Orthopaedic Surgery

CLINICAL ARTICLE

Comparison of the Clinical Outcomes of Full-Endoscopic Visualized Foraminoplasty and Discectomy *Versus* Microdiscectomy for Lumbar Disc Herniation

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Objective: This retrospective case-control study aimed to evaluate and compare the clinical outcomes of full-endoscopic visualized foraminoplasty and discectomy (FEVFD) with microdiscectomy (MD) for lumbar disc herniation (LDH).

Methods: Data from 198 patients who presented with LDH between January 2016 and December 2017 treated by either FEVFD or MD were retrospectively analyzed. The inclusion criteria were single-level LDH, unilateral radiating leg pain with or without positive Lasegue's sign, and failure of standard conservative treatment for at least 12 weeks. The patients were categorized into an FEVFD group ($n = 102$) or an MD group ($n = 96$), according to the surgical procedure performed. Operative time, time in bed after surgery, postoperative hospitalization time, complications, and reoperations were recorded. Visual analog scales (VAS) for leg and back pain, Oswestry Disability index (ODI), 36-Item Short-Form Health Survey physical function (SF36-PF), and bodily pain (SF36-BP) scores were assessed and compared between the two groups.

Results: The demographic data and baseline characteristics of the two groups were not significantly different. Operative time for the FEVFD group (73.82 ± 20.73 min) was longer than that for the MD group (64.74 ± 17.37 min) ($P = 0.003$), and fluoroscopy time for the FEVFD group (1.71 ± 0.58s) was longer than that for the MD group (1.30 ± 0.33s) ($P < 0.001$). However, time in bed experienced in the FEVFD group (8.51 ± 2.10 h) was less than that in the MD group (9.24 ± 2.01 h) ($P = 0.014$), and postoperative hospitalization time experienced in the FEVFD group (2.89 ± 0.83d) was also shorter than that in the MD group (4.94 ± 1.35d) ($P < 0.001$). All patients completed 24 months of follow-up. Postoperative scores at each follow-up for the VAS for leg and back pain, ODI, SF36-PF, and SF36-BP all improved significantly for both groups, as compared to the preoperative data ($P < 0.05$). The mean preoperative and postoperative scores for the VAS for leg and back pain, ODI, SF36-PF, and SF36-BP were not significantly different between the two groups. According to the modified MacNab criteria, the outcomes of the procedures were rated as excellent or good by 92.16% and 93.75% of the patients in the FEVFD and MD groups, respectively. One patient suffered a nerve root injury during the discectomy, one patient suffered from a dural tear, and two patients suffered from a residual herniation in the FEVFD group. One patient in the MD group suffered from poor wound healing. Moreover, recurrence happened in two cases in the FEVFD group, and in one case in the MD group.

Conclusion: FEVFD and MD are both reliable techniques for the treatment of symptomatic LDH. FEVFD resulted in a more rapid recovery and equivalent clinical outcomes after 24 months of follow-up.

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Introduction

Lumbar disc herniation (LDH) is a major cause of lower back pain and sciatica, resulting in a massive socioeconomic burden worldwide[1,2]. Microdiscectomy (MD), which is regarded as an acceptable surgical procedure to treat LDH, is commonly used to treat LDH in western countries[3,4]. Percutaneous endoscopic lumbar discectomy (PELD) techniques have become well-developed in the last few decades[5–7], with discectomy with the Yeung endoscopic spine system (YESS), transforaminal endoscopic spine system (TESSYS), and full-endoscopic discectomy *via* the transforaminal approaches being the most popular[5–7]. Even with advances in these PELD techniques, the working cannula needs to be established with the aid of intervention technique during both YESS and TESSYS techniques, increasing the intraoperative fluoroscopy time. Traditional PELD techniques performed under local anesthesia are often uncomfortable, with terrible intraoperative experience for the patients. In addition, it is difficult to perform discectomy at L5–S1 and above with traditional full-endoscopic discectomy *via* the transforaminal approaches due to the iliac crest [7–9].

To overcome the shortcomings of these PELD techniques, a newly developed procedure called full-endoscopic visualized foraminoplasty and discectomy (FEVFD) has been developed to treat LDH[10,11]. Compared with the above mentioned traditional PELD techniques, FEVFD was performed with excellent endoscopic visualization under general anesthesia, enabling safe and adequate decompression of the nerve root and the spinal canal[10]. All patients who underwent FEVFD had reasonable intraoperative experience under general anesthesia[10]. It was demonstrated that FEVFD resulted in significant improvements in pain scores and low complication rates for the treatment of L4-L5 and L5-S1 disc herniation under general anesthesia[10].

Traditional PELD techniques and MD have been compared in previous studies； these studies reported that both traditional PELD techniques and MD are safe and effective surgical procedures in treating LDH[12–16]. However, to the best of our knowledge, there have not been any studies comparing FEVFD with traditional surgical techniques, such as MD. Therefore, patients with LDH treated by either FEVFD or MD were retrospectively analyzed in the present case–control study. The purpose of the present study was to: (i) describe FEVFD and MD for the treatment of single-level LDH; (ii) evaluate the efficacy and feasibility of FEVFD and MD for the treatment of single-level LDH; and (iii) to compare the clinical outcomes of FEVFD and MD for the treatment of single-level LDH.

