

Surgical outcomes of decompressive laminectomy by transspinous approach for degenerative lumbar spinal stenosis

Melih Ücer,¹ İlhan Aydın,² Abdullah Emre Tacyildiz,³ İhsan Dogan,⁴ Erhan Emel⁵

Abstract

Objectives: To assess clinical and radiographical outcomes of transspinous decompression technique for the treatment of degenerative central lumbar spinal stenosis.

Methods: The single-centre, non-randomised interventional, prospective, observational study was conducted Neurosurgery Clinic of Mazhar Osman Research and Training Hospital for Psychiatry and Neurology, Istanbul, Turkey from May 2013 and May 2016 and comprised adult patients with refractory symptoms from degenerative central lumbar spinal stenosis who underwent lumbar spinous process-splitting laminectomy. Pre- and post-operative Oswestry Disability Index score, visual analogue scale for overall pain, maximum walking distance and anteroposterior diameter of the spinal canal on magnetic resonance imaging were assessed on follow-up examination. SPSS 22 was used for data analysis.

Results: Of the 89 patients, 7(7.86%) were lost to follow-up, while 82(92.14%) completed the study. Of them, 42(51%) were women and 40(49%) were men. Overall mean age was 63.86 ± 10.02 years (range: 40-85 years). A total of 95 transspinous decompressive laminectomies were performed. Mean number of decompressed spinal segments was 1.16. Median duration of surgical procedure was 45 min, while mean length of hospital stay was 1.22 ± 0.47 days. Mean decrease in pre-operative Oswestry Disability Index score at 1-year was 56.4% and overall visual analogue scale was 55.9%. Mean increase of 155.2% was documented over pre-operative maximum walking distance. Radiological assessment revealed a 40.7% increase in the mean and anteroposterior diameter of the spinal canal at the level of the target lesion. The improvement in various parameters was statistically significant ($p < 0.001$).

Conclusion: Lumbar spinous process-splitting laminectomy led to significant improvement with respect to patient-reported perceived recovery, functional disability and radiological evidence of effective surgical decompression in patients with lumbar spinal stenosis.

Keywords: Lumbar vertebrae, Spinal stenosis, Laminotomy, Laminectomy, Surgical decompression, Magnetic resonance imaging. (JPMA 68: 1618; 2018)

Introduction

Acquired lumbar spinal stenosis (LSS) is a common debilitating condition in older people which typically results from degenerative disease processes, such as bone hypertrophy, osteoarthritis of facet joints, ligamentous hypertrophy, disc protrusion, spondylolisthesis or a combination of any of these elements. The most

commonly affected lumbar segments are L3-L5, which results in compression of nerve roots and cauda equina. Typical symptoms include back and leg pain, neurogenic intermittent claudication and the resultant functional disability.^{1,2}

Initial treatment approach is conservative and typically includes physical therapy, administration of non-steroidal anti-inflammatory drugs (NSAIDs) and opioids and steroid injections.³ However, the gold standard treatment for symptomatic lumbar stenosis refractory to conservative management is facet-preserving laminectomy.² This surgical decompression procedure involves extensive

¹Kanuni Sultan Süleyman Research and Training Hospital, Istanbul, Turkey, ²Van Research and Training Hospital, Turkey, ^{3,5}Mazhar Osman Research and Training Hospital for Psychiatry and Neurology, Istanbul, Turkey, ⁴University of Wisconsin-Madison, Madison, Wisconsin, USA.

Correspondence: Melih Ücer. Email: melihucer@hotmail.com

dissection for detachment of the bilateral paravertebral muscles (PVMs) from the spinous processes and the lamina. In addition, the posterior midline ligaments, such as the supraspinous and interspinous ligaments lose their original attachments when the spinous processes are removed.³⁻⁵ The reported disadvantages of extensive resection of the posterior bone, posterior ligaments and muscular structures include increase in post-operative pain, peri-operative blood loss, length of stay (LOS) at hospital, and adverse consequences of iatrogenic injury, like denervation atrophy of PVMs, lower back pain, segmental malalignment, instability and the so-called failed back surgery syndrome.²⁻⁶ Therefore, various minimally invasive techniques for spinal surgery have been developed to achieve comparable surgical outcomes with less surgical morbidity. Although these techniques show promise, they generally require specialised equipment, more technical expertise and tend to be associated with a steep learning curve.^{2,7,8}

Lumbar spinous process-splitting laminectomy (LSPSL), an alternative to conventional laminectomy first described in 2005,⁵ is a posterior midline structure-preserving decompressive technique, with the advantage of a traditional midline approach that neurosurgeons are familiar with.⁸ It also avoids the need for specialised tubular retractors. Preliminary results suggest excellent decompression with less extensive muscle damage compared to that in both traditional and other tubular techniques for decompression of lumbar spine. However, there have been few reports on clinical outcomes and radiographical evaluation after LSPSL.^{2,8,9}

The current study was planned to assess clinical and radiographical outcomes of transspinous decompression technique for the treatment of degenerative central LSS.

