Journal of Orthopaedic Surgery and Research

RESEARCH Open Access

Comparison of percutaneous endoscopic lumbar discectomy (PELD) and unilateral biportal endoscopic (UBE) discectomy in the treatment of far lateral lumbar disc herniation (FLLDH): a retrospective study

Liang Li[1†], Jilong An[2†], Lei Guo[1], Xiuqi Shan[1], Yapeng Sun[1], Jiaqi Li[1], Fei Zhang[1] and Wei Zhang[1*]

Abstract

Purpose This study aimed to compare the clinical efficacy of percutaneous endoscopic lumbar discectomy (PELD) and unilateral biportal endoscopic (UBE) discectomy in treating patients with far lateral lumbar disc herniation (FLLDH).

Methods From January 2020 to January 2022, 65 patients with FLLDH underwent either PELD or UBE discectomy. Among them, 35 were treated with PELD (25 males and 10 females, average age 35.3 ± 12.7), and 30 were treated with UBE (21 males and 9 females, average age 43.5 ± 9.2). Factors such as operation time, fluoroscopy frequency, length of hospitalization, in-bed time after operation, hospitalization cost, complications, visual analogue scale (VAS, 0–10), Oswestry Disability Index (ODI, 0–100%), and modified MacNab criteria were assessed and compared between the two groups.

Results The demographic data were well matched between the PELD group and UBE group, without significant differences ($P > 0.05$). After surgery, both surgical procedures achieved significant improvement in VAS and ODI scores ($P < 0.05$). Compared to the UBE group, the PELD group had lower VAS scores for low back pain on the first postoperative day ($P < 0.05$), but no significant differences were found in alleviating leg pain in patients postoperatively between these two surgical procedures ($P > 0.05$). The PELD group was superior to the UBE group, showing shorter hospital stay ($P < 0.05$). Conversely, the UBE group exhibited significantly longer operation time and higher hospitalization cost than the PELD group ($P < 0.05$).

Conclusions Both PELD and UBE discectomy are safe and effective surgical procedures which can achieve satisfactory results in treating FLLDH. PELD causes less back pain in the immediate postoperative period. PELD offers advantages in rapid recovery, while UBE discectomy is a suitable option for patients with conditions such as high iliac crest, hypertrophy of the transverse process, or intolerance to pain under local anesthesia.

†Liang Li and Jilong An contributed equally to this work.

*Correspondence:

Full list of author information is available at the end of the article

Keywords Percutaneous endoscopic lumbar discectomy, Foraminoplasty, Unilateral biportal endoscopic discectomy, Far lateral lumbar disc herniation

Introduction

Far lateral lumbar disc herniation (FLLDH) refers to disc herniation that occurs either within or beyond the intervertebral foramen. Depending on its precise anatomical location, it can be classified as foraminal, extraforaminal, or both extra- and intraforaminal. This rare type of disc herniation accounts for approximately 2.6–11.7% of all lumbar disc herniations (LDHs), and typically compresses the upper exiting nerve root, resulting in abnormalities in sensation and movement in the lower back and leg regions [1–3]. Particularly, compression of the dorsal root ganglion(DRG) can lead to dysesthesia or hyperalgesia in the nerve distribution area of the lower limbs [4–6]. With the widespread application of high-resolution computed tomography (HRCT) and magnetic resonance imaging (MRI), the misdiagnosis rate has decreased [2, 7–9]. Surgery is typically required if conservative treatment proves ineffective [3, 10].

Transforaminal lumbar interbody fusion (TLIF) surgery has been known for favorable outcomes in treating FLLDH. However, it is associated with longer operation time, more bleeding, and higher costs [11]. With the advent of the minimally invasive spine surgery (MISS) paradigm, there has been a growing preference for less invasive procedures [12]. In 1997, YEUNG and colleagues introduced the Yeung Endoscopic Spine System (YESS) [13], followed by the Transforaminal Endoscopic Surgical System (TESSYS) by HOOGLAND and others in 2003 [14]. Spinal endoscopic technology has been gradually adopted to treat various types of disc herniation [15]. Percutaneous endoscopic lumbar discectomy (PELD) has evolved to allow foramenoplasty using instruments such as trephines and drills under visual endoscopy [16, 17]. This has expanded the operative scope and enables comprehensive nucleus removal for diverse lumbar disc herniation cases [15, 18–20]. It has demonstrated significant efficacy, especially in treating FLLDH [15, 21].

The unilateral biportal endoscopic (UBE) technique represents a relatively new minimally invasive surgical approach. In this dual-portal setup, the endoscope and surgical instruments are kept separate, minimizing interference and reducing surgical blind spots [22]. The endoscopic view is expansive and clear, facilitating exposure of pertinent anatomical structures, enabling layer-by-layer separation, and mitigating iatrogenic injury and nucleus residue, Typically used to treat central and paracentral LDH [23, 24]. Research indicated that both PELD and UBE discectomy had achieved favorable results in addressing intraspinal disc herniation. Nonetheless, PELD outperformed UBE discectomy in areas such as intraoperative blood loss, operative time, length of hospital stay, and short-term postoperative pain relief [24–26]. Some practitioners have begun to employ UBE surgery for FLLDH, with positive outcomes [27, 28].

However, which of the two surgical techniques (PELD or UBE discectomy) is superior in treating FLLDH remains unclear. The objective of this research is to compare the clinical efficacy and safety of these two surgical methods in the treatment of FLLDH.

Method

Inclusion and exclusion criteria

This retrospective study was approved by the Ethics Committee of our hospital, and all patients provided written informed consent. From January 2020 to January 2022, the data of hospitalized patients with FLLDH who underwent PELD or UBE discectomy in the Third Hospital of Hebei Medical University were retrospectively collected. All surgeries were performed by Wei Zhang generally followed the principle of randomization when selecting surgical methods. There were 88 patients initially collected, with 2 cases at the L2-3 level, 13 cases at the L3-4 level, 38 cases at the L4-5 level, and 35 cases at the L5-S1 level. To minimize statistical bias, we only included a total of 73 cases from the L4-5 and L5-S1 levels. According to the following inclusion and exclusion criteria, 65 patients were found suitable for our study.

The inclusion criteria included the following: (1) clinical symptoms of back or leg radiating pain; (2) magnetic resonance images (MRI) with a single-level soft herniated disc at foraminal or extraforaminal area (including cranial or caudal migration) associated with symptoms; (3) conservative treatment failed after 4-6weeks; (4) follow-up of at least 1 year. The exclusion criteria included the following: (1) segmental instability (defined as >3 mm translation, or >5° angulation); (2) recurrent LDH; (3) Moderate or severe spinal stenosis; (4) spondylolisthesis; (5) spinal tumors; (6) ankylosing spondylitis; (7) lumbar vertebral fracture.

Three experienced senior doctors (Y.P.S., L.G., and J.Q.L.) reviewed patients' clinical symptoms, physical examination charts, and radiological resources, including radiographs, MRI, and CT. Patients were excluded if any one of the three senior doctors determined that any of the exclusion criteria were met.

Surgical techniques of PELD and UBE discectomy

PELD

We developed personalized surgical plans for each patient based on the specific location of the disc herniation observed in preoperative MRI and CT scans, particularly confirming if there was cranial or caudal migration on sagittal plane of MRI. The position of the working channel may vary slightly depending on the location of the herniation. Generally, we followed a principle of exposing structures layer by layer from the outside inwards. The following is an introduction to the PELD procedure.

