Electromyographic study to predict functional outcome of transforaminal epidural steroid injection in lumbosacral radiculopathy

Hussein Sultan[a], Tamer H. Shehata[b], Wafaa S. El-Emary[a], Shehad M. Fakhry[a]

Departments of [a]Physical Medicine, Rheumatology and Rehabilitation, [b]Neurosurgery, Faculty of Medicine, Alexandria University, Alexandria, Egypt

Correspondence to Wafaa S. El-Emary, MD, Department of Physical Medicine, Rheumatology and Rehabilitation, Faculty of Medicine, Alexandria University, Alexandria, Egypt Tel: +20 100 638 2394; e-mail: wafaaelemary@gmail.com

Received 25 January 2018
Accepted 7 June 2018

Egyptian Rheumatology & Rehabilitation
2019, 46:27–34

Context
Epidural steriod injections (ESIs) are commonly used for managment of lumbosacral radiculopathy (LSR). Predicting outcomes after ESIs could be another valuable application of needle electromyography (EMG) in these patients.
Aim
The aim was to determine if EMG study can predict the functional outcome of transforaminal ESIs in patients with LSR.
Materials and methods
The study included 20 patients with clinical diagnosis of LSR. Peripheral nerve conduction study, late responses, somatomsensory evoked potentials, and needle EMG were performed in both lower limbs followed by transforaminal ESI under fluoroscopic guidance. The functional outcome was evaluated using visual analog scale for pain and Oswestry disability index (ODI) that were performed before and after injections.
Results
There were statistically significant decrease in pain severity (visual analog scale; P=0.022) and in ODI (improvement in functional score; P=0.029) after injection in patients with symptom duration less than 3 months compared with patients with longer duration of symptoms. In patients with negative EMG findings, there was a significantly greater reduction in pain severity ($P<0.01$) and ODI score ($P<0.01$) after injection compared with patients with positive findings. Regression analysis showed that negative needle EMG findings were significant predictors of pain reduction (P=0.001) and functional improvement (P=0.002) in patients with LSR after ESI.
Conclusion
This study supports the notion that EMG studies can be used for prediction of functional outcome in patients with LSR performing transforaminal ESI.

Keywords:
disability index, electromyography, epidural injection, functional outcome, lumbosacral radiculopathy, pain, transforaminal

Egypt Rheumatol Rehabil 46:27–34

1110-161X

Introduction

Lumbosacral radiculopathy (LSR) is one of the most common disorders evaluated by neurologists and a common cause of referral for electrophysiological assessment [1]. Etiology of LSR includes nerve root compression from pathology in the intervertebral disc, such as a prolapsed lumbar intervertebral or surrounding structures, spondylolisthesis, facet joint arthropathy, or synovial cysts [2]. It may also occur as a result of diversity of lesions including infectious, inflammatory, and neoplastic disorders [3]. Patients might present with pain, numbness, and weakness or any of these symptoms [2]. Pain is commonly in the form of back pain radiating into the leg and exacerbated by back flexion or extension, sitting, coughing, or straining and relieved by lying down or sometimes walking [1].

There is no gold standard for the diagnosis of LSR. Accordingly, a combination of history, physical examination, imaging, and electrodiagnostic testing is used to reach diagnosis of LSR [4]. Needle electromyography (EMG) is commonly used to assess muscle activity and integrity of the neuromuscular system. Therefore, it can help in determining if there is axonal injury of the motor nerve fibers or roots supplying muscles [5].

Decisions regarding optimal management are not easy to make in patients with radicular low back pain [6,7].

However, epidural steroid injection (ESI) is a common treatment option for patients complaining of low back pain and sciatica. It is indicated for treating radicular and low back pain caused by herniated disc, chemical neuritis, and spondylosis. ESIs are most effective during the acute phase of pain and inflammation [8]. Radicular pain is more likely to respond to ESIs than back pain. Response rates reaches up to 90% in patients with symptoms duration less than 3 months and may fall under 50% in patients with symptoms more than a year. A poor response rate is predicted by prior lumbar surgery, severe compression spinal stenosis, and/or a large herniated disc [9].

The three routes of entry to the epidural space are caudal, interlaminar, and transforaminal. All are actively practiced today and have their own unique risks and benefits [10]. Transforaminal ESI has been developed only in the past 10–15 years and is designed to administer the most target specific agent in the affected root. Recent outcome studies reveal greater duration of pain relief and avoidance of surgery compared with interlaminar injections [11–13].