Materials and methods

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: (i) single-level LDH; (ii) unilateral radiating leg pain, with or without positive Lasegue's sign; (iii) failure of standard conservative treatment for at least 12 weeks; and (iv) herniated disc verified by magnetic resonance imaging (MRI) and computed tomography (CT), in accordance with the clinical symptoms and signs.

The exclusion criteria were as follows: (i) aged >65 or < 18 years; (ii) a history of lumbar surgery; (iii) LDH combined with other spinal disorders requiring surgery, such as spinal canal stenosis or lumbar spondylolisthesis; (iv) LDH at two or more segments; (v) a progressive neurological deficit, such as cauda equina syndrome, needing urgent surgical intervention; and (vi) LDH combined with serious diseases that contraindicate general anesthesia and surgery.

Patient Data and Ethics Statement

Data from 198 patients who presented with LDH between January 2016 and December 2017 treated using either FEVFD or MD under general anesthesia were retrospectively analyzed. These patients were categorized into either an FEVFD group or an MD group according to the surgical procedure performed. This study was approved by the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology. Written informed consent was provided by all participants.

Surgical Technique

FEVFD

The surgery was performed under general anesthesia in a prone position. The FEVFD procedure was performed using

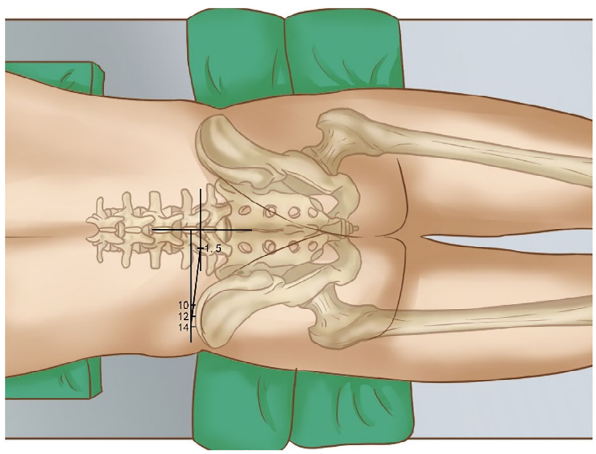

Fig 1 Full-endoscopic visualized foraminoplasty and discectomy was performed under general anesthesia in prone position. The entry point of the assumed approach was 12–14 cm lateral to the spinal middle line above the iliac crest.

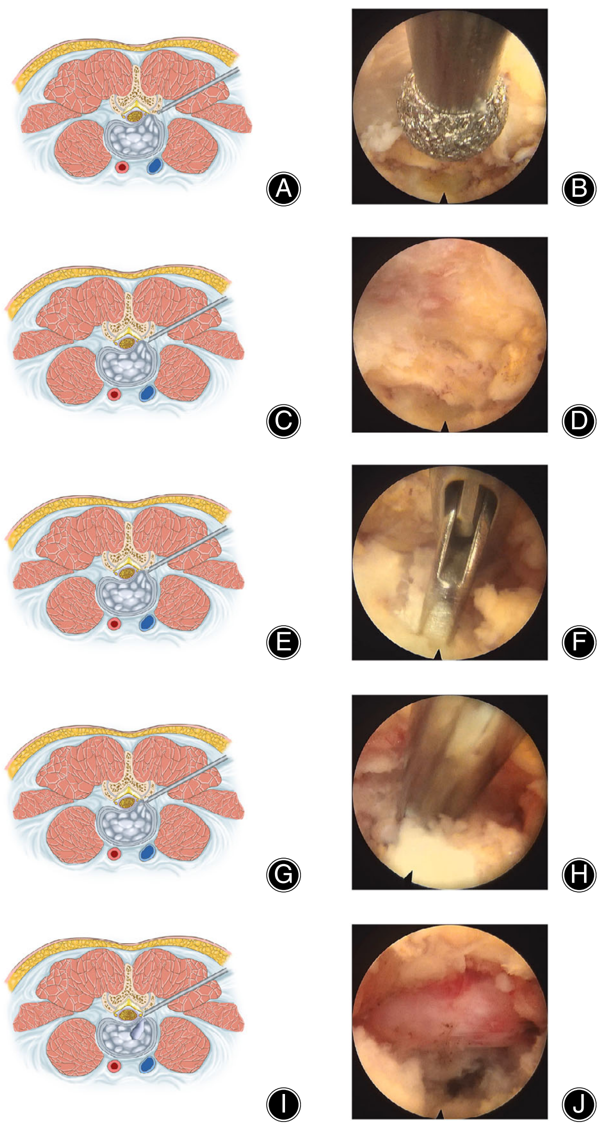

Fig 2 Surgical procedures of full-endoscopic visualized foraminoplasty and discectomy. A and B, Working cannula established along the foramina, and full-endoscopic visualized foraminoplasty performed. C and D, Working cannula directed toward the annulus fibrosus opening. E, F, G and H, Full-endoscopic visualized discectomy performed. I and J, Adequate decompression of the nerve root was ensured.

