Unilateral Laminotomy For Decompression of Lumbar Stenosis is Effective and Safe: A Prospective Randomized Comparative Study

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Objective: The purpose of this study is to determine the efficacy and safety of unilateral laminotomy for decompression of lumbar stenosis (LS). Although minimally invasive procedures are gaining increasing popularity in the treatment of spinal disorders, minimally invasive techniques are not standard in the surgical treatment of lumbar stenosis yet.

Methods: Fifty-two consecutive patients with lumbar stenosis were randomized to two treatment groups (unilateral laminotomy for decompression-Group 1, decompressive laminectomy-Group 2). Maximum walking distance (MWD), Oswestry Disability Index (ODI), spinal MRI and CT, and flexion-extension radiography were used to assess clinical outcome, adequacy of decompression and postoperative instability.

Results: Excellent-good clinical outcome was obtained in 88% of patients in Group 1 and in 69% of patients in Group 2. Increase in MWD and dural sac area after surgery were adequate in both groups. Postoperative spinal instability occurred in five patients in Group 2, none in Group 1. There was no surgical complication in the groups.

Conclusions: Unilateral laminotomy for decompression is an effective and safe technique for treatment of LS. This technique ensures adequate decompression and good clinical outcome. It does not cause spinal instability.

Key words: Minimally invasive surgery, spinal instability, dural sac area, Oswestry Disability Index, lumbar stenosis

Unilateral Laminotomy Lumbar Stenozun Dekompresyonunda Etkili ve Güvenlidir: Prospektif Randomize Karşılıştırılmış Çalışma

Amaç: Bu çalışmanın amacı lomber dar kanalin dekompresyonunda unilateral laminotominin etkinliğini ve güvenliğini değerlendirmektir. Minimal invaziv tekniğin spinal hastalıkların tedavisinde popülaritesini artırmak için minimal invaziv teknikler halen lomber dar kanalin cerrahi tedavisinde standart tedavi değildir.

Yöntem: Lomber dar kanalı bulunan arısalık 52 hasta iki tedavi grubuna ayrılmıştır (unilateral laminotomy-Grup 1, dekompresif laminektomi-Grup 2). Klinik son durum, dekompresyonun yeterliliği ve ameliyat sonrası instabilite için Maksimum yürüme mesafesi (MWD), Oswestry Sakatlık Ölçeği (ODI), spinal MRG ve BT ve fleksiyon-ekstansiyon radyorafisi kullanılmıştır.

Bulgular: Grup 1'de hastaların %88'inde, Grup 2'de %69'unda mükemmel-iyi klinik son durum elde edilmiştir. Her iki grupta da ameliyat sonrası MWD ve dural kese alanında artış yeterlidir. Ameliyat sonrası Grup 1'de hiç bir hasta Grup 2'de ise 5 hasta spinal instabilite gelişmiştir. İki grupta da cerrahi komplikasyon yoktur.

Anahtar Kelimeler: Minimal invaziv cerrahi, spinal instabilite, dural kese alanı, Oswestry Sakatlık Ölçeği, lomber dar kanal

INTRODUCTION

Unilateral laminotomy for decompression of lumbar stenosis (LS) was described as subarticular fenestration technique in 1988(26). Spetzger et al investigated the practicability of unilateral laminotomy for LS in a cadaveric study(19), and Weiner et al modified and put this technique into practice(24). There are many clinical studies on decompression via unilateral laminotomy and other minimally invasive techniques such as bilateral foraminotomies, laminoplasty(5,6,8,9,15,17,21,24,26). Minimally invasive techniques are not the standard surgical treatment modalities for LS yet. Decompressive laminectomy is still the most common technique. It is known that minimally invasive techniques preserve structural integrity of the spine. Unilateral laminotomy for decompression of LS is the most outstanding of minimally invasive techniques as bilateral foraminotomies, laminoplasty, transforaminal endoscopic surgery, and endoscopic interlaminar canal decompression. Bilateral foraminotomies and laminoplasty require bilateral muscle dissection which makes the “minimality” of these procedures disputable. Transforaminal endoscopic surgery is rarely performed, not well established, and is not effective in central stenosis(14). Endoscopic interlaminar canal decompression is still an experimental technique(19). Studies investigating the safety and efficiency of unilateral laminotomy for LS decompression are scarce(3,8,9,21,24). The aim of this study is to investigate the efficacy and safety of unilateral laminotomy of LS.

