Original Article

Comparison of Three Surgical Approaches for the Treatment of Lumbar Spinal Stenosis: Total Laminectomy, Unilateral Approach for Bilateral Decompression, and Total Laminectomy with Posterior Transpedicular Screw Fixation

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Abstract

Introduction: Lumbar spinal stenosis (LSS) is one of the most common diseases for spinal surgery and many surgical techniques are used for treatment. **Objective:** The aim of this retrospective study was to observe the clinical and radiological results of total laminectomy (TL), unilateral approach for bilateral decompression, and posterior transpedicular fixation–interbody fusion with TL. **Materials and Methods:** The data of 112 patients who underwent surgical treatment for LSS with different surgical techniques were reviewed retrospectively. The patients were divided into 3 groups according to the surgical technique. In the first group, patients underwent TL, in the second group, patients underwent bilateral decompression via unilateral hemilaminectomy, and in the third group, patients underwent posterior transpedicular fixation–interbody fusion with TL. Preoperative and postoperative evaluations were done by visual analog scale (VAS) and functional back pain scales (FBPSs). Furthermore, three groups were compared in respect of operation time, bleeding, and complications. **Results:** The difference between preoperative and postoperative VAS and FBPS scores were statistically significant in all groups. Operation time, bleeding, and hospital stay were greater in fusion group than decompression-alone groups. The VAS improvement rate was 66%, 70%, and 62% in Group 1, Group 2, and Group 3, respectively. In addition, improvement of FBPS scores between preoperative and postoperative period was statistically significant for the three groups ($P < 0.05$). **Conclusion:** Decompression with fusion surgery had no significant difference compared with decompression alone in patient's clinical outcome and safety.

Keywords: *Fusion surgery, laminectomy, lumbar stenosis*

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Introduction

Lumbar spinal stenosis (LSS) is one of the most common diseases for spinal surgery. LSS occurs mainly between 5th and 7th decades of life.[1,2] LSS is defined as narrowing of the spinal canal with neuronal and vascular structures surrounding the bone and soft tissue, due to facet joint hypertrophy, ligament hypertrophy, disc degeneration, and/or osteophytes.[3,4] In general, symptoms include intermittent claudication (with or without radiculopathy) in 50–100 m, numbness, tingling, and weakness.[5,6] Surgical intervention is usually preferred in the treatment of symptomatic LSS. Although classical total laminectomy (TL) is still preferred, there is an increase in the number of minimally invasive methods such as unilateral approach for bilateral decompression with the advancement of technology. On the other hand, our accumulated knowledge on

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spine dynamics may direct us to spine stabilization in LSS. This study provides a comparative analysis of the clinical and radiological results obtained in classical TL, unilateral approach for bilateral decompression, and posterior transpedicular fixation–interbody fusion with TL in LSS patients.[7-11]

Materials and Methods

The clinical, radiological, and surgical aspects of 112 patients with LSS who underwent surgical intervention between 2016 and 2021 at Manisa Celal Bayar University School of Medicine Department of Neurosurgery were analyzed retrospectively. Ethics committee approval was obtained from The Animal Experiments Local Ethics Committee of Manisa Celal Bayar University (285/May 09, 2022).

The main surgical indication was neurogenic claudication with back and/or radicular pain associated with clinical history and definite radiological evidence of LSS with magnetic resonance ımaging (MRI), computed tomography (CT), and functional radiograms. Patients with concomitant disorders such as acute spinal trauma, spinal infections, spinal malignancy and/or metastasis, degenerative spondylolisthesis, and evidence of spinal instability were excluded from the study.

Patients groups

The patients were divided into 3 groups according to the surgical technique. None of the patients in all groups had significant radiologic instability in hyperflexion and hyperextension radiographs. Although the indications were the same, patients were treated by 3 different surgeons using different surgical methods.

- Group 1 (n = 35), patients underwent TL
- Group 2 (n = 42), patients underwent unilateral approach for bilateral decompression (unilateral hemilaminectomy [UHL])
- Group 3 (n = 35), patients underwent TL with posterior transpedicular screw fixation and interbody fusion (TLTSF).

