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Original Article

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Far-Lateral Transforaminal Unilateral Biportal Endoscopic Lumbar Discectomy for Upper Lumbar Disc Herniations

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Objective: The upper lumbar region has distinctive anatomical characteristics that contribute to the challenges of performing discectomy. We introduce far-lateral transforaminal unilateral biportal endoscopic (UBE) lumbar discectomy for central or paracentral disc herniations in the upper lumbar region.
Methods: We conducted retrospective review of the patients who underwent a far-lateral transforaminal UBE lumbar discectomy at our institution from January 2018 to September 2024. The electronic medical records, operative records, and radiologic images of the patients were reviewed.
Results: A total of 27 patients underwent far-lateral transforaminal UBE lumbar discectomy for central or paracentral disc herniations in the upper lumbar region. The patient had a mean age of 54.0 ± 13.7 years. Operation was performed at the L1–2 level in 3 patients (11.1%), L2–3 in 9 patients (33.3%), and L3–4 in 15 patients (55.6%). The patients were followed-up for a mean of 27.7 ± 19.3 months. The Oswestry Disability Index was significantly decreased from 36.3 ± 6.8 preoperatively to 3.7 ± 3.3 at last follow-up ($p < 0.001$). The visual analogue scale (VAS) back was significantly decreased from 7.8 ± 0.9 preoperatively to 3.1 ± 0.6 postoperative day 2 ($p < 0.001$). The VAS leg was significantly decreased from 8.1 ± 0.8 preoperatively to 2.3 ± 0.7 postoperative day 2 ($p < 0.001$).
Conclusion: The far-lateral transforaminal UBE lumbar discectomy would be a viable surgical option for upper lumbar disc herniations.

Keywords: Disc herniation, Discectomy, Endoscopic spine surgery, Lumbar, Unilateral biportal endoscopy

INTRODUCTION

The incidence of upper lumbar disc herniation has been known to be 1%–11% of all disc herniation.[1] As unilateral biportal endoscopic (UBE) spine surgery has gained popularity, UBE lumbar discectomy has been performed via the interlaminar approach not only for lower lumbar disc herniations but also for upper lumbar disc herniations.[2,3] However, upper lumbar disc herniation has distinctive characteristics compared to lower lumbar disc herniation because anatomical differences exist between the upper and lower lumbar regions.[4-8] Regarding bone anatomy, the upper lumbar vertebra has narrower lamina and more vertically oriented facet joints, in contrast to the wider lamina and more coronally oriented facet joints of the lower lumbar vertebra. Kozanek et al.[9] reported that the facet joint angle increased from the upper lumbar region to the lower

lumbar region. Due to these anatomical characteristics, partial hemilaminectomy for the interlaminar approach may cause an isthmus fracture, leading to segmental instability in the upper lumbar region more than in the lower lumbar region.[5,10,11] Regarding neural anatomy, the thecal sac in the upper lumbar region contains densely packed rootlets and has a narrow free cerebrospinal fluid space, which may reduce buffering against traction injury from the dura to the rootlets.[12] Therefore, the postoperative neurologic deficit may occur due to thecal sac retraction following the interlaminar approach for upper lumbar discectomy because of the proximity of the conus medullaris. Therefore, the interlaminar approach has disadvantages for upper lumbar disc herniations due to anatomical characteristics in terms of bone and neural anatomy.

Percutaneous endoscopic lumbar discectomy (PELD) through the far-lateral transforaminal approach has been performed for central or paracentral disc herniation in upper lumbar regions.[12-16] To overcome the limitations of the interlaminar approach in UBE lumbar discectomy for upper lumbar disc herniations, we adopted the concept of the far-lateral transforaminal approach from PELD to UBE lumbar discectomy. The paraspinal approach for UBE spine surgery has been performed to address foraminal pathology.[17,18] With more lateral entrance from the paraspinal approach, far-lateral transforaminal UBE lumbar discectomy could be performed to address central or paracentral disc herniations. However, there is a paucity of literature on far-lateral transforaminal UBE lumbar discectomy, which is a far-lateral approach from the paraspinal approach. We hypothesized that far-lateral transforaminal UBE lumbar discectomy would effectively remove upper lumbar disc herniations and lead to improved clinical outcomes. The purpose of this study was to present the far-lateral transforaminal UBE lumbar discectomy and to evaluate the clinical and radiologic outcomes.

MATERIALS AND METHODS

This study was conducted at a single center and approved by the Institutional Review Board (IRB) of The Leon Wiltse Memorial Hospital. Informed consents were waived by IRB due to the retrospective nature of the study (IRB No. 2024-W10).

1. Materials

We conducted a retrospective review of the patients who underwent far-lateral transforaminal UBE lumbar discectomy at our institution from January 2018 to September 2024. The operations were performed by a single surgeon (JSH) who has over 5 years of experience in UBE spine surgery. The electronic medical records, operative records, and radiologic images of the patients were reviewed. Demographic data, disc herniation level and location, presence and extent of migration, and operative characteristics were assessed. The extent of migration was classified as low, high, or very high based on previous literature.[19-21]

2. Inclusion and Exclusion Criteria

The inclusion criteria of this study were patients who underwent far-lateral transforaminal UBE lumbar discectomy for (1) a single-level disc herniation, (2) an upper lumbar (L1–2, L2–3, or L3–4) disc herniation, (3) a central or paracentral disc herniation, and (4) a follow-up period of more than 12 months.

The exclusion criteria included (1) multilevel pathology, (2) lower lumbar (L4–5, L5–S1) disc herniations, (3) foraminal or extraforaminal disc herniations, (4) disc herniation caused by trauma, (5) infection, (6) revision surgery, and (7) patients who underwent an interlaminar approach.

