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Outcomes of discectomy by using full-endoscopic visualization technique via the interlaminar and transforaminal approaches in the treatment of L5-S1 disc herniation

An observational study

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Abstract

The purpose of this retrospective study was to assess the clinical outcomes of discectomy by using full-endoscopic visualization technique via the interlaminar approach versus the transforaminal approach under general anesthesia in the treatment of L5-S1 disc herniation.

Sixty patients with L5-S1 disc herniation were non-randomly recruited and assigned into two groups. One group (thirty patients) underwent discectomy by using full-endoscopic visualization technique via the interlaminar approach under general anesthesia, while the other group (thirty patients) underwent discectomy by using full-endoscopic visualization technique via the transforaminal approach under general anesthesia. The operative time, fluoroscopy time, and perioperative complications were recorded. The visual analog scale (VAS) score for leg and back pain and Oswestry disability index (ODI) score were evaluated preoperatively and at 3, 6, and 18 months postoperatively.

The mean operative time and fluoroscopy time in the interlaminar group were significantly shorter compared with those in the transforaminal group. The mean VAS and ODI postoperative scores were significantly improved over the preoperative scores in both groups. According to the MacNab classification system, more than 90.0% of the patients achieved an excellence/good rating in both groups. An intraoperative epineurium injury occurred in both groups. The total recurrence rate during 18 months follow-up was 3.3% in the interlaminar group and 0% in the transforaminal group.

It is efficient and safe to perform discectomy by using full-endoscopic visualization technique via both interlaminar and transforaminal approaches under general anesthesia in patients with L5-S1 disc herniation. Discectomy performed by using full-endoscopic visualization technique via the interlaminar approach requires a shorter operative time and suffers less radiation exposure than the transforaminal approach.

Abbreviations: LDH = lumbar disc herniation, MRI = magnetic resonance imaging, ODI = Oswestry disability index, PELD = percutaneous endoscopic lumbar discectomy, TESSYS = transforaminal endoscopic spine system, VAS = Visual Analog Scale, YESS = Yeung endoscopic spine system.

Keywords: discectomy, foraminoplasty, full-endoscopic visualization technique, general anesthesia, interlaminar approach, laminectomy, transforaminal approach

1. Introduction

Lumbar disc herniation (LDH) is the most common spinal degenerative disease and often requires surgical treatment, such as discectomy. Although open discectomy can achieve satisfactory results, various minimally invasive procedures have been investigated by spine surgeons, such as microsurgical discectomy, microendoscopic discectomy and so on.[1–3] Percutaneous endoscopic lumbar discectomy (PELD) is another minimally-invasive procedure with numerous advantages over open discectomy, such as less paravertebral muscle injury, greater preservation of bony structures, and the avoidance of excessive nerve root retraction.[4–6] Early PELD techniques include percutaneous nucleotomy using a posterolateral approach, and percutaneous posterolateral discectomy.[7,8] With additional advancements, the Yeung endoscopic spine system (YESS), and transforaminal endoscopic spine system (TESSYS) were developed.[4,5,9] Full-endoscopic discectomy via the transforaminal and interlaminar approaches was first reported in 2005 and 2006, respectively.[10,11] Although reduced traumatization and quicker recovery have been achieved, PELD is usually performed under local

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anesthesia, inducing an uncomfortable experience or even terrible pain in the patients, especially when the nerves are stimulated during surgery.[4,5,9,12] In the present study, full-endoscopic visualization technique was developed, offering the opportunity to safely perform endoscopic lumbar discectomy under general anesthesia.[13] Furthermore, the high iliac crest and narrow foramen at L5-S1 renders performing PELD via the transforaminal approach difficult, while full-endoscopic visualized foraminoplasty enables performing discectomy by using full-endoscopic visualization technique in any case, even those involving L5-S1.[14,15]

Although full-endoscopic visualization technique can be applied to perform discectomy via both interlaminar and transforaminal approaches in the treatment of L5-S1 disc herniation, it remains unclear which approach is better, and whether it is safe to perform these surgeries under general anesthesia. The purpose of the present study was to assess the clinical outcomes of discectomy by using full-endoscopic visualization technique via the interlaminar approach versus the transforaminal approach under general anesthesia in the treatment of L5-S1 disc herniation.