The usefulness of EMG as a predictive tool for the success of ESI is still controversial. A review of the literature revealed few recent studies [2,14–17] that evaluated the usefulness of EMG in predicting pain and functional improvement after ESI. For predicting outcomes after ESI, needle EMG could be a valuable tool to identify appropriate patients for ESI.

Aim

The aim of this study was to determine if EMG studies can predict pain reduction and improve functional outcome after transforaminal ESIs in patients with LSR.

Materials and methods

This study included 20 patients complaining of low back pain and sciatica owing to LSR. Participants were included in the study if they fulfilled the following criteria [2,18]:

(1) Presenting history and pain diagram demonstrating LBP radiating down the lower limb in the distribution of L4, L5, or S1 dermatomes.
(2) MRI demonstrating nerve impingement of the L4, L5, and/or S1 nerve roots.
(3) Physical examination consistent with radicular irritation or neurological findings of sensory, motor, and/or reflex abnormalities in the L4, L5, or S1 nerve root distribution.
(4) Duration of symptoms 12 months or less.

Patients with LSR who do not respond to conservative care (including anti-inflammatory medications, analgesic drugs, life style modification, and/or physical therapy) were selected for transforaminal ESI [19].

Exclusion criteria for epidural steriod injection

Patients who were not candidates for epidural injection were those having the following:

(1) Symptoms requiring early surgical treatment (severe motor weakness, cauda equina syndrome, or hyperalgic sciatica).
(2) Structural spinal deformities (scoliosis >40° or spondylolisthesis).
(3) Received any spinal injection in the past month.
(4) Previous low back surgery.
(5) Post-traumatic or surgical stenosis.
(6) History of allergic reaction to steroids or anesthetics.
(7) Anticoagulation therapy with warfarin.
(8) Pregnancy.
(9) Peripheral neuropathy associated with any systemic disease.
(10) Neuromuscular disorders.
(11) Spinal disorders.

The nature of the present study was explained to all patients. Verbal and written consents were obtained from all patients. Research protocol was approved by the Ethical Committee of Faculty of Medicine, Alexandria University.

Baseline evaluation before injection

Thorough history taking and clinical examination were performed to determine root level affection and laterality of LSR. In addition, MRI was done for all studied patients to assist, with clinical examination, in proper selection of the affected root levels for injection.

Electrodiagnostic studies [20] were performed for all the studied patients bilaterally and included the following: motor nerve conduction studies (for posterior tibial and common peroneal nerves), late responses (tibial F-wave and gastrosoleus H-reflex), and mixed and dermatomal somatosensory-evoked potentials (SSEP) over the dermatomal territory of L4, L5, and S1 roots. Needle EMG [20] was performed, and the examined muscles were selected according to the affected nerve roots. Recording of

muscle activity was done at rest (sensitivity was set at 50 μV/division, and analysis time was 100 ms), minimal volition (the sensitivity was set at 200 μV/division, and analysis time was 100 ms), and maximal volition (the sensitivity was set at 200 μV/division, and analysis time was 1 s). Sensory nerve conduction studies (for sural and superficial peroneal nerves) were done bilaterally to exclude peripheral neuropathy.

Parameters assessed in patients before injection included pain assessment using numerical visual analog scale (VAS) [21] and assessment of functional status by Oswestry disability index (ODI) [22].

Transforaminal epidural steroid injection

All participants were then scheduled to undergo a transforaminal ESI of methylprednisolone under fluoroscopic guidance at the suspected level of pathology. The injection site and level of injection were determine by MRI results and supported by dermatomal clinical examination.

All injections were performed as outpatient procedures. With the patient lying prone, a wide area of the back was exposed and disinfected. Transforaminal ESI was conducted under biplane fluoroscopic guidance. The classic injection site underneath the pedicle in the 'safe triangle' [9,23]. With fluoroscopic guidance, 12-cm, 22-G spinal needle was then advanced into the safe triangle. The needle position was checked using biplane fluoroscopy followed by injection of 1 ml contrast material. Posteroanterior and lateral spot radiographs were obtained to document contrast material distribution. Bupivacaine hydrocholoride (0.5 ml/0.5%, marcaine spinal 0.5% heavy; AstraZeneca, USA) and 40 mg (1 ml) of methylprednisolone acetate were slowly injected.

