TRANSFORAMINAL VERSUS ENDOSCOPIC EPIDUROPLASTY IN POST-LUMBAR LAMINECTOMY SYNDROME: A PROSPECTIVE, CONTROLLED, RANDOMIZED STUDY

Ahmed Fawzi El Molla, MD, FIPP, PGcert
Professor of Anesthesia & Pain Medicine department. Director of pain relief unit (Medical Research Institute, Alexandria University, Egypt)
Fellow of Interventional Pain Practice-Texas-USA
Postgraduate Certificate of Pain Management-Cardiff University, UK

Annotation. The study primary goal was to evaluate the efficacy of non-endoscopic and endoscopic epiduroplasty on chronic leg pain severity in post-lumbar laminectomy syndrome (PLS) patients. The secondary goals were to evaluate low back pain, functional abilities, satisfaction, and complications after the procedures.

Seventy-two patients were allocated randomly into two groups. The Trans group (n = 35) in whom patients underwent transforaminal epiduroplasty and EDS group (n = 37) in whom patients underwent endoscopic epiduroplasty. Pain severity were measured by visual analogue score (VAS) for both leg and back pain and functional activities were assessed using Waddell and Main score with a follow-up to 12 months. Satisfaction was observed at 3 and 12 months.

In both groups the follow-up VAS-leg pain score showed significant reduction at 1, 3, 6, 9, and 12 months, but EDS group showed significant reduction at 1 and 12 months compared to Trans group. The follow-up VAS-back pain score in both groups showed significant reduction up to 6 months, but EDS group showed significant reduction at 1, 3, 6, and 9 months compared to Trans group. Functional activities scores showed statistical significant improvement up to 6 months in both groups and 9, 12 months in EDS group when compared to the preoperative values with no statistical difference between groups at all intervals. Satisfaction scores showed significant improvement at 3 and 12 months in both groups but EDS group showed significant improvement at 3 and 12 months compared to Trans group. No complications occurred and side effects were minimal.

Both transforaminal and endoscopic epiduroplasty give meaningful improvement in both pain and disability in post-lumbar laminectomy syndrome. However, endoscopic epiduroplasty appears to have better benefits.

Key words: endoscopic epiduroplasty, post-laminectomy syndrome, transforaminal epiduroplasty.

INTRODUCTION

“Post-lumbar laminectomy syndromes” (PLS) following surgical spinal procedures have been attributed to post-operative fibrosis, adhesions, and inflammation [1; 2]. It has been reported that repeating the surgical procedure does not always solve the problem [3]. Instead, it may produce further complications [4]. In such patients, the painful symptoms reflect a combination of pathological processes, such as interruption of blood flow, venous congestion, ischemia, axonal damage and intraneural fibrosis [5; 6]. Epidural steroid injection has been one of the “gold standards” in the management of chronic low back pain and PLS for over than 40 years. Controversy, however, continues its efficacy, with conflicting conclusions found in two systematic reviews [7; 8]. Forceful epidural injection as a method has been tried. This is, however, an inaccurate and very incomplete way of possibly achieving a degree of adhesiolysis [9]. Using fluoroscopy in patients with previous back surgery, epidural steroid injection solution will spread to reach the level of pathology in only 26% of cases [10]. Transforaminal epiduroplasty (TFEPI) may be indicated on those occasions when the nerve roots are difficult to “open”, but their clinical effectiveness needs further support [11]. Epiduroscopy (EDS) allows more accurate placement of drugs within the epidural space, which may improve the efficacy of epidural steroids in “PLS” [10; 12].
At the present time, only a few prospective studies have been conducted to establish the benefits of EDS [13—15], although retrospective studies have described the clinical effectiveness and cost-effectiveness of EDS in patients with herniated disks or severe low back pain after back surgery [12; 16]. The hypothesis that targeted epidural medication delivery nearby the desired nerve root may result in better pain relief. Therefore, TFEPI (transforaminal) was evaluated with the endoscopic epidural targeted approach (intraforaminal). The proposed benefits of these two targeted medication delivery were believed to overcome the compliance gradient which may be caused by the adhesions which may “shield” the compromised nerve root. The primary goal of the current study was to evaluate the efficacy of the non-endoscopic and endoscopic techniques of targeted epidural injection to improve chronic leg pain severity in PLS patients. The secondary goals were to evaluate the low back pain severity, functional abilities, satisfaction/dissatisfaction, and complications (if any).

