Outcomes of two minimally invasive decompressive techniques for degenerative lumbar spinal stenosis

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Background
Minimally invasive decompressive procedures have evolved into the modern standard surgical solution for degenerative lumbar spinal stenosis (DLSS) patients, such as the bilateral laminotomy and the unilateral laminotomy for bilateral decompression (ULBD) that is characterized by ipsilateral and contralateral microdecompression under the midline posterior structures and has been successfully used with proven efficacy.
Objective
To compare the effect of the size of the skin incision and the method of handling the multifidus muscle on the clinical outcomes of the endoscopic laminotomy versus the standard microscopic laminotomy for DLSS.
Patients and methods
Primary outcome data included the numerical rating scale for back and leg symptoms and Oswestry Disability Index to quantify pain and disability, respectively. Secondary outcome data included operative time, blood loss, and modified Mcnab criteria.
Results
At the end of the follow-up period, the rate of successful outcome of the endoscopic group was 87.2 and 77.8% for the control group after initial improvement by 87% at 3-month follow-up. The incidence of complications was 13% in both groups.
Conclusion
For DLSS, the endoscopic ULBD in experienced hands would have a better outcome than the microscopic ULBD regarding the postoperative clinical outcome and patient satisfaction.

Keywords:
endoscopic, lumbar spinal stenosis, microscopic, spine

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Introduction

Degenerative lumbar spinal stenosis (DLSS) is the most common cause for spinal surgery in the geriatric population [1]. Neurogenic claudication is the chief complaint of patients [2].

Open laminectomy has been traditionally the standard operative technique for DLSS with unsatisfactory long-term outcome [3,4]. Aryanpur and Ducker [5] suggested that complete decompression may not be necessary to achieve symptomatic relief. Significant stenosis of up to 45% has been found in asymptomatic patients [6]. Subsequently, minimally invasive decompressive procedures have evolved into the modern standard surgical solution for DLSS, such as the bilateral laminotomy [5,7] and the unilateral laminotomy for bilateral decompression (ULBD) which was initially described by Young *et al.* [8] and subsequently modified by McCulloch [9]. This microscopic technique that is characterized by ipsilateral and contralateral microdecompression is performed under the midline posterior structures and has been successfully used with proven efficacy for the treatment of DLSS patients [10,11].

Successive tube dilators and retractors were designed to minimize disruption of the paraspinal musculature in endoscopic ULBD [12,13]. Several studies have shown better patient outcomes of endoscopic ULBD when compared with those of the traditional open laminectomy [14–17].

A review of the literature has shown no studies comparing the clinical outcome of endoscopic versus microscopic ULBD. The goal of this study was to compare the effect of the size of the skin incision and the method of handling the multifidus muscle on the clinical outcomes of those two minimally invasive decompressive procedures for DLSS.

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Patients and methods

This was a prospective, randomized, controlled trial of patients with DLSS. All the participants gave their written consent in accordance with the Helsinki Declaration [18]. All the participants gave their written consent in accordance to the Helsinki Declaration. The study was approved by the Ethical Research Committees of Zagazig University Hospitals. We enrolled in our study 60 patients with clinically symptomatic DLSS who fulfilled the inclusion criteria for our study. The patients were divided into two groups: 30 patients each who were treated with either endoscopic ULBD (group A) utilizing the METRx system (Medtronic Sofamor Danek Inc., Memphis, Tennessee, USA), or microscopic ULBD (group B=control group) utilizing an operative microscope, at our Orthopaedic Department, Zagazig University, Egypt, between May 2012 and August 2016 and the last follow-up visit took place in August 2018.