2. Patients and methods

2.1. Patients

In this retrospective, non-randomized controlled cohort study, 60 patients with L5-S1 disc herniation were recruited between March 2015 and August 2016. The patients were assigned into two groups; one group (30 patients) underwent discectomy by using full-endoscopic visualization technique via the interlaminar approach under general anesthesia, while the other group (30 patients) underwent discectomy by using full-endoscopic visualization technique via the transforaminal approach under general anesthesia. The baseline demographic and clinical characteristics of both groups are summarized in Table 1.

Inclusion criteria were as follows: 1-level herniated disc at L5-S1, with radiating pain in the unilateral lower limb with a typical sign, such as a positive Lasegue's sign; failure of 3 months of standard conservative treatment, such as non-steroid anti-inflammatory drug administration and bed rest; and magnetic resonance imaging (MRI) and/or computed tomography (CT) indicating a herniated disc at L5-S1, consistent with clinical symptoms and signs.[13]

Exclusion criteria were as follows: extreme lateral LDH; radiographic findings suggesting spinal canal stenosis, lumbar spondylolisthesis, segmental instability; evidence of infection, tumor, or other lesions; and a surgical history involving the corresponding segment.[13]

Every patient meets all inclusion criteria without any one of the exclusion criteria could be selected to undergo discectomy by using full-endoscopic visualization technique via the interlaminar or transforaminal approach.

Table 1

General information of patients in the 2 groups.

	Interlaminar group	Transforaminal group
N	30	30
Male/Female	22/8	20/10
Age, years	35.9 ± 12.5 (20–63)	36.7 ± 9.6 (23–57)
Central	6	4
Paracentral	8	11
Prolapsus/sequestered	16	15
Symptoms		
Low back pain	28	26
Leg pain	29	30
Signs		
Lasegue's sign +	28	28
Paresthesia in lower leg	27	26
Lower extremity weakness	26	24

2.2. Ethics statement

This study was conducted in accordance with the Declaration of Helsinki, with approval from the ethics committee of our hospital. Written informed consent was obtained from all patients.

2.3. Full-endoscopic instruments

A full-endoscopic surgical system (Spinendos, Munchen, Germany) was applied. A direction-variable drill (Spinendos) was used to perform full-endoscopic visualized laminectomy and discectomy via the interlaminar approach and was also used to perform full-endoscopic visualized foraminoplasty and discectomy via the transforaminal approach. A radiofrequency electrode (Trigger-Flex, NY) was applied to control bleeding during surgery.

2.4. Surgical technique

2.4.1. Full-endoscopic visualization technique via the interlaminar approach. Full-endoscopic visualized laminectomy and discectomy was performed via the interlaminar approach under general anesthesia and in the lateral position.[13] All operations were performed by the senior author, who has many years of experience in microsurgical discectomy and microendoscopic discectomy. Posteroanterior and lateral fluoroscopies were obtained by C-arm fluoroscopy to locate the intervertebral gap and interlaminar window. An 8 mm incision was made at the entry point of the soft tissue expander (pencil-like puncture rod). A soft tissue expander was inserted to the interlaminar window along the medial side of the facet joint, without breaking through the ligamentum flavum. After confirmation of the surgical segment by fluoroscopy, the working cannula, and endoscopic surgical system were introduced. The subsequent procedures were performed with excellent visualization via the endoscopic camera system under constant irrigation. In some patients with a narrow interlaminar space, laminectomy was performed to enlarge the interlaminar space. A radiofrequency electrode was applied to control bleeding. After breaking through the ligamentum flavum, the herniated nucleus pulposus was removed to ensure sufficient decompression of the nerve root (Fig. 1).

2.4.2. Full-endoscopic visualization technique via the transforaminal approach. Full-endoscopic visualized foraminoplasty and discectomy was performed via the transforaminal approach under general anesthesia and in the prone position. All operations were performed by the senior author. Posteroanterior and lateral fluoroscopies were obtained to locate the intervertebral gap and foramina. The puncture target and direction were then marked according to the fluoroscopy images. The intervertebral foramina are about 1.5 cm lateral to the spinal midline, and the entry point of the assumed approach was 12 to 14 cm lateral to the spinal midline, above the iliac crest.[16] A soft tissue expander (pencil-like puncture rod) was applied along the direction of the foramina via an 8 mm incision. After confirmation of the surgical segment and the location of the soft tissue expander by fluoroscopy, the working cannula and endoscopic surgical system were inserted. All subsequent steps were performed with excellent endoscopic visualization under constant irrigation. Full-endoscopic visualized