Additionally, patients with a follow-up period of less than 12 months were excluded.

Based on previous literature, we defined the upper lumbar region as L1–2, L2–3, or L3–4 segments and the lower lumbar region as L4–5 or L5–S1 segments.[12,22,23]

3. Indications of the Far-Lateral Transforaminal UBE Lumbar Discectomy

Overall, the surgical indications for far-lateral transforaminal UBE lumbar discectomy were similar to those of microdiscectomy. Conservative treatment, including medication, physical therapy, and epidural steroid injections, was attempted before surgery in most patients, except for those with motor function deficits. The indications for surgery were as follows: (1) persistent back or leg pain caused by lumbar disc herniation that did not improve after at least 4–6 weeks of conservative treatment, (2) intractable pain despite conservative treatment, and (3) motor function deficits caused by disc herniation.

The indications for the far-lateral transforaminal UBE lumbar discectomy were as follows: (1) upper lumbar disc herniations, (2) central or paracentral disc herniations, and (3) soft disc herniations.

Less favorable conditions were as follows: (1) foraminal stenosis due to facet hypertrophy or degenerative scoliosis, (2) very high upward migrated disc herniation (beyond the inferior border of the upper pedicle), (3) high downward migrated disc herniation (from the middle of the lower pedicle to the inferior margin of the lower pedicle), (4) segmental instability, (5) a history of prior transforaminal approach surgery.

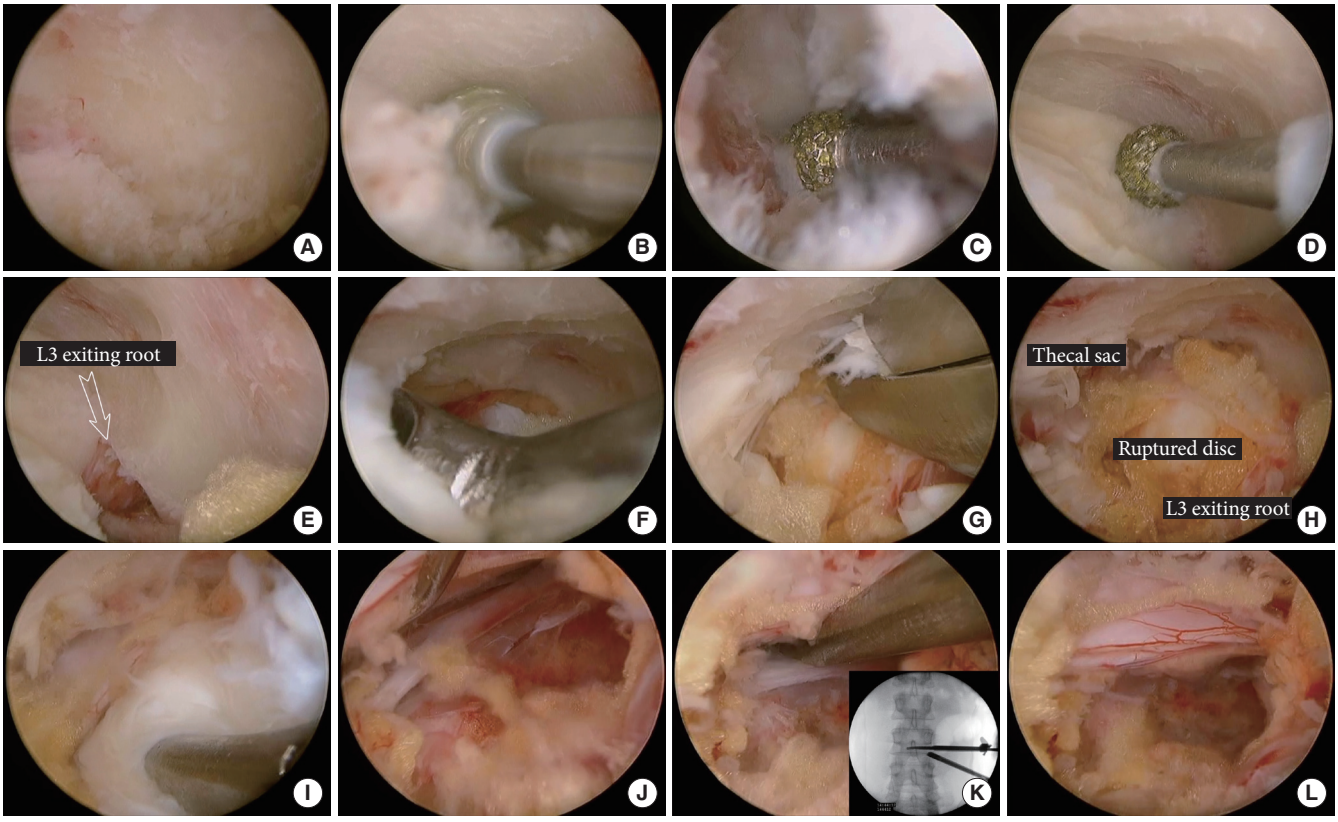

Fig. 1. Step-by-step intraoperative endoscopic view of far-lateral transforaminal unilateral biportal endoscopic lumbar discectomy for L3–4 central disc herniation. (A) Exposure of the isthmus. (B) Drilling of the isthmus. (C) Resection of the superior articular process to widen the working space. (D) Undercutting of the isthmus. (E) Identification of the L3 exiting root. (F) Detachment of the ligamentum flavum. (G) Further undercutting of the isthmus and removal of the ligamentum flavum. (H) Exposure of the thecal sac, L3 exiting root, and disc herniation. (I) Removal of the disc herniation. (J) Probe the ventral aspect of the thecal sac to check for a remnant disc fragment. (K) The C-arm image confirms sufficient reach to the central zone. (L) Complete decompression of the thecal sac and exiting nerve root.