The surgery was performed under local anaesthesia with patients in the lateral position with the affected side upward. The lesion was examined using a C-arm X-ray machine, and the puncture point and direction were determined and marked. An entry point was selected 11 to 13 cm adjacent to the midline of the spinous process at the responsible segment level. Infiltrative anesthesia was administered to the skin, deep fascia, and muscle layers using the prepared local anesthetic. Under the anteroposterior and lateral view of the C-arm X-ray machine, the puncture needle was located at the herniated nucleus pulposus position shown in the preoperative radiological examination. A guidewire was inserted through the core of the puncture needle, which was then removed. A 7 mm skin incision was made, and sequential dilating sheaths were placed, and the positions of the sheaths were viewed in the anteroposterior and lateral perspective. From the anteroposterior view, the sheath was located at the outer edge of the pedicle line, and from the lateral view, the sheath was at the intervertebral level. After the working channel was inserted through the sheath, the sheath was removed, leaving the working channel in place. Foraminal herniations may require foraminoplasty in certain cases. The 30-degree foraminoscope was inserted, and the soft tissue was separated to relax the nerve root, thereby exposing the disc. The herniated nucleus pulposus was then removed through the combined rotation of the working channel and endoscope, employing nucleus forceps of varying sizes and angles. Once the nerve root was thoroughly released, it was observed to be freely floating and mobile within the infusion fluid. The representative case is presented in Fig. 1a–i.

UBE discectomy

The UBE discectomy was performed under general anaesthesia with patients in the prone position on support pads, allowing the abdomen to hang freely. Consider, for instance, the case of left FLLDH between L4 and L5. The C-arm X-ray machine was used to obtain a lateral view of the lumbar spine, and the head of the bed was elevated to align the L4-L5 intervertebral space perpendicular to the ground. A horizontal line 'a' was centered on the isthmus of the left pedicle of L4, a vertical line 'b' was drawn on the outer edge of the left pedicle between L4 and L5, and a parallel line 'c' was drawn 2 cm outside of 'b'. The intersection points between lines 'a' and 'c', each 1.5 cm from the head and tail, mark the surgical incision (Fig. 2). The cranial portal functioned as the observation channel, and the caudal portal as the operating channel. After routine disinfection and draping, incisions were made in the skin, subcutaneous tissue, and fascia. An expander was then directly inserted through the paravertebral muscles to the L4 isthmus, bluntly separating the muscle tissue that covered the isthmus. Following this, a cannula, along with its core, was placed into the observation channel; the core was then removed, and a 30-degree scope was inserted. Through the working channel, soft tissue around the isthmus was further peeled using a radiofrequency electrode, exposing the tip of the L5 superior articular process, the lateral edge of the L4 inferior articular process, and the lower edge of the L4 transverse process. Under endoscopic visualization, the outer area of the L4 isthmus was removed using a high-speed drill, followed by the excision of part of the lower edge of the L4 transverse process and the tip of the L5 superior articular process. Simultaneously, Kerrison punches bit off part of the lateral edge of the L4 inferior articular process, thereby exposing the ligamentum flavum in the intervertebral foramen. Nerve dissectors were utilized to gently release and separate the nerve roots from ligamentum flavum adhesions, followed by careful removal of the ligamentum flavum to expose the nerve root. Pre-hemostasis was then performed using a radiofrequency electrode. Subsequently, nerve dissectors were employed to separate the nerve root, expose the herniated nucleus pulposus, and separate it from surrounding soft tissue adhesions. The herniated nucleus tissue was removed using nucleus forceps. Finally, a drainage tube was placed in the surgical field, and the incision was meticulously closed in layers [27].The representative case is presented in Fig. 3a-i.

Assessment method

Perioperative information, including surgical time, fluoroscopy rate, in-bed time after operation, hospital stay, total cost, and complications, was assessed through clinical records and video files. The PELD surgery time was recorded from local anesthesia to closure, and the UBE discectomy surgery time was noted from incision to closure. Postoperative in-bed time was defined as the number of days the patient stays in bed after surgery. The visual analogue scale (VAS) (0–10) was used to assess the pain of leg and back preoperatively and at 1 day, 3 months and 12 months postoperatively. The Oswestry Disability Index (ODI) (0-100%) was employed to evaluate the quality of daily life of patients preoperatively and at 12 months postoperatively. Patients' satisfaction of clinical outcomes was assessed according to the modified MacNab criteria (excellent, good, fair, poor). Lumbar spine MRI was obtained during the patient's follow-up.

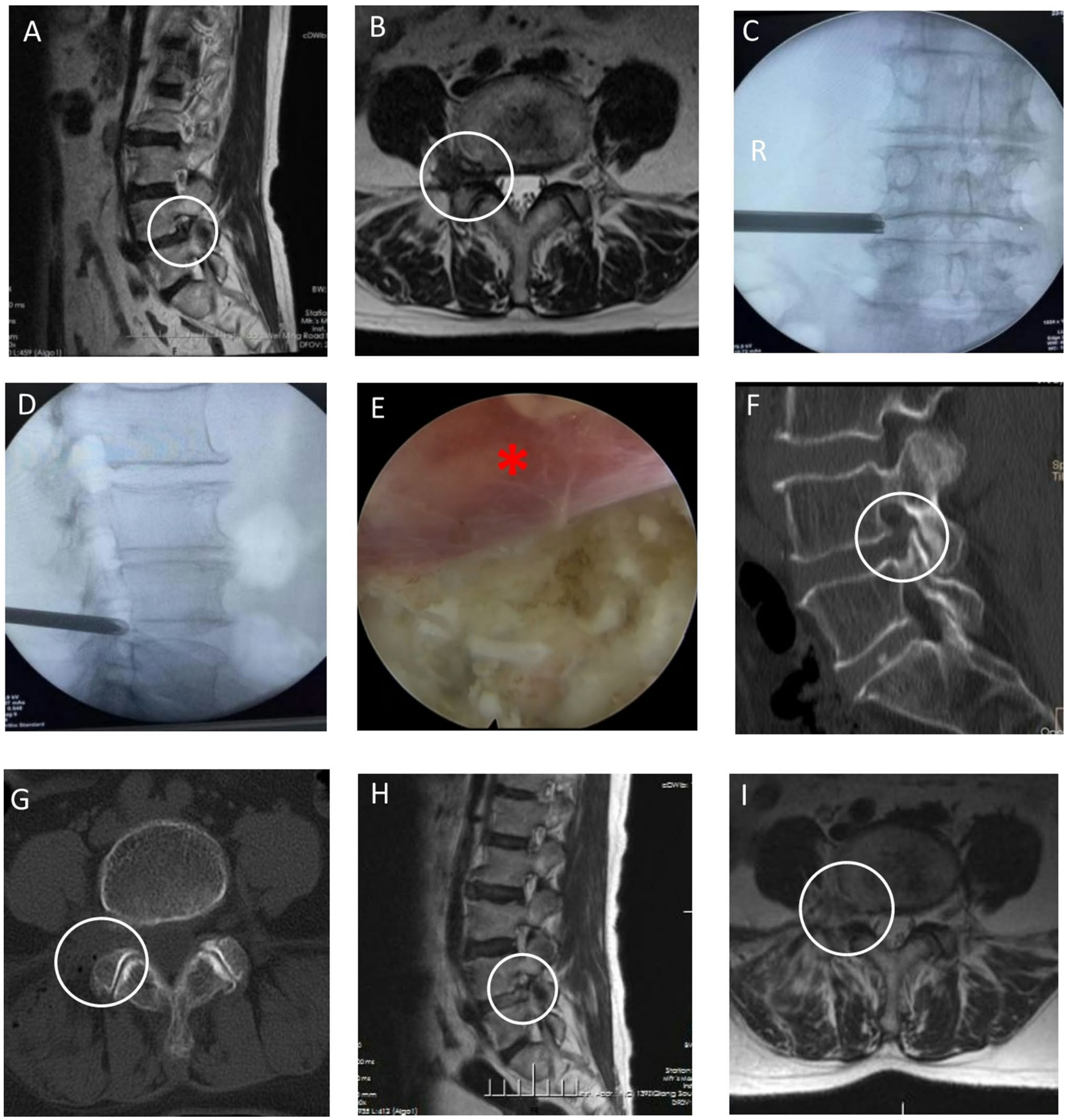

Fig. 1 A 33-year-old female patient diagnosed with L4-5 far lateral lumbar disc herniation underwent the PELD surgery. **a** and **b**, Preoperative magnetic resonance images (MRI) showing disc herniation (within the circle). **c** and **d**, In the anteroposterior view, the working channel was located in the extraforaminal region, while in the lateral view, the anterior edge of the working channel was aligned with the posterior edge of the disc. **e**, Sufficient decompression of the exiting nerve root (asterisk) was ensured. **f** and **g**, One-day postoperative vertebrae computed tomography (CT) scans showed better preservation of the superior articular process (within the circle). **h** and **i**, MRI scans 12 months after the surgery showed the herniated nucleus pulposus was thoroughly excised (within the circle)