MATERIAL AND METHODS

Patients

The study protocol was approved by the institutional ethics committee of Cumhuriyet University Faculty of Medicine. Fifty-two patients underwent surgery for lumbar stenosis refractory to conservative treatment between January 2006 and February 2009. Inclusion criteria were as follows: 1) Symptoms of neurogenic claudication or radiculopathy; 2) radiological evidence of degenerative lumbar stenosis; 3) absence of associated pathological entities such as instability and significant disc herniation; and 4) absence of previous surgery for lumbar spine disorder. Fifty-two patients were randomly assigned to one of the following groups: Group 1 (n=26) consisted of patients who underwent unilateral laminotomy for decompression, and Group 2 (n=26) consisted of patients treated by decompressive laminectomy. Patient characteristics in the groups are shown in Table 1. Differences between the groups in terms of sex, age, affected level, and number of decompressed levels are statistically insignificant.
Table 1. The baseline characteristics of the patients.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (Unilateral laminotomy)</th>
<th>Group 2 (Laminectomy)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>26</td>
<td>26</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Male: Female</td>
<td>11:15</td>
<td>10:16</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>60.65±10.02</td>
<td>57.53±8.46</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Affected level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-L3</td>
<td>6</td>
<td>6</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>L3-L4</td>
<td>15</td>
<td>15</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>L4-L5</td>
<td>20</td>
<td>18</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>L5-S1</td>
<td>3</td>
<td>5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Neurological findings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td>16</td>
<td>19</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Sensory</td>
<td>18</td>
<td>17</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Reflex</td>
<td>16</td>
<td>20</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Number of decompressed levels</td>
<td>44</td>
<td>44</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

Preoperative Assessment

Neurological status of the patients was evaluated by physical examination and maximum walking distance (MWD). MWD of patients was tested on a treadmill (TEPA TM Pro 2000, Ankara, Turkey) with a speed of 2700 m/h and a maximum walking time of 15 minutes, or a maximum distance of 900 m. Pain and disability were assessed by Oswestry Pain and Disability Questionnaire (4). Axial MRI of the dural tube is obtained and a simplified formula for cross-sectional area is used utilizing coronal and sagittal diameters in accordance with the approximate geometric shape of the lumbar dural tube in accordance with Hamanishi et al (7). Spinal CT was used to evaluate facet joint and lateral recess. MRI was the main investigation for diagnosis and surgical planning of LS. Lumbar flexion-extension films were obtained to assess spinal instability. Spinal instability was evaluated as following criteria: 1) anterior translation greater than 8% (L1-2 to L4-5) or greater than 6% (L5-S1) of the vertebral body width; 2) posterior translation greater than 9% (L1-S1); 3) angular displacement (sagittal rotation) in flexion greater than -9° (L5-S1) or greater than 1° (L5-S1)(11). All radiological investigations were evaluated by neuroradiologist who was blinded to the hypothesis of the study.

Surgical Procedures

All patients underwent surgery under general endotracheal anesthesia in genupectoral position. An operating microscope (Carl Zeiss Co., Oberkochen, Germany) was used during unilateral laminotomy for decompression (Group 1).

Decompression by Unilateral Laminotomy

All operations were performed by one author (MG). Image intensifier was used to localize the involved segment. The skin and fascia were incised in the midline. The paraspinal muscles were dissected free from their bony attachments on the spinous
process and the lamina to expose the bony detail. Unilateral laminotomy was performed followed by ipsilateral medial facetectomy and foraminotomy. After ipsilateral decompression, the microscope was angulated medially and the patient was tilted contralaterally for visualization of the inferior surfaces of contralateral laminae and interspinous ligament. The spinous process was undercut with a high-speed burr. The contralateral ligamentum flavum and the medial aspects of the contralateral facet joints were resected partially by Kerrison rongeur for decompression.

**Decompressive Laminectomy**

The skin and fascia were incised in the midline. The paraspinal muscles were dissected free bilaterally from their bony attachments on the spinous process and lamina to expose the bony detail. The spinous process and the laminae of the involved segment or segments were resected totally; the medial aspects of the facet joints were resected partially.