Surgical approach

Total laminectomy

All operations were performed under general anesthesia in prone position. After C arm fluoroscopy for the spinal level localization, a midline skin incision was made and classical opening was performed. The lumbosacral fascia was opened in the midline and the paravertebral muscles were subperiosteally stripped from the vertebral column bilaterally until to facets. There was no need for wide lateral enlargement and did not exceed 1/3 of the medial surface of the facets. This is important point for the prevention of spinal instability. Then, TL was performed using Kerrison rongeurs.[7-9,12]

Unilateral approach for bilateral decompression

All operations were performed under general anesthesia in the prone position. After C arm fluoroscopy for the spinal level localization, a midline skin incision of approximately 2–3 cm, depending on the number of levels to be decompressed, was made. The lumbosacral fascia was opened in the midline and the paravertebral muscles were subperiosteally stripped from the vertebral column either on the disc or severe stenotic side or on the side where leg pain was more severe. Unilateral approach for bilateral decompression was performed using a surgical microscope. Using Kerrison rongeur or a high-speed drill, the upper and lower laminae, hypertrophic ligamentum flavum, and the base of the spinous process were removed. By tilting the operating table to positioned contralateral, the microscope angle was changed to be able to see the other side. With this maneuver, an angle of approximately sixty degree perspective was achieved. At this view, contralateral ligamentum flavum was excised easily and contralateral foraminotomy was performed.[11,13-16]

Total laminectomy with transpedicular screw fixation and fusion

All operations were performed under general anesthesia in the prone position. After C arm fluoroscopy for the spinal level localization, a midline skin incision was made. Skin incision must be elongated one level above and below exposing the level (s) of interest. The lumbosacral fascia was opened in the midline and the paravertebral muscles were subperiosteally stripped from the vertebral column bilaterally; a wide dissection was performed to visualize the transverse processes at all levels. First, transpedicular polyaxial screws were placed in each pedicle under fluoroscopic guidance. Then, TL was performed using Kerrison rongeurs. Following decompression, interbody fusion was made, and the screw system was fixed with rods. Allogeneic bone graft was used for fusion. The bone grafts were placed on and between the transverse processes.[9,10,17-19]

Statistical analysis

All statistical analyses were performed using IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0.Armonk, NY: IBM Corp. Descriptive statistical methods (mean and standard deviation) were used for data summarization; number of people and nominal variables were shown as (n) and (%), respectively. The one-way analysis of variance/Kruskal–Wallis test was used to determine the differences between the groups in terms of continuous

variables. The differences between the preoperative and postoperative values of individuals were examined with the Wilcoxon test. Nominal variables were evaluated with Pearson's Chi-square/Fisher's exact test. For $P < 0.05$, the results were considered statistically significant.

Results

Epidemiologic and clinical data were examined retrospectively. The ages of the patients ranged from 39 to 90 years, and the mean age at referral was 64 years. In Group 1, there were 35 patients (16 male and 19 female) and the mean age was 66 years. In Group 2, there were 42 patients (13 males and 29 females). The mean age was 65 years. In Group 3, there were 35 patients (12 males and 23 females). The mean age was 61 years [Table 1].

The mean follow-up time was 41 months (range, 6–70 months). Each patient underwent detailed neurologic and radiologic examination to determine LSS.

Table 1: General characteristics of patients

	Group 1	Group 2	Group 3
No patient: 112	35	42	35
Age (minimum–maximum)	66 (39-90)	65 (42-81)	61 (42-72)
Gender (male/female)	16/19	13/29	12/23
Operation level			
L1-2	-	1 (1.2)	-
L2-3	3 (6.5)	5 (6.3)	7 (10)
L3-4	14 (30.4)	16 (20.2)	21 ((30)
L4-5	23 (50)	37 (46.8)	33 (47.1)
L5-S1	6 (13)	20 (25.3)	9 (12.8)
Complications			
Infection	No	1 patient	No
Screw malposition	No	No	3 patients
Listhesis	1 patient	1 patient	No
Dural tear	2 patient	2 patient	1 patient
Neurologic deficits	No	1 temporary sensory loss	3 temporary sensory loss
Adjacent segment disease	-	-	-
Radicular pain	No	No	1 patient
CSF fistula	No	1 patient	2 patients

CSF: Cerebro spinal fluid

Surgery levels

Surgical decompression was performed at 195 levels in 112 patients.

In Group 1 (n = 35), 25 patients (71.42%), nine patients (25.71%), and 1 (2.85%) patient underwent single-level, two levels, and three levels decompression surgery, respectively. There was no four or more levels' surgery in this group.