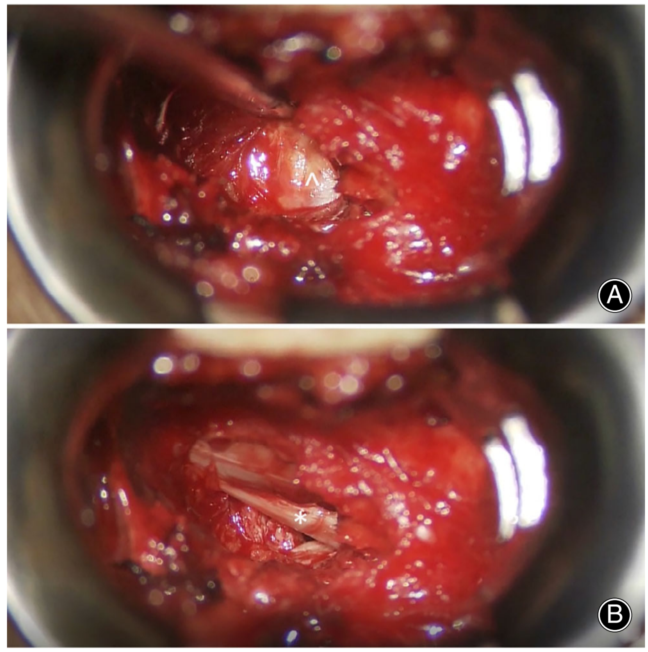

Fig 3 Surgical procedures of microdiscectomy. A, ligamentum flavum (^) exposed. B, Nerve root (*) ensured adequate decompression.

the surgical technique described by Hua *et al.*[10]. The intervertebral gap and foramina were located by posteroanterior and lateral fluoroscopy. The entry point of the assumed approach was 12–14 cm lateral to the spinal middle line above the iliac crest (Fig. 1)[10]. After inserting the puncture rod toward the intervertebral foramina, the surgical level and location of the puncture rod was confirmed by both posteroanterior and lateral fluoroscopy[10]. The working cannula and endoscopic surgical system (Spinendos, Munich, Germany) were then inserted toward the intervertebral foramina along the puncture rod[10]. All subsequent steps, including foraminoplasty, annulus fibrosus fenestration, and discectomy were performed under constant irrigation with excellent endoscopic visualization[10]. Before ending the operation, we confirmed that there was adequate decompression of the nerve root, the freed nerve root could be identified, and there was no free disc tissue or active bleeding (Fig. 2)[10].

MD

The surgery was performed under general anesthesia in prone position. Lateral fluoroscopy was used to locate the intervertebral gap. The lamina and ligamentum flavum of the affected level was exposed *via* a 25 mm posterior midline incision. A minimally invasive lumbar Casper retractor was then applied, and part of the lamina and ligamentum flavum was removed using a Kerrison under direct microscopic (Zeiss, Jena, Germany) visualization. Subsequently, a discectomy was performed under direct microscopic visualization, ensuring complete decompression of the nerve root (Fig. 3).

Clinical Outcome Assessment

Operative time, fluoroscopy time, postoperative time in bed, hospitalization time, complications, and reoperations were recorded for each patient.

TABLE 1 Baseline characteristics of patients in the two groups

	FEVFD group	MD group	*P*
N	102	96	-
Age (years)	40.05 ± 12.79	41.62 ± 11.35	0.379
Sex (male)	75 (73.53%)	65 (67.71%)	0.370
BMI (kg/m²)	23.28 ± 3.21	23.47 ± 3.28	0.656
Type of disc herniation			0.522
Central	24 (23.53%)	21 (21.88%)	-
Paracentral	73 (71.57%)	67 (69.79%)	-
Far lateral	5 (4.90%)	8 (8.33%)	-
Surgical segment			0.943
L3-L4 or above	2 (1.96%)	4 (4.17%)	-
L4-L5	67 (65.69%)	59 (61.46%)	-
L5-S1	33 (32.35%)	33 (34.37%)	-

BMI, Body mass index; FEVFD, full-endoscopic visualized foraminoplasty and discectomy; MD, microdiscectomy.

TABLE 2 Comparison of operative time, fluoroscopy time, postoperative bed time and hospitalization time in the two groups

	FEVFD group	MD group	*P*
N	102	96	-
Operative time (minutes)	73.82 ± 20.73	64.74 ± 17.37	0.003
Fluoroscopy time (seconds)	1.71 ± 0.58	1.30 ± 0.33	<0.001
Postoperative time in bed (hours)	8.51 ± 2.10	9.24 ± 2.01	0.014
Hospitalization time (days)	2.89 ± 0.83	4.94 ± 1.35	<0.001

FEVFD, full-endoscopic visualized foraminoplasty and discectomy; MD, microdiscectomy.

Visual Analog Scales

The Visual Analog Scale (VAS) for leg and back pain, was used to evaluate the pain level of patients. The VAS scoring system was self-completed by the patient. Patients marked a location on the 10-cm line corresponding to the amount of pain they experienced. 0 indicated no pain and 10 the most severe pain.

Oswestry Disability Index

Oswestry Disability Index (ODI) is a principal condition specific outcome measure used to assess patient progression in routine clinical practice. The ODI score system was divided into 10 sections: pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and traveling. Each section was scored 0–5. If all 10 sections were completed the score was calculated as follows: total score out of total possible score ×100. If one section was missed (or not applicable), the score was calculated as: (total score/(5 × number of questions answered)) × 100%. Scores were as follows: 0%–20% was considered mild dysfunction; 21%–40% was moderate dysfunction; 41%–60% was severe dysfunction; 61%–80% was considered as disability, and 81%–100% was considered as either bedridden for long-term or exaggerating the impact of pain on their life.