**Postoperative Assessment**

The patients were examined, MWD was measured, and ODI questionnaire was applied at postoperative first and sixth months. Spinal MRI and CT scans to evaluate widening in spinal canal (Figures 1 and 2) and to measure spinal area, and flexion-extension films to investigate instability were obtained. Average time of follow up was 9.1 months (6 months to 3 years). But, all comparisons and statistical analysis in and between groups were made as to 1. and 6. month follow ups.

The safety of surgical techniques both unilateral laminotomy and laminectomy was assessed as to surgical complication rate. These complications include neural injury, dural tear and infection.

**Statistical Analysis**

Statistical analysis was performed using SPSS (ver. 14.0) software. Independent-samples t test, paired-samples t test, Fisher's exact test, Wilcoxon test and chi square test were used for statistical analysis. All values are expressed as mean ± SD. A p-value less than 0.05 was considered statistically significant.

**Fig 1:** Preoperative CT (A) and MRI (C) and postoperative CT (B) and MRI (D) of a case in unilateral laminotomy group (Group 1).
RESULTS

In Group 1, preoperative and postoperative mean MWDs were 172.23±196.06 and 288.65±278.05 m, respectively. In Group 2, preoperative and postoperative mean MWDs were 62.00±110.86 and 203.65±283.04 m, respectively. The differences between the mean pre and postoperative MWDs of the groups were statistically insignificant (p>0.05). The differences between pre and postoperative mean MWD were statistically significant in each group (p<0.05) (Table 2).

In Group 1, preoperative mean ODI score was 79.61±8.78, postoperative mean ODI score was 25.92±20.43. In Group 2, preoperative mean ODI score was 74.46±10.07, postoperative mean ODI score was 32.15±28.94. Difference between preoperative mean ODI scores of Group 1 and Group 2 was statistically insignificant (p>0.05). The differences between preoperative and postoperative mean ODI scores were significant statistically in each group (p<0.05) (Table 2).

When the patients were classified as to the severity of ODI scores (Table 3), 12 patients had minimal, 11 patients had moderate, 1 patient had severe disability, 1 patient was crippled and 1 patient was bedridden in Group 1; in Group 2, 10 patients had mild, 8 patients had moderate, 4 patients had severe disability, 2 patients were crippled and 2 patients were bedridden (Table 4). Mild and moderate disabilities meet the excellent and good results regarding clinical outcome. Twenty three (88%) patients had excellent-good clinical outcome in Group 1 while 18 (69%) patients had excellent-good clinical outcome in Group 2. This difference was statistically insignificant (p>0.05).

Dural sac area increased significantly by decompression in both groups. Increase in dural sac area after surgery was 440% (1.15/0.26 mm²) in Group 1, 520% (1.46/0.28 mm²) in Group 2. Differences between pre and postoperative mean dural sac area were statistically significant in
both groups (p<0.05) (Table 2). Increase in dural sac area in Group 2 was higher than that of Group 1 and this difference was statistically significant (p<0.05).

Postoperative spinal instability occurred in 5 patients in Group 2, none in Group 1. Unilateral total facetectomy was performed in seven patients in Group 2, there was no total facetectomies in Group 1. The differences were statistically significant (p<0.05).

There was no surgical complication in the groups.

Table 2. Preoperative and postoperative mean MWD, ODI scores, and dural sac area in unilateral laminotomy group (Group 1) and laminectomy group (Group 2)

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Statistical Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preop</td>
<td>172,23±196,06</td>
<td>62,00±110,86</td>
<td>t=2,48 p=0,016*</td>
</tr>
<tr>
<td>Postop</td>
<td>288,65±278,05</td>
<td>203,65±283,04</td>
<td>t=2,30 p=0,030</td>
</tr>
<tr>
<td>ODI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preop</td>
<td>79,61±8,78</td>
<td>74,46±10,07</td>
<td>t=1,96 p=0,055</td>
</tr>
<tr>
<td>Postop</td>
<td>25,92±20,43</td>
<td>32,15±28,94</td>
<td>t=0,91 p=0,370</td>
</tr>
<tr>
<td>DSA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preop</td>
<td>0,26±0,12</td>
<td>0,28±0,16</td>
<td>t=0,41 p=0,678</td>
</tr>
<tr>
<td>Postop</td>
<td>1,15±0,41</td>
<td>1,46±0,48</td>
<td>t=2,47 p=0,017*</td>
</tr>
</tbody>
</table>

MWD: Maximum walking distance, ODI: Oswestry disability index, DSA: Dural sac area
*p<0.05 significant
**Postoperative MWD, DSA and ODI records are belong to postoperative assessment in 6. month.