PATIENTS AND METHODS

This prospective, controlled, and randomized study was approved by the local ethics committee and the written informed consent was obtained. Seventy-two patients were classified as having PLS [17], who suffered from both chronic low back pain and chronic radicular pain (mainly from mono-segmental radicular pain). Patients were randomly allocated, according to a computer-randomized table, into both groups. The Trans group \( n = 35 \) in whom they underwent TFEPI whereas, EDS group \( n = 37 \) in whom they underwent endoscopic epiduroplasty.

Epidural steroid injections in both groups were previously performed three times without significant pain relief \( \leq 30\% \). The median (range) time between the latest epidural injection and the mentioned procedures was 3 (2-10) months. In addition, all other modalities of conservative treatment failed to provide substantial pain relief of at least 6 weeks or longer with a drug therapy of oral pregabablin in a dose of 300 mg/day and oral celecoxib 200 mg/day. Routine laboratory investigations were performed that included complete blood count, prothrombin and partial thromboplastin time, platelet function studies and bleeding time. All procedures have been performed under fluoroscopy with injection of non-ionic water soluble contrast agent; iohexol (Omnipaque 240), which was used either for confirmation of proper localization of epidural space in the Trans group (see fig. 1) or for localization of the sacral canal in EDS group.

Inclusion criteria were as follows: age between 30 and 55 years, a duration of pain of at least 2 years, and predominance of leg pain rather than low back pain.

Exclusion criteria were included: patients who developed signs of progressive motor disorders or incontinence, local or systemic infections, coagulation disorders, glaucoma, malignancy, pregnancy, language barriers, and mental handicaps. In addition, patients with multi-segmental pain manifestations such as burning sensations, dysesthesia or paresthesia in the planter region or in a wider leg or perineal area were also excluded.

TECHNIQUES

The standard ASA monitor recommendations for conscious sedation (EGC, SO2, BP & HR), were used.

IV access was ensured before the commencement of the procedure. Safety measures were considered such as the procedure was done while the patient was awake and Cooperative; under local anesthesia (lidocaine 1%) and conscious sedation (fentanyl 1 ug kg\(^{-1}\) and midazolam increments up to 5 mg), in order to allow the physician and patient to communicate during the procedure. In both groups the patients were placed in prone position on a radio-lucent table with pillow under the lower abdomen in order to reduce the lumbar lordosis.

TRANSFORAMINAL EPIDUROPLASTY

Using sterile preparation under fluoroscopic guidance, both the desired lumbar level and side were identified based on the clinical assessment. Needle journey must end on the lateral view at the posterior aspect of the intervertebral foramen (at the junction of the upper 1/3 and the lower 2/3 of the foramen) and showed the “tunnel vision”; the needle appeared as a dot on the x-ray screen. At this point, advancement of the tip of the needle was done so as to enter the foramen [11; 18]. Aspiration should be negative before 3 cc of iohexol (Omnipaque 240) was injected. The later injection should show opening of the entered neuroforamen (figure 1). Then 1500 IU of hyaluronic acid in 10 cc preservative-free (PF) saline followed by, a mixture of 10 cc of 0.25% hupivacaine and 80 mg of methylprednisolone (MP) were injected. After a period of 5 minutes, injection of 10 cc of hypertonic saline (NaCl 10%) was followed in three divided doses over 10 minutes. Occasionally, the patient may complain of severe burning sensation during injection of NaCl 10%. Should this occur, the injection must be stopped for another 5 minutes.
After sterile preparation, a flexible, 0.9 mm fibre optic endoscope (Karl Storz™, Germany) was introduced into the caudal epidural space through the introducer after confirmation by fluoroscopic spread of iohexol (omnipaque 240 mg/ml), up to 10 cc. The painful nerve root was identified by pain provocation test (gentle mechanical stimulation of the nerve root exactly reproduced the patient’s pain) using the tip of EDS [19]. If adhesions at the suspected nerve root were seen we mobilized them by means of the tip of EDS (figure 2) and 1500 IU of hyaluronidase in 10 cc PF saline, followed by a mixture of 10 cc of bupivacaine 0.25% and 80 mg MP were injected. Thereafter, 10 cc of NaCl 10% was injected in the same manner as in the Trans group.

At the end of both procedures, the patient was observed for 24 hours and discharged on the next day. After treatment, patients were instructed to visit the pain clinic or contacted via telephone for routine assessment every 1, 3, 6, 9, and 12 months.

FOLLOW-UP PROTOCOL

Each patient underwent standard physical examination and asked to complete a 100 mm VAS questionnaire, in which 0 mm represented no pain and 100 mm the worst imaginable pain, for low back pain (VAS-back) and leg pain (VAS-leg) on walking for at least 500 meter before the procedures and 1, 3, 6, 9, and 12 months thereafter. Assessment of either VAS-back or VAS-leg was not done either on the first 24 hours or up to 1 month. As from previous experience, 5 pilot cases from each group experienced pain from both procedures which assumed to result in a study bias.

