticular nerve compression (mean [95% CI] 7.7[1.1–14]; Table 2) were the only to show statistically significant improvement in ODI. All MRI findings groups improved in FTF and none improved in SLR after three weeks (Table 2).

4.3. Clinical test strata

The group with neurologic deficit and those with positive Slump test improved statistically significantly in all outcomes. Those without neurologic deficit improved only in ODI. The negative Slump test group showed the lowest and a statistically non-significant improvement of the four outcomes (Table 2).

4.4. Predictive analysis

Slump test results at BL predicted definite treatment response after 3 weeks in VAS leg pain ($p = 0.031$). Slump test ($p = 0.006$) and high-grade subarticular

nerve compression ($p = 0.008$) predicted definite treatment response in ODI (Table 3). All other BL variables (Table 1) and variables immediately post TESI failed to predict definite treatment response to TESI. In the multivariate analysis, the Slump test alone entered the models (VAS leg pain, $R^2 = 0.10$; ODI, $R^2 = 0.17$). The greatest and the lowest definite treatment response rates in VAS leg pain were found for the positive and negative Slump test group (33% and 15%), respectively and the greatest and the lowest definite treatment response rates in ODI were found for the subarticular nerve compression group and the negative Slump test group (57% and 6%), respectively (Table 3).

5. Discussion

In subjects with chronic low back related leg pain, a group with an expected response rate lower than for those with acute symptoms [2,32], we found a definite treatment response rate after 3 weeks of approximately 25%. However, our aim was not to evaluate treatment effect but to compare sub-group differences. Subjects with a positive Slump test demonstrated a significantly greater improvement compared to the group with negative Slump test and, as opposed to findings on MR images and of the neurologic examination, the Slump test was the only predictor of definite treatment response to TESI in VAS leg pain after 3 weeks in this study.

In order to successfully treat patients with radicular pain, e.g. with TESI, the disorder needs to be accurately diagnosed. As there is no consensus in distinguishing radicular pain from pseudoradicular pain [33], we stratified our sample by MRI findings and clinical findings suggestive of nerve root involvement based on previous publications [10,11,34], and

Table 3

Distribution of subjects with definite treatment response and negative response to TESI after 3 weeks evaluated by VAS leg pain and ODI, and χ^2 analyses to determine sub-group differences

	Improvement in VAS leg pain #				Improvement in ODI #			
	Definite treatment response (n = 27)	Negative response (n = 36)	Definite treatment response rate (%)	P-value†	Definite treatment response (n = 24)	Negative response (n = 40)	Definite treatment response rate (%)	P-value†
Location of DH				0.631				0.706
Central/subarticular	17	20	28		16	23	27	
Foraminal/extraforaminal	5	9	20		4	10	17	
No DH	5	7	33		4	7	25	
Subarticular compression				1.000				0.008
High-grade	3	4	21		8	3	57	
Low-grade	24	32	28		16	37	19	
Foraminal compression				0.540				0.421
High-grade	7	7	28		5	12	20	
Low-grade	20	29	27		19	28	25	
Neurologic deficit				0.650				0.826
Yes	18	22	26		18	29	26	
No	9	14	30		6	11	20	
Slump test				0.031				0.006
Positive	22	20	33		22	24	33	
Negative	5	16	15		2	16	6	

#Definite treatment response, VAS leg pain $\geq 50\%$ and ODI ≥ 10 points improvement; Negative response, VAS leg pain $\leq 0\%$ and ODI ≤ 0 points (subjects with non-definite improvement, VAS leg pain 1–49% and ODI 1–9 points improvement are excluded from the analyses). † χ^2 analysis, P-value < 0.05 in bold. Abbreviations: DH, disc herniation; VAS leg pain, visual analogue scale for leg pain; ODI, Oswestry disability index.

aimed to determine groups of likely favorable response to TESI. Previous studies on TESI suggested low-grade nerve root compression [11,35] and foraminal DH [10] as predictors of favorable response to treatment, however, our results failed to support these findings [10,11,35]. By contrast, we showed a significantly better response rate (ODI) for subject with high-grade subarticular nerve compression compared to those with low-grade compression.

Neurologic deficit, using electromyography (EMG) [12], was suggested as a predictor of favorable response to TESI and EMG was shown to be more specific than MRI in detecting radicular pain [36]. However, the use of EMG prior to TESI is debated as these results could not be reproduced [13] and as EMG usage increases the economic costs [37]. We determined neurologic deficit by clinical examination and, in agreement with previous results [11], we failed to predict the outcome after 3 weeks. A positive Slump test, however, predicted the outcome of this study. More importantly, in contrast to those with a negative Slump test, all primary and secondary outcomes improved significantly for the group with a positive Slump test. Thus, our results are in agreement with results by Stretanski where a relationship between positive Slump test and perineural inflammation was suggested and a more successful response to TESI was shown for the group with inflammation [34].