To check the effect of the transforaminal ESI, all patients were asked to refrain from drug or physical therapy for sciatica over the 2-week period after injection.

Follow-up evaluation 2 weeks after epidural steriod injection

Primary outcome measures were assessed in patients 2 weeks after the injection, and they included pain assessment using VAS and assessment of functional status by ODI.

Secondary outcomes were greater than 50% improvement in VAS for pain and in functional score (ODI).

Statistical analysis

Data were analyzed using the statistical package for the social sciences (SPSS ver. 20; SPSS Inc., Chicago, Illinois, USA). The distribution of quantitative variables was tested for normality per group using Kolmogorov–Smirnov test, which revealed that the data are not normally distributed. Quantitative data were described using median and range whereas qualitative data were described using number and percentage. Mann–Whitney *U*-test was used to compare quantitative parameters between the two groups. Kruskal–Wallis test was used to compare quantitative parameters between the three groups. Linear regression model was used to predict percentage improvement in pain score and ODI score. Significant predictors detected by univariate analysis were entered in the model by Enter method, and the model was assessed using *F*-test and r^2. In all statistical tests, level of significance used was 0.05, below which the results were considered to be statistically significant.

Results

This study included 20 patients, with eight males and 12 females. Their mean age was 42.60±10.94 years, and median age was 44 years, ranging between 25 and 68 years. They complained of low back pain and sciatica owing to LSR. Seven patients were complaining of right sciatica and 13 patients were complaining of left sciatica.

The mean duration of symptoms was 5.25±2.97 months, median was 5.5 months, ranging from 1 to 10 months. Seven (35%) patients had disease duration less than 3 months, four (20%) patients had disease duration 3–6 months, whereas nine (45%) patients had disease duration greater than 6 months.

On the clinical level, all cases were diagnosed as unilateral radiculopathy. One patient had L4 radiculopathy, three patients had L5 radiculopathy, five patients had S1 radiculopathy, two patients had L4, 5 radiculopathy, three patients had L5, S1 radiculopathy, and six patients had L4, 5, S1 radiculopathy. This was supported by MRI findings, which have shown similar root level affection.

Table 1 demonstrates peripheral electrodiagnostic studies of both lower limbs. According to normal values obtained from literature, none of the studied patients had abnormalities in the peripheral motor, sensory conduction studies and/or late responses. Mixed and dermatomal SSEP mean latencies of the

Table 1 Peripheral conduction study parameters of the studied patients (motor conduction studies, sensory conduction studies, and late responses)

	Mean±SD	Minimum–maximum
Motor conduction velocities		
Posterior tibial nerve		
DL (ms)	4.37±0.74	3.1–6
CMAP (mV)	18.55±6.11	10.50–37.50
CV (m/s)	45.6±3.4	40.8–53.3
Minimum F latency	47.13±4.34	40.60–54.40
Common peroneal nerve		
DL (ms)	4.47±0.83	2.80–6.5
CMAP (mV)	4.63±1.79	2.0–9.50
CV (m/s)	46.96±2.16	44.6–51.28
Sensory conduction velocities		
Sural nerve		
PL (ms)	3.56±0.37	2.80–4.34
SNAP (μV)	17.92±5.70	6.51–35.30
CV (m/s)	47.74±4.91	40.92–57.60
Superficial peroneal nerve		
PL (ms)	3.55±0.68	2.31–4.63
SNAP (μV)	14.78±5.61	5.56–25.30
CV (m/s)	47.09±5.07	40.0–58.30
H-reflex (ms)	30.65–1.89	27.0–34.10

CMAP, compound muscle action potential; CV, conduction velocity; DL, distal latency; PL, peak latency; SNAP, sensory nerve action potential.

Table 2 Mixed and dermatomal somatosensory-evoked potentials latencies of the studied patients

	Mean±SD	Minimum–maximum
Mixed (right) (ms)	40.67±3.25	35.30–47.20
Mixed (left) (ms)	41.26±3.95	35.80–53
L4 (right) (ms)	43.36±3.81	36.60–53.20
L4 (left) (ms)	43.91±3.14	38.20–50.40
L5 (right) (ms)	46.83±3.79	40.00–53.00
L5 (left) (ms)	48.12±4.70	42.00–60.60
S1 (right) (ms)	44.85±3.20	36.80–53.40
S1 (left) (ms)	45.73±2.66	38.80–50

studied patients are presented in Table 2. According to SSEP, seven patients had single-level radiculopathy and 13 patients had multiple-level affection.