Sensory deficit was graded as marked (50% hypesthesia), mild (> 50%) and (< 100% hypesthesia) or none by pin-prick sensation in the suspected dermatome while motor deficit was graded as marked (grade 3), mild (grade 4) or none (grade 5) by quantitative manual muscle testing of the suspected muscle groups [20]. Immediate post-procedure neurological monitoring (sensory and motor) was done to exclude any possibility of accidental subdural/subarachnoid injection, signs of arachnoiditis or other neurologic complications during the follow-up. Drug therapy was continued during the 12-month follow-up period in all patients. If patients developed progressive motor disorders or bladder dysfunction, definitive surgical management would considered. Complications were monitored with each follow-up period.

Functional activities were assessed using Waddel and Main score [20]. Zero represents a severe functional restriction, whereas a score of 9 indicates good function. These parameters were checked pre-operatively and at 1, 3, 6, 9 and 12 months. In addition, a five level satisfaction/dissatisfaction scale (0 = very dissatisfaction, 1 = mild dissatisfaction, 2 = mild satisfaction, 3 = moderate satisfaction and 4 = very satisfaction) was noted at 3 and 12 months after treatment.

Patients were asked to register any temporary pain increase and/or subjective sensory or motor deficits caused by the treatment. Success was defined as a reduction of VAS-leg of at least 50%. A single non-treating independent physician or pain nurse, who were blinded to the technique, made all follow-up assessment at 1, 3, 6, 9, and 12 months without any discussion with the patient about the technique and reported all scores to the treating physician just before the patient’s visit.
STATISTICAL ANALYSIS

Statistical analysis was performed utilizing SPSS for Windows, version 15. Distribution of sensory and motor deficit and gender between groups were treated by Chi-squared test. Unpaired “t” test was utilized to compare the means of age, weight, height duration of symptoms and walking distance between two groups. Wilcoxon signed rank test used to compare the follow-up data with the preoperative data, while between groups compared using Mann-Whitney rank sum test. Differences were considered statistically significant when P values were less than 0.05. Power analysis was done to detect a difference of 20% between groups. The group sample size of 35 and 35 patients in each group achieves a 100% power.

RESULTS

Two patients in the EDS group were excluded from analysis because of accidental dural puncture in one patient and inability to advance the introducer through the sacrococygeal ligament in another patient (figure 3).

The male/female ratio, age, height, weight, duration of symptoms, walking distance, and neurological deficits were comparable between the study groups (table 1). Preoperative pain severity scores for leg and back pain in both groups were comparable. The preoperative functional abilities for both groups were also comparable.

In all patients of both groups, the follow-up VAS-leg pain score showed statistical significant reduction (P < 0.0001) as compared to the preoperative values at 1, 3, 6, 9, and 12 months. The follow-up pain scores (VAS-leg) in EDS group showed statistically significant reduction (P < 0.0001) at 1 and 12 months compared to Trans group (figure 4).

In contrast, the follow-up VAS-back pain score in both groups showed statistical significant reduction (P < 0.0001) up to 6 months as compared to the preoperative values. The follow-up pain scores (VAS-back) in EDS group showed statistical significant reduction (P < 0.0001) at 1, 3, 6, and 9 months compared to Trans group. However, at 12 month there was no significant difference between the two groups (figure 5).

Functional activities (Waddel and Main score) showed very poor pre-operative abilities with a baseline of 1.66 ± 1.37 and 1.83 ± 1.27 in the Trans group and EDS group, respectively. In the post-procedure, the total function scores showed statistical significant improvement (P < 0.001) up to 6 months in both groups when compared to the preoperative values. Whereas these scores showed statistical significant improvement (P < 0.001) in EDS group at 9 and 12 months. However, the differences between the follow-up functional activities in between groups showed no significant difference (P > 0.05) at all time intervals (figure 6).