4. Surgical Technique

The far-lateral transforaminal approach was chosen instead of the interlaminar approach for UBE lumbar discectomy. Because the far-lateral transforaminal UBE lumbar discectomy allowed not to perform laminectomy, which may cause segmental instability at the upper lumbar region due to narrow lamina and vertically oriented facet joint. Additionally, neurologic deficits due to thecal sac retraction would be avoided with the far-lateral transforaminal UBE lumbar discectomy.

To ensure fluent water outflow from the working channel, a long semitubular retractor is required. Except for the long semitubular retractor, no additional specialized instruments are necessary because routine spine surgery instruments, such as pituitary forceps, Kerrison rongeur, and high-speed drills, already have long shafts. Therefore, with routine spine surgery instruments, the long distance from the incision to the target can be adequately covered. Regarding the endoscope, we used a 0° endoscope in all cases.

Fig. 1 presents a step-by-step intraoperative endoscopic view. Supplementary video clip 1 shows surgical technique of the far-lateral transforaminal UBE lumbar discectomy.

1) Establishing 2 portals

Patients were placed in a prone position on a spinal table under general anesthesia. The locations of working and endoscopic portals were determined according to the surgical trajectory. We decided on a surgical trajectory on the axial images of preoperative magnetic resonance imaging (MRI) depending on the location of disc herniation, then measured the distance from the midline to the portal entrance (6–8 cm in general). Skin incisions were made 6–8 cm lateral to the midline. The working portal was made on the disc level, and the endoscopic portal was made 5–6 cm apart from the working portal. The 2 portals of the right approach are located more caudally than the left approach (Fig. 2).

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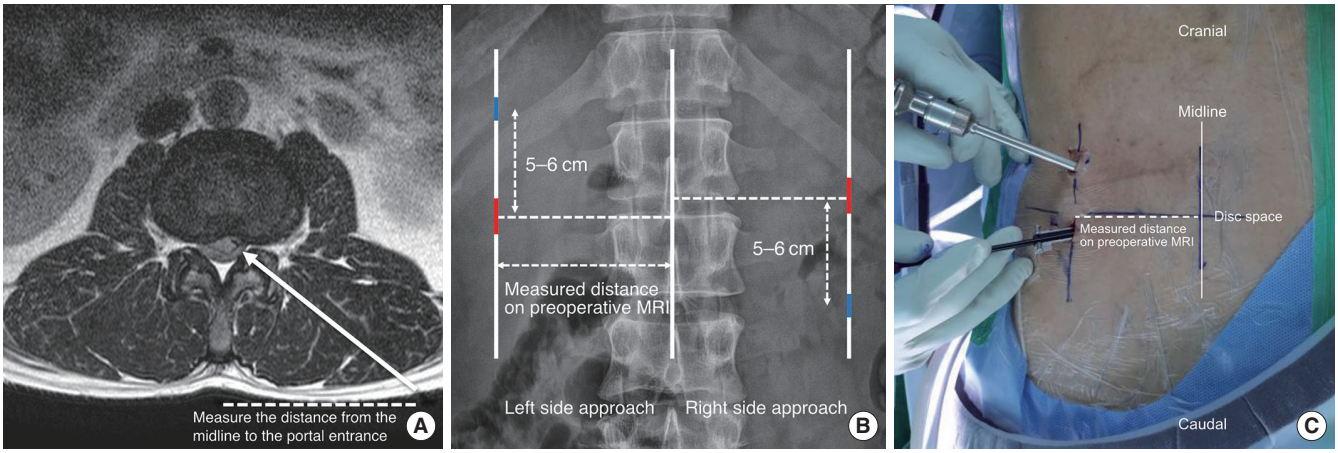

Fig. 2. Locations of endoscopic and working portals. (A) Shows the surgical trajectory and the measurement of the distance from the midline to the portal entrance on the preoperative T2-weighted axial magnetic resonance imaging (MRI) image. (B) Shows entry points of endoscopic and working portals on plain radiographs. (C) Shows an overview of the operative field.

2) Docking

The docking point of the endoscope and instrument was the isthmus of the upper vertebra. Triangulation of the endoscope and instrument should be achieved at the docking point.

3) Bone work and removal of ligamentum flavum

After soft tissue dissection, we drilled the lateral aspect of the isthmus and base of transverse process using a high-speed drill. If the working space is narrow due to facet hypertrophy, the tip of the superior articular process of the lower vertebra should be drilled out. Drilling of the isthmus and base of the transverse naturally detached the ligamentum flavum from the attachment site. When ligamentum flavum was detached, perineural fat and exiting root would be exposed. Because we identified the exiting root, we could remove the ligamentum flavum using pituitary forceps or a Kerrison rongeur, with a low risk of exiting nerve root injury due to inadvertent grasping of the nerve. After removal of the ligamentum flavum, the thecal sac, exiting root, and ruptured disc fragments were exposed.

4) Discectomy

Discectomy was performed under direct visualization of the thecal sac and exiting nerve root. Then, the thecal sac and exiting nerve root were fully decompressed. In addition, we could confirm that there was no remnant disc fragment at the ventral aspect of the thecal sac without thecal sac retraction because of the far-lateral entrance of the endoscope. It contrasted with the interlaminar approach, which may require excessive thecal sac retraction to observe the ventral aspect of the thecal sac. After confirmation of the complete removal of the disc and decompression of the neural elements, we inserted a drainage catheter via working portals and finished the operation.

5. Clinical Outcomes

Clinical outcomes were evaluated using the Oswestry Disability Index (ODI), the visual analogue scale (VAS) for back pain, and the VAS for leg pain. We compared the ODI between preoperatively and last follow-up, and the VAS back and leg between preoperatively, postoperative 2 day, and last follow-up, respectively.