There were statistically significant decrease in pain severity (P=0.001) and improvement in functional score after injection (P=0.001; Table 3).

The mean percentage of improvement in pain severity (VAS) was 63.51±22.16, ranged between 0 and 100, and the median was 64.55. The mean percentage of improvement in ODI was 63.68±23.29, ranged between 0 and 93.5, and the median was 64.25.

One of the outcome measures in the current study was the percentage of patients who achieved greater than 50% improvement in VAS for pain and in functional score (ODI). Sixteen (80%) patients achieved greater than 50% improvement in VAS whereas 17 (85%) patients achieved greater than 50% improvement in functional score by ODI. Patients were categorized as responders (who achieved >50% improvement in pain and function) and nonresponders (<50% improvement in pain and function).

Table 3 Comparison of pain severity (visual analog scale) and functional score (Oswestry disability index) before and after injection in the studied patients

	Before injection	After injection
VAS for pain		
Minimum–maximum	5.0–9.0	0.0–7.0
Mean±SD	7.25±1.21	2.60±1.57
Median	7.0	2.5
Z (P)	3.853 (<0.001*)	
ODI		
Minimum–maximum	42.0–90.0	4.0–48.0
Mean±SD	63.0±13.40	22.55±14.1
Median	64.0	20.0
Z (P)	3.825 (<0.001*)	

ODI, Oswetry disability index; VAS, visual analog scale. *P≤0.05, statistically significant.

Patients with symptom duration less than 3 months showed significant decrease in pain (P=0.022) and improvement in function (P=0.029) after injection compared with patients with longer duration of symptoms (Table 4).

Pain severity and functional outcome after ESI were not affected by the number of root level affection determined by somatosensory evoked potential (SEP) (Table 5).

Needle EMG study done before injection demonstrated that 13 patients had negative EMG findings and seven patients had positive findings in the form of abnormal rest potentials, neuropathic motor unit action potentials, or abnormal interference pattern. Patients with negative EMG findings showed significant decrease in pain severity (P=0.001) and improvement in functional score (P=0.001) after injection compared with EMG positive group (Table 6). Regression analysis showed that negative needle EMG findings were significant predictors of decrease in pain (P=0.001) and improvement in functional outcome (P=0.002) in patients after ESIs (Table 7).

Discussion

The current study was initiated to determine if EMG studies can predict functional outcomes in patients with LSR undergoing transforaminal ESI. This study included 20 patients, comprising 12 (60%)

Table 4 Comparison between different groups of patients according to duration of symptoms regarding visual analog scale and Oswestry disability index before and after injection as well as percentage improvement

	Duration of symptoms			$^{KW}\chi^2$	*P*
	<3 (*n*=7)	3–6 (*n*=4)	>6 (*n*=9)		
VAS					
Before injection					
Minimum–maximum	5.0–9.0	6.0–8.0	6.0–9.0	1.565	0.457
Mean±SD	6.71±1.50	7.25±0.96	7.56±1.13		
Median	7.0	7.50	8.0		
After injection					
Minimum–maximum	0.0–4.0	1.0–7.0	3.0–5.0	7.624*	0.022*
Mean±SD	1.71±1.25	3.0±2.83	3.89±0.78		
Median	2.0	2.0	4.0		
Significance between groups		P_1=0.558; P_2=0.004*; P_3=0.233			
Percentage improvement					
Minimum–maximum	42.8–100.0	0.0–87.50	37.50–57.10	6.923*	0.031*
Mean±SD	72.87±18.55	58.33±40.39	48.43±7.53		
Median	75.0	72.9	50.0		
Significance between groups		P_1=0.850; P_2=0.008*; P_3=0.161			
ODI					
Before injection					
Minimum–maximum	42.0–64.0	42.0–78.0	24.0–90.0	4.195	0.123
Mean±SD	55.43±9.14	60.0±17.66	67.11±18.66		
Median	60.0	60.0	68.0		
After injection					
Minimum–maximum	4.0–22.0	8.0–48.0	6.0–56.0	7.057*	0.029*
Mean±SD	13.71±7.52	21.0±18.87	34.56±13.31		
Median	16.0	14.0	34.0		
Significance between groups		P_1=0.564; P_2=0.006*; P_3=0.279			
Percentage improvement					
Minimum–maximum	58.30–93.50	0.0–89.70	24.0–75.0	7.107	0.029*
Mean±SD	74.41±14.50	60.48±40.95	48.81±16.23		
Median	66.60	76.10	52.8		
Significance between groups		P_1=1.000; P_2=0.005*; P_3=0.217			