36-Item Short-Form Physical Function and Bodily Pain Health Survey

The MOS 36-Item Short-Form health survey (SF36) includes multi-item scales that assess eight health concepts: physical functioning (PF), bodily pain (BP), role limitations due to physical problems, general health, vitality, social functioning, role limitations due to emotional problems, mental health, and perceptions[17–19]. The interpretation of the SF-36 has been made much easier with the standardization of mean scores and standard deviations for all SF-36 scales[19]. It can be illustrated by comparing the SF-36 profile scored using the original 0–100 scoring algorithms based on the summated ratings method and the norm-based scoring algorithms[19]. SF36-PF and SF36-BP were evaluated preoperatively and postoperatively.

Modified MacNab Criteria

The modified MacNab criteria was also used to evaluate clinical outcomes. The results were classified as excellent, good, fair or poor: excellent indicated no pain and no restriction of movement, allowing the patient to work normally; good indicated occasional pain, allowing the patient to work normally; fair indicated slight progress; poor indicated no progression [20].

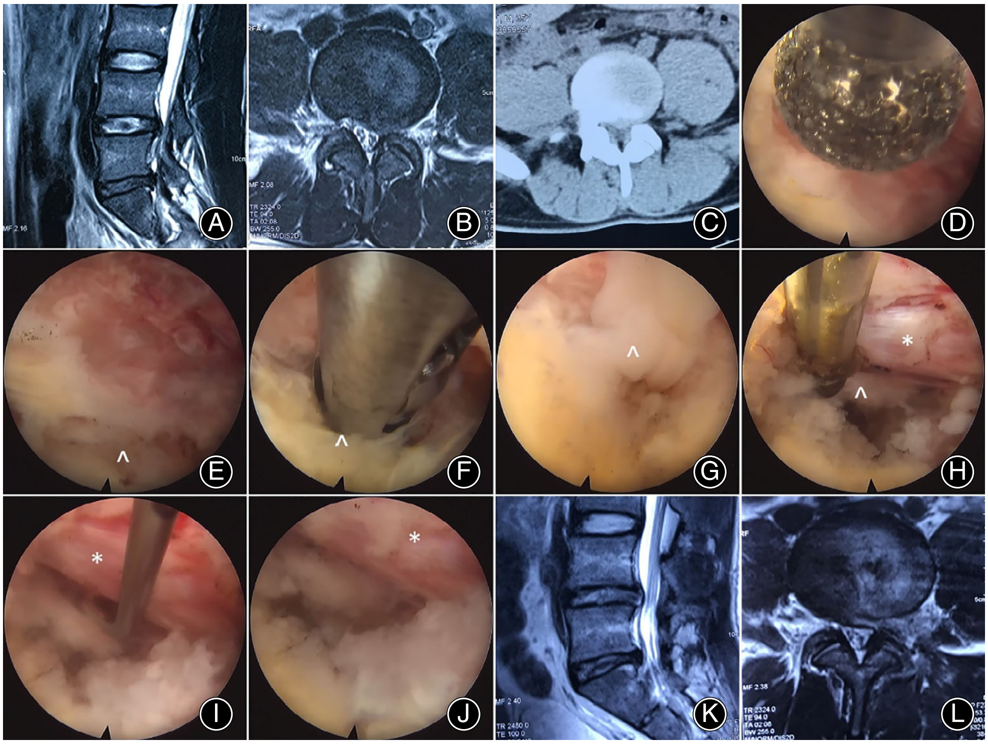

Fig 4 Full-endoscopic visualized foraminoplasty and discectomy under general anesthesia performed on a 25-year-old male patient diagnosed with L4-L5 disc herniation. A and B, preoperative magnetic resonance imaging (MRI) scans. C, preoperative computed tomography (CT) scans. D and E, full-endoscopic visualized foraminoplasty performed with the aid of a direction-variable drill, and the foramina was exposed. F and G, full-endoscopic visualized discectomy was performed. H, a radiofrequency electrode is applied to control bleeding. I and J, the traversing nerve root were exposed, and sufficient decompression of the traversing nerve root was ensured. K and L, MRI scans 3 months after the surgery. Snowflake (*), nerve root, triangle (^), dural sac.