Statistical analysis

Statistical analysis was performed using SPSS 23.0 (SPSS Inc., Chicago, IL). A probability value 0.05 was considered to indicate a statistically significant difference. Comparisons of demographic data and surgical parameters were conducted using the t test. Analyses of categorical data were carried out with chi-square tests (including Fisher's exact test). Mann–Whitney U test for nonparametric data and Student t test.

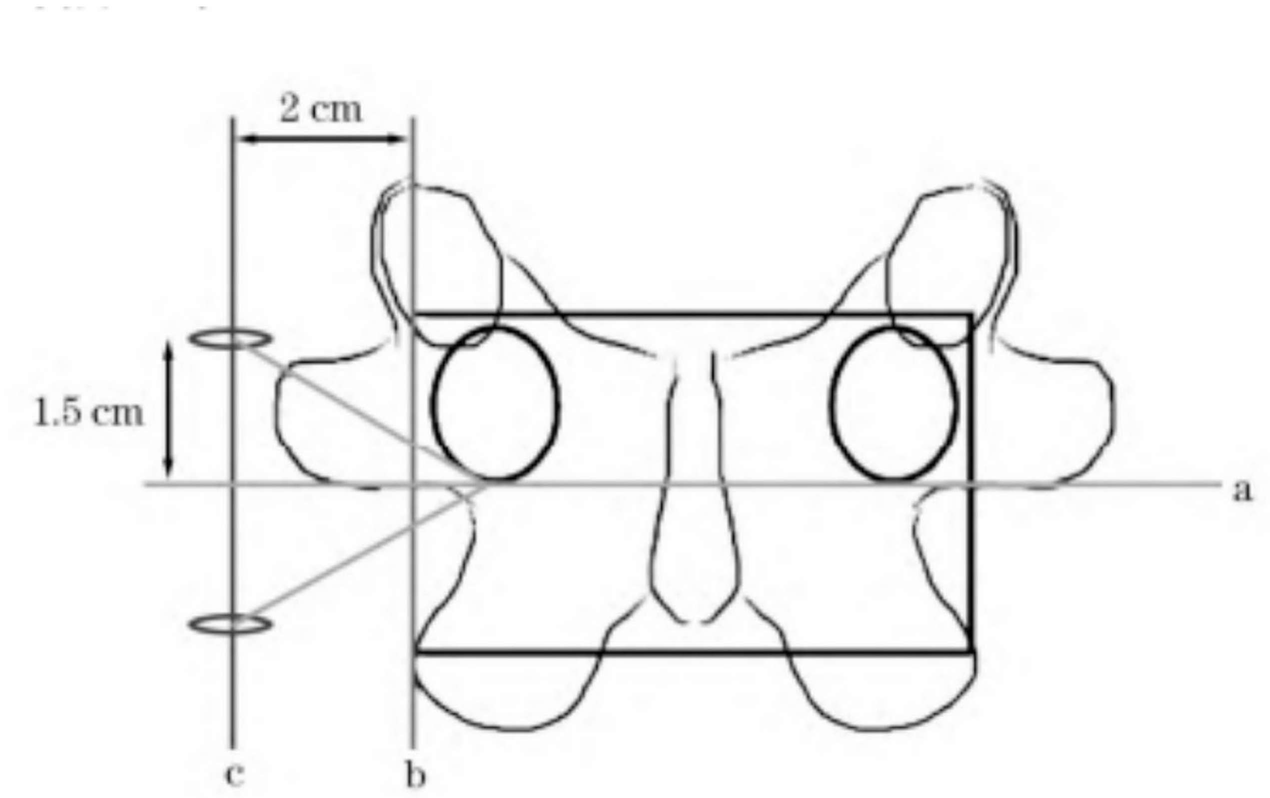

Fig. 2 Mark of the surgical incision in UBE discectomy

Results

The mean age of the 65 patients was 40.0 ± 10.1 years (ranging from 15 to 58 years), with males constituting 70.1% (46/65) of the two groups. Among these patients, 35 received PELD, and 30 received UBE discectomy. We observed that all patients included in this study with foraminal disc herniation also exhibited varying degrees of extraforaminal herniation. Therefore, based on the location of the herniation included in the present study, we classified the herniation types to extra- and intraforaminal and extraforaminal disc herniation. In this study, 31 patients (47.69%) had extra- and intraforaminal, and 34 patients (52.31%) had extraforaminal disc herniation. A total of 48 (73.8%) patients had cranial migration and 17 (26.2%) had FLLDH at the disc level. A *P*-value greater than 0.05 confirmed the absence of statistically significant differences in baseline and clinical characteristics between the two groups (Table 1).

In this research, the mean surgical times were 97.4 ± 28.5 min for the PELD group and 120.3 ± 22.6 min for the UBE group, with the surgical time for the UBE group being notably longer than that of the PELD group ($P < 0.001$) (Fig. 4a). The intraoperative fluoroscopy counts were 10.5 ± 4.3 times for the PELD group and 5.3 ± 2.9 times for the UBE group, with the counts for the PELD group being significantly higher (Fig. 4b). The postoperative in-bed time of the PELD group were 1.2 ± 0.2 days and 1.3 ± 0.3 days for the UBE group. There was no statistically significant difference in the postoperative in-bed time between the two groups. However, the PELD group had significantly shorter hospitalization stay (3.6 ± 1.1 days) compared to the UBE group (5.2 ± 0.8 days) (Fig. 4c). Furthermore, the total hospital costs for the UBE group were significantly higher, amounting to ¥36,299 ± 7562.3, compared to the PELD group, which was ¥24,380.3 ± 4396.2 ($P < 0.001$) (Fig. 4d) (Table 2).