6. Radiologic Outcomes

We evaluated the radiologic outcomes using postoperative MRI within 2 days after operation. At the level of the disc herniation, which represented the narrowest space, we measured the cross-sectional area (CSA) of the dural sac on T2-weighted axial images of preoperative MRI. After surgery, the CSA was reassessed at the same level on T2-weighted axial images of postoperative MRI. The preoperative and postoperative CSAs were then compared to assess the extent of dural sac decompression.

7. Statistical Analysis

Statistical analyses were conducted using R ver. 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria). A p-value less than 0.05 was considered statistically significant. All tests were 2-sided. Continuous variables are presented as the mean ± standard deviation or median (range). Categorical variables are presented as a number (%). The paired t-test was used to compare the ODI between the preoperative and last follow-up, as well as to compare the CSA of the dural sac between preoperative and postoperative MRI. The one-way repeated

measured analysis of variance (ANOVA) was used to compare the VAS back and leg between preoperative, postoperative day 2, and last follow-up, followed by *post hoc* multiple comparison tests using Bonferroni adjustment. The sphericity assumption for ANOVA was assessed using Mauchly test. If sphericity was not met, the Greenhouse-Geisser correction was conducted.

RESULTS

1. Demographics

A total of 27 patients underwent far-lateral transforaminal UBE lumbar discectomy for central or paracentral upper lumbar disc herniations. The patient had a mean age of 54.0 ± 13.7 years, with 17 males (63.0%) and 10 females (37.0%). The mean body mass index was 25.7 ± 2.9 kg/m². The operation was performed at the L1–2 level in 3 patients (11.1%), L2–3 in 9 patients (33.3%), and L3–4 in 15 patients (55.6%). Disc herniations were located in the central zone for 17 patients (63.0%) and in the paracentral zone for 10 patients (37.0%). Migrated disc herniations were present in 16 patients (59.3%), with 14 (51.9%) showing upward migration and 2 (7.4%) showing downward migration. The mean length of postoperative hospital stay was 3.6 ± 1.7 days. The mean operation time was 74.8 ± 18.2 minutes. The patients were followed-up for a mean of 27.7 ± 19.3 months (Table 1).

2. Clinical Outcomes

Table 2 and Fig. 3 show the clinical outcomes following the operation. The ODI was significantly decreased from 36.3 ± 6.8 preoperatively to 3.7 ± 3.3 at the last follow-up ($p < 0.001$). The VAS back was significantly different between preoperatively, postoperative day 2, and at the last follow-up ($p < 0.001$). The VAS back was significantly decreased from 7.8 ± 0.9 preoperatively to 3.1 ± 0.6 postoperative day 2 ($p < 0.001$), and to 2.7 ± 1.3 at

Table 1. Demographics and characteristics of the operation (N = 27)

Variable	Value
Age (yr)	54.0 ± 13.7
Sex	
Female	10 (37.0)
Male	17 (63.0)
Body mass index (kg/m²)	25.7 ± 2.9
Operative level	
L1–2	3 (11.1)
L2–3	9 (33.3)
L3–4	15 (55.6)
Approach side	
Right	17 (63.0)
Left	10 (37.0)
Location of disc herniation	
Central	17 (63.0)
Paracentral	10 (37.0)
Migration of disc herniation	
None	11 (40.7)
Downward	2 (7.4)
Low	2 (100)
High	0 (0)
Very high	0 (0)
Upward	14 (51.9)
Low	5 (35.7)
High	7 (50.0)
Very high	2 (14.3)
Length of postoperative hospital stays (day)	3.6 ± 1.7
Operation time (min)	74.8 ± 18.2
Follow-up period (mo)	27.7 ± 19.3

Values are presented as mean ± standard deviation or number (%).

Table 2. Clinical outcomes following the fat-lateral transforaminal UBE upper lumbar discectomy

Variable	Preoperative	POD 2	Last follow-up	p-value
Clinical outcomes				
ODI	36.3 ± 6.8	-	3.7 ± 3.3	< 0.001***
VAS back	7.8 ± 0.9	3.1 ± 0.6	2.7 ± 1.3	< 0.001***
VAS leg	8.1 ± 0.8	2.3 ± 0.7	2.0 ± 0.7	< 0.001***
Radiologic outcome				
CSA of the dural sac (mm²)	70.7 ± 36.7	110.0 ± 47.3	-	0.001**

Values are presented as mean ± standard deviation.
UBE, unilateral biportal endoscopy; POD, postoperative day; ODI, Oswestry Disability Index; VAS, visual analogue scale; CSA, cross-sectional area.
**$p < 0.01$. ***$p < 0.001$.

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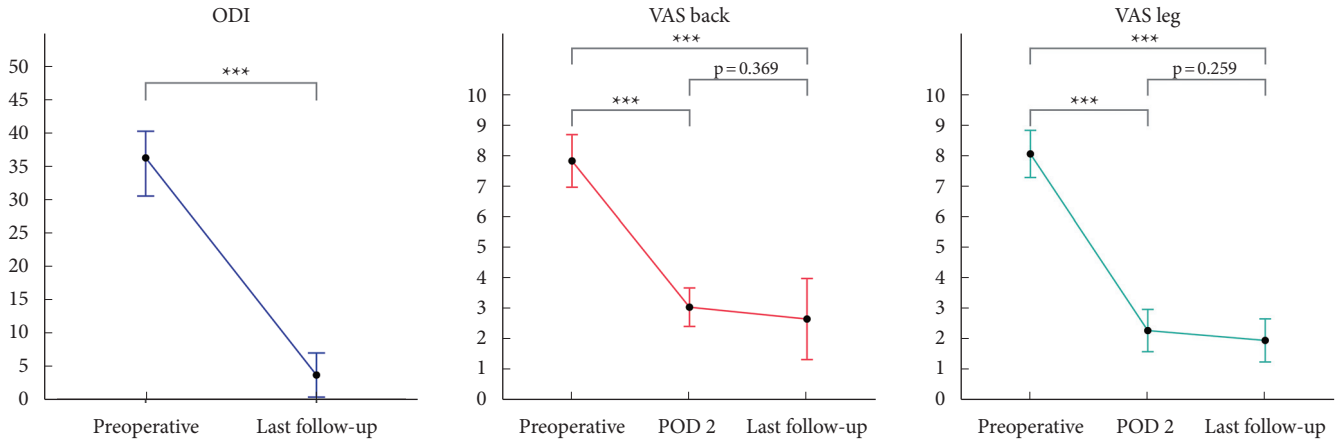