Determination of the general indication for surgery was made by the authors who experienced spine surgeons, randomization was open since the patients must sign a detailed informed consent and was made by the nonphysician study staff alternating between the endoscopic ULBD and the microscopic ULBD in the sequence of presentation were allocated so that patient 1 got the first type of surgery (Microendoscopic), and number 2 the second type (Microscopic). Preoperative MRI studies, and the T_2-weighted axial MRI were reviewed to determine the level of stenosis. Preoperative lumbar dynamic (flexion–extension) radiographs were reviewed for evidence of instability. Furthermore, only patients who completed the 24 months of follow-up were included in the final analysis of this study. All operations were performed by the authors who have considerable experience in both techniques.

Inclusion criteria included (a) neurogenic claudications as expressed by the patients as leg pain and/or heaviness limiting standing, walking, or both; (b) a history of walking intolerance; (c) MRI confirmation of central canal stenosis (central sagittal diameter <10 mm) with or without lateral recess stenosis (lateral recess diameter <3 mm); and (d) failure of conservative therapy.

Exclusion criteria included (a) previous spinal surgery at the same level; (b) dynamic instability determined by the presence of sagittal vertebral translation greater than 3 mm and angulation more than 10° on a dynamic radiograph; (c) isthmic spondylolisthesis; (d) cauda equina syndrome; (e) far-lateral disk herniation pressing the nerve root in the extraforaminal region.

Demographic data

In group A, 14 men and 12 women ranged in age from 48 to 65 years (average, 56.5 years). In group B, 16 men and 11 women ranged in age from 49 to 67 years (average, 58 years). Thirty-eight (71.7%) patients were 60 years of age or older. The mean duration of symptoms was 12.6 months for group A and 13.5 months for group B. All patients had received conservative treatment in the form of limited daily activity, NSAIDs, muscle relaxants, neurotrophins, opioid analgesics, and a comprehensive course of 30 sessions of physiotherapy (mean, 5.2 months). Patient characteristics are listed in Table 1. Patients of both groups had a very similar clinical profile (e.g. radicular pain related to exercise and radiculopathic neurological deficits such as numbness, muscle weakness, and/or hyporeflexia). Overall, a total of 72 laminotomies were performed in the 53 patients; 36 (68%) patients (group A, 19 and group B, 17) were decompressed at one level, 15 (28.3%) patients (group A, seven and group B, eight) at two levels, and two (3.8%) patients (one patient for each group) at three levels.

Evaluation

Primary (subjective) outcome data included: numerical rating scale (NRS) (range, 0–100) [19] for back and leg symptoms and Oswestry disability index (ODI) [20], version 2.0. The final score is calculated and presented as a percentage (0% represents no pain and disability and 100% represents the worst possible pain and disability) both NRS and ODI were used for preoperative and postoperative evaluation. The modified Mcnab criteria [21] were used only for postoperative evaluation.

Secondary (objective) outcome data included: (a) all the patients who had preoperative lumbar dynamic (flexion–extension) radiographs and 3, 12, and 24 months postoperative lumbar dynamic (flexion–extension) radiographs. These were reviewed for evidence of instability and/or progression of spondylolisthesis. A single radiologist who was not affiliated with the study, blinded to the procedure and the clinical results of decompression, reviewed all

Table 1 Patients' characteristics

Mean	Group A	Group B	*P* value[a]
Age (year)	60.4±5.07	59.8±5.66	0.590
Decompressed levels	1.55±0.74	1.57±0.71	0.569
Operative time (min)	90.18±10.36	93.14±10.78	0.132
Blood loss (ml)	36.11±9.19	52.77±9.6	0.001

[a]Assessed by independent samples *t* test.

preoperative and postoperative studies. (b) Operative time and blood loss (Table 1). Reoperation at the same level for any reason was considered a poor outcome, regardless of the ultimate level of function.