Table 3. Disability level or functional grades regarding ODI scores

<table>
<thead>
<tr>
<th>Disability (ODI score)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal disability (0%-20%)</td>
<td>The patient can cope with most living activities. Usually no treatment is indicated apart from advice on lifting sitting and exercise.</td>
</tr>
<tr>
<td>Moderate disability (20%-40%)</td>
<td>The patient experiences more pain and difficulty with sitting lifting and standing. Travel and social life are more difficult and they may be disabled from work. Personal care sexual activity and sleeping are not grossly affected and the patient can usually be managed by conservative means.</td>
</tr>
<tr>
<td>Severe disability (40%-60%)</td>
<td>Pain remains the main problem in this group but activities of daily living are affected. These patients require a detailed investigation.</td>
</tr>
<tr>
<td>Crippled (60%-80%)</td>
<td>Back pain impinges on all aspects of the patient's life. Positive intervention is required.</td>
</tr>
<tr>
<td>Bedridden (80%-100%)</td>
<td>These patients are either bed-bound or exaggerating their symptoms.</td>
</tr>
</tbody>
</table>

ODI= Oswestry Disability Index
Table 4. Pre and postoperative disability levels of the patients regarding ODI

<table>
<thead>
<tr>
<th>Disability</th>
<th>Group 1 Preop</th>
<th>Postop</th>
<th>p value</th>
<th>Group 2 Preop</th>
<th>Postop</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal</td>
<td>0</td>
<td>12</td>
<td></td>
<td>0</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>0</td>
<td>11</td>
<td></td>
<td>0</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>1</td>
<td>1</td>
<td>0.001</td>
<td>2</td>
<td>4</td>
<td>0.001</td>
</tr>
<tr>
<td>Crippled</td>
<td>8</td>
<td>1</td>
<td></td>
<td>15</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Bedridden</td>
<td>17</td>
<td>1</td>
<td></td>
<td>9</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

ODI= Oswestry Disability Index

**DISCUSSION**

Acquired lumbar stenosis is a common degenerative process among the elderly and may significantly decrease quality of life. Indeed, stenosis of the lumbar canal is now the most common indication for spinal surgery in patients over 65 years of age.[8]

Extensive laminectomy with medial facetectomy and foraminotomy is commonly used for treatment of LS. Aim of techniques such as laminectomy or other unroofing procedures is wide decompression but they may frequently cause spinal instability.[13,16,17] Long-term results of decompressive laminectomy for LS[6,17] and a meta-analysis demonstrate that successful short term results of surgery are not maintained in a substantial percentage of patients[23]. Loss of midline supraspinous/interspinous ligament complex may lead to loss of flexion stability, thereby increasing the risk of delayed spinal instability.[22] Instability with resultant chronic pain syndrome has been suggested as a potential cause of poor outcome.

Mullin et al detected instability in 54% of flexion-extension radiograms of decompressive laminectomy patients with long-term follow-up.[13] The use of wide decompressive procedures for spinal stenosis, without regard for the integrity of the laminae and facet joints and without preservation of the spinous processes and interspinous ligaments, may lead to mechanical failure of the spine and a chronic pain syndrome.[6,16,22,23] According to Rompe, Schulitz observed 46 patients after decompressive laminectomy for 3-10 years[17] of which thirty percent developed spinal instability; a correlation between low back pain and instability was found.

The major advantage of minimally invasive procedures lies in reduction of tissue exposure and trauma. Since tissue disruption is the most important trigger of the surgical stress response, it is reasonable to modify current practice in favor of minimally invasive procedures.[5] Despite this advantage, minimally invasive techniques are not widely utilized. Possible causes of this condition are high cost hardware, high learning curve for these procedures, and lack of convincing clinical studies on minimally invasive procedures. Minimally invasive techniques described in late 1980s have not been standard in surgical treatment of LS.[24,26] Of minimally invasive techniques for treatment of LS, unilateral laminotomy for decompression is the most outstanding. Although there are many clinical studies reporting affirmative results,[3,8,9,10,15,17,19,24,21] number of randomized comparative studies on this technique are insufficient.[9,15,17,21]. This prospective randomized comparative study may provide further reliable data on this issue.