Fig. 3. Clinical outcomes of the far-lateral transforaminal approach in unilateral biportal endoscopy upper lumbar discectomy. ODI, Oswestry Disability Index; VAS, visual analogue scale; POD, postoperative day. ***p < 0.001.

the last follow-up (p < 0.001). However, the VAS back was not significantly different between postoperative day 2 and at the last follow-up (p = 0.369). The VAS leg was significantly different between preoperatively, postoperative day 2, and at the last follow-up (p < 0.001). The VAS leg was significantly decreased from 8.1 ± 0.8 preoperatively to 2.3 ± 0.7 postoperative day 2 (p < 0.001), and to 2.0 ± 0.7 at the last follow-up (p < 0.001). However, the VAS leg was not significantly different between postoperative day 2 and at the last follow-up (p = 0.259).

3. Radiologic Outcomes

Postoperative MRI showed well-decompressed neural elements including the thecal sac and nerve root in all patients. The mean CSA of the dural sac significantly increased from the preoperative measurement (70.7 ± 36.7 mm^2) to the postoperative measurement (110.0 ± 47.3 mm^2), with a p-value of 0.001 (Table 2). Additionally, there was no epidural hematoma compressing neural elements.

4. Complications

One patient had recurred back and leg pain due to a postoperative discal cyst at index level 1 month after the operation (illustrative case 2). The patient underwent revision surgery for a discal cyst, and recurred symptoms were resolved. Except for one complicated case of the postoperative discal cyst, there were no other complications, including dural tear, postoperative neurologic deficit, epidural hematoma, infection, and retroperitoneal fluid collection.

5. Illustrative Cases

Fig. 4 shows preoperative, and postoperative T2-weighted axial MRI images of representative cases. Additionally, we have provided detailed descriptions of 2 illustrative cases.

1) Case 1

A 32-year-old man presented with left buttock pain and lateral thigh pain that had been for 3 months. Physical examination revealed decreased sensory perception along the left lateral thigh. Motor weakness was not observed. Preoperative MRI revealed central disc herniation with downward migration at the L3–4 level (Fig. 5A and B). We performed far-lateral transforaminal UBE lumbar discectomy. Ruptured disc fragments were completely removed during the operation, and the thecal sac was fully decompressed. Postoperative MRI showed no residual disc fragment (Fig. 5C and D). The patient's symptoms have been resolved during 12 months of follow-up periods without recurrence of disc herniation.

2) Case 2

A 27-year-old woman presented with left buttock pain and antero-lateral thigh pain that had been for 3 months. Physical examination revealed decreased sensory perception along the lateral thigh, and no definite motor weakness was observed. Preoperative MRI revealed left paracentral disc herniation at the L3–4 level (Fig. 6A and B). We performed far-lateral transforaminal UBE lumbar discectomy. Postoperative MRI showed no residual disc fragment and a fully decompressed thecal sac (Fig. 6C and D). The patient's symptoms had been resolved following the operation. However, 1 month after the operation, the back and leg pain had recurred. Follow-up MRI showed a discal cyst at the previous operation level with neural compression (Fig. 6E and F). The patient underwent revision surgery for the discal cyst. The revision surgery was performed with a contra-lateral approach to preserve the facet joint, which may be violated with an ipsilateral interlaminar approach due to the narrow lamina