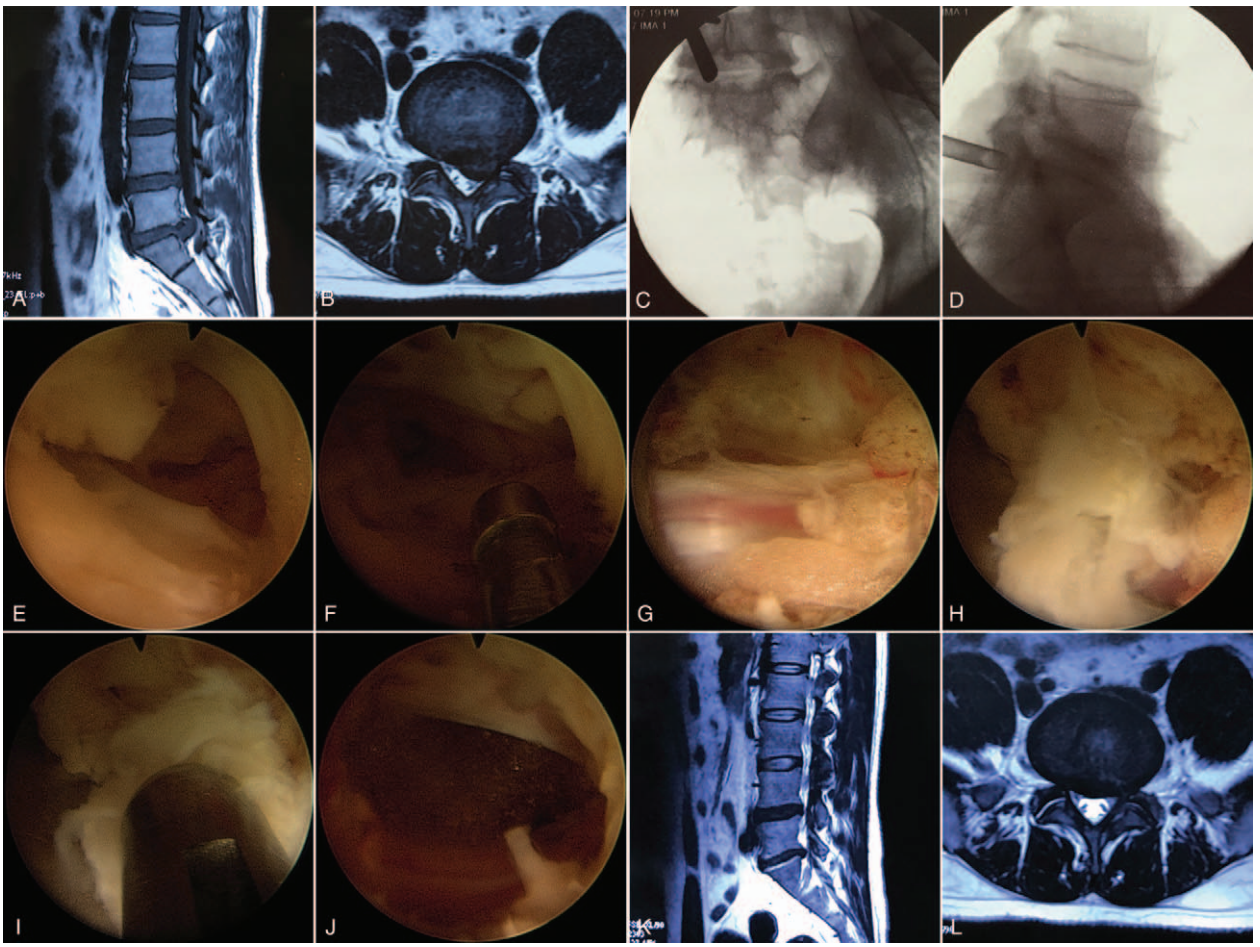

Figure 1. Procedures of the discectomy performed by using full-endoscopic visualization technique via the interlaminar approach on a 32-year-old male patient diagnosed with lumbar disc herniation at L5-S1. (A and B) Preoperative MRI scans; (C and D) intraoperative anteroposterior and lateral fluoroscopy confirm the intervertebral gap and interlaminar space; (E) the ligamentum flavum exposed and incised; (F) a radiofrequency electrode is applied to control bleeding; (G) the dural sac and traversing nerve root are exposed; (H) the herniated nucleus pulposus is exposed; (I) the herniated nucleus pulposus is extracted; (J) the dural sac, traversing nerve root, and axilla after decompression; (K and L) MRI scans 3 months after the surgery. MRI = magnetic resonance imaging.