In the current study, the overall complication rate was 14.3% ($n = 5$) for the PELD group and 16.7% ($n = 5$) for the UBE group (Table 2). The statistical analysis revealed no significant difference between the groups ($P = 0.862$). In the UBE group, there was one instance of dural tear, requiring conversion to open surgery, while the PELD group showed no incidental durotomy. In the PELD group, there were 2 instances of sensory impairment and 1 instance of motor dysfunction. The UBE group had one case each of wound hematoma, nerve injury, and motor dysfunction. Both groups had no wound infections. Recurrence of herniation occurred in two patients in the PELD group and one patient in the UBE group. At 1 year, the reoperation rate was 5.7% ($n = 2$) for the PELD group and 6.7% ($n = 2$) for the UBE group. The specific

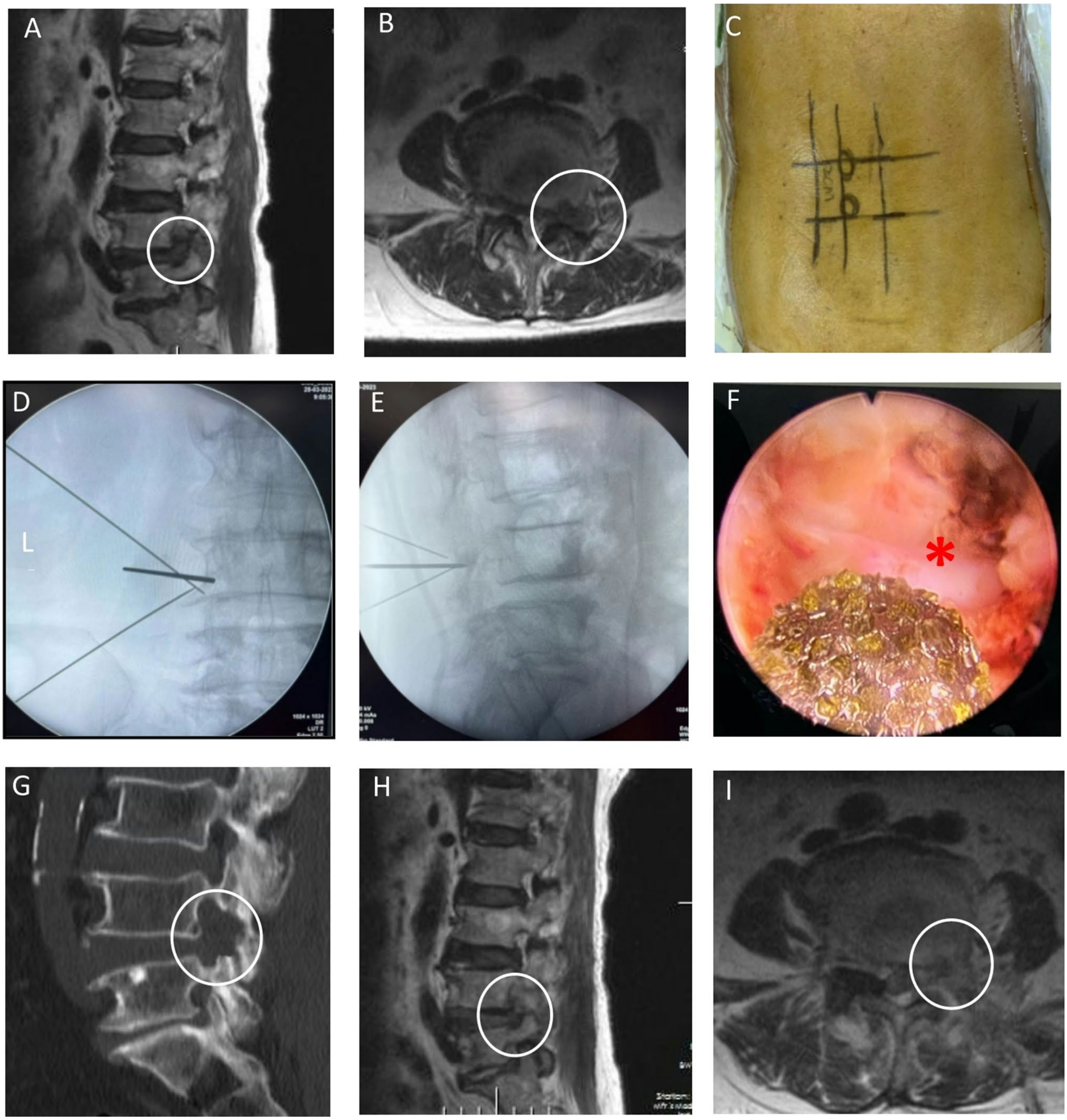

Fig. 3 A 55-year-old male patient diagnosed with L4-5 far lateral lumbar disc herniation underwent the UBE discectomy. **a** and **b**, Preoperative magnetic resonance images (MRI) showing disc herniation (within the circle). **c**, The intraoperative incision was positioned about 2 cm lateral to the pedicle. **d** and **e**, Intraoperative Kirschner's needle localization on x-ray anteroposterior and lateral views; The needle was injected gradually so that the needle tip touched the isthmus of L4. **f**, Remove part isthmus of L4 and the tip of the L5 superior articular process to reveal the exiting nerve root (asterisk). **g**, CT image showed that decompression of the L4-5 foraminal area was sufficient. Partial bone of the L4 isthmus and a small amount of bone at the tip of the L5 superior articular process were removed (within the circle). **h** and **i**, MRI scans 12 months after the surgery showed the herniated nucleus pulposus was almost excised (within the circle)

Table 1 Baseline clinical characteristics and demographic data of 65 patients

	PELD (*n* = 35)	UBE (*n* = 30)	*P* value
Age (y)	35.3 ± 12.7	43.5 ± 9.2	0.126
Male sex, No. (%)	25 (71.4)	21 (70)	1.000
BMI (Kg/m^2)	25.3 ± 3.7	25.2 ± 2.9	0.199
Symptoms, No. (%)			
BP	26 (74.3)	21 (70.0)	0.784
LP	33 (94.3)	28 (93.3)	1.000
Lasegue sign, No. (%)	33 (94.3)	29 (96.7)	1.000
Affected level, No. (%)			0.324
L4-5	20 (57.1)	13 (43.3)	
L5-S1	15 (42.9)	17 (56.7)	
Type of herniation, No. (%)			0.862
extra- and intraforaminal	17 (48.6)	14 (46.7)	
extraforaminal	18 (51.4)	16 (53.3)	
ODI score	57.9 ± 17.5	56.3 ± 13.2	0.646
VAS (BP)	4.3 ± 1.7	4.6 ± 2.4	0.621
VAS (LP)	7.8 ± 1.1	7.3 ± 1.3	0.190

PELD percutaneous endoscopic lumbar discectomy, *UBE* unilateral biportal endoscopic, *No.* Number, *BMI* body mass index, *BP* back pain, *LP* leg pain, *ODI* Oswestry Disability Index, *VAS* visual analogue scale

information regarding the secondary operation for both groups is recorded in Table 3.

We compared the VAS, ODI, and patient satisfaction between the two groups according to the type of intervertebral disc herniation, observing significant improvements in postoperative VAS and ODI scores for all types of disc herniation in both groups (Tables 4 and 5). There were no significant differences in VAS and ODI scores between the groups at 3 and 12 months after surgery ($P > 0.05$). However, the PELD group showed lower VAS score for low back pain on the first day after surgery compared to the UBE group ($P < 0.05$) (Fig. 5a-d). Based on the modified MacNab criteria, the PELD group achieved an 88.2% good to excellent rate for extra- and intraforaminal disc herniation and 100% for extraforaminal disc herniation. Meanwhile, the satisfaction rates in the UBE group were 92.9% for extra- and intraforaminal disc herniation and 87.5% for extraforaminal disc herniation, respectively.

Discussion

Questionnaires have found that patients prefer minimally invasive surgical methods for treating spinal diseases, attributing this preference to advantages like rapid recovery and reduced trauma [29, 30]. Many studies have further corroborated that minimally invasive surgery could achieve therapeutic effects equivalent to open surgery [31–34]. Among these techniques, PELD and UBE discectomy are two relatively novel minimally invasive techniques that researchers have found to be significantly effective in treating intraspinal disc herniations [18, 24, 25, 35]. However, as of now, few studies have been conducted to compare the clinical efficacy and safety of these two techniques in treating FLLDH.

This study found that both the PELD and UBE groups were able to achieve satisfactory effects at the 1-year follow-up after surgery. However, the PELD group demonstrated a shorter hospital stay, resulting in a more rapid recovery. PELD can achieve reliable clinical results with 100% satisfaction for extraforaminal herniation. Meanwhile, the operation time for patients in the UBE group significantly increased, and the cost was also higher.