Endoscopic unilateral laminotomy for bilateral decompression

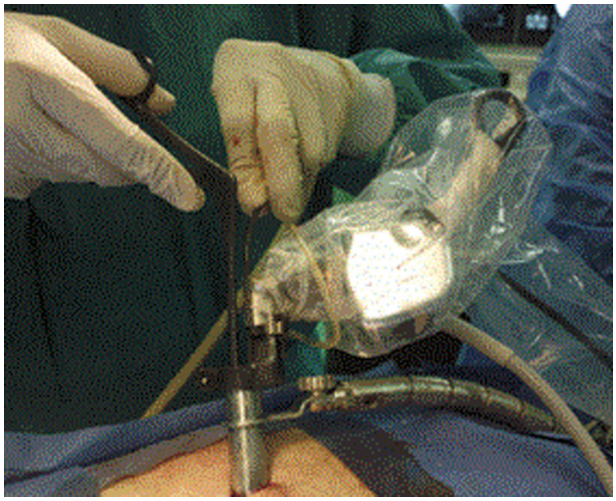
After introduction of general anesthesia, the stenotic level was localized by fluoroscopy. After making an 18–25 mm paramedian skin incision, a rigid endoscope was inserted into the tubular retractor. Unilateral laminotomy and flavectomy were performed endoscopically (Fig. 1).

A careful medial facetectomy was performed enough to decompress the lateral recess and undermine the entrance zone of the foramen to decompress the exiting nerve root. A long 90° ball-tipped probe was passed through the foramen over the nerve root to insure that there is no residual foraminal stenosis. At this stage, a discectomy could be performed if the bulging dis is one of the stenosing elements (Fig. 2). The endoscope was then angulated medially to visualize the volar surface of the spinous process which was undercut by a burr or a Kerrison punch (Fig. 2). The hypertrophied medial facet was partially resected after contralateral laminotomy and flavectomy. The whole procedure was repeated at the contralateral side of the neighboring stenotic level only, when there is a long-segment (two or more levels) stenosis as planed preoperatively. The reason of bilateral approach on different levels is to avoid formation of one long continuous incision made by two or more neighboring small incisions (endoscopic or microscopic) in long-segment lumbar stenosis. The incision was closed in layers by using Vicryl.

Microscopic unilateral laminotomy for bilateral decompression

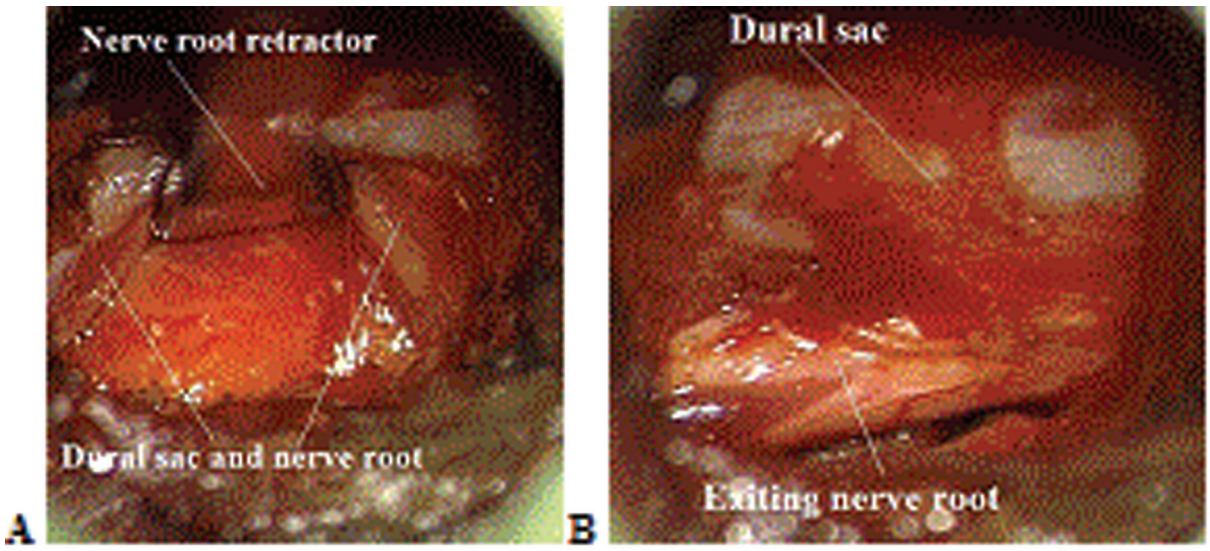
After patient preparation, a 3–6 cm (according to the patient's body build) midline skin incision was made and the paraspinal muscles were retracted using a self-retaining retractor. The operative microscope was brought and adjusted over the incision after being