Interestingly, for the group with positive Slump test, our results showed a statistical significant improvement in the primary outcome and a simultaneous significant improvement in FTF, and this improvement for FTF well exceeded the previously described minimal detectable change of 4.5 cm [21]. Thus, our results seem to support previous results [16,21] that showed FTF to be a useful additional outcome measure for patients with radicular pain.

In agreement with previous results [38], the measures obtained 30 min-post-TESI failed to predict the primary outcomes after 3 weeks. The explanation of this might be that the local anesthetics provide an immediate pain relief whereas corticosteroids have anti-inflammatory properties [39] that provide a delayed response especially for the subjects with inflammation.

Our results showed an overall widespread variation in treatment response among the subjects and the rates of definite treatment response to TESI were relatively low (24–27%). Previously, chronic symptoms and foraminal nerve compression predicted poor response to TESI [2,14,16] and the general long mean duration of symptoms and high frequency of cases with foraminal nerve compression in the present study might explain the low response rates. The definite treatment response rates for those with negative and positive Slump test varied between 6% and 33%. This

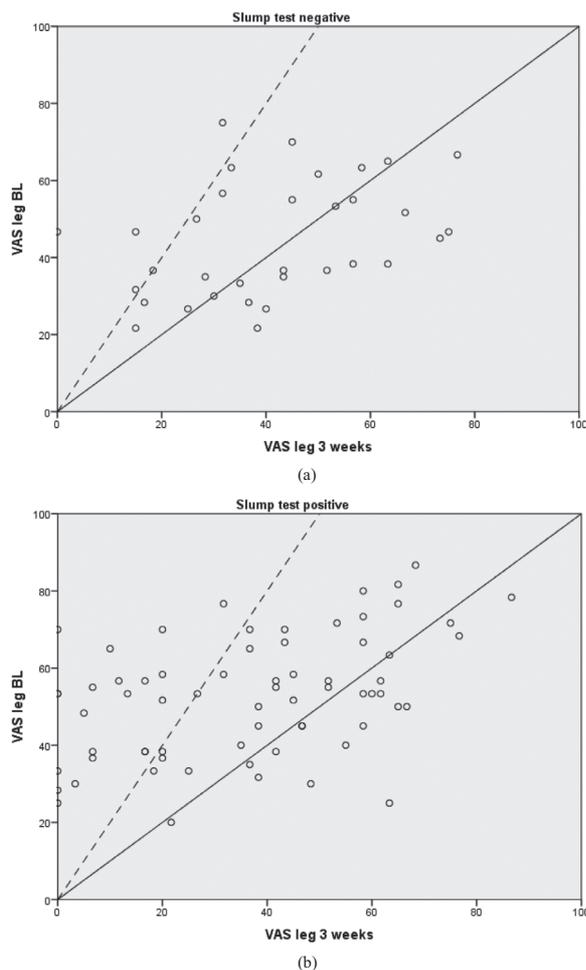


Fig. 3. (a) and (b) Relationship between VAS leg pain at baseline (BL) and at the 3-week follow-up for subjects with negative Slump test and positive Slump test, respectively. The subjects displayed above the dotted lines had definite treatment response ($\geq 50\%$ improvement) and the subjects displayed below the solid lines showed negative response.

obvious variation in response to TESI among our subjects emphasizes the importance of sub-group analysis.

Our study had limitations, firstly the study design restrained us from evaluating the overall effectiveness of TESI due to lack of control group. However, our study was designed to identify differences between groups identified using MRI and clinical testing at the time point when the effect of TESI was expected to be the greatest [2]. Longer-term follow-up and the inclusion of a control groups are needed to shed light on the effectiveness of TESI in patients with low back related leg pain. Secondly, TESI was performed under fluoroscopy but without contrast medium. However, contrast spreading is difficult to analyze and the use of con-

trast medium is debated [40,41]. The position of the needle is regarded as the most significant factor when distributing TESI and the present study followed the previously stated and reliable methods [16,40,41]. Finally, selection bias in the inclusion process could have occurred as all patients with unilateral low back related leg pain were not referred to TESI from the clinic (i.e. surgery could have been decided upon without a prior TESI in some few cases). Still, our sample has similar characteristics as previous reports on TESI treatment and chronic radicular pain [14,42] but the results presented here may not be generalizable to all subjects with chronic low back related leg symptoms.

Although MRI findings and clinical neurologic assessment is useful in determining the level of TESI treatment, the findings in the present study suggest that the Slump test appears superior in predicting short-term response to TESI. Thus, we recommend clinicians to use the Slump test prior to deciding on TESI treatment where better outcome could be expected among those with a positive Slump test as opposed to those with a negative test.

6. Conclusion

In patients treated with TESI due to chronic low back related leg pain, MRI findings and neurologic deficit failed to predict the 3-week treatment response. Patients with positive Slump test showed the greatest favorable 3-week response to TESI whereas patients with negative Slump test had no or minor respective effect.

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Conflict of interest

None to report.

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