As reported in existing literature, the postoperative nerve injury rate for PELD surgery ranges from 0–1.2% [16, 17]. In this study, the PELD group experienced no case of nerve injury which was mainly attributed to the fact that addressing extraforaminal disc herniation during surgery rarely required the use of a trephine or drilling to complete foraminoplasty. When dealing with foraminal disc herniation, only a slight removal of the ventral part of the superior articular process (SAP) was required to further excise the herniated disc. Furthermore, all procedures were performed under direct visualization with an endoscope, allowing clear exposure of the exiting nerve roots, thereby significantly reducing the risk of nerve injury [36]. The operation time for the PELD group in this study was notably shorter than that of the UBE group. In our experience, this phenomenon may be related to the need for detailed exploration of the patient's anatomical structure, intraoperative extensive lamina removal, adequate hemostasis, and the use of biportal techniques during the UBE procedure. In contrast, PELD, which involves a single-portal approach to the intervertebral foramen, is relatively simpler, provides clearer intraoperative visualization, and allows for more direct manipulation, resulting in a shorter operative time in this study [37, 38]. The UBE group reported one case of nerve injury which occurred when this surgical approach was initially introduced. It is important to noted that UBE discectomy for far lateral disc herniation

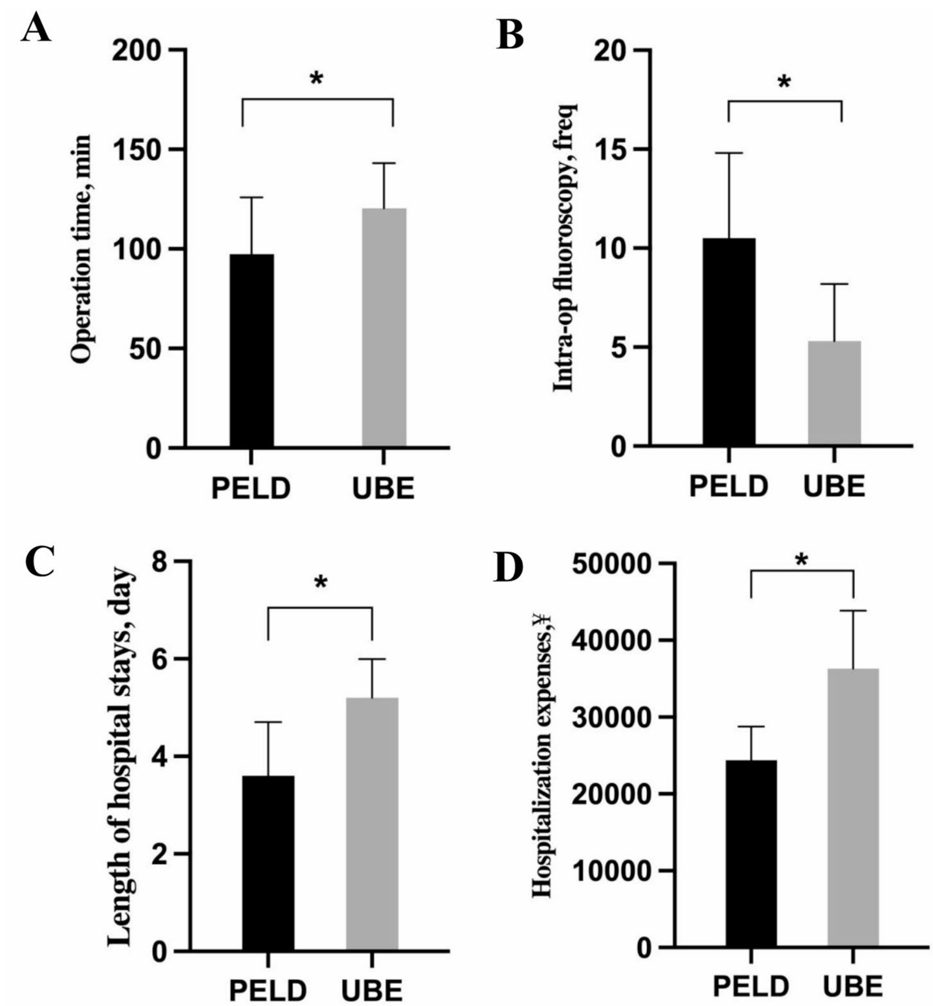

Fig. 4 Comparisons of surgical characteristics between two groups. **a**, Operative time, min. **b**, Intra-operative fluoroscopy, freq. **c**, Length of hospital stays, day. **d**, Hospitalization expenses, ¥. $^{*}P < 0.05$

and intraspinal disc herniation are two entirely different surgical approaches, with the former presenting a steeper learning curve for most beginners [39]. With the accumulation of surgical experience, it is anticipated that both the operation time, the incidence of nerve injury and complications within the UBE group will decrease significantly.

Compared to the UBE group, the PELD group had lower VAS scores for low back pain on the first postoperative day when treating either extra- and intraforaminal or extraforaminal disc herniation. This may be due to the extensive dissection of soft tissues and more lamina removal in UBE discectomy [37, 38]. Some studies suggested that the transforaminal approach of PELD to address disc herniation at the L5-S1 level was difficult, as the patients' high iliac crest led to complications in the puncturing process [40, 41]. However, in this research, FLLDH was addressed by placing the working channel outside the foramen and positioning the puncture point closer to the spinous process, which could alleviate this

Table 2 Peri-operative information of patients

Operative characteristics	PELD (n = 35)	UBE (n = 30)	P value
Operation time, min	97.4 ± 28.5	120.3 ± 22.6	P < 0.001*
Intra-op fluoroscopy, freq	10.5 ± 4.3	5.3 ± 2.9	P < 0.001*
Postoperative In-bed time, day	1.2 ± 0.2	1.3 ± 0.3	0.126
Length of hospital stays, day	3.6 ± 1.1	5.2 ± 0.8	P < 0.001*
Hospitalization expenses, ¥	24,380.3 ± 4396.2	36,299 ± 7562.3	P < 0.001*
Total complications	5 (14.3%)	5 (16.7%)	0.862
Dural tear	0	1	
Nerve root injury	0	1	
Wound hematoma	0	1	
Motor deficit	1	1	
Sensory impairment	2	0	
Wound infection	0	0	
Recurrence	2	1	
Reoperation within 1y	2 (5.7)	2 (6.7)	0.840

PELD percutaneous endoscopic lumbar discectomy, *UBE* unilateral biportal endoscopic

problem. Notably, the UBE technique was unaffected by the height of a patient's iliac crest, making it a suitable treatment option for those with very high iliac crests. In addition, patients with hypertrophic transverse processes may encounter difficulties in puncturing in the PELD group [18], and such patients might consider UBE surgery as an alternative. Some patients cannot endure severe neurological symptoms in the lateral position, and others were particularly sensitive to pain during the puncture and establishment of the working channel which might be intolerable and led to the termination of the procedure. As a result, they might refuse surgery under local anesthesia. For these patients, UBE treatment was a viable option. Since the UBE procedure was performed under general anesthesia, the patients experienced no discomfort during the surgery.