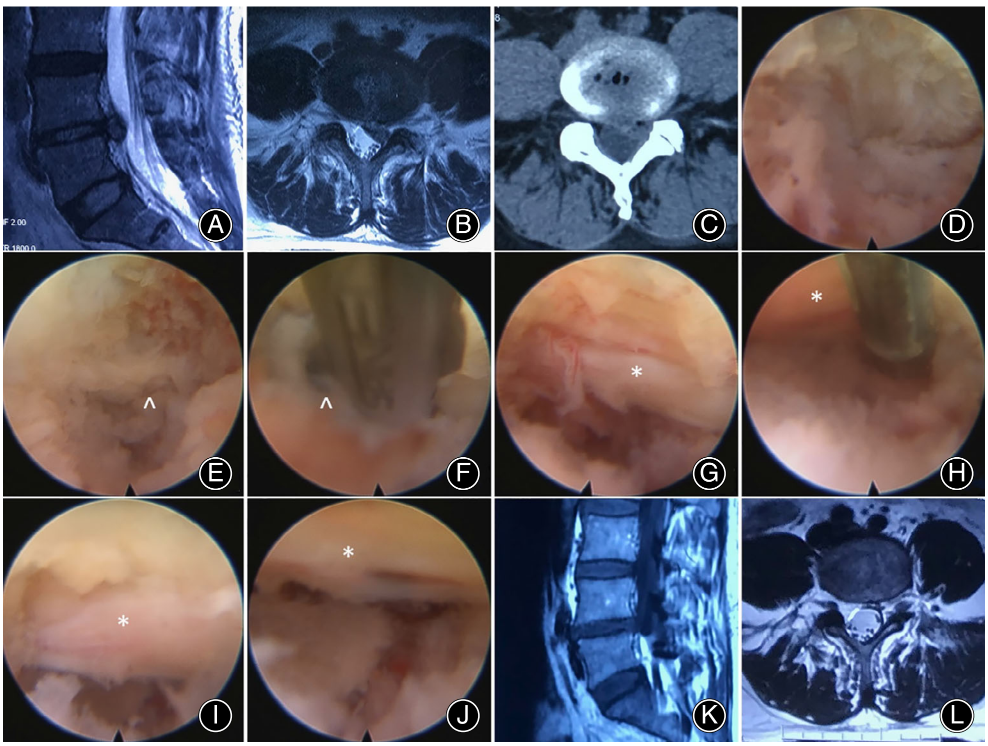

Fig 5 Full-endoscopic visualized foraminoplasty and discectomy under general anesthesia performed on a 49-year-old male patient diagnosed with L4-L5 disc herniation. A and B, preoperative magnetic resonance imaging (MRI) scans. C, preoperative computed tomography (CT) scans. D and E, full-endoscopic visualized foraminoplasty performed with the aid of a direction-variable drill, and the foramina was exposed. F and G, full-endoscopic visualized discectomy was performed. H, a radiofrequency electrode is applied to control bleeding. I and J, the traversing nerve root were exposed, and sufficient decompression of the traversing nerve root was ensured. K and L, MRI scans 3 months after the surgery. Snowflake (*), nerve root, triangle (^), dural sac.

Statistical Analysis

Data are presented as mean ± standard deviation. SPSS 22.0 software (IBM Corp., Armonk, NY, USA) was used to perform the statistical analyses, and GraphPad Prism 6 software (Graph Pad Software, Inc., San Diego, CA, USA) was used to generate plots. Normal distribution of the data was assessed using the Kolmogorov–Smirnov test. Nonparametric data were analyzed by the Mann–Whitney U test or the Wilcoxon

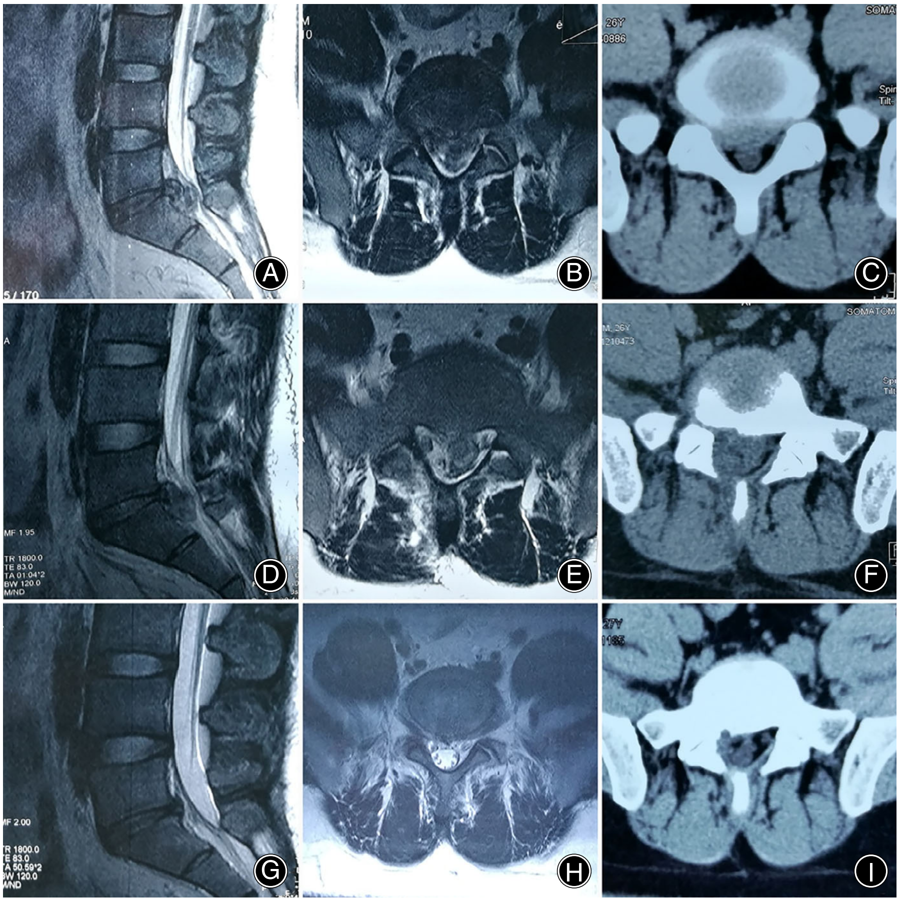

Fig 6 Microdiscectomy under general anesthesia performed on a 26-year-old male patient diagnosed with L5-S1 disc herniation. A and B, preoperative magnetic resonance imaging (MRI) scans. C, preoperative computed tomography (CT) scan. D and E, postoperative MRI scans 1 week after the surgery. F, postoperative CT scan 1 week after the surgery. G and H, postoperative MRI scans 12 months after the surgery. postoperative CT scan 15 months after the surgery.

signed-rank test. A *P*-value of less than 0.05 was considered statistically significant.