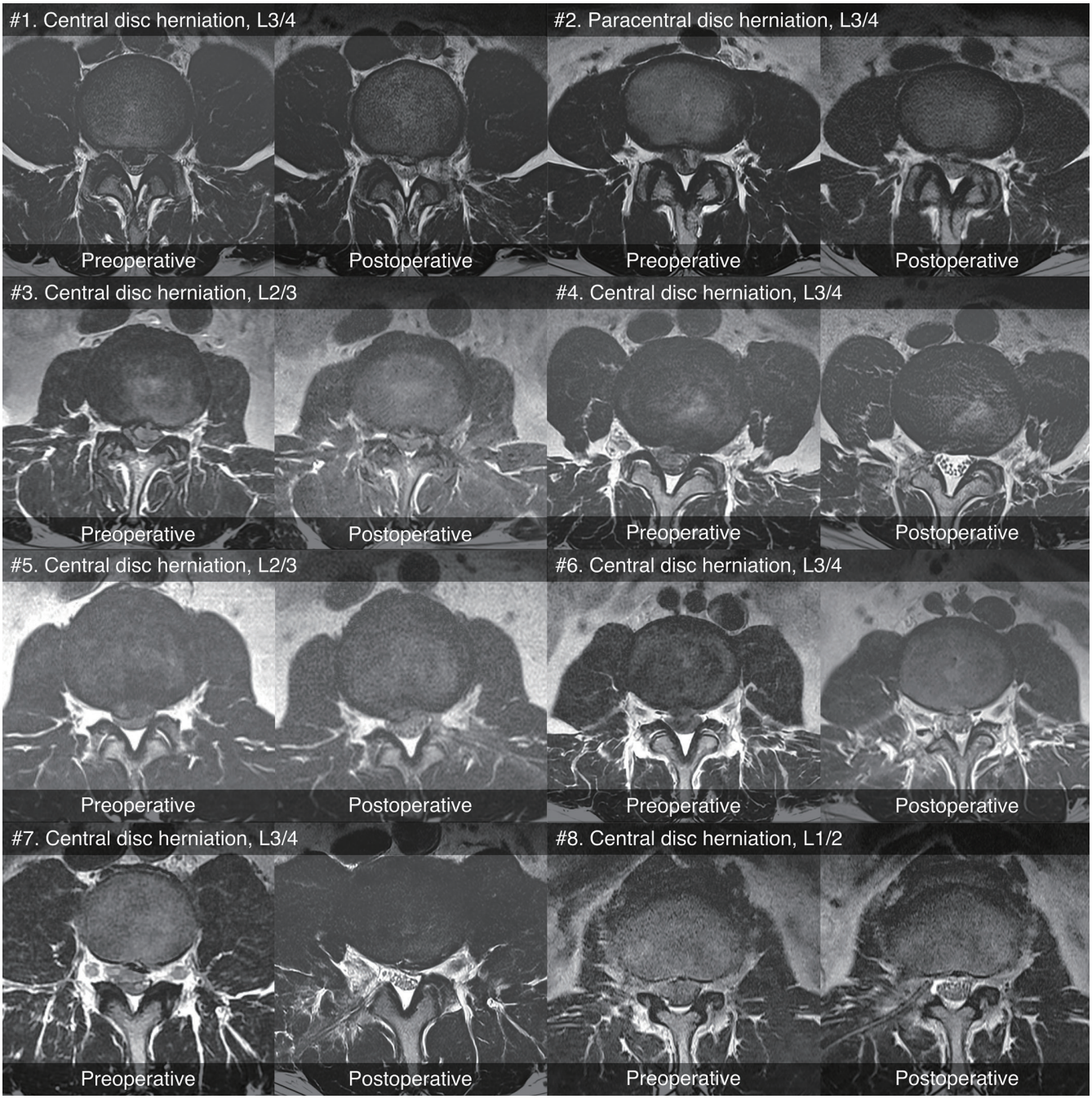

Fig. 4. T2-weighted axial magnetic resonance imaging images of representative cases at preoperative and postoperative.

of the L3. Postrevisional operation MRI showed a completely decompressed thecal sac and removal of the discal cyst (Fig. 6G and H). The patient's symptoms have been resolved during 6 months of follow-up periods without recurrence.

DISCUSSION

In this study, 27 patients underwent far-lateral transforaminal UBE lumbar discectomy for central or paracentral upper lumbar disc herniations. The far-lateral transforaminal UBE lumbar discectomy significantly improved the clinical (ODI, and VAS back and leg) and radiologic outcomes without laminectomy.

1. Far-Lateral Transforaminal UBE Lumbar Discectomy

Previous literature reported the UBE paraspinal approach, which applied Wiltse's approach in UBE spine surgery.[17,18] The

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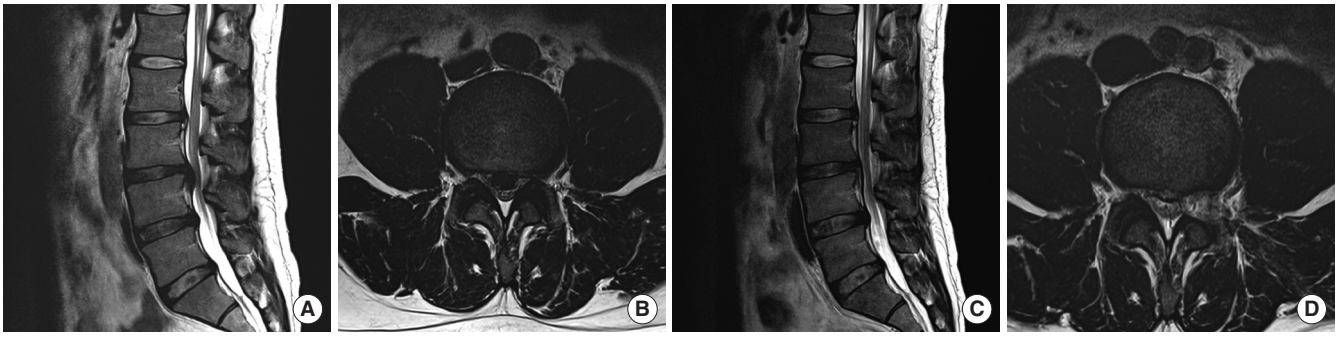

Fig. 5. A 32-year-old man presented with left buttock pain and lateral thigh pain. (A, B) Preoperative magnetic resonance imaging (MRI) revealed central disc herniation with downward migration at the L3–4 level. We performed unilateral biportal endoscopy discectomy through the far-lateral transforaminal approach. Ruptured disc fragments were completely removed during the operation, and the thecal sac was fully decompressed. (C, D) Postoperative MRI showed no residual disc fragment.