This research revealed that patients in the PELD group experienced a notably shorter duration of hospital stay compared to those in the UBE group. Patients in

Table 4 Comparison of VAS, ODI, and MacNab evaluation between two groups for extra- and intraforaminal disc herniation

	PELD (n = 17)	UBE (n = 14)	P value
VAS (LP)			
Pre-	7.8 ± 1.3	7.2 ± 1.5	0.675
1 day post-	3.2 ± 1.8	2.9 ± 0.9	0.965
3 mo post-	2.4 ± 1.4	2.2 ± 1.7	0.816
12 mo post-	1.7 ± 1.5	1.9 ± 1.5	0.633
P value (pre- and 3mo post-)	P < 0.001*	P < 0.001*	
VAS (BP)			
Pre-	4.2 ± 2.3	4.0 ± 2.2	0.288
1 day post-	1.8 ± 1.1	2.8 ± 1.5	0.002*
3 mo post-	1.5 ± 1.8	1.6 ± 1.2	0.550
12 mo post-	1.2 ± 1.4	1.3 ± 1.7	0.689
P value (pre- and 3mo post-)	P < 0.001*	P = 0.003*	
ODI score			
Pre-	60.5 ± 22.0	53.3 ± 13.2	0.218
12 mo post-	5.3 ± 4.1	3.7 ± 2.5	0.552
P value	P < 0.001*	P < 0.001*	
MacNab evaluation			
Excellent	11	8	
Good	4	5	
Fair	2	1	
Poor	0	0	
Excellence/good rate(%)	15 (88.2)	13 (92.9)	1.000

PELD percutaneous endoscopic lumbar discectomy, *UBE* unilateral biportal endoscopic, *BMI* body mass index, *BP* back pain, *LP* leg pain, *ODI* Oswestry Disability Index, *VAS* visual analogue scale, *Pre-* preoperative, *post-* postoperative

Table 3 Cases of the secondary operation of two groups

Case, No	Sex	Age, y	Affected level	Type of herniation	Initial surgery	Time from initial surgery	reason for secondary operation	Secondary operation
1	female	28	L4-5	extra- and intraforaminal	PELD	five months	recurrence	TLIF
2	female	26	L5-S1	extra- and intraforaminal	PELD	three months	recurrence	TLIF
3	male	35	L4-5	extraforaminal	UBE	2days	hematoma	Exploratory surgery
4	male	42	L4-5	extraforaminal	UBE	six months	recurrence	TLIF

PELD percutaneous endoscopic lumbar discectomy, *UBE* unilateral biportal endoscopic, *TLIF* transforaminal lumbar interbody fusion

Table 5 Comparison of VAS, ODI, and MacNab evaluation between two groups for extraforaminal disc herniation

	PELD (*n* = 18)	UBE (*n* = 16)	*P* value
VAS (LP)			
Pre-	7.9 ± 1.5	7.3 ± 1.4	0.237
1 day post-	1.9 ± 0.8	2.3 ± 0.9	0.831
3 mo post-	1.8 ± 1.2	2.2 ± 1.7	0.673
12 mo post-	1.3 ± 1.5	1.8 ± 1.5	0.082
P value (pre- and 3mo post-)	*P* < 0.001*	*P* < 0.001*	
VAS (BP)			
Pre-	4.2 ± 2.7	4.7 ± 3.2	0.106
1 day post-	2.5 ± 1.7	3.5 ± 1.4	0.011*
3 mo post-	2.1 ± 1.8	2.3 ± 1.4	0.430
12 mo post-	1.4 ± 1.2	1.2 ± 1.5	0.605
P value (pre- and 3mo post-)	*P* = 0.010*	*P* = 0.011*	
ODI score			
Pre-	55.6 ± 18.2	52.3 ± 16.2	0.467
12 mo post-	8.8 ± 7.1	8.5 ± 10.8	0.295
P value	*P* < 0.001*	*P* < 0.001*	
MacNab evaluation			
Excellent	12	10	
Good	6	4	
Fair	0	2	
Poor	0	0	
Excellence/good rate(%)	18 (100)	14 (87.5)	0.214

PELD percutaneous endoscopic lumbar discectomy, *UBE* unilateral biportal endoscopic, *BMI* body mass index, *BP* back pain, *LP* leg pain, *ODI* Oswestry Disability Index, *VAS* visual analogue scale, *Pre-* preoperative, *post-* postoperative

the PELD group were typically able to start ambulating and be discharged 24–36 h postoperatively. In contrast, patients in the UBE group could also begin bedside activities with a drainage tube on the first postoperative day. However, the drainage tube was typically required for 48 to 60 h, and it could only be removed when the drainage volume was less than 30 ml to reduce the risk of incision hematoma, after which the patient could be discharged. This implies that the PELD group can achieve a faster recovery, enabling patients to resume daily activities more promptly. The expenses of the PELD group were found to be lower than those of the UBE group, possibly due to the cost of general anesthesia and endoscopic instruments used in UBE surgery. This represents a significant financial advantage for patients with limited economic resources.

In this study, no significant difference was observed in the occurrence of complications between the two groups. The PELD group had no cases of nerve injury, while the UBE group had one. Additionally, the UBE group recorded one case of hematoma and one case of dural injury. The PELD group had one patient with motor dysfunction and two with sensory disturbances. The UBE group had one patient with motor dysfunction. All four patients recovered after the postoperative administration of dexamethasone and mannitol. The recurrence rate, ranging from 0 to 6.9% as reported in the literature [26, 42–44], remains a major concern for patients undergoing minimally invasive spine surgery. Compared with UBE, PELD may be associated with a higher recurrence rate of disc herniation due to limited operational ability and decreased disc removal. However, the recurrence rates were comparable between the two groups in this study during a 12-month follow-up. The short follow-up period is a limitation of this study, and a long-term research is required to further evaluate the recurrence rate and clinical efficacy of the two groups.

Conclusion

Both surgical methods, UBE discectomy and PELD, can achieve satisfactory effects in treating far lateral lumbar disc herniation, with PELD potentially leading to a faster recovery, and PELD causes less back pain in the immediate postoperative period. Patients with excessively high iliac crests, hypertrophied transverse processes, or those who cannot tolerate pain under local anesthesia can opt for UBE treatment. However, this study's limitations include a relatively small sample size and a short