Results

General Results

Demographic data and baseline characteristics of the patients in the two groups are summarized in Table 1. The age, sex, body mass index (BMI), type of disc herniation, and surgical levels of the two groups were not statistically different.

The mean operative times, fluoroscopy times, postoperative times in bed, and hospitalization times for each of the two groups are summarized in Table 2. The mean postoperative time in bed, and hospitalization time of the MD group were significantly longer than those of the FEVFD group, while the operative time, and fluoroscopy time of the MD group was significantly shorter than that of the FEVFD group. Representative cases of FEVFD group are presented in Figs 4 and 5, and the representative case of MD group is presented in Fig. 6.

Functional Evaluation

VAS

The mean preoperative and postoperative scores for the VAS for leg and back pain, for the FEVFD group were not significantly different from the scores for the MD group. However, the mean VAS scores for leg and back pain at each follow-up decreased significantly following surgery for both groups.

ODI

The mean preoperative and postoperative ODI scores for the FEVFD group were not significantly different from the scores for the MD group. However, the mean ODI score at each follow-up decreased significantly following surgery for both groups.

SF36-PF and SF36-BP

The mean preoperative and postoperative scores for SF36-PF and SF36-BP for the FEVFD group were not significantly different from the scores for the MD group. Conversely, the SF36-PF and SF36-BP scores at each follow-up increased significantly following surgery for both groups (Table 3, Fig. 7).

Modified MacNab Criteria

According to the modified MacNab criteria, the outcomes of the procedures were rated as excellent or good by 92.16% and 93.75% of the patients in the FEVFD and MD groups, respectively (Table 4).

TABLE 3 Comparison of VAS scores, ODI scores, SF36-PF scores and SF36-BP scores in the two groups

Variables		FEVFD group	MD group	*P*
N		102	96	-
VAS score for leg pain	pre-op	7.31 ± 1.35	7.48 ± 1.20	0.516
	3 months post-op	1.85 ± 0.75*	1.78 ± 0.73*	0.491
	6 months post-op	1.64 ± 0.48*	1.57 ± 0.50*	0.356
	12 months post-op	1.52 ± 0.54*	1.44 ± 0.54*	0.267
	24 months post-op	0.96 ± 0.48*	0.93 ± 0.46*	0.625
VAS score for back pain	pre-op	3.75 ± 0.89	3.61 ± 0.74	0.370
	3 months post-op	1.88 ± 0.62*	1.97 ± 0.72*	0.398
	6 months post-op	1.72 ± 0.62*	1.64 ± 0.62*	0.351
	12 months post-op	1.54 ± 0.54*	1.49 ± 0.54*	0.494
	24 months post-op	1.08 ± 0.66*	1.02 ± 0.60*	0.502
ODI score	pre-op	46.38 ± 9.38	47.38 ± 9.29	0.367
	3 months post-op	16.20 ± 5.15*	16.48 ± 5.02*	0.762
	6 months post-op	15.45 ± 4.28*	15.69 ± 4.10*	0.788
	12 months post-op	14.87 ± 4.03*	15.07 ± 3.86*	0.806
	24 months post-op	12.46 ± 4.51*	12.99 ± 4.29*	0.323
SF36-PF score	pre-op	49.70 ± 13.87	50.36 ± 14.20	0.547
	3 months post-op	85.49 ± 8.91*	85.94 ± 9.01*	0.648
	6 months post-op	91.47 ± 4.70*	91.51 ± 4.87*	0.940
	12 months post-op	94.61 ± 4.08*	94.84 ± 4.13*	0.682
	24 months post-op	96.37 ± 3.99*	96.77 ± 4.04*	0.410
SF36-BP score	pre-op	44.28 ± 22.74	43.80 ± 23.36	0.837
	3 months post-op	85.37 ± 11.94*	85.85 ± 11.82*	0.566
	6 months post-op	89.39 ± 6.25*	89.98 ± 6.18*	0.276
	12 months post-op	92.43 ± 6.72*	92.64 ± 6.85*	0.767
	24 months post-op	94.65 ± 6.78*	95.00 ± 6.82*	0.628

FEVFD, full-endoscopic visualized foraminoplasty and discectomy; MD, microdiscectomy; ODI, Oswestry Disability Index; pre-op, Preoperative; post-op, Preoperative; VAS, Visual Analog Scale; 36-Item Short-Form Health Survey physical function (SF36-PF score); 36-Item Short-Form Health Survey bodily pain (SF36-BP score).; * $P < 0.05$ *versus* preoperative data.

Complications

One patient in the FEVFD group with L4-L5 disc herniation suffered a nerve root injury during the discectomy, but the subsequent motor deficit of the patient's big toe improved after 3 months. Another patient in the FEVFD group suffered from a dural tear. One patient in the MD group suffered from a dural tear. In the present study, the neurological complication rate was 1.96% for the FEVFD group and 1.04% for the MD group.