In Group 2 (n = 42), 18 patients (42.85%), 13 patients (30.95%), nine patients (21.42%), and 2 patients (4.76%) underwent single-level, two levels, three levels, and four levels decompression surgery, respectively.

In Group 3 (n = 35), 12 patients (34.28%), 14 patients (40%), six patients (17.14%), and three patients (8.57%) underwent single-level, two levels, three levels, and four levels decompression surgery, respectively.

LSS was located most frequently at L4-L5 level (93 levels), followed by L3-L4 level (51 levels).

Visual analog scale scores

The visual analog scale (VAS) improvement rate was 66%, 70%, and 62% in Group 1, Group 2, and Group 3, respectively. Although there was no statistically significant difference between groups, clinical improvement was slightly better in Group 2 than the others. In addition, the difference between preoperative and postoperative VAS scores was statistically significant in all groups [$P < 0.05$, Table 2].

Functional back pain scale

Functional back pain scale (FBPS) was developed in 2000 by Stratford and Binkley.[20] It aims to evaluate disability in patients with back pain. It is a self-administered questionnaire consisting of 12 items that measure the patient's ability to perform physical activities. The 12 items cover different domains. Each item scored on a 6-point scale (0–5 points) and total FBPS scores can vary from 0, the lowest functional level, to 60, the highest functional level. It may be completed between 30 s and 5 min[20,21] [Table 3].

Table 2: Pre-and postoperative comparison of visual analog scale and functional back pain scale

Pain and functionality	Pain relief (VAS)		Functionality (FBPS)	
	Preoperative	Last follow-up (P)	Preoperative	Last follow-up (P)
Group 1	7.48±1.42	2.54±0.58 (<0.05)*	22.94/60	47.29/60 (<0.05)*
Group 2	7.52±1.46	2.26±0.38 (<0.05)*	23.95/60	49.33/60 (<0.05)*
Group 3	7.74±1.14	2.94±0.58 (<0.05)*	21.76/60	46.28/60 (<0.05)*
Statistical comparison of three groups (P)	>0.10**	>0.10**	>0.10**	>0.10**

*Statistical significance within the group itself, **Statistical significance between groups. VAS: Visual analog scale, FBPS: Functional back pain scale

Improvement of FBPS scores between preoperative and postoperative period was statistically significant for three groups ($P < 0.05$). However, there was no statistically significant difference for the 6th month follow-up FBPS score between groups [$P > 0.10$, Table 2].

Operation time

The average operation time was 65 min (40–100 min) in Group 1. However, it was 82.5 min (60–120 min) in Group 2 and 120 min (75–210 min) in Group 3. Group 3 had the longest average operation time and the difference was statistically significant when compared to other groups ($P < 0.001$). In addition, the difference was statistically significant in comparison of Group 1 and 2 [$P < 0.05$, Table 4].

Complications

Radicular leg pain developed in one patient in Group 2 and two patients in Group 3 (who had screw malposition), in the early postoperative period. Temporary sensory loss was detected in one patient in Group 2 and in three patients (who had screw malposition) in Group 3. In one patient superficial wound infection occurred on surgical incision in Group 2. While dural tear occurred in two patients in both Group 1 and Group 2, dural injury occurred in only one patient in Group 3. Transpedicular screw malposition was seen in three patients in group 3. Listhesis were developed in one patient each in both Group 1 and Group 2 at postoperative period. Adjacent segment disease developed in one patient in Group 3 [Table 4].

Table 3: Functional back pain scale

0: Unable to do the activity, 3: Medium difficulty, 5: Normal	Mark one number on each line					
	0	1	2	3	4	5
Usual work, etc.						
Usual hobbies, etc.						
Heavy activities home						
Bending or stooping						
Shoes or socks						
Lifting from floor						
Sleeping						
Standing 1 h						
Walking 1.5 km						
2 flights of stairs						
Sitting 1 h						
Driving (or travel by car) 1 h						
Subtotal						
Total	..../60					

Table 4: Comparison of surgical parameters

	Incision length (cm)	Blood loss (mL)	Operation time (min)
Group 1	8.45±2	125±25 (75-175)	65 (40–100)
Group 2	6.8±2.5	100±25 (50-175)	82.5 (60–120)
Group 3	10.5 (8-16)	350±75 (175-525)	120 (75–210)
Statistical analysis (P)	<0.05	G1 versus G2 >0.01	<0.05
		G1–G2 versus G3 <0.05	