Table 1

Patient’s characteristics. Data are median and (range) for age, mean (SD) for height and weight or numbers

<table>
<thead>
<tr>
<th></th>
<th>Trans group (n = 35)</th>
<th>EDS group (n = 35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (M/F)</td>
<td>21/14</td>
<td>18/17</td>
</tr>
<tr>
<td>Age (years)</td>
<td>40 (55—30)</td>
<td>36 (50—35)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>147 (9)</td>
<td>149 (7)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>82 (11)</td>
<td>87 (8)</td>
</tr>
<tr>
<td>Duration of pain (month)</td>
<td>28</td>
<td>26</td>
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<tr>
<td>Walking distance</td>
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<td></td>
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<tr>
<td>&lt; 100 meter</td>
<td>14</td>
<td>16</td>
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<tr>
<td>100—500 meter</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>&gt; 500 meter</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Neurological deficits</td>
<td></td>
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<tr>
<td>Motor</td>
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<tr>
<td>Marked</td>
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<td>0</td>
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<tr>
<td>Mild</td>
<td>13</td>
<td>6</td>
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<tr>
<td>Non</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Involved dermatomes</td>
<td></td>
<td></td>
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<tr>
<td>L1–4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>L4–5</td>
<td>21</td>
<td>17</td>
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<tr>
<td>L5–S1</td>
<td>11</td>
<td>13</td>
</tr>
</tbody>
</table>

Figure 3. Patients follow-up diagram
Figure 4. Leg pain score in and between groups (individual points represent mean ± SD)  
* p < 0.001 compared to base value, # p < 0.001 compared between groups

Figure 5. Back pain score in and between groups (individual points represent mean ± SD)  
* p < 0.001 compared to base value, # p < 0.001 compared between groups
Figure 6. Functional score in and between groups
(individual points represent mean ± SD)
* p < 0.001 compared to base value, # p < 0.001 compared between groups

Figure 7. Dissatisfaction/satisfaction after treatment

Figure 8. Granuloma at the sacral hiatus after epiduroscopy

The differences in the five-level satisfaction scores between the study groups when compared to the preoperative periods showed a statistical significance deference (P < 0.001) and (P < 0.0001) at 3 and 12 months respectively. Also, in comparison between groups EDS group showed statistical significant improvement (P < 0.001) in the satisfaction score at 3 and 12 months (figure 7).

In EDS group adhesions onto the nerve root were clearly seen in most patients (figure 2). With movement of epiduroscope in order to examine this area, along with the
constant saline flow, mobilization of adhesions away from the nerve root (epiduroplasty) was observed directly. However, in some patients an increase in transmitted nerve root pulsation was observed. Other endoscopic views included fibrous bands, reddish inflammation, hypervascularity and granuloma tissues were found around the suspected painful nerve root. None of the patients developed post operative neurological complications during follow-up periods. Side-effects encountered were some persistent low back discomfort in all patients which was subsided after 2—3 weeks by the administration of the patient’s usual analgesic medications. One patient in the Trans group developed non-persistent paresthesia of the lower limb which subsided spontaneously after 4 weeks. In EDS group four patients developed transient headache which subsided in one day, two patients had two-day fluid leak of saline from the sacral hiatus and one patient had presacral granuloma which partially subsided within two weeks (figure 8).

**DISCUSSION**

Post laminectomy fibrosis forms as a result of a chronic chemical irritation, neurogenic inflammation, a probable autoimmune response to nucleus pulposus and impaired fibrinolysis [21—24]. Adhesion may interfere with the mobility of the dural sleeves of the spinal roots with subsequent pain. The mobility of nerve roots may be restored by adhesiolysis [25].

Adhesions surrounding nerve roots may also interfere with their nutrition and blood supply [26] and are potent contributors to radicular pain [21; 26]. In disease states, especially with adhesive arachnoiditis, nutrition of the nerve root becomes critical [23; 26]. Impairment of intraneural blood flow is probably the final common pathway leading to abnormalities in nerve conduction and pain generation [23; 27]. It is possible that adhesiolysis reduces pain generation through improvement in nerve root nutrition by removal of obstruction to blood supply and CSF flow. Mechanical adhesiolysis may allow room for the restoration of blood supply and nerve root nutrition, resulting in reversal of nerve dysfunction and pain relief [26; 28].

The main finding of the current study was that the targeted epidural injection via the endoscopic epiduroplasty appears to achieve better benefits than the transforaminal epiduroplasty. Adhesiolysis could be responsible for the long-term pain relief in the EDS group. Three mechanisms were postulated to achieve adhesiolysis in endoscopic epiduroplasty [15; 29]. First, mechanical adhesiolysis was performed by manipulation of the tip of epiduroscope. Second, hydrostatic adhesiolysis was achieved by the distension of the epidural space and the pressure of the irrigating saline which may be responsible for the mobilization of adhesions. Furthermore, hydrostatic adhesiolysis may result in diluting local tissue concentration of inflammatory mediators. In this regard, previous studies have reported the importance of inflammatory mediators in causing low back and leg pain [30; 31]. Both mechanical and hydrostatic adhesiolysis would not be achieved in the transforaminal epiduroplasty. Lastly, “chemical” (medication-induced) adhesiolysis would be achieved by hyaluronidase and NaCl 10% injections. In this regard, hyaluronidase and NaCl 10% have been used to enhance the effect of lysis of epidural adhesions [14; 29]. Hyaluronidase was added because of its ability to hydrolyze the glycosaminic bonds of hyaluronic acid (e.g. nucleus pulposus) and other mucopolysaccharides of connective tissue. Clinically, it renders tissues more permeable to injected fluids, and reduces swelling and edema due to trauma. It also reduces fibrosis, which is important because defects in fibrinolytic activity have been described in PLS patients, leading to fibrin deposits and chronic inflammation [32].