Studies investigating unilateral laminotomy for decompression do not
report postoperative spinal instability\(^{(3,5,8,9,15,17,19,21,24)}\). Mayer et al demonstrated decrease in paraspinal muscle strength with atrophy after extensive muscle retraction during surgical decompression\(^{(12)}\). See and Kraft found long-term electromyographic abnormalities and correlated these with failed back surgery syndrome\(^{(18)}\). Retraction of multifidus muscle beyond the midpoint of the facet joint tethers the medial branch of dorsal ramus within the mamilloaccessory groove, risking muscular denervation. Unilateral laminotomy for bilateral decompression limits ipsilateral retraction to the level of the medial facet border. Contralaterally, no elevation or retraction of the paraspinal musculature is undertaken, thereby minimizing the risk of iatrogenic muscular trauma\(^{(24)}\). Unilateral laminotomy for decompression preserves the integrity of both facet and ligament-muscle complex. Bresnahan et al biomechanically evaluated graded posterior element removal for treatment of lumbar stenosis\(^{(2)}\). They suggested that removal of posterior bony elements associated with laminectomy produces the greatest change in segmental motion during flexion, extension, left and right axial rotation; following a minimally invasive procedure, postoperative segmental motion is similar to the intact spine; increased posterior element removal resulted in increased motion when compared to the minimally invasive approach in all loading conditions except for lateral bending; preservation of the posterior spinal elements associated with minimally invasive surgery could minimize rates of developing de novo postoperative changes in spinal alignment\(^{(2)}\). Therefore, this technique is optimal to preserve spinal stability.

We evaluated clinical outcome after surgery by ODI. In Group 1, there was excellent-good result in 23 patients (88%) while 18 patients (69%) had excellent-good result in Group 2. Although this difference is statistically insignificant, success rate of unilateral laminotomy is apparently higher than that of laminectomy. Another indicator of clinical outcome after surgery is MWD. The difference between postoperative MWD of groups was insignificant which shows that decompression is adequate in both surgical techniques.

Another important issue for clinical success in surgical treatment of LS is adequate decompression. In this study, dural sac area was measured by Hamanishi technique\(^{(7)}\) in axial MR images. Increase in dural sac area after surgery was 440% (1.15/0.26 mm\(^2\)) in Group 1, 520% (1.46/0.28 mm\(^2\)) in Group 2. Although the difference between postoperative mean dural sac areas of the groups was significant, increase of dural sac area in Group 1 is adequate in terms of clinical outcome and radiological evaluation. Complete decompression as previously suggested by Aryanpur and Ducker\(^{(1)}\) may not be necessary to achieve symptomatic relief. Thomas et al reported a statistically significant increase in dural sac area after laminotomy or laminectomy but found no statistical relationship between the extent of decompression and clinical outcome\(^{(20)}\). To enlarge the dural sac area just above a symptomatic threshold level may be sufficient to achieve a good clinical result\(^{(15)}\). There is a relationship between severity of stenosis and surgical outcome such that patients with a greater than 50% reduction in dural sac area are more likely to have a successful outcome\(^{(25)}\). In conclusion, unilateral laminotomy is effective for decompression of LS.

There was no postoperative instability in unilateral laminotomy group in this study while 5 patients (19%) had postoperative spinal instability in the laminectomy group. In laminectomy group, unilateral total facetectomy was performed in seven patients but postoperative spinal instability occurred in only two of these patients.

The results of this study show that unilateral laminotomy for decompression
of LS eliminates most of the reasons of failure and seems as an optimal surgical technique. Only one issue remains to be discussed; whether unilateral laminotomy is safe or not. In many studies comparing unilateral laminotomy and laminectomy for treatment of LS complications rates differ\(^{(3,8,9,10,16,24)}\). Dural tear is the most frequent surgical complication in these surgical procedures whose incidence is 13% in Kotil et al's unilateral laminotomy series\(^{(10)}\). In another comparative study, incidence of dural tear is 12.5% in unilateral laminotomy group, 20% in laminectomy group\(^{(21)}\). Another frequent surgical complication is nerve root injury; fortunately severe nerve root injury is infrequent in all techniques. In our study, there was no complication in the groups. These results show that unilateral laminotomy is safe for decompression of LS.

**CONCLUSION**

Unilateral laminotomy is a safe and effective surgical technique for treatment of LS. This technique ensures adequate decompression, good clinical outcome, prevents postoperative spinal instability, and has a low complication rate.

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