Significance between groups was done using Mann–Whitney test. $^{KW}\chi^2$, χ^2 for Kruskal–Wallis test; ODI, Oswerty disability index; P_1, *P* value for comparing between groups (<3 months and 3–6 months); P_2, *P* value for comparing between groups (<3 months and >6 months); P_3, *P* value for comparing between groups (3–6 months and >6 months); VAS, visual analog scale. *$P \leq 0.05$, statistically significant.

females and eight (40%) males, with mean age of patients of 42.60±10.94 years.

In the current study, 16 (80%) patients achieved greater than 50% improvement in pain, whereas 17 (85%) patients achieved greater than 50% improvement in functional score. Patients were categorized as 'responders' and 'nonresponders' to be consistent with prior studies [7,24] of clinical outcomes following ESI. Many studies [7,24–28] showed improvement of pain and function after ESI; however, percentage of improvement was variable. Lutz *et al.* [7] and Botwin *et al.* [24] both reported more than 70% decrease in VAS scores for pain at the early follow-up. Ng *et al.* [25], Lee *et al.* [26], and Karppinen *et al.* [27] had only 35–45% leg pain improvement at the 2-week follow-up. McCormick *et al.* [28] also reported that 28% of all patients reported greater than 50% improvement in pain and 20% discontinued opioids at short-term follow-up. The variation of the results regarding percentage of improvement could be attributed to different methodologies including study design and outcome measures used.

A high percentage of improvement in the current study might be related to the lumbar transforaminal injection route which accurately delivers a high concentration of corticosteroid to the site of painful nerve root compared with the other routes of injection. Moreover, injection under fluoroscopic guidance ensures both accurate positioning of the needle tip as well as that the contrast medium reaches the target area by spreading peripherally around nerve root and medially through the intervertebral foramen to the epidural space [29].

In the current study, shorter duration of symptoms was a reliable determinant of better outcome compared

Table 5 Comparison between patients with different SEP level affection regarding visual analog scale and Oswestry disability index before and after injection as well as percentage improvement

	SEP		Z	*P*
	Single level (*n*=7)	Multiple level (*n*=13)		
Pain				
VAS before injection				
Minimum–maximum	5.0–9.0	5.0–9.0	1.130	0.258
Mean±SD	7.29±1.25	7.23±1.24		
Median	7.0	7.0		
VAS after injection				
Minimum–maximum	1.0–7.0	0.0–4.0	1.114	0.265
Mean±SD	3.29±2.06	2.23±1.17		
Median	3.00	2.0		
Percentage improvement				
Minimum–maximum	0.0–87.5	33.3–100.0	1.407	0.159
Mean±SD	54.6±29.42	68.3±16.55		
Median	62.5	66.6		
ODI				
Before injection				
Minimum–maximum	42.0–82.0	42.0–90.0	0.704	0.481
Mean±SD	63.43±15.82	62.77±12.61		
Median	70.0	64.0		
After injection				
Minimum–maximum	8.0–48.0	4.0–44.0	0.132	0.895
Mean±SD	27.86±14.89	19.69±13.39		
Median	25.0	18.0		
Percentage improvement				
Minimum–maximum	0.0–89.7	24.0–93.50	0.175	0.861
Mean±SD	53.37±27.89	69.22±19.35		
Median	52.8	72.7		

ODI, Oswerty disability index; SEP, somatosensory evoked potential; VAS, visual analog scale; *Z*, *P*, *Z* and *P* values for Mann–Whitney test.