None of the patients in the FEVFD group suffered from poor wound healing, while one patient (1.04%) in the MD group suffered from poor wound healing. There were two patients (1.96%) with residual herniation in the FEVFD group, whereas there were no such patients in the MD group. Recurrence happened in two cases (1.96%) in the FEVFD group, and in one case (1.04%) in the MD group.

Therefore, the total complication rate during the 24-month follow-up period was 5.88% in the FEVFD group and 3.12% in the MD group (Table 5). Within the 24-month follow-up period, two patients in the FEVFD group chose to undergo reoperation; one of them underwent a second FEVFD and the other underwent a minimally invasive transforaminal lumbar interbody fusion. Only one patient in the MD group chose to undergo reoperation and that patient underwent a minimally invasive transforaminal lumbar interbody fusion.

Discussion

MD is well-developed and currently is the most popular technique for the treatment of LDH. In addition, it has been the most reliable surgical procedure for use with discectomies, especially for difficult cases, such as high-grade migrated discs and severe calcified herniated discs[14]. We previously have shown, however, that FEVFD under general anesthesia is efficient and safe for the treatment of LDH[10]. In the present study, we compared the clinical outcomes of FEVFD with those of MD. We demonstrated that patients with similar demographic data and baseline characteristics who had LDH and underwent either FEVFD or MD under general anesthesia obtained satisfactory outcomes, as seen during a 24-month follow-up. Notably, patients in the FEVFD group achieved a more rapid postoperative rehabilitation, with a shorter postoperative time in bed and a shorter overall hospitalization time. This may be due to shorter incision lengths and operative times, and/or milder postoperative incision pain. However, the preoperative and postoperative VAS scores for leg and back pain, ODI scores, SF36-PF scores, and SF36-BP scores for the two groups were not significantly different. Given the advantages of the quicker recovery time for the FEVFD group, this procedure may become a new acceptable technique. However, the reported hospitalization time for each group may vary

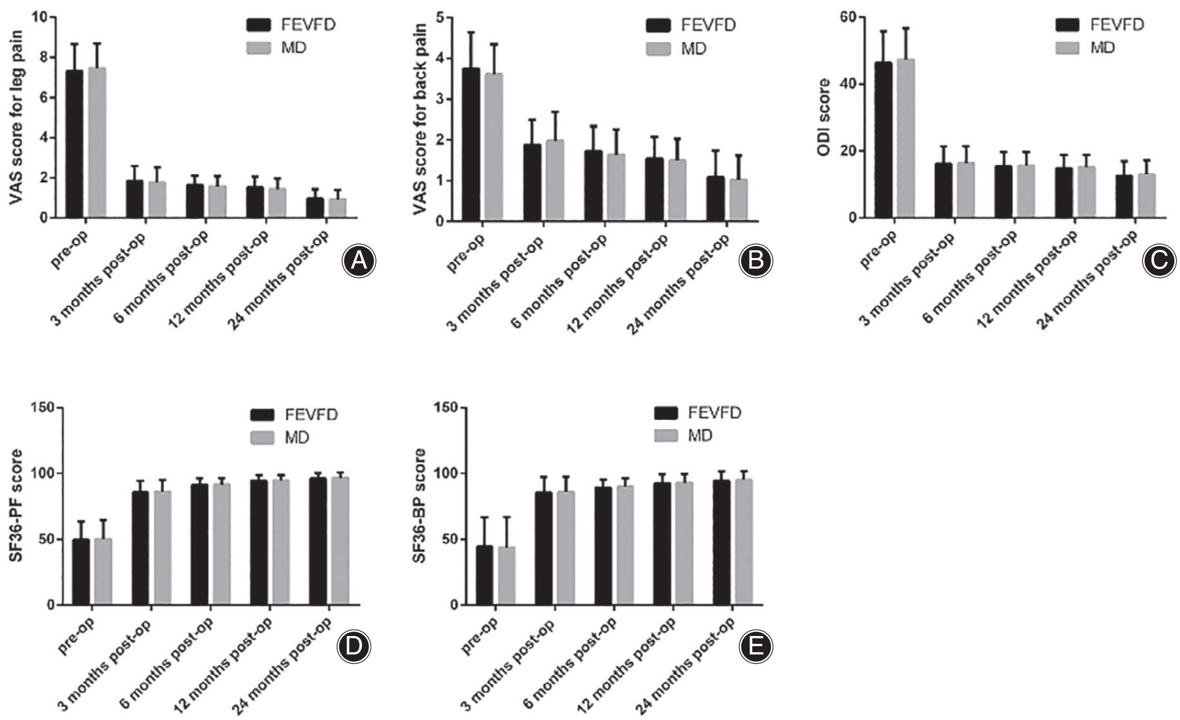

Fig 7 The mean visual analog scale (VAS) scores for leg and back pain, Oswestry disability index (ODI) scores, SF36-PF scores, and SF36-BP scores. A, VAS scores for leg pain. B, VAS scores for back pain. C, ODI scores. D, SF36-PF scores. E, SF36-BP scores. Pre-op indicates preoperative; post-op, postoperative; FEVFD, full-endoscopic visualized foraminoplasty and discectomy; MD, microdiscectomy.