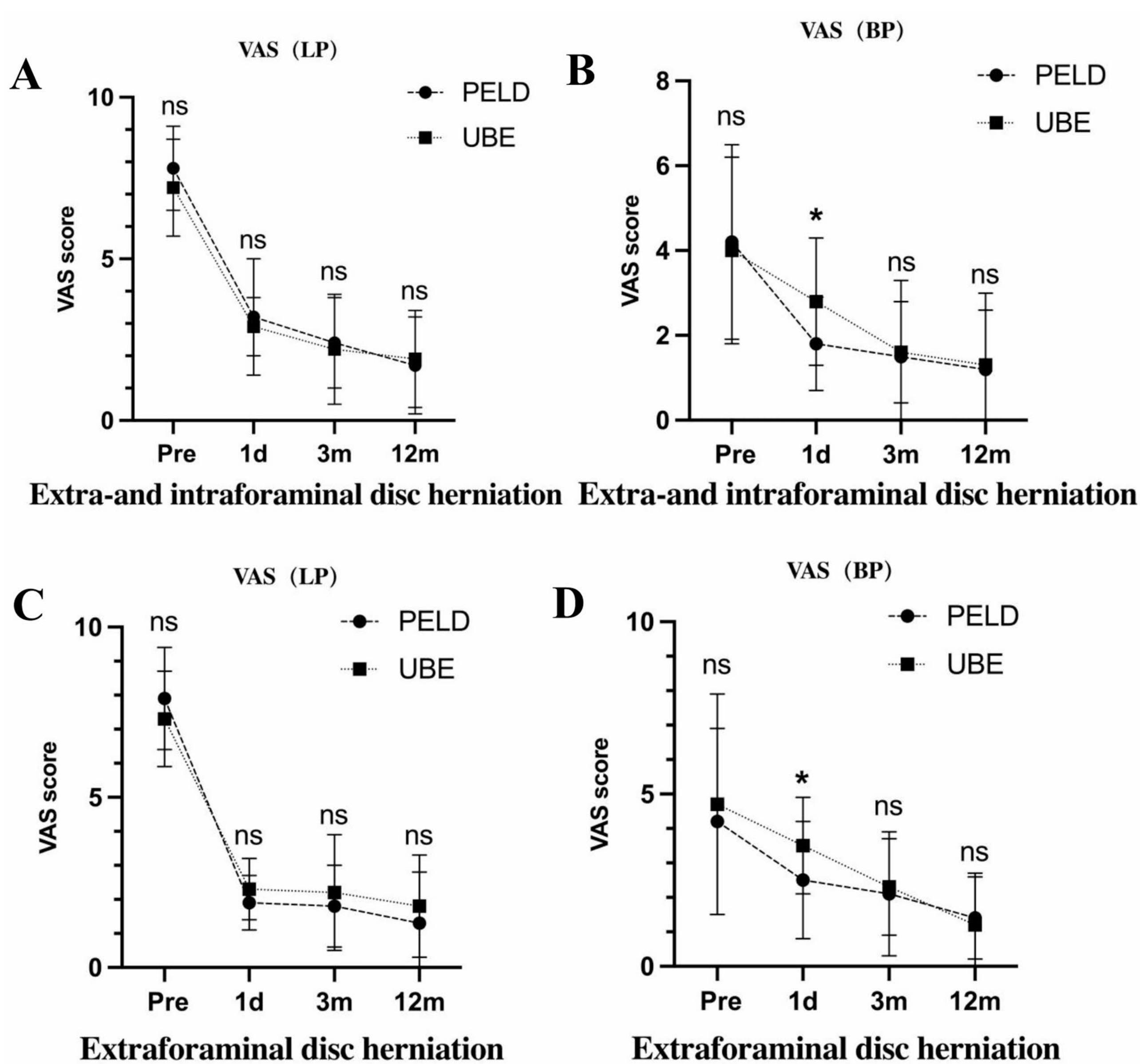

Fig. 5 Comparisons of VAS scores between two groups. **a**, VAS score (leg pain) of extra- and intraforaminal disc herniation. **b**, VAS score (back pain) of extra- and intraforaminal disc herniation. **c**, VAS score (leg pain) of extraforaminal disc herniation. **d**, VAS score (back pain) of extraforaminal disc herniation. * $P < 0.05$. NS not significantly

follow-up period. Further prospective, randomized controlled trials are needed to confirm the current research findings.

Abbreviations

CT	Computed tomography
MRI	Magnetic resonance imaging
ODI	Oswestry disability index
VAS	Visual analogue scale
UBE	Unilateral biportal endoscopy
PELD	Percutaneous endoscopic lumbar discectomy
FLLDH	Far lateral lumbar disc herniation

Acknowledgements
Not applicable.

Author contributions
LL, JA contributed equally, First Author: Liang Li, MD; Jilong An, MD, LL, JA and WZ conceived the idea for the study; LL, JA, XS and WZ designed the study. LL, XD, LG and YS collected the relevant data and followed up the patients. JL and FZ prepared the figures and tables and performed the statistical analyses. All the authors interpreted the data and contributed to preparation of the manuscript. LL and JA wrote the manuscript, WZ reviewed and approved the final version. All authors read and approved the final manuscript.

Funding
Bureau of Science and Technology of Hebei Province (22377708D).
Hebei Provincial Government funded Provincial Medical Talent Project in 2022.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
We confirm that all methods were carried out in accordance with relevant guidelines and regulations. All patients' data collection was informed in advance, and informed consent was obtained from all subjects.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Spinal Surgery, Hebei Medical University Third Hospital, Shijiazhuang 050000, China
[2]Department of Spinal Surgery, Affiliated Hospital of Hebei University, Baoding 071000, China