Patients and Methods

The single-centre, non-randomised interventional, prospective, observational study was conducted at Neurosurgery Clinic of Mazhar Osman Research and Training Hospital for Psychiatry and Neurology, Istanbul, Turkey from May 2013 and May 2016 after approval was obtained from the institutional ethics committee. Written informed consent was obtained from all the participants. Those included were symptomatic adult patients who were refractory to conservative therapies underwent an extensive pre-operative neurological and radiological assessment, which included lumbar anteroposterior and

lateral (AP/LAT) X-rays, lumbar lateral flexion-extension X-rays, lumbar spinal magnetic resonance imaging (MRI) and/or lumbar computed tomography (CT). Subsequently, patients with refractory symptoms from degenerative central LSS were included, while those with spinal instability, history of previous lumbar surgery, congenital lumbar stenosis, degenerative lumbar spondylolisthesis and degenerative or acquired lumbar scoliosis due to trauma, infection or abnormal bone metabolism were excluded from the study. Patients were enrolled irrespective of their age, gender, duration of symptoms and location of LSS.

Age, gender, duration and type of symptoms and treatment history were recorded pre-operatively. Data pertaining to surgical characteristics, Oswestry Disability Index (ODI) score, visual analogue scale (VAS) for overall pain in the leg and lower back, maximum walking distance (MWD), anteroposterior (AP) diameter of the spinal canal on MRI, surgical complications and follow-up characteristics were prospectively collected. The surgical procedure comprised transspinous decompressive technique.⁵ A similar approach was adopted for lesions at different segments. All stages of the decompressive surgery were performed under a surgical microscope by the experienced senior professional. For one-level decompressive laminectomy, routine preparation was followed by general endotracheal anaesthesia with the patient in prone position. A posterior midline skin incision was made following localisation of the level of spinal process using C-arm fluoroscope, and the subcutaneous tissue dissected until the thoracolumbar fascia over spinous process(es) to be split was identified. The spinous process(es) of the involved segment(s) was split longitudinally in the middle with the use of a high-speed drill equipped with a fine 2-mm diamond-tipped burr (Midex-Rex, Medtronic, USA). The spinous process was then divided at its base from the lamina. All muscular attachments to the lateral walls of spinous process(es) were left intact. The interspinous ligaments were also incised longitudinally up to the sublaminar area. A self-retaining retractor was used to retract the split halves of the spinous process until the medial edges of the facet joints were identified laterally. The inner side of the lamina was then resected partially to expose the hypertrophic ligamentum flavum and the dural tube. Decompression was extended to the foraminal areas and lateral recesses by excision of the hypertrophic ligamentum flavum, which