with longer symptom duration. This was in agreement with Lee *et al*. [26] who found that treatment was more effective in patients with sciatica of less than 6-month duration (acute or subacute) than in those with sciatica of greater than 6-month duration (chronic), but this difference lacked statistical significance. Similarly, Cooper *et al*. [30] found that patients with acute symptoms experience higher success rates than those with symptoms greater than 3-month duration. Accordingly, the duration of symptoms before the procedure was found to be the best factor for predicting infiltration efficacy of ESI [29]. Vad *et al*. [31] reported the negative effect of a long pain duration of over 1 year in two patients on the outcome. In 69 patients with disc herniation, Lutz *et al*. [7] found that patients with a preinjection symptom duration of more than 24 weeks did not respond favorably. Karppinen *et al*. [27] reported 45% decrease in leg pain after 2.4 months mean pain duration, and Ng *et al*. [25] reported only 25% in more chronic patients (16.9 months).

The poor outcome of longer duration of symptoms could be explained by chronic compression resulting in microvascular injury that can result in nerve root ischemia, edema, and demyelination. Irreversible neurophysiologic changes related to chronic inflammation, including irritation, may take place with chronic neural compression. These changes might render the nerve root refractory to management with the local steroid injection [29]. Accordingly, it could be suggested that in treating patients with radiculopathy, we should be applying these treatments early in the course of the disease to change long-term outcome.

The results of the current study showed that negative EMG findings were predictive of greater improvement in pain and functional scores compared with positive findings. This could be explained by the fact that EMG is a study of the motor nerves, and abnormal EMG findings (positive EMG) suggest motor nerve dysfunction. This indicates that the radiculopathy is more advanced than in patients with negative EMG findings. More severe cases (with positive EMG) would be less likely to respond to ESI than the less severe groups (with pain and sensory dysfunction only and negative EMG). Accordingly, EMG findings can help in selecting the subset of patients likely to have favorable functional outcome after ESI.

Table 6 Comparison between electromyography negative and positive groups regarding pain severity by visual analog scale and Oswestry disability index before injection, after injection as well as percentage improvement

	EMG		Z	*P*
	Negative (*n*=13)	Positive (*n*=7)		
VAS before injection				
Minimum–maximum	5.0–9.0	6.0–9.0	0.163	0.870
Mean±SD	7.23±1.36	7.29±0.95		
Median	8.0	7.0		
VAS after injection				
Minimum–maximum	0.0–3.0	3.0–7.0	3.446	0.001*
Mean±SD	1.77±0.93	4.14±1.35		
Median	2.0	4.0		
Percentage improvement				
Minimum–maximum	60.0–100.0	0.0–62.50	3.456	0.001*
Mean±SD	75.08±11.84	42.0±21.10		
Median	75.0	42.80		
ODI before injection				
Minimum–maximum	42.0–78.0	48.0–90.0	1.550	0.121
Mean±SD	59.69±11.46	69.14±15.44		
Median	62.0	68.0		
ODI after injection				
Minimum–maximum	4.0–33.0	25.0–48.0	3.455	0.001*
Mean±SD	14.23±8.13	38.0±8.39		
Median	14.0	38.0		
Percentage improvement				
Minimum–maximum	52.8–93.50	0.0–57.70	3.369	0.001*
Mean±SD	75.88±13.03	41.0±21.33		
Median	78.10	51.90		

EMG, electromyography; ODI, Oswerty disability index; VAS, visual analog scale; *Z*, *P*, *Z* and *P* values for Mann–Whitney test. *$P \leq 0.05$, statistically significant.

Table 7 Linear regression predicting pain and Oswestry disability index improvement in the studied patients

	β	SE	*t*	*P*
Linear regression predicting pain improvement				
EMG negative findings	–40.185	10.162	3.955	0.001*
Duration of symptoms (months)	1.678	1.674	1.003	0.330
Linear regression predicting ODI improvement				
EMG negative findings	–39.564	10.823	3.655	0.002*
Duration of symptoms (months)	1.106	1.782	0.620	0.543

EMG, electromyography; ODI, Oswerty disability index. *$P \leq 0.05$, statistically significant.