Received: 5 February 2025 / Accepted: 10 May 2025
Published online: 24 May 2025

References
1. Berra LV, Di Rita A, Longhitano F, Mailland E, Reganati P, Frati A, Santoro A. Far lateral lumbar disc herniation part 1: imaging, neurophysiology and clinical features. World J Orthop. 2021;12(12):961–9.
2. Abdullah AF, Ditto EW 3rd, Byrd EB, Williams R. Extreme-lateral lumbar disc herniations. Clinical syndrome and special problems of diagnosis. J Neurosurg. 1974;41(2):229–34.
3. Al-Khawaja DO, Mahasneh T, Li JC. Surgical treatment of Far lateral lumbar disc herniation: a safe and simple approach. J Spine Surg. 2016;2(1):21–4.
4. Zhang B, Dong B, Wang L, Wang Y, Gao Z, Li Y, Wang H, Lu X. Comparison of the efficacy of autologous Lp-PRP and Lr-PRP for treating intervertebral disc degeneration: in vitro and in vivo study. J Orthop Surg Res. 2024;19(1):731.
5. Chen W, Yang W, Meng B, Wang X, Duan H, Xu Q, Li H. Validation and the role of PDK4 relevant to ferroptosis in degenerative lumbar disc disease. J Orthop Surg Res. 2025;20(1):30.
6. Chen H, Tang T, Xue C, Liu X, Xi Z, Xie L, Kang R. Exploration and breakthrough in the mode of intervertebral disc cell death May lead to significant advances in treatments for intervertebral disc degeneration. J Orthop Surg Res. 2024;19(1):825.
7. Perno JR, Rossitch E Jr. Extreme lateral lumbar disc herniation. Diagnosis and management. N C Med J. 1993;54(5):224–6.
8. Zhao D, Sha B-x, Zeng L-f, Liang G-h, Huang H-t, Pan J-k, Liu J, Zhao S. Exploring and analyzing two aging related genes FPR1 and UCHL1 and their potential molecular mechanisms in aggravating lumbar disc herniation. J Orthop Surg Res. 2024;19(1):841.
9. Liu C, Ge X, Li Y. Repair of annulus fibrosus defects using decellularized annulus fibrosus Matrix/chitosan hybrid hydrogels. J Orthop Surg Res. 2024;19(1):535.
10. Qian J, Lv X, Luo Y, Liu Y, Jiang W. Unilateral biportal endoscopic discectomy versus percutaneous endoscopic lumbar discectomy in the treatment of lumbar disc herniation linked with posterior ring apophysis separation: A retrospective study. World Neurosurg. 2025;193:957–63.
11. Li P, Yang F, Tong Y, Chen Y, Song Y. Comparison of percutaneous transforaminal endoscopic decompression and transforaminal lumbar interbody fusion in the treatment of Single-Level lumbar disc herniation with modic type I changes. J Pain Res. 2021;14:3511–7.
12. Momin AA, Steinmetz MP. Evolution of minimally invasive lumbar spine surgery. World Neurosurg. 2020;140:622–6.
13. Yeung AT. Minimally invasive disc surgery with the Yeung endoscopic spine system (YESS). Surg Technol Int. 1999;8:267–77.
14. Hoogland T, Schubert M, Miklitz B, Ramirez A. Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: a prospective randomized study in 280 consecutive cases. Spine (Phila Pa 1976). 2006;31(24):E890–897.
15. Kim HS, Paudel B, Jang JS, Lee K, Oh SH, Jang IT. Percutaneous endoscopic lumbar discectomy for all types of lumbar disc herniations (LDH) including severely difficult and extremely difficult LDH cases. Pain Physician. 2018;21(4):E401–8.
16. Ouyang ZH, Tang M, Li HW, Zou MX, Li XL, Wang WJ, Yan YG. Full-Endoscopic foraminoplasty using a visualized bone reamer in the treatment of lumbar disc herniation: A retrospective study of 80 cases. World Neurosurg. 2021;149:e292–7.
17. Hua W, Zhang Y, Wu X, Gao Y, Li S, Wang K, Yang S, Yang C. Full-Endoscopic visualized foraminoplasty and discectomy under general anesthesia in the treatment of L4-L5 and L5-S1 disc herniation. Spine (Phila Pa 1976). 2019;44(16):E984–91.
18. Pan M, Li Q, Li S, Mao H, Meng B, Zhou F, Yang H. Percutaneous endoscopic lumbar discectomy: indications and complications. Pain Physician. 2020;23(1):49–56.
19. Li X, Hu Z, Cui J, Han Y, Pan J, Yang M, Tan J, Sun G, Li L. Percutaneous endoscopic lumbar discectomy for recurrent lumbar disc herniation. Int J Surg. 2016;27:8–16.
20. Gadjradj PS, Harhangi BS, Amelink J, van Susante J, Kamper S, van Tulder M, Peul WC, Vleggeert-Lankamp C, Rubinstein SM. Percutaneous transforaminal endoscopic discectomy versus open microdiscectomy for lumbar disc herniation: A systematic review and Meta-analysis. Spine (Phila Pa 1976). 2021;46(8):538–49.
21. Sun W, Wang J, Hu Y, Tao J, Yang C. Efficacy and safety of unilateral biportal endoscopy compared with transforaminal route percutaneous endoscopic lumbar decompression in the treatment of lumbar spinal stenosis: minimum 1-year Follow-up. J Pain Res. 2025;18:1071–80.
22. Kim SK, Kang SS, Hong YH, Park SW, Lee SC. Clinical comparison of unilateral biportal endoscopic technique versus open microdiscectomy for single-level lumbar discectomy: a multicenter, retrospective analysis. J Orthop Surg Res. 2018;13(1):22.
23. Lin GX, Huang P, Kotheeranurak V, Park CW, Heo DH, Park CK, Park JY, Kim JS. A systematic review of unilateral biportal endoscopic spinal surgery: preliminary clinical results and complications. World Neurosurg. 2019;125:425–32.
24. Chang H, Xu J, Yang D, Sun J, Gao X, Ding W. Comparison of full-endoscopic foraminoplasty and lumbar discectomy (FEFLD), unilateral biportal endoscopic (UBE) discectomy, and microdiscectomy (MD) for symptomatic lumbar disc herniation. Eur Spine J. 2023;32(2):542–54.
25. Jiang HW, Chen CD, Zhan BS, Wang YL, Tang P, Jiang XS. Unilateral biportal endoscopic discectomy versus percutaneous endoscopic lumbar discectomy in the treatment of lumbar disc herniation: a retrospective study. J Orthop Surg Res. 2022;17(1):30.
26. Hao J, Cheng J, Xue H, Zhang F. Clinical comparison of unilateral biportal endoscopic discectomy with percutaneous endoscopic lumbar discectomy for single l4/5-level lumbar disk herniation. Pain Pract. 2022;22(2):191–9.
27. Park JH, Jung JT, Lee SJ. How I do it: L5/S1 foraminal stenosis and far-lateral lumbar disc herniation with unilateral bi-portal endoscopy. Acta Neurochir (Wien). 2018;160(10):1899–903.
28. Lin L, Ke Z-Y, Chu L, Cheng Y, Zhao G-S, Zhong D, Cai X, Chen X-L. Full-endoscopic lumbar discectomy via lateral superior articular process approach for treating Far lateral lumbar disc herniation: a retrospective study and technical note. Int Orthop. 2023;47(11):2843–50.
29. White CA, Patel AV, Butler LR, Amakiri UO, Yeshoua BJ, Steinberger JM, Cho SK, Kim JS. Comparison of patient preference, understanding, and sentiment for minimally invasive versus open spine surgery. Spine (Phila Pa 1976). 2022;47(4):309–16.
30. Narain AS, Hijji FY, Duhancioglu G, Haws BE, Khechen B, Manning BT, Colman MW, Singh K. Patient perceptions of minimally invasive versus open spine surgery. Clin Spine Surg. 2018;31(3):E184–92.
31. Pokorny G, Amaral R, Marcelino F, Moriguchi R, Barreira I, Yozo M, Pimenta L. Minimally invasive versus open surgery for degenerative lumbar pathologies:a systematic review and meta-analysis. Eur Spine J. 2022;31(10):2502–26.
32. Alvi MA, Kerezoudis P, Wahood W, Goyal A, Bydon M. Operative approaches for lumbar disc herniation: A systematic review and multiple treatment Meta-Analysis of conventional and minimally invasive surgeries. World Neurosurg. 2018;114:391–e407392.
33. Kanno H, Aizawa T, Hahimoto K, Itoi E. Minimally invasive discectomy for lumbar disc herniation: current concepts, surgical techniques, and outcomes. Int Orthop. 2019;43(4):917–22.
34. Cheng X, Bao B, Wu Y, Cheng Y, Xu C, Ye Y, Dou C, Chen B, Yan H, Tang J. Clinical comparison of percutaneous transforaminal endoscopic discectomy and unilateral biportal endoscopic discectomy for single-level lumbar disc herniation. Front Surg. 2023;9:1107883.
35. Kotheeranurak V, Liawrungrueang W, Quillo-Olvera J, Siepe CJ, Li ZZ, Lokhande PV, Choi G, Ahn Y, Chen C-M, Choi K-C, et al. Full-Endoscopic

lumbar discectomy approach selection: A systematic review and proposed algorithm. Spine. 2023;48(8):534–44.
36. He J, Tang J, Jiang X, Ren H, Cui J, Liang Z, Zhang J, Liang D. Efficacy and safety of foraminoplasty performed using an endoscopic Drill to treat axillary disc herniation. World Neurosurg. 2020;138:e413–9.
37. Kim JE, Choi DJ. Unilateral biportal endoscopic decompression by 30° endoscopy in lumbar spinal stenosis: technical note and preliminary report. J Orthop. 2018;15(2):366–71.
38. Hwa Eum J, Hwa Heo D, Son SK, Park CK. Percutaneous biportal endoscopic decompression for lumbar spinal stenosis: a technical note and preliminary clinical results. J Neurosurg Spine. 2016;24(4):602–7.
39. Xu J, Wang D, Liu J, Zhu C, Bao J, Gao W, Zhang W, Pan H. Learning curve and complications of unilateral biportal endoscopy: cumulative sum and Risk-Adjusted cumulative sum analysis. Neurospine. 2022;19(3):792–804.
40. Li M, Yang H, Yang Q. Full-Endoscopic technique discectomy versus micro-endoscopic discectomy for the surgical treatment of lumbar disc herniation. Pain Physician. 2015;18(4):359–63.
41. Choi KC, Park CK. Percutaneous endoscopic lumbar discectomy for L5-S1 disc herniation: consideration of the relation between the Iliac crest and L5-S1 disc. Pain Physician. 2016;19(2):E301–308.
42. Chen Z, Zhang L, Dong J, Xie P, Liu B, Wang Q, Chen R, Feng F, Yang B, Shu T, et al. Percutaneous transforaminal endoscopic discectomy compared with microendoscopic discectomy for lumbar disc herniation: 1-year results of an ongoing randomized controlled trial. J Neurosurg Spine. 2018;28(3):300–10.
43. Zhou C, Zhang G, Panchal RR, Ren X, Xiang H, Xuexiao M, Chen X, Tongtong G, Hong W, Dixson AD. Unique complications of percutaneous endoscopic lumbar discectomy and percutaneous endoscopic interlaminar discectomy. Pain Physician. 2018;21(2):E105–12.
44. Soliman HM. Irrigation endoscopic discectomy: a novel percutaneous approach for lumbar disc prolapse. Eur Spine J. 2013;22(5):1037–44.

Publisher's note