foraminoplasty was performed, grinding the ventral surface of the superior articular process to enlarge the intervertebral foramina. A radiofrequency electrode was applied to control bleeding. The herniated nucleus pulposus tissue was then removed to ensure sufficient decompression of the nerve root (Fig. 2).

2.5. Post-operation treatment

No drainage was required after surgery in each case of both groups. Analgesic such as opioid was unnecessary after operation.

2.6. Clinical evaluation

The operative time, fluoroscopy time, and perioperative complications were recorded. The visual analog scale (VAS) score for leg and back pain, and the Oswestry disability index (ODI) score were evaluated preoperatively and at 3, 6, and 18 months postoperatively. The MacNab criteria were used to evaluate surgical effectiveness.

2.7. Statistical analysis

All data are presented as the mean ± standard deviation. Group differences were evaluated using independent-samples *t* tests, and within-group differences in preoperative and postoperative data were evaluated using paired-samples *t*-tests. Statistical analyses were performed using SPSS 18.0 (SPSS Inc., Chicago, IL) and corresponding graphs were generated using GraphPad Prism 6 (GraphPad Software, Inc., CA). A *P* value less than .05 was considered to indicate statistical significance.

3. Results

3.1. Clinical outcomes

The mean operative time in the interlaminar group was shorter than that in the transforaminal group ($P < .05$) (Table 2). In both groups, the operative time rapidly decreased over the earlier cases and tapered to a steady state in the latter cases. However, the learning curve of the transforaminal group was steeper than that of the interlaminar group (Fig. 3). The mean fluoroscopy time in the interlaminar group was shorter than that in the transforaminal group ($P < .05$) (Table 2).

In both groups, mean postoperative VAS and ODI scores were significantly improved compared with the preoperative scores ($P < .05$). However, there were no significant group differences in preoperative and postoperative VAS and ODI scores ($P > .05$) (Fig. 4, Table 3). According to the MacNab classification system, 90.0% of the patients in the interlaminar group and 93.3% of the patients in the transforaminal group achieved an excellence/good rating (Table 3).