Figure 2



Endoscopic ULBD (left), using the pituitary rongeur and suction during the discectomy step of the decompression procedure. Note the angle of the tubular retractor to decompress midline and contralateral structures. ULBD, unilateral laminotomy for bilateral decompression.

Figure 1



Endoscopic views: (a) nerve root retractor retracting the dural sac and nerve root medially to undermine the lateral recess or to perform discectomy and (b) the dural sac after decompression.

covered by sterilized draping. Then the surgical procedure was done exactly as in the endoscopic procedure for the ipsilateral side and the contralateral side after medial angulation of the operative microscope (Fig. 3).

Follow-up

The mean period of follow-up in group A was 24.55 ±1.57 months and 24.29±1.74 months in group B. The patients were followed up at 3, 12, and 24 months. Follow-up data were obtained from clinic follow-up visits by two independent physicians: before surgery, after surgery at day 1 (60 patients in hospital before discharge). All patients had intramuscular NSAID injection for pain control and mobilization was permitted after complete recovery from anesthesia but strenuous activities were postponed until 1–2 moths postoperatively, 2 weeks for stitches removal, 3 months (58 patients), 12 months (56 patients), and at the final follow-up visit at 24 months (53 patients) (88.3%). The final follow-up visit took place in August 2017.

We analyzed only the results of the patients who completed at least 24 months of follow-up. Seven patients were lost for the following reasons: two surgery-unrelated deaths and five patients did not attend the outpatient clinic follow-up visits. The final count was 53 (88.3%) patients in both groups. Four patients 26/30(86.7%) were lost in group A, and three 27/30 (90%) patients were lost in group B.

Statistical analysis

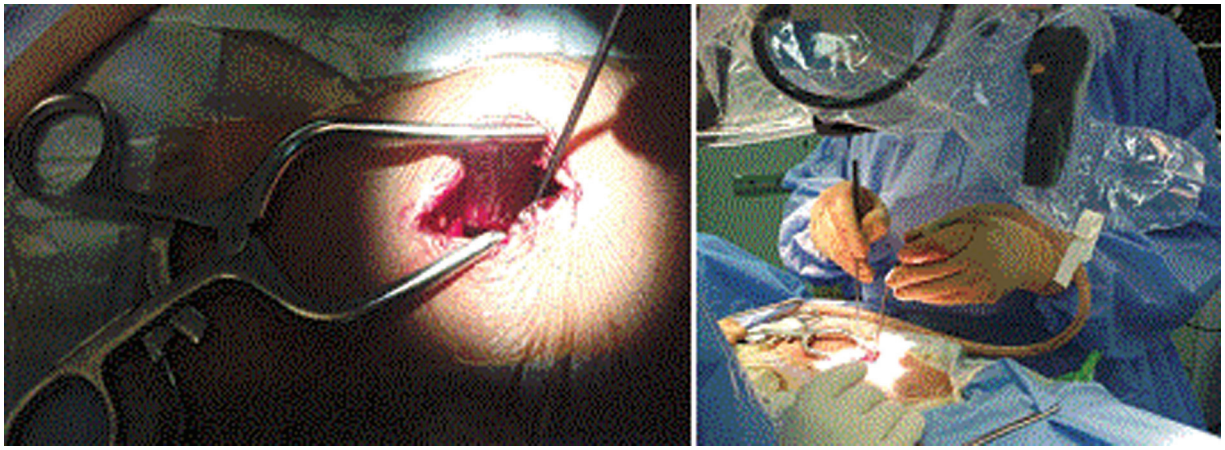
All statistical analyses were carried out using the SPSS (Statistical Package of Social Sciences; SPSS Inc., Chicago, Illinois, USA) for Windows software program, version 17.0. A P value of less than 0.05 was considered statistically significant. The results were expressed as mean±SD. Paired t test and a χ^2 test were used to test the differences between the two groups in terms of categorical data and one-way analysis of variance test was used to test for significant differences between baseline and for various follow-up measurements.