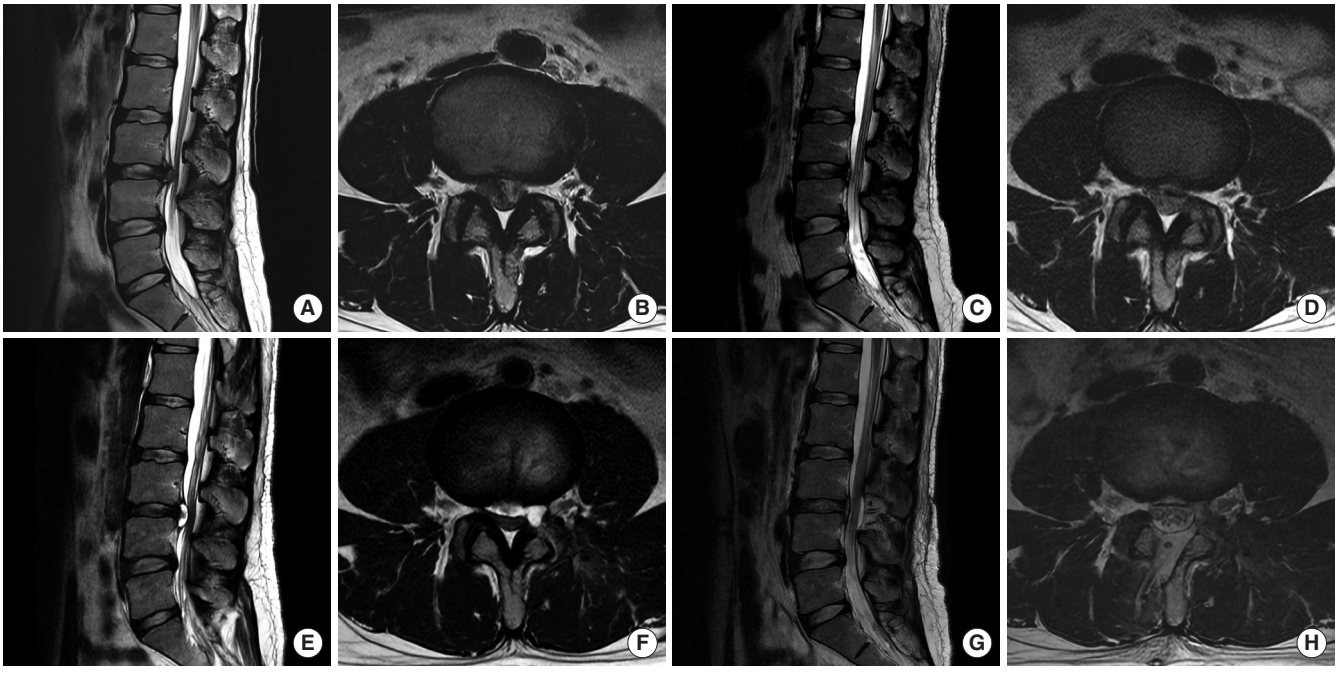

Fig. 6. A 27-year-old woman presented with left buttock pain and antero-lateral thigh pain. (A, B) Preoperative magnetic resonance imaging (MRI) revealed left paracentral disc herniation at the L3–4 level. We performed unilateral biportal endoscopy discectomy through the far-lateral transforaminal approach. (C, D) Postoperative MRI showed no residual disc fragment and fully decompressed thecal sac. The patient's symptoms had been resolved following the operation. However, 1 month after the operation, the back and leg pain had recurred. (E, F) Follow-up MRI showed a discal cyst at the previous operation level with neural compression. The patient underwent revision surgery for the discal cyst. The revision surgery was performed with a contra-lateral approach to preserve facet joint, which may be violated with the ipsilateral interlaminar approach due to the narrow lamina of the L3. (G, H) Postrevisional operation MRI showed a completely decompressed thecal sac and removal of the discal cyst. The patient's symptoms have been resolved during 6 months of follow-up periods without recurrence.

paraspinal approach could address foraminal or extraforaminal lesions with preservation of facet joint, therefore avoiding fusion surgery. Kerr et al.[18] reported a paraspinal approach to address extraforaminal disc herniations with a unilateral bitubular endoscopic discectomy, which is a modification of UBE lumbar discectomy. The differences between the paraspinal approach and far-lateral transforaminal UBE lumbar discectomy is the target pathology. The target pathology of the paraspinal approach is foraminal or extraforaminal disc herniations, whereas the target pathology of far-lateral transforaminal UBE lumbar discectomy

is central or paracentral disc herniations. With more lateral entrance from the paraspinal approach, far-lateral transforaminal UBE lumbar discectomy could effectively access the paracentral or central disc herniations, similar to PELD.

The upper lumbar region has a relatively wider neural foramen than the lower lumbar region.[12,24-26] Furthermore, the upper lumbar vertebra would have less degenerative change, such as facet hypertrophy than the lower lumbar vertebra. Therefore, the far-lateral transforaminal UBE lumbar discectomy would be an alternative surgical option to the interlaminar approach for upper lumbar discectomy.

2. Case Selection for the Far-Lateral Transforaminal UBE Lumbar Discectomy

Given that far-lateral transforaminal UBE lumbar discectomy is a novel surgical technique for addressing upper lumbar disc herniations, proper case selection is crucial to ensure complete disc removal and adequate neural decompression. Several factors should be considered when performing a far-lateral transforaminal UBE lumbar discectomy, particularly those that may obstruct access to the foramen. Facet hypertrophy, especially the superior articular process, can obstruct the neural foramen. Additionally, hypertrophied facets make endoscopic surgical anatomy confusing, leading to disorientation. In the lower lumbar region, which bears a greater mechanical load than the upper lumbar region, facet hypertrophy occurs more frequently, often limiting the feasibility of far-lateral transforaminal UBE lumbar discectomy.[27-29] Although far-lateral transforaminal UBE lumbar discectomy can be performed in patients with facet hypertrophy by extensively resecting the superior articular process, it is not feasible to perform. Furthermore, due to the more horizontal facet angle compared to that of the upper lumbar region, the surgical trajectory in the lower lumbar region should be shallower than in the upper lumbar region.[12] This shallower trajectory results in a more lateral portal entrance, making the procedure more challenging. Additionally, at the L5–S1 level, the iliac bone may obstruct the surgical corridor, making the procedure unfeasible. However, unlike the upper lumbar region, the lower lumbar region has a wider lamina, making UBE lumbar discectomy or microdiscectomy via the interlaminar approach a more feasible alternative to far-lateral transforaminal UBE lumbar discectomy. In patients with degenerative scoliosis, foraminal stenosis would occur on the concave side, making the transforaminal approach challenging. Not only does foraminal stenosis restrict access, but the confined space also causes crowding of the endoscope and instruments, impairing maneuverability and making surgery more challenging.