TABLE 4 Comparison of MacNab evaluation in the two groups

Variables	FEVFD group	MD group	*P*
N	102	96	-
MacNab evaluation			0.840
Excellence	66	63	-
Good	28	27	-
Fair	6	5	-
Poor	2	1	-
Excellence/good rate	92.16%	93.75%	-

FEVFD, full-endoscopic visualized foraminoplasty and discectomy; MD, microdiscectomy.; $P < 0.05$ *versus* preoperative data.

TABLE 5 Comparison of perioperative complications and reoperation in the two groups

Variables	FEVFD group	MD group	*P*
N	102	96	-
Neurological complications	2 (1.96%)	1 (1.04%)	0.598
Dural tear	1 (0.98%)	1 (1.04%)	0.966
Nerve root injury	1 (0.98%)	0 (0.0%)	0.332
Poor wound healing	0 (0.00%)	1 (1.04%)	0.303
Residue	2 (1.96%)	0 (0.0%)	0.169
Recurrence	2 (1.96%)	1 (1.04%)	0.598
Total complications	6 (5.88%)	3 (3.12%)	0.353
Reoperation	2 (1.96%)	1 (1.04%)	0.598

FEVFD, full-endoscopic visualized foraminoplasty and discectomy; MD, microdiscectomy.

depending on the overall treatment practices in different countries. For example, because of different medical insurance policies or cultural variations, some hospitals may perform this procedure as an ambulatory surgery or may discharge the patient 1 day after the discectomy surgery[21].

Even though transforaminal PELD techniques are effective for treating all types of herniations, including recurrent or migrated disc herniations, they also have many disadvantages[8,22–25]. The distribution of the various types of disc herniations within our two groups was not significantly different. The transforaminal PELD techniques are particularly suited to excision of foraminal and extraforaminal herniated discs, as well as the widening of the foramen for the exiting nerve root, while MD provides easier access to the lateral recesses[13,21]. Due to anatomical limitations, however, such as a narrow foramen or a high iliac crest, transforaminal PELD was previously considered to be difficult to perform at the L5–S1 level[7,9]. However, with advancements in foraminoplasty techniques, lesions at the L5–S1 level are no longer considered contraindications for transforaminal PELD[6,10,12]. FEVFD, though, is safer than TESSYS due to improvements in surgical techniques, such as the use of an endoscope throughout the procedure for greater visualization[10]. Additionally, our previous study demonstrated that the clinical outcomes of FEVFD performed at the L5–S1 level were comparable to those seen at the L4–5 level[10]. As a result, surgical segments at both L4–L5 and L5–S1 were included in the present study.

Even though they were not significantly different from each other, the neurological and total complication rates for the FEVFD group were higher than those for the MD group. FEVFD was performed with excellent endoscopic visualization, thereby making it possible to ensure adequate and safe decompression of the nerve root and spinal canal[5,23]. Despite these advantages, FEVFD is a newly developed procedure with its own disadvantages, such as a steep learning curve[10,26,27]. A specific training course, as well as personal experience, is necessary for surgeons to master the key techniques required for effective use of FEVFD. In the present study, one case of a dural tear and another of nerve root injury occurred in the FEVFD group, and it is interesting to note that these two patients were operated on during the earlier stages of the learning curve.

Whether FEVFD or MD was performed for patients with LDH and the number of recurrences and subsequent reoperations were important concerns for the after-surgery period in this study. The reoperation rates for PELD have been reported to be from 2.3% to 15%, while the reoperation rates for MD have been reported to be between 3.3% and 14.4%[6,7,9,16,28–30]. Incomplete decompression may occur in patients with central herniated discs, migrated herniated discs, and axillary-type herniated discs, leading to a higher risk of early recurrence[14,29]. As previously described, disc fragment remnants occurred in two cases in the FEVFD group. It is necessary to ensure complete removal of herniated masses, including basal and extruded parts, to reduce recurrence rates[31]. Furthermore, surgeons must carefully evaluate the amount of protruded disc removed to avoid early recurrence. Common causes of reoperation are incomplete removal of herniated disc material and early recurrence[29]. In cases with a high-grade migrated herniated disc, it is difficult to remove the herniated masses *via* conventional PELD techniques due to rigid instrumentation, poor visualization, and an inability to reach and grasp herniated fragments[29]. Conversely, we routinely performed full-endoscopic visualized foraminoplasty during FEVFD to gain access at the level of the disc herniation, making it easier to remove the migrated herniated disc with a widened foramen and better intraoperative visualization[10]. There were no significant differences in terms of complications, recurrence, or reoperations between these two groups. Furthermore, the recurrence and reoperation rates in the present study were slightly lower than those in previous studies. More recurrences and reoperations may occur during longer follow-up periods.

The present study has certain limitations. First, it was a retrospective, non-randomized controlled cohort study. Therefore, more prospective, randomized controlled studies and comparative studies with larger sample sizes and longer follow-up periods should be conducted to further assess clinical outcomes. Second, the disc herniation recurrence rate after discectomy should be more thoroughly evaluated after a longer follow-up period. Third, there is a statistical bias due to relatively small sample sizes. Additionally, the patient-reported clinical outcomes may be influenced by the heterogeneity of preoperative conservative treatments among the participants.

Conclusions

Both FEVFD and MD are reliable techniques for the treatment of symptomatic LDH. However, FEVFD resulted in faster recovery than MD and equivalent clinical outcomes after 24 months of follow-up. FEVFD should also be considered as an acceptable technique for treating LDH.

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