Results

In the endoscopic group, the mean operative time was 90.18±10.36 min. The mean blood loss was 36.11 ±9.19 ml. In the control group, the mean operative time was 93.14±10.78 min. The mean blood loss was 52.77±9.6 ml (Table 1).

In the endoscopic group, the neurogenic claudicant leg pain relief was statistically significant, the mean NRS leg score significantly decreased from 7.61±0.91 to 1.21 ±0.59 (P=0.001) postoperatively, whereas the mean back pain insignificantly increased from 3.2±0.89 to 3.6 ±0.54 postoperatively (P=0.584) and remained stable till the final follow-up evaluation. In the control group, the leg pain relief was statistically significant, the mean NRS leg score significantly decreased from 7.5±0.9 preoperatively to 1.27±0.71 (P=0.001). The score was taken during the first week postoperatively and remained stable till the final follow-up evaluation, whereas the mean NRS back pain insignificantly increased from 3.11±0.76 preoperatively to 3.8±0.4 postoperatively(P=0.523) during the first 12 months postoperatively, then it significantly increased to 6.8 ±0.4 at the final follow-up evaluation (P=0.001). There

Figure 3



Open microscopic ULBD (left), using the self-retaining retractor to laterally retract the lumbar multifidus muscle and open microscopic ULBD (right), using the probe during flavectomy. The microscope is covered with sterilized draping. ULBD, unilateral laminotomy for bilateral decompression.

was no statistically significant difference between the mean NRS back pain and leg pain preoperative scores of the two groups (P=0.262) (P=0.308) (Table 2).

In the endoscopic group, the disability improvement was statistically significant and the mean ODI score significantly decreased from 73.036±5.64% preoperatively to 16.69±6% at the final follow-up. In the control group, the disability improvement was statistically significant and the mean ODI score significantly decreased from 72.37±5.94% preoperatively to 22.25±7.2% at the final follow-up (P=0.001). There was no statistically significant difference between the mean preoperative scores of the two groups (P=0.326) (Table 2).

At the final evaluation, according to Mcnab criteria, in the endoscopic group, the overall results were good to excellent in 84.6% (22/26) of the patients, fair in 11.5% (3/26), and poor in 3.8% (1/26). In the control group, at the final evaluation, according to Mcnab criteria, the overall results were good to excellent in 77.8% (21/27) of the patients, fair in 7.4% (2/27), and poor in 14.8% (4/27) (Table 3).

If the excellent and good categories were regarded as successful and fair and poor were considered failures, the total success rate of the endoscopic group was 84.6%. For the control group, the success rate was77.8% at the end of the follow-up period.

Complications

There were no serious complications in either group, such as nerve root injury, cauda equina syndrome, spondylodiscitis, or deep venous thrombosis. Dural tears were encountered in two (7.7%) patients in the endoscopic group A and three (11.1%) patients in the microscopic group B. Fortunately, the five dural tears were tiny and were managed using SurgiSeal and tailored patch form dorsolumbar fascia without residual postoperative cerebrospinal fluid leakage. One (3.7%) patient in the microscopic group and one (3.8%) patient in the endoscopic group had superficial wound infection.

During the follow-up period, five (9.4%) patients underwent reoperation; two patients underwent repeated decompression at previously operated levels due to residual stenosis or restenosis (one patient in each group); and three patients underwent spinal fusion for progressive lumbar instability due to decompression of two or three motion segments [one (3.8%) patient in the endoscopic group A and two (7.4%) patients in the microscopic group B]. These patients were partially recovered after the repeated surgery, but remained in the poor outcome group during the long-term follow-up.