Case presentations

Case 1

A 64-year-old male presented with back and right leg pain. The history revealed that he had suffered from back pain for approximately 5 years. In addition to back pain, right leg pain had started 5 months ago. He described neurogenic claudication at 50 m. His neurological examination was normal. Radiological examinations determined L3-4 and L4-5 spinal stenosis. He underwent L3 and L4 TL. Postoperative period was uneventful and he was discharged on postoperative 3rd day. However, after 1 year, he admitted with the complaints of recurrent low back and right leg pain after falling. Lumbar CT demonstrated L4-5 listhesis and right L4 vertebra pedicle fracture. In 2nd operation, posterior transpedicular screw fixation and fusion were performed. Postoperative period was uneventful and he was discharged on the postoperative 4th day [Figure 1].

Case 2

A 65-year-old female presented with complaints of back and left leg pain that had started 3 years ago. She described neurogenic claudication at 80–100 m. Her neurological examination was normal. Radiological examinations determined L4-5 spinal stenosis. She underwent surgery and bilateral decompression was done via left unilateral hemilaminectomy. Postoperative period was uneventful and she was discharged on postoperative 3rd day. However, after 18 months, she presented with a complaint of severe low back pain

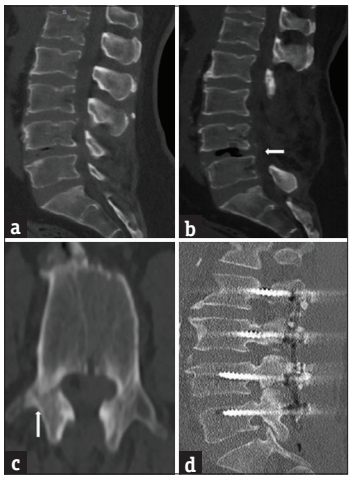

Figure 1: Computed tomography before first operation determined lumbar stenosis (a). One year after the total laminectomy surgery, L4-5 listhesis and L4 vertebra pedicle fracture occurred after falling (white arrows) (b and c). Pedicle screws were seen after second surgery (d)

that started 2 months ago. Lumbar MRI determined L4-5 listhesis. She went second surgery and L4-5 posterior transpedicular screw fixation and fusion surgery were performed. Postoperative period was uneventful and she was discharged on the postoperative 5th day [Figure 2].

Case 3

A 43-year-old male presented with complaints of back and left leg pain that had started 2 years ago. He described neurogenic claudication at 50 m. His neurological examination was normal. Radiological examinations determined L4-5 spinal stenosis. He underwent L4 and L5 TL with L4-5 bilateral transpedicular screw fixation and interbody fusion. Postoperative period was uneventful and he was discharged on the postoperative 4th day. On follow-up, we demonstrated fusion on the postoperative 1st year [Figure 3].

Discussion

Lumbar canal stenosis is the most common pathological condition that causes spinal degeneration. Symptomatic patients who fail conservative treatment are considered candidates for surgical treatment. The primary goal of surgical intervention in LSS is decompression of direct cauda equina or nerve roots , relieve of symptoms, and improve of functions. A variety of surgical techniques such as laminectomy, foraminotomy, discectomy, minimally invasive implants, fusion, and endoscopic approaches are used.[22-25] However, two major surgical approaches, unilateral approach and midline approach, are used. The unilateral approach is used to preserve midline osteoligamentous structures, the contralateral facet joint, and the contralateral paravertebral muscle. The midline approach is used to preserve the left and right facet joints and the enthesis of the paravertebral muscle.[8,9,12-15] In addition to these two major surgical approaches, there has been an increase in the use of the lumbar spinal fusion procedure because biomechanical studies have shown a correlation between the extent of decompression and postoperative instability.[26] However, still, there is no consensus whether treating these patients would be more effective with or without fusion.[27] In this study, we compared the clinical efficacy and radiological results of TL, unilateral approach for bilateral decompression, and posterior transpedicular screw fixation with fusion.