Studies demonstrating the usefulness of EMG findings in predicting outcome after ESI showed variable results. Tong *et al.* [17] demonstrated that results after ESI were not significantly different in different EMG groups. Similarly, Cosgrove *et al.* [32] found no relationship between EMG findings and pain or functional improvement 6 weeks after interlaminar ESI. Another study by Marchetti *et al.* [33] showed no differences in pain relief 6 weeks after an ESI in patients with EMG evidence of LSR versus those without. On the contrary, Annaswamy *et al.* [2] found that individuals with EMG findings of radiculopathy with active denervation (myotomal spontaneous activity) were more likely to experience improvements in pain and function 2 and 6 months after ESI. They explained their results by reporting that positive EMG identified the 'objective' cases of radiculopathy versus the 'subjective' cases of radiculopathy, where other variables were also major factors contributing to the symptoms; therefore, these participants did not respond to ESI. They also reported that the main presenting symptom of pain was multifactorial in etiology; therefore, the response to interventions (such as ESI) used to treat the pain differ among patients subgroups. Fish *et al.* [16] also found that patients with EMG-confirmed LSR who received ESI showed greater functional improvement at 3 months as compared with those with radicular pain but no EMG evidence of radiculopathy. They observed improvement in ODI but not in pain in patients with positive EMG findings [16]. McCormick *et al.* [28] also suggested that there was no difference in pain

reduction after ESI regarding the presence or absence of myotomal spontaneous activity.

Future studies on a larger scale should be done to verify the predictive value of EMG on outcome of transforaminal ESI as well as to study psychological factors and medications that could augment the response to ESI. In addition, similar studies with long follow-up period (3–6 months) should be done to assess the long-lasting effect of ESI.

Conclusion

It can be concluded that negative EMG findings is a significant predictor of pain reduction and functional improvement in patients with LSR undergoing ESI. In addition, shorter symptom duration is a reliable determinant of significant improvement in pain severity and functional score after ESI compared with longer symptom duration.

Accordingly, transforaminal ESI is recommended early in the course of the LSR for better outcome. Needle EMG is recommended before ESI to predict outcomes and help to guide treatment decisions.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1 Liang H, Katz N. Clinical evaluation of patients with a suspected spine problem. In: Frymoyer W, editor. The adult spine: principles and practice. New York: Raven 1991. 223–239

2 Annaswamy M, Bierner M, Chouteau L. Needle electromyography predicts outcome after lumbar epidural steroid injection. Muscle Nerve 2012; 45:346–355.

3 Deyo RA, Diehl AK. Cancer as a cause of back pain: frequency, clinical presentation, and diagnostic strategies. J Gen Intern Med 1988; 3:230–238.

4 Karen B. Electrodiagnosis of lumbar radiculopathy. Phys Med Rehabil Clin N Am 2013; 24:79–80.

5 Mills R. The basics of electromyography. J Neurol Neurosurg Psychiatry 2005; 76:32–35.

6 Braune J, Wunderlich T. Diagnostic value of different neurophysiological methods in the assessment of lumbar nerve root lesions. Arch Phys Med Rehabil 1997; 78:518–520.

7 Lutz E, Vad B, Wisneski J. Fluoroscopic transforaminal lumbar epidural steroids: an outcome study. Arch Phys Med Rehabil 1998; 79:1362–1366.

8 Singh V, Manchikanti L. Role of caudal epidural injections in the management of chronic low back pain. Pain Physician 2002; 5:133–148.

9 Artuso JA. Back pain and needles: epidural steroid injections for radicular back pain. J Lancaster General Hosp 2007; 2:95–100.

10 Abdi S, Datta S, Trescot AM, Schultz DM, Adlaka R, Atluri SL, *et al.* Epidural steroids in the mamagment of chronic spinal pain: a systematic review. Pain Physician 2007; 10:185–212.

11 Schaufele MK, Hatch L, Jones W. Interlaminar versus transforaminal epidural injections for the treatment of symptomatic lumbar intervertebral disc herniations. Pain Physician 2006; 9:361–366.

12 Riew KD, Yin Y, Gilula L, Bridwell KH, Lenke LG, Lauryssen C, Goette K. The effect of nerve root injections on the need for operative treatment of lumbar radicular pain. A prospective, randomized, controlled, double-blind study. J Bone Joint Surg Am 2000; 82:1589–1593.

13 Smith C, Booker T, Schaufele K. Interlaminar versus transforaminal epidural steroid injections for the treatment of symptomatic lumbar spinal stenosis. Pain Med 2010; 11:1511–1515.

14 Chouteau W, Bierner M, Annaswamy M. Predictive value of electromyography of response to lumbar epidural steroid injections in patients with lumbar radiculopathy. Am J Phys Med Rehab 2009; 88:S6.