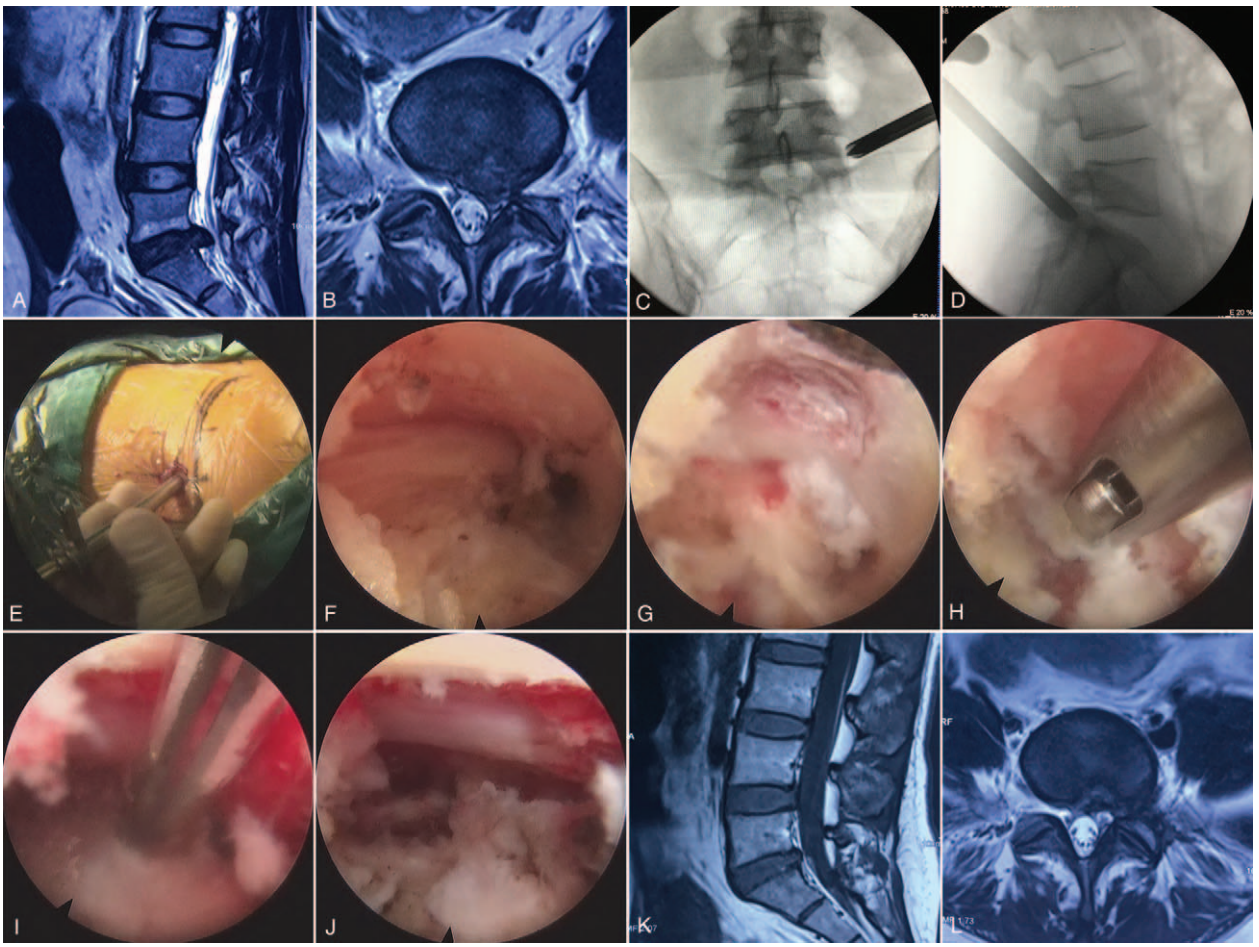

Figure 2. Procedures of the discectomy performed by using full-endoscopic visualization technique via the transforaminal approach on a 36-year-old female patient diagnosed with lumbar disc herniation at L5-S1. (A and B) Preoperative MRI scans; (C and D) intraoperative anteroposterior and lateral fluoroscopy confirm the intervertebral gap and foramina; (E) the surgery is performed under general anesthesia in the prone position; (F) the superior articular process is exposed; (G) foraminoplasty is performed using drills; (H) the herniated nucleus pulposus is extracted; (I) a radiofrequency electrode is applied to control bleeding; (J) the dural sac, traversing nerve root after decompression; (K and L) MRI scans 5 months after the surgery. MRI = magnetic resonance imaging.

3.2. Perioperative complications and recurrence

In the interlaminar group, an intraoperative epineurium injury occurred (3.3%), without cerebrospinal fluid fistula. No limb paralysis or postoperative infections were observed after surgery. One case suffered recurrence 10 weeks after surgery, resulting in a total recurrence rate of 3.3% during the 18-month follow-up. 29 cases (96.7%) return to work three months after surgery. The recurrence case was treated by minimally-invasive transforaminal lumbar interbody fusion.

In the transforaminal group, an intraoperative epineurium injury occurred (3.3%), without cerebrospinal fluid fistula. No limb paralysis or postoperative infections were observed after surgery. No visceral organ or vascular injury occurred. 30 cases (100%) return to work three months after surgery. In addition, no recurrence occurred during the 18-month follow-up (0%).

Table 2

Comparison of operative time and fluoroscopy time in the 2 groups.

	Interlaminar group	Transforaminal group	*P*
N	30	30	—
Operative time, minutes	66.8 ± 24.4 (40–150)	84.5 ± 38.4 (45–210)	.039
Fluoroscopy time, seconds	1.3 ± 0.3 (1.0–2.0)	1.9 ± 0.7 (1.0–4.0)	.000