To date, several studies have reported that adequate decompression to be the most successful surgical option for LSS.[28-30] Klingler *et al*. treated 10 consecutive patients with lumbar stenosis via bilateral crossover approach and reported statistically significant improvement on the VAS after a follow-up of 10.5 months.[28] Kim *et al*. operated 122 LSS patients via unilateral laminotomy-bilateral decompression and significant improvements in the extent of symptoms, patient satisfaction, and quality of life were observed 12 months after the surgery.[29] In another study, Bouknaitir *et al*. treated 186 patients via wide laminectomy, segmental bilateral laminotomies and UHL with bilateral decompression. The authors reported that there were no differences in patient-reported outcome measure among the three cohorts at 5-year

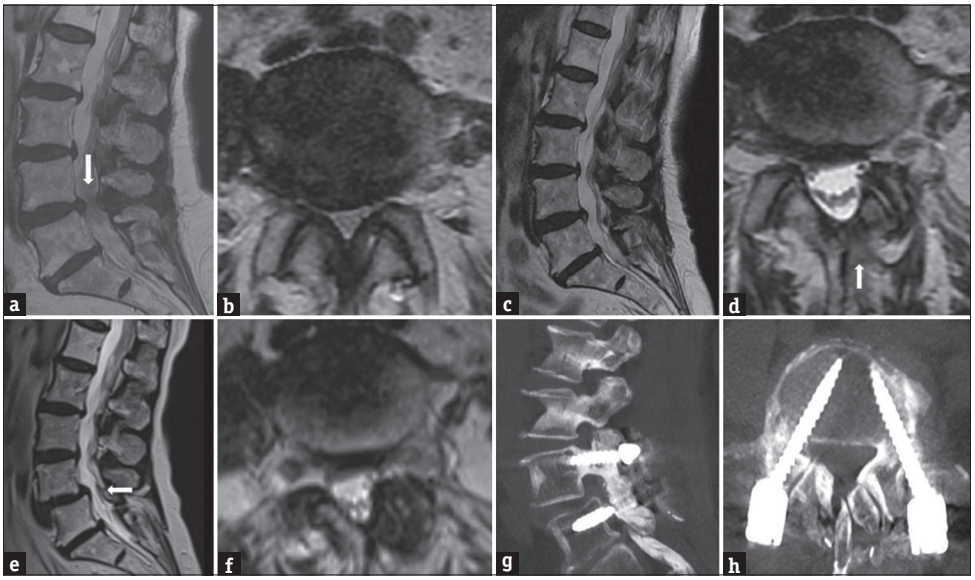

Figure 2: Sagittal and axial sections of lumbar MRI demonstrated L4-5 spinal stenosis (white arrow) (a and b). Sagittal and axial sections of lumbar MRI in postoperative period revealed decompression of dura mater at L4-5 vertebra level. White arrow shows left hemilaminectomy defect (c and d). Eighteen months after the first surgery, sagittal and axial sections demonstrated L4-5 listhesis (white arrow) (e) and lumbar stenosis (f) respectively. L4-5 posterior transpedicular screw placements were seen (g and h). MRI: Magnetic resonance imaging

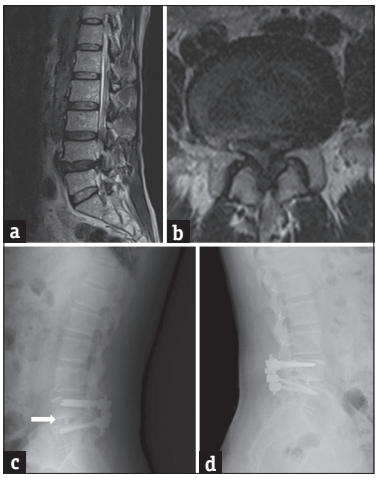

Figure 3: Sagittal and axial sections of lumbar MRI demonstrated L4-5 spinal stenosis (white arrow) (a and b). Postoperative early and postoperative 1st year radiographs demonstrated L4-5 bilateral transpedicular screw fixation and interbody fusion (white arrow), respectively (c and d). MRI: Magnetic resonance imaging

follow-up.[30] Although various surgical techniques without fusion surgery have been used in the treatment of LSS, their superiority for clinical efficiency over conventional laminectomy has not been determined.[31,32] Hatakka *et al*. reported that decompression may have a small, statistically significant but probably clinically insignificant effect on lumbar lordosis, sagittal vertical axis, and pelvic tilt.[33] In this study, 77 of 112 patients were treated with decompression surgery alone. 35 of 77 were treated via TL and the remaining were treated with UHL. Similar to literature, VAS and FBPS values were slightly better in unilateral hemi-laminectomy group than TL group, but the differences were not statistically significant.[34-37]