15 Bierner M, Annaswamy M, Chouteau L. Predictive value of electromyography for response to epidural steroid injection in patients with lumbar radiculopathy. Muscle Nerve 2009; 40:710.

16 Fish E, Shirazi P, Pham Q. The use of electromyography to predict functional outcome following transforaminal epidural spinal injections for lumbar radiculopathy. J Pain 2008; 9:64–70.

17 Tong C, Williams C, Haig J, Geisser ME, Chiodo A. Predicting outcomes of transforaminal epidural injections for sciatica. Spine J 2003; 3:430–434.

18 Cho SC, Ferrante MA, Levin KH, Harmon RL, So YT. Utility of electrodiagnostic testing in evaluating patients with lumbosacral radiculopathy: an evidence-based review. Muscle Nerve 2010; 42:276–282.

19 Kirkadly-Willis WH, Yong-Hing K. Lateral recess, lateral canal, and foraminal stenosis. In: Watkins RG, Collis JS, editors. Lumbar discectomy and laminectomy. Rockville: Aspen Publishers Inc; 1987. 245–252

20 Preston C, Shapiro E, editor. Electromyography and neuromuscular disorders: clinical-electrophysiologic correlations. 3rd ed. China: Elsevier; 2013.

21 Wewer ME, Lowee NK. A critical review of visual analogue scale in the measurement of clinical phenomena. Res Nur Health 1990; 13:227–236.

22 Fairbank JCT, Couper J, Davies JB. The Oswestry low Back Pain Questionnaire. Physiotherapy 1980; 66: 271–273.

23 Boduk N, Aprill C, Derby R. Epidural steroid injection. In: White AH, editor. Spine care. Vol. 1. St. Louis: Mosby 1995. 322–343

24 Botwin KP, Gruber RD, Bouchlas CG, Torres-Ramos FM, Sanelli JT, Freeman ED, *et al.* Fluoroscopically guided lumbar transformational epidural steroid injections in degenerative lumbar stenosis: an outcome study. Am J Phys Med Rehabil 2002; 81:898–905.

25 Ng L, Chaudhary N, Sell P. The efficacy of corticosteroids in periradicular infiltration for chronic radicular pain: a randomized, double-blind, controlled trial. Spine (Phila Pa 1976) 2005; 30:857–862.

26 Lee KS, Lin CL, Hwang SL, Howng SL, Wang CK. Transforaminal periradicular infiltration guided by CT for unilateral sciatica – an outcome study. Clin Imaging 2005; 29:211–214.

27 Karppinen J, Malmivaara A, Kurunlahti M, Kyllönen E, Pienimäki T, Nieminen P, *et al.* Periradicular infiltration for sciatica: a randomized controlled trial. Spine (Phila Pa 1976) 2001; 26:1059–1067.

28 McCormick Z, Cushman D, Caldwell M, Marshall B, Ghannad L, Eng C, *et al.* Does electrodiagnostic confirmation of radiculopathy predict pain reduction after transforaminal epidural steroid injection? A multicenter study. J Nat Sci 2015; 1:e140.

29 Cyteval C, Fescquet N, Thomas E, Decoux E, Blotman F, Taourel P. Predictive factors of efficacy of periradicular corticosteroid injections for lumbar radiculopathy. AJNR Am J Neuroradiol 2006; 27:978–982.

30 Cooper G, Lutz GE, Boachie-Adjei O, Lin J. Effectiveness of transforaminal epidural steroid injections in patients with degenerative lumbar scoliotic stenosis and radiculopathy. Pain Physician 2004; 7:311–317.

31 Vad VB, Bhat AL, Lutz GE, Cammisa F. Transforaminal epidural steroid injections in lumbosacral radiculopathy: a prospective randomized study. Spine (Phila Pa 1976) 2002; 27:11–16.

32 Cosgrove JL, Bertolet M, Chase SL, Cosgrove GK. Epidural steroid injections in the treatment of lumbar spinal stenosis efficacy and predictability of successful response. Am J Phys Med Rehabil 2011; 90:1050–1055.

33 Marchetti J, Verma-Kurvari S, Patel N, Ohnmeiss DD. Are electrodiagnostic study findings related to a patient's response to epidural steroid injection? PM R 2010; 2:1016–1020.