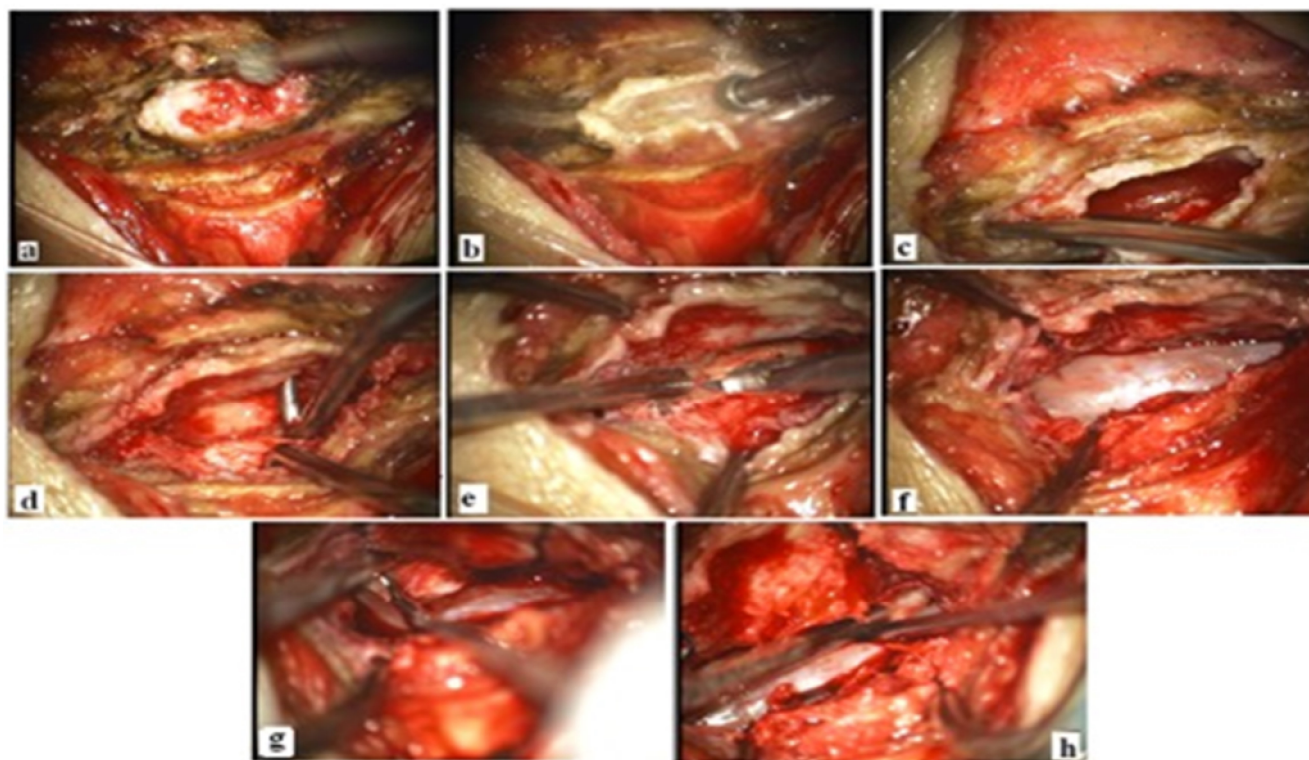


Figure-1: Demonstration of surgical stages of the lumbar spinous process-splitting laminectomy technique in order. Exposure of the spinous processes of the involved segments (A). Drilling of the spinous process (B). Incision of the interspinous ligaments (C). Placement of the self-retaining retractor (D). Retraction of the split halves of the spinous process (E). Resection of the inner side of the lamina (F). Further decompression of the intravertebral foramina and lateral recesses (G). Removal of the hypertrophic ligamentum flavum (H).

compressed the spinal nerve roots, and undercutting the medial side of the facet joints. Bleeding was controlled with bipolar coagulation and use of haemostatic agents. Decompression was achieved, and a laminoplasty procedure was performed by re-approximating the split spinous processes, using transosseous restorable sutures and repair of the interspinous ligaments with interrupted sutures (Figure-1).

All patients were allowed to walk on 4th day after surgery and discharged within 1-2 days post-operatively. Primary outcome measures included ODI score and VAS to assess both functional disability and the perceived recovery, and one radiological outcome measure in the shape of diameter of the spinal canal to assess radiological effectiveness of the decompressive surgery. The primary outcome measures were evaluated on the day before the surgery and at a minimum of 1 year after surgery. Patients completed a self-evaluation questionnaire which contained components of ODI and the VAS for overall pain pre- and post-operatively. Patients were blinded to

their scores at each evaluation to minimise the scope for bias. A clinically meaningful improvement was defined as 30% change from the baseline.¹⁰ This corresponds to a mean difference of 1.5 for the VAS, 2 for the numerical rating scale and 10 for the ODI.

The ODI is a reliable means for assessment of disability in patients with lower back pain. It is one of the principal condition-specific outcome measures used in the management of spinal disorders due to being a simple and multidimensional tool with the advantage of easy patient comprehension and compliance.¹¹⁻¹³ Its psychometric properties are well-acknowledged. ODI contains 10 questions related to limitation of activities of daily living. Each variable is rated on a 5-point scale (0-5), which is summarised and converted into a percentage score. Final scores range from 0 to 100; lower score indicating less severe pain and disability.¹³ Mean ODI scores at each time-point as well as the change in ODI scores was calculated.¹¹ The Turkish version of the questionnaire was validated in 2004.¹⁴

VAS and numerical rating scales are simple and quick pain assessment instruments for measurement of pain intensity. These are relatively easy to understand and use, and have been shown to have satisfactory sensitivity, reliability and accuracy. Furthermore, by assigning a numerical value to the pain intensity, these methods offer the advantage of quantification of the pain.¹⁵⁻¹⁸ VAS was assessed on a 10cm horizontal line. The left end of the scale represented "no pain" (score 0) and the right end represented the 'most severe pain imaginable' (score 10).¹⁸ The patients were then instructed to indicate the current intensity of pain in leg and back separately at each time-point. The averages of the sum of VAS leg and back pain scores as well as the change in average VAS scores were calculated and included in the analyses.