Discussion

Getty *et al.* [22] introduced unilateral and bilateral laminotomy for decompression of DLSS as a less invasive surgical option. Comparable results have

Table 3 Mcnab criteria comparison between groups A and B

	Mean	Group A [*n*/*N* (%)]	Group B [*n*/*N* (%)]	*P* value[a]
Mcnab criteria	Excellent and good	22/26 (84.6)	21/27 (77.8)	0.000
	Fair	3/26 (11.5)	2/27 (7.4)	0.000
	Poor	1/26 (3.8)	4/27 (14.8)	0.000

[a]Assessed by independent samples *t* test.

Table 2 Outcomes comparison between group A and group B

Mean	Group A	Group B	*P* value[a]
Follow-up duration (month)	24.55±1.57	24.29±1.74	0.348
NRS of back pain			
Preoperative	3.2±0.89**	3.11±0.76	0.262
3–12 months postoperative	3.6±0.54	3.8±0.4	0.523
At the final interview	3.6±0.54**	6.6±0.4	0.000
NRS of leg pain			
Preoperative	7.61±0.91	7.50±0.90	0.308
At the final interview	1.21±0.59	1.27±0.71	0.322
ODI			
Preoperative	73.036±5.64	72.37±5.94	0.261
At the final interview	16.69±6	22.25±7.2	0.001

A positive significance level was assumed at a P value less than 0.05, values are mean±SD. NRS, numerical rating scale (0–10); ODI, Oswestry disability index; the mean ODI score is multiplied by 2 to give the mean disability score which is expressed in the table.
[a]Assessed by independent samples *t* test. **The mean difference between the preoperative and postoperative (final interview) NRS for back pain for group A was statistically insignificant (P=0.584).

been reported since then and the success rate ranged from 59 to85.3% [5,7].

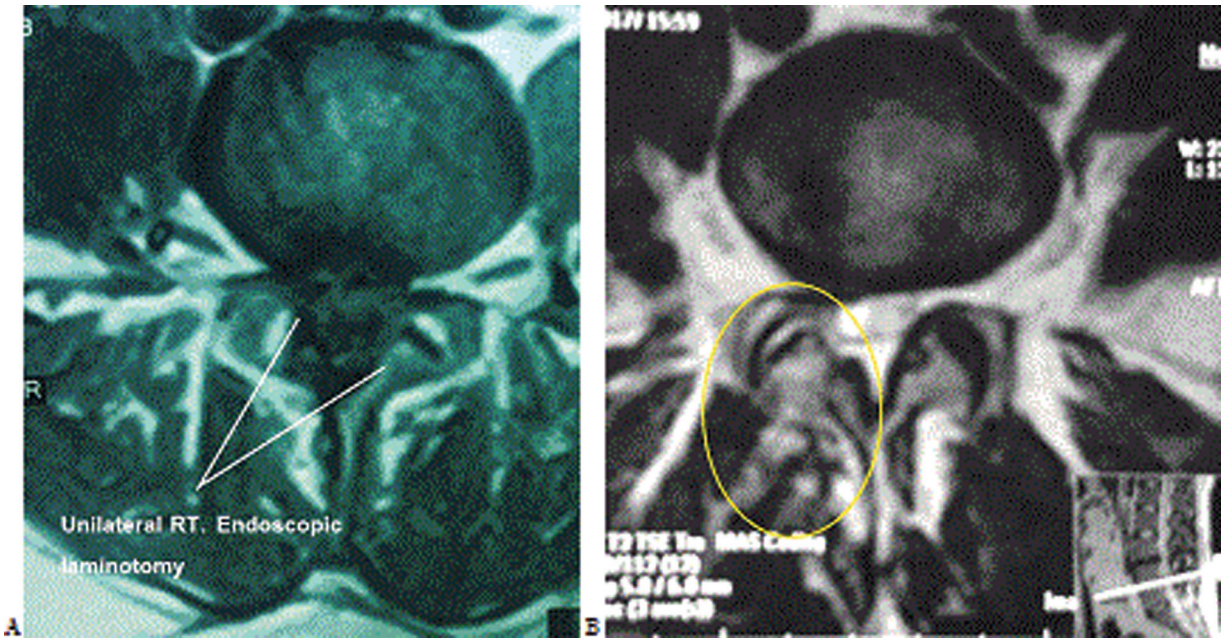
In the present study, the surgical complication rate in the endoscopic group was 3.6% (two patients had accidental durotomy) and in the microscopic group was 9.3% (two patients had accidental durotomy and three patients had wound infection) which is comparable to those reported by other studies [1,10–17]. Also, the 8.3% incidence of reoperation for restenosis and secondary spinal instability is comparable to those reported by other studies in the literature [1,10,17].