In recent years, the rates of operations that include lumbar fusion have increased dramatically. The average rate of inpatient spinal fusion for LSS during the period from 2001 to 2011 in the United States was 41.1 per 100,000 Medicare beneficiaries.[38] Spinal fusion aims to eliminate back pain by joining two or more adjacent vertebrae under the theory that stabilization will reduce symptoms. However, the evidence of the effectiveness of lumbar fusion surgery for treating spinal stenosis has not been fully established.[39-43] Aimar *et al*. analyzed 1001 patients who were treated for spinal stenosis. Their study included 367 patients who had undergone decompression and 634 who had undergone decompression plus arthrodesis. Of the 1001 patients, 123 reported a very poor outcome, 136 a poor outcome, 39 a fair outcome, 97 a good outcome, and 605 an excellent outcome. The authors compared the groups for Oswestry disability index (ODI) improvement and they found that there was no statistically significant difference between the 2 groups.[44] A meta-analysis by Shen *et al*. showed that fusion and nonfusion surgeries had no differences in clinical effects, while fusion surgery involved a longer length of stay than nonfusion surgery.[45] Yamashita *et al*. evaluated the relationship between functional disability, patient satisfaction, and walking ability in a cohort of 77 patients who were treated with decompression with or without fusion. They found that patients improved on all outcome measures, but patient satisfaction was not always tied to functional improvement as defined by the ODI. Persistent difficulty in walking was associated with lower patient satisfaction. However, this paper does not provide useful evidence because patients were chosen for fusion based on the preoperative diagnosis of spondylolisthesis, so no comparison between decompression alone or decompression plus fusion can be made.[46] In another study, Zouboulis *et al*. performed a prospective evaluation of a group of 41 patients who were treated with laminectomy and instrumented fusion for stenosis. The authors reported that the patients' clinical improvement on the ODI and VAS was statistically significant after a mean follow-up of 3.7 years. Recurrent stenosis was not observed, and 39 of 41 patients were satisfied with the outcome. Three patients with improvement initially had later surgery because of instability. The most important shortcoming of the study was patients with normal alignment, scoliosis, spondylolisthesis, and multilevel diseases were all included in one group.[47] Many questionnaires such as FBPS, Roland–Morris disability questionnaire (RMQ), ODI, and short-form 36-health survey (SF-36 h) focusing on function have been developed in patients with low back pain. Koç *et al*. demonstrated that FBPS has good correlation with RMQ, ODI, and SF-36 h.[21] Hence, we used VAS and FBPS for the evaluation of patients. In our study, 35 of 112 patients were treated with decompression and fusion surgery. In the following period, fusion was detected in all patients. Clinical outcomes were evaluated by VAS and FBPS. While the VAS improvement rate was 60%, the mean score of FBPS was 21.76/60 in preoperative period and it was increased to 46.28/60 at the 6th month follow-up. In comparison of decompression with and without fusion surgery, both VAS and FBPS scores were improved in groups. However, differences were not statistically significant.

In previous reports, complication rates and parameters such as hospitalization time and blood loss were evaluated. Transfeldt *et al*. reported that the group receiving decompression alone had the lowest rate of complications.[48] Similarly, Masuda *et al*. reported that the complication rate in the decompression group was lower than that in the fusion group and the high infection

rate and adjacent-segment degeneration in the fusion group might be due to the long operative time and use of instrumentation.[49] The result in our research showed that fusion surgery meant a longer length of stay, longer operation time, longer incision length, and greater blood loss than for the nonfusion groups. All these parameters were statistically significant between the fusion and nonfusion groups. However, although complication rates were slightly higher in fusion group, the difference was not statistically significant.

Limitation of the study

This is a retrospective study from one center and VAS for back pain and leg pain were not measured separately.

Conclusion

Addition of fusion to decompression in LSS had no significant difference compared to decompression alone in patient's clinical outcomes. Therefore, we think that it would be better to use minimally invasive surgery (UHL) or conventional surgical techniques (TL), since fusion surgery (TLTSF) takes longer to operate, requires larger surgical incisions, causes greater blood loss, and has slightly higher complication rates.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initial s will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Contribution details

The manuscript has been read and approved by all the authors, the requirements for authorship as stated earlier in this document have been met, and each author believes that the manuscript represents honest work.

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Conflicts of interest

There are no conflicts of interest.

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