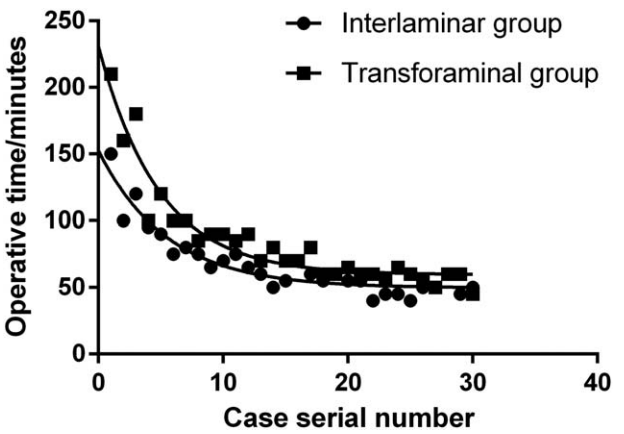

Figure 3. The learning curves for full-endoscopic visualization technique via the interlaminar and transforaminal approaches.

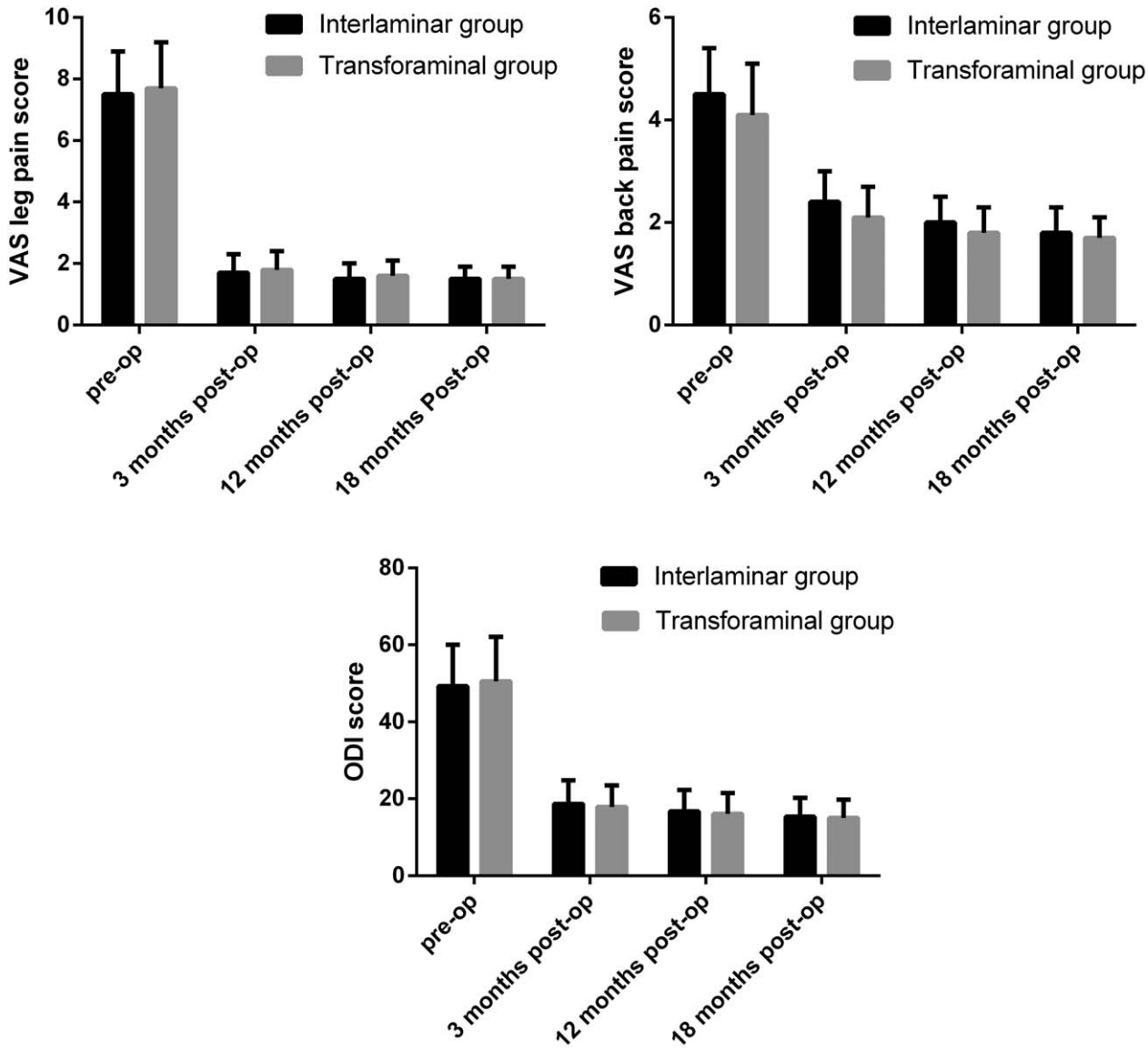

Figure 4. The mean VAS scores for leg and back pain, and ODI scores. (A) VAS scores for leg pain; (B) VAS scores for back pain; (C) ODI scores. Pre-op, pre-operation; post-op, post-operation. ODI = Oswestry disability index, VAS = Visual Analog Scale.