To assess the effectiveness of surgical decompression radiologically, AP diameter of the spinal canal was measured at the intervertebral disc level of the involved spinal segment on computed axial T2-weighted MRI sections (Siemens, Erlangen, Germany), pre-operatively and at a minimum 1 year post-operatively.¹⁹⁻²¹ MWD, surgical complications, duration of surgical procedure and LOS were the secondary outcome measures. MWD was assessed on the day before the surgery and at 1 year post-operatively as a secondary clinical outcome measure based on self-reported distance without pain. Of note, the reduction in walking distance is considered a hallmark symptom of lumbar stenosis.² SPSS 22 was used for data analysis. Continuous variables were presented as mean $\pm$ standard deviation (SD), and categorical variables as frequencies and percentages. Differences between pre-operative and post-operative (follow-up) outcomes were assessed with paired t test. All statistical tests were 2-tailed, and the significance level was fixed at 0.05.



Figure-2: Preoperative Magnetic resonance image (A). Magnetic resonance image obtained 1 year postoperatively (B). Axial computerised tomography scan obtained 1 month postoperatively (C).

Table-1: Baseline characteristics of patients.

Variables	Values
Gender	
Male, n (%)	40 (48.6)
Female, n (%)	42 (51.4)
Mean age in years (range)	63.86 $\pm$ 10.02 (40-85)
Pre-operative symptoms	
Back pain, n (%)	82 (100)
Leg pain, n (%)	82 (100)
Leg numbness, n (%)	45 (55.2)
Neurogenic intermittent claudication, n (%)	57 (69.05)
Urinary incontinence, n (%)	8 (9.75)

Table-2: Surgical characteristics and secondary outcomes.

Variables	Values
Number of decompressed segments	
Single-level, n (%)	54 (65.8)
2-level, n (%)	28 (34.2)
Operative levels	
L2-L3, n (%)	6 (5.61)
L3-L4, n (%)	27 (28.08)
L4-L5, n (%)	49 (52.8)
L5-S1 (%)	13 (13.48)
Mean length of hospital stay, day (range)	1.22 (1-2)
Complications	
Dural tear, n (%)	6 (7.31)
Re-operation, n (%)	3 (3.65)

Results

Of the 89 patients, 7(7.86%) were lost to follow-up for unknown reasons, while 82(92.14%) completed the study. Of them, 42(51%) were women and 40(49%) were men. Overall mean age was 63.86 $\pm$ 10.02 years (range: 40-85 years). Mean duration of symptoms was 4.88 $\pm$ 0.50 years (Table-1).

A total of 95 transspinous decompressive laminectomies were performed. Of these, 54(59%) were one-level and 28(41%) were two-level surgeries. Mean number of decompressed spinal segments was 1.16. The most

frequent operative level was L4-L5 in 49(53%) patients. Concomitant discectomy was not performed. Median length of surgical procedure was 45min, while mean LOS was 1.22 $\pm$ 0.47 days. No deaths or major complications were encountered. Nine (10.9%) of the patients developed

Table-3: Pre- and post-operative outcome measures.

Outcome measures	Pre-operative Mean $\pm$ SD (min.%-max.%)	Post-operative Mean $\pm$ SD (min.%-max.%)	p
ODI	68 $\pm$ 3.54 (62-76)	29.66 $\pm$ 5.41 (16-42)	<0.001
VAS	7.19 $\pm$ 0.525 (6-8)	3.17 $\pm$ 0.811 (2-5)	<0.001
Maximum walking distance (m)	188.8 $\pm$ 84.36 (100-400)	481.9 $\pm$ 193.5 (200-1000)	<0.001
AP diameter of the spinal canal (mm)	9.75 $\pm$ 1.53 (6-12)	13.72 $\pm$ 1.46 (12-17)	<0.001

ODI; Oswestry Disability Index, VAS; Visual analogue scale, AP; Anteroposterior; SD: Standard deviation

surgical complications, with dural tear being the most common (Table-2).