The overall results of both groups were comparable during the first 12 months of the postoperative period. Although the mean ODI and NRS leg and back scores for the endoscopic group and the mean ODI and NRS leg scores for the control group showed significant improvement at the end of the 36 months follow-up period, the NRS back scores for the control group showed deterioration at 36 months after initial significant improvement at 3–12 months follow-up postoperatively ($P<0.001$) (Table 2). This may be explained by the technical differences between the two procedures such as the size of skin incision and the method of handling of the lumbar multifidus (LMF) muscles. In the endoscopic technique we used a muscle-splitting approach using sequential dilators and a 20 mm diameter tubular retractor, whereas in the microscopic technique we made a 3–6 cm skin incision according to the patient's body build, and an LMF muscle stripping and retraction approach to gain access to the spinal canal with the high possibility of injury to the medial branch of the dorsal ramus (Fig. 4).That nerve courses around the superior articular process lies in a groove between the mammillary process and the accessory process and supplies the LMF muscle and its inevitable tethering by retraction of the LMF muscle will lead to LMF muscle denervation and subsequent decrease in its strength with associated atrophy on postoperative computed tomography [23] and electromyographic studies that was correlated with postoperative failed-back surgery syndrome [24].

The current study presents the first comparison study between two minimally invasive techniques for the treatment of DLSS. The 36 months follow-up period allowed observation of the persistence of the initial good outcome. Also, the prospective nature, the homogeneity of the patient population, the detailed prescription of the surgical procedures, and the independent observers are strengths of the current study.

One of the shortcomings of our study is the relatively small number of patients in both groups. Another

Figure 4



(a) Postoperative MRI axial view showing the endoscopic right laminotomy boundaries with intact but undermined left lamina, also showing the near-normal appearance of the lumbar multifidus muscle with minimal degree of fibrosis on the endoscopic right laminotomy side. (b) MRI axial view (1-year postmicroscopic ULBD) shows the decompressed lumbar spinal canal and lateral recess with preserved facet joints (yellow circle), it also shows the increased amount of fibrosis in the lumbar multifidus muscle on the operated side (right side). ULBD, unilateral laminotomy for bilateral decompression.

shortcoming is that postoperative spinal computed tomography or MRI scans to assess the amount of decompression were not performed routinely. However, the amount of radiologically confirmed decompression is poorly correlated to the surgical outcome [25,26]. Niggemeyer *et al*. [27] found in their meta-analysis that the least invasive surgical procedure and decompression without any fusion could obtain the most favorable results in patients with DLSS.

Conclusion

For DLSS, the endoscopic ULBD in experienced hands would have a better outcome than the microscopic ULBD regarding the postoperative clinical outcome and patient satisfaction and we recommend the use of a tubular retractor system that allows gradual muscle splitting, preserve spinal stability, and that can be used efficiently with an endoscope or a microscope and their use remains a subject of the surgeon's preference.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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