4. Discussion

PELD via the interlaminar or transforaminal approach achieves minimal traumatization, rapid rehabilitation, less intraspinal adhesions, and facilitation of revision operations.[17–20] Moreover, traditional PELD, using techniques such as YESS and TESSYS, is usually performed under local anesthesia, which may cause severe pain, while full-endoscopic visualization technique can be used to perform discectomy under general anesthesia. Although there is no communication with the patients during the procedures, discectomy performed by using full-endoscopic visualization technique under general anesthesia ensures the safety of the surgery via improved visualization of the procedures.[17–20]

Full-endoscopic discectomy via the interlaminar approach can be easily used to perform by spine surgeons with experience in microsurgical discectomy and microendoscopic discectomy, due to the similarity in the approach.[11,18,19] In the present study, full-endoscopic visualization technique was developed and applied via both interlaminar approach and transforaminal approaches. In the interlaminar approach group, full-endoscopic visualized laminectomy and discectomy were performed under visualization to guarantee complete decompression, ensure minimal trauma, and prevent iatrogenic nerve injury.[12,18,19] While in the transforaminal approach group, full-endoscopic visualized foraminoplasty and discectomy were performed under visualization to guarantee complete decompression, ensure minimal traumatization, and prevent iatrogenic nerve injuries.[11,18,19,21] Various endoscopic tools, such as a bone cutter and reamer, can be used in foraminoplasty, and a drill is used in both laminectomy and foraminoplasty.[6]

Previous studies on PELD via the interlaminar and transforaminal approaches have reported the mean operative times ranging 22.0 to 71.3 minutes and 22.0 to 86.0 minutes, respectively.[15,18,22–28] The mean operative times of both groups in the present study were consistent with those in the literature. Furthermore, the mean operative time of the interlaminar group was significantly less than that of the transforaminal group.

Table 3

Comparison of VAS and ODI Scores, MacNab evaluation in the 2 groups.

	Interlaminar group (N = 30)	Transforaminal group (N = 30)
VAS leg pain scores		
Pre-op	7.5 ± 1.4	7.7 ± 1.5
3 months Post-op	1.7 ± 0.6*	1.8 ± 0.6*
12 months Post-op	1.5 ± 0.5*	1.6 ± 0.5*
18 months Post-op	1.4 ± 0.4*	1.5 ± 0.4*
VAS back pain scores		
Pre-op	4.5 ± 0.9	4.1 ± 1.0
3 months Post-op	2.4 ± 0.6*	2.1 ± 0.6*
12 months Post-op	2.0 ± 0.5*	1.8 ± 0.5*
18 months Post-op	1.8 ± 0.5*	1.7 ± 0.4*
ODI, %		
Pre-op	49.3 ± 10.7	50.6 ± 11.5
3 months Post-op	18.7 ± 6.1*	17.9 ± 5.6*
12 months Post-op	16.8 ± 5.5*	16.1 ± 5.4*
18 months Post-op	15.4 ± 4.8*	15.0 ± 4.8*
MacNab evaluation		
Excellence	21	22
Good	6	6
Fair	2	2
Poor	1	0
Excellence/good rate	90.0%	93.3%

ODI = Oswestry disability index, Post-op = preoperative, Pre-op = preoperative, VAS = Visual Analog Scale.
* $P < .05$ versus preoperative data.

During traditional PELD using YESS and TESSYS techniques, preoperative localization of the puncture target, punching procedures, and foraminoplasty are performed under fluoroscopy, resulting in too much radiation exposure. Previous studies have reported the mean fluoroscopy times during interlaminar and transforaminal endoscopic discectomy of 0.6 to 5.5 seconds and 6.5 to 39.4 seconds, respectively.[12,15,26,29,30] In this study, preoperative and intraoperative fluoroscopy was only applied to locate the puncture target and working cannula. full-endoscopic visualization technique provides an opportunity to establish the working cannula under visual control, with less radiation exposure and a shorter fluoroscopy time compared to those in traditional PELD.[15,29,30] Furthermore, the mean fluoroscopy time in the interlaminar group was significantly shorter than that in the transforaminal group.