Mean duration of follow-up was 1.3 years (range:1-3 years). All patients (100%) reported a difference between the pre- and post-operative groups of 10 points on the ODI and 2 points on overall VAS at 1 year, implying favourable surgical results. Mean reduction in ODI score and overall VAS was 56.4% and 55.9%, respectively. Mean increase in MWD after surgery was 155.2%. On radiological evaluation, mean increase in AP diameter of the spinal canal at intervertebral disc of the stenotic spinal level was 40.7%. The difference in all parameters was significant ($p < 0.001$) (Figure 2, Table3).

Discussion

The study noted clinical and radiographical outcomes of decompressive laminectomy performed by a transspinous approach in patients with degenerative central LSS. Transspinous approach in a short operative time and as an overnight procedure improved functional disability and produced a perceived recovery based on ODI score, overall VAS and MWD, with an acceptable complication rate. Furthermore, effective decompression was confirmed on radiological evaluation. The findings demonstrate that transspinous approach was a safe and effective surgical treatment and could be recommended as a minimally invasive decompressive procedure for the treatment of LSS.

Although conventional laminectomy is widely used today, this classical approach is associated with persistent post-operative back pain, increased blood loss, longer LOS and several complications. Newer minimally invasive surgical techniques, such as unilateral laminotomy, bilateral laminotomy and LSPLS, limit the amount of bone excised from the vertebra, minimises

damage to back muscles and ligaments during surgical exposure, maintain spinal stability and decrease the risk of post-operative complications.^{2,5,21,22}

We prefer to perform LSPLS by the transspinous approach at our centre (Figure-3). A few studies have been published on LSPLS or its modifications.^{4-8,20,23-27} These have usually included a brief description of the technique and outcomes in patients with LSS; most have retrospectively compared outcomes with those of conventional laminectomy.^{4,5,7,8,20,27} except for three prospective studies.^{6,23,26} The cohort size of our single-centre prospective study is larger than that of most studies,^{4-7,26,27} similar to that of some studies,^{8,20,23} and smaller than one study.²⁷

The characteristics of our patient group were globally comparable to those of the LSPLS group of the reported studies, including number of patients,^{8,20,23} mean age,²³ gender distribution^{5,20,23} and pre-operative symptoms.^{4-8,20,23,26-28} However, our study had the highest rate of patients lost to follow-up among all the LSPLS studies.^{4-8,20,23,26,27} Although the inclusion criteria were similar to those used in the reported studies,^{4-8,20,26,27} we did not use a radiological criterion for the spinal diameter for lumbar stenosis to include LSS patients into the study, as in one study.²³ Most of the studies reported only LSPLS outcomes,^{4-6,8,20,26} whereas some reported outcomes of an additional concomitant discectomy to LSPLS procedure (Marmot operation).^{7,23}

In LSPLS literature, most of the studies reflected the results of single-level decompressive surgery, in our study we included cases with also double, triple or more levels of decompression.^{4,7,8,20,23} This is a confounding factor for

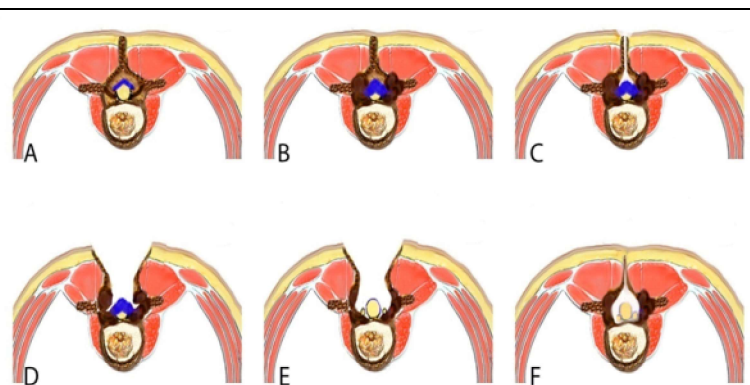


Figure-3: Surgical techniques of lumbar spinous process-splitting laminectomy. Normal spinal cord and vertebral canal anatomy (A). Spinal cord compression due to ligamentum flavum hypertrophy and hyperosteois (B). Forming of intraspinal process canal (C). Separation of both side laminas (D). Decompression (E). Final appearance (F).

interpreting single-level surgery. However, the mean number of decompressed spinal segments is 1.16 in the current study. This is the least rate among the similar studies,^{5,6,26,27} with the results based on mostly single-level surgery.