In this regard, adhesiolysis is a controversial topic in the treatment of patients with PLS. Several groups have stressed that lysis of epidural adhesions is an effective therapeutic option [12; 15; 16] whereas others asserted that there is no correlation between therapeutic effect and the degree of lysis of epidural adhesions [33]. In addition, hyaluronidase and NaCl 10% have been used to enhance the effect of lysis of epidural adhesions which was not used in the previous studies [12; 15; 16; 33]. Consistent with the results of the current study, other authors [34] showed better long-term effects that observed in the monosegmental radicular pain groups in elderly patients with degenerative spinal stenosis after endoscopic epiduroplasty. Previous reports in patients with chronic refractory back pain or failed back surgery indicated that results after endoscopic epiduroplasty vary between individuals [15; 35].

The improvement after TFEPI for up to 12 months, as regard VAS-leg when compared to the preoperative pain scores, might be attributed to the dilution or “wash out” of inflammatory mediators with saline and other injectates near by the targeted nerve root. In addition, the “chemical” adhesiolysis induced with the injection of hyaluronidase and NaCl 10% might be of help. The rationale for transforaminal injection of a total of 30 ml of injectate was assumed to ensure the opening of the possible adhesions around the painful nerve root from exterior and to be comparable with the injected volume from interior in the en-
endoscopic epiduroplasty, thus avoiding any study bias. Moreover, in a protocol for transforaminal epiduroplasty a total of 16 cc of a mixture of local anesthetic (LA), hyaluronidase, and PF saline was injected and followed by infusion of NaCl 10% via a catheter over 20 minutes without serious complications [11]. In the current study, 20 cc of a mixture was transforaminaly injected and followed by 10 cc NaCl 10% in three divided doses over 10 minutes, therefore the injection of such volume with other safety measures taken in the current study could not potentially unsafe. Despite of that transforaminal injection of such volume in the epidural space should be done with caution until wide clinical use is achieved in order to avoid any potential outcomes. The improvement in VAS-back and functional ability in the transforaminal epiduroplasty in the first 6 months when compared to the preoperative values might be also explained on the previous basis.

The initial improvement of pain scores in both techniques may reflect LA and steroids reaching the area causing these symptoms. LAs induce sympathetic nerve blockade and therefore improve blood flow to the ischemic neural element [36]. While steroids reduce inflammatory edema of the injured nerve root and therefore improve intraneural blood flow [37].

There was also an improvement in the satisfaction of both groups at 3 and 12 months which might be attributed to the placebo response. This finding was dissimilar with Richardson et al’s study [15] who did not find differences in the satisfaction scores at 2 and 12 months by the use of endoscopic epiduroplasty in a prospective case series. This might be attributed to the continuation of the preoperative medication in the current study and/or individual variations. In contrast to Richardson et al’s study [15] only minor side — effects ensued and no serious complications were generated which might be attributed to the safety procedures in the current study.

It is noteworthy, to emphasize that although the epiduroscopic views may themselves confirm the presence of adhesions around the compromised nerve root. The current study could not confirm that the major contributor for the post-endoscopic epiduroplasty improvement in pain relief would be attributed to adhesiolysis. This limitation should be overcome in the future studies by doing both pre- and post-procedure epidurography, as a trial to find a correlation between therapeutic effect and degree of adhesiolysis. Another limitation that may result in a study bias, was the localization of the compromised nerve root was clinically performed and reconfirmed by pain provocation test in endoscopic epiduroplasty, whereas in the transforaminal epiduroplasty the localization was performed only by the clinical assessment. The use of a nerve stimulator in the future may be of help to overcome this limitation.

In conclusion, both transforaminal and endoscopic epiduroplasty resulted in meaningful improvement in both pain and disability in post-lumbar laminectomy syndrome. However, endoscopic epiduroplasty appears to have better benefits.

REFERENCES