Due to extensive exposure of the intervertebral disc and nerve root, scarring of the epidural space has been observed postoperatively after conventional surgeries.[31–35] Although only 10% become clinically symptomatic, epidural adhesions have been confirmed on MRI images in many cases.[34] However, full-endoscopic visualization technique via the interlaminar approach preserves most of the ligamentum flavum, and reduces the formation of epidural scar adhesion.[22] Furthermore, no scarring in the access area, and only slight scarring in the spinal canal has been observed in cases of recurrent herniation.[19] Full-endoscopic visualization technique via the transforaminal approach avoids the irritation of the spinal canal and the formation of epidural scar adhesion.

Although minimal traumatization was achieved by full-endoscopic visualization technique, it may be difficult to identify muscle, facet cysts, and ligaments under endoscopic visualization, which increases the risk for iatrogenic injury.[36] Nerve injury, dural tears, and cerebrospinal fluid fistula may occur during surgery. An intraoperative epineurium injury occurred in both groups of the present study. During discectomy performed by using full-endoscopic visualization technique via the transforaminal approach, surgeons must also be vigilant against visceral organ and vascular injuries.[37]

Whether conventional discectomy or full-endoscopic discectomy is applied, recurrence is another important issue. The recurrence rate after PELD has been reported to be 0% to 7.4%.[9,12,14,18,20,25,27,37–43] In the present study, the recurrence rates in the interlaminar and transforaminal groups were 3.3% and 0% respectively, during the 18-month follow-up. Although the recurrence rates in the present study are low, more recurrences may occur in a longer follow-up period. Complete removal of the herniated mass, including the basal and extruded parts, is recommended to reduce the risk of recurrence.[44]

Although cases of recurrent disc herniation were excluded from the present study, full-endoscopic visualization technique via both interlaminar and transforaminal approaches is possible for revision surgeries. Furthermore, full-endoscopic visualization technique via the transforaminal approach can be used to perform discectomy with unscarred virgin tissue to avoid the risk of iatrogenic neural injury and dural tears after surgeries via the interlaminar approach.[12,14,17] Full-endoscopic visualization technique via the interlaminar approach can also be used to perform discectomy with unscarred virgin tissue in cases treated by surgeries via the transforaminal approach.

However, full-endoscopic visualization technique also has some disadvantages, such as a steep learning curve.[36,42] Because the approach is the same as that in conventional discectomy, surgeons are more familiar with full-endoscopic discectomy via the interlaminar approach. As a result, young surgeons may master the full-endoscopic visualization technique via the interlaminar approach more easily than those in the transforaminal approach. Furthermore, in cases of L5-S1 disc herniation, the high iliac crest and narrow foramen determine the difficulty of full-endoscopic visualization technique via the transforaminal approach.[15] In the present study, steep learning curves were observed in both groups, with a steeper learning curve in the transforaminal group compared to that in the interlaminar group. Because of steep learning curves, full-endoscopic visualization technique should be used to perform discectomy by surgeons with experience in microsurgical discectomy and microendoscopic discectomy to reduce the operative time and perioperative complications, and ensure the sufficient decompression of the nerve root.

The present study was also of some limitations, as it is a retrospective, non-randomized controlled cohort study with a small sample size and short follow-up period. It may be difficult to compare the true disc herniation recurrence rate after discectomy in such a short follow-up period. The senior author's personal experience in full-endoscopic visualization technique via both approaches may also bias the results. Further prospective, randomized, controlled studies, as well as more comparative studies, with larger sample sizes and longer follow-up periods, should be conducted to assess the clinical outcomes.

5. Conclusions

It is efficient and safe to perform discectomy by using full-endoscopic visualization technique via both interlaminar and transforaminal approaches under general anesthesia in patients with L5-S1 disc herniation. Full-endoscopic visualization technique via the interlaminar approach requires a shorter

operative time and suffers less radiation exposure than the transforaminal approach.

Author contributions

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Software: Wenbin Hua.
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