A Cochrane systematic review analysed all the available lumbar laminectomy or laminotomy studies evaluating primary and secondary outcome measures, and determined that one or more of the following outcome measures have been used in the reviewed articles; primary outcomes including functional disability (e.g. ODI, Japanese Orthopedic Association [JOA]^{29,30} scores; and Roland-Morris Disability Questionnaire³¹ scores), perceived recovery and leg pain, and secondary outcomes including LOS, complication incidence, surgically-induced spinal instability, paraspinal muscle denervation, muscle cell injury, walking distance, back pain, length of surgical procedure, peri-operative blood loss and post-operative use of analgesics.² Our study did not include all of the above outcome measures, but most of them. More importantly, few LSPSL studies have assessed radiological outcome based on CT or MRI measurements, such as AP diameter of spinal canal, which is a strength of our study.^{20,23}

The minimal duration of follow-up for studies reported in the LSPSL literature is mostly 6 months and, prospective long-term results with a minimum of 2 years of follow-up are currently lacking.² Our study had a mean follow-up period of 1 year, as in most similar reports,^{4,6-8,23} even though several patients were followed for up to 3 years in our study.

A study⁵ retrospectively compared outcomes of LSPSL with those of conventional laminectomy in patients with LSS. It reported similar clinical results achieved with both techniques based on the JOA score. However, it also found significantly less muscular atrophy and fatty infiltration of the paraspinal muscles in patients treated by LSPSL compared to those treated by traditional laminectomy, based on post-operative MRI.⁵ Some retrospective observational studies of LSPSL demonstrated significant improvements in pain and overall health and function scores of patients.^{8,20} One study²⁰ reported that LSPSL achieved effective central and lateral recess decompression, which minimised injury to paraspinal muscles. Three retrospective comparative studies reported that LSPSL or its modifications were less invasive and produced superior clinical outcomes. Thus, they present

an effective alternative to conventional laminectomy.^{4,7,27}

Three randomised controlled studies have been published on LSPSL. One²³ compared the results of Marmot operation with conventional decompression and found significant clinical improvements at 1 year in favour of LSPSL based on functional outcome measures (JOA score, VAS and the Prolo³² scale). It also reported less muscle trauma with LSPSL.²³ However, another study found no significant difference with respect to clinical outcomes of LSPSL and traditional laminectomy at 1 year.²⁶ One study⁶ reported significantly less pain in the early post-operative period and lower incidence of post-operative muscle atrophy after LSPSL compared to those with conventional laminectomy, ostensibly due to minimal trauma to paraspinal muscles.⁶ However, a systematic review including these 3 randomised controlled study found that the newer techniques of surgery for lumbar canal stenosis delivered results no different from those of conventional laminectomy with respect to self-care ability, leg pain and perceived recovery of symptoms, even though others have reported some potential benefits of these techniques, avoidance of detachment of tendons and minimal tissue retraction.^{6,8,23}

In the current study, 6 (16.7 %) patients developed a dural tear during repair. Of them, 3 (8.3%) underwent repeat surgery due to persistent pain. Although the rate of dural tear is slightly higher than that of similar studies,^{6,20,23,26} it is an acceptable rate given the steep learning curve for this technique.

Our study has several limitations. This is a single-centre, non-randomised study with limited long-term follow-up. The lack of a control or a comparative interventional group is a shortcoming. The number of patients lost to follow-up is higher than that reported elsewhere. Thus, the complication rate might have been underreported. Assessment of several outcomes could not be included, such as surgically-induced spinal instability, paraspinal muscle denervation, particularly multifidus muscle atrophy, muscle cell injury, peri-operative blood loss and post-operative use of analgesics.

Further multicenter long-term researches are necessary to determine the exact role of LSPLS vis-a-vis conventional laminectomy, using standardised definitions of LSS and surgical success. In spite of these drawbacks, the strength of this study is that all patients underwent the same surgical technique as mostly single-level surgery was performed by a single surgeon. Therefore, our series is

relatively homogeneous which makes our results valuable.

Conclusion

LSPSL led to significant improvement in perceived recovery, functional disability and radiological effectiveness in patients with LSS, with an acceptable complication rate. LSPSL can be recommended as a promising minimally invasive decompressive surgery for the treatment of LSS.

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