Another critical consideration is disc migration. A very high upward migrated disc, extending beyond the inferior border of the upper pedicle, is a less favorable condition for this approach. Although this study included 2 cases of very high upward migration in which the herniated disc was completely removed, this was possible because the herniated disc was removed completely as a single fragment. The endoscopic view of far-lateral transforaminal lumbar discectomy reaches the lower margin of the upper pedicle, but the endoscopic view beyond the lower margin of the upper pedicle is limited. If residual disc fragments remain above this level, they must be removed blindly using instruments such as a hook, which makes complete removal more difficult. Similarly, regarding downward migration, the endoscopic view is also restricted below the mid-portion of the lower pedicle. Therefore, a highly downward migrated disc herniation extending beyond this level is also considered a relative contraindication.

The choice of the surgical approach side is another factor influencing the endoscopic view. When approaching from the left, the trajectory of the endoscope is cranial-to-caudal, making it relatively easier to remove a downward migrated disc. Conversely, when approaching from the right, the trajectory of the endoscope is a caudal-to-cranial view, facilitating the removal of a upward migrated disc. These anatomy and surgical approach should be considered carefully when performing far-lateral transforaminal UBE lumbar discectomy.

3. Advantages of the Far-Lateral Transforaminal UBE Lumbar Discectomy

The far-lateral transforaminal UBE lumbar discectomy has some advantages compared to other approaches for upper lumbar disc herniations. First, the facet joint could be preserved compared to the interlaminar approach. Interlaminar approach with partial hemilaminectomy has been a conventional surgical method for upper lumbar discectomy.[6,30-32] However, partial hemilaminectomy for interlaminar approach may lead to segmental instability due to anatomical characteristics of the upper lumbar vertebra, which are narrow lamina and vertically oriented facet joints. On the contrary, far-lateral transforaminal UBE lumbar discectomy does not require laminectomy, and preserve the facet joints. Second, disc herniation could be removed without thecal sac retraction. Although the contra-lateral approach has been reported to preserve the facet joint at the upper lumbar level, the contralateral approach has limitations for upper lumbar discectomy.[33,34] Because thecal sac retraction has to be performed during contralateral approach for upper lumbar discectomy. Especially, central disc herniation would require excessive thecal sac retraction.

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Furthermore, residual central disc herniation may remain even after surgery. Thecal sac retraction at the upper lumbar region has a risk of postoperative neurologic deficit due to the proximity of conus medullaris and highly crowded rootlet in the thecal sac in contrast to the lower lumbar region. With the far-lateral transforaminal UBE lumbar discectomy, paracentral or even central disc herniation would be removed without thecal sac retraction. Because of far-lateral entrance, endoscope and instrument have shallow entrance angle, which allows access to central zone of intervertebral disc level through foramen with minimal thecal sac retraction. Additionally, due to the narrow lamina of the upper lumbar vertebra, the distance from the foraminal zone to the central zone is close to the upper lumbar level compared to the lower lumbar level, and it facilitates the removal of central disc herniation. Third, the far-lateral transforaminal UBE lumbar discectomy has clear visualization of the ventral aspect of the thecal sac. Son et al. introduced keyhole laminotomy (translaminar approach) for upper lumbar disc herniation.[5] Keyhole laminotomy would also preserve facet joint and limit neural retraction due to narrow laminotomy. However, clear visualization of the ventral aspect of the thecal sac may not be feasible. In contrast, the far-lateral transforaminal UBE lumbar discectomy offers clear visualization of the ventral aspect of the thecal sac, allowing for confirmation of complete removal of herniated disc without residual disc herniation. Although the transdural approach has been reported for central disc herniation in the upper lumbar region to ensure complete disc removal, it carries a risk of postoperative cerebrospinal fluid leakage and subsequent pseudomeningocele formation.[35,36]

PELD has the same advantages as the far-lateral transforaminal UBE lumbar discectomy in terms of facet joint preservation, minimal neural retraction, and clear visualization of the ventral thecal sac. Because the far-lateral transforaminal UBE lumbar discectomy originated from PELD by adopting the concept of the far-lateral transforaminal approach. The difference between these 2 surgical methods is whether the operation is uniportal or biportal endoscopic spine surgery. We applied the far-lateral transforaminal approach to UBE lumbar discectomy. The decoupling of the endoscope and instrument through 2 portals allows for enhanced maneuverability, resulting in a less steep learning curve compared to PELD.

4. Comparison to Microdiscectomy

To evaluate the benefits of far-lateral transforaminal UBE lumbar discectomy over microdiscectomy, a direct comparison between these operations is necessary. However, as this study is a case series, such a comparison was not feasible. Nevertheless, considering that the concept of the far-lateral transforaminal UBE lumbar discectomy originated from PELD, although fundamental differences exist between PELD, a uniportal surgery, and UBE lumbar discectomy, a biportal surgery, we believe that an indirect comparison may be possible through studies comparing PELD with microdiscectomy. Jarebi et al. reported a retrospective matched comparative study on PELD and microdiscectomy with a 2-year follow-up.[37] They found no significant differences in clinical outcomes, including ODI and VAS back and leg pain. However, PELD demonstrated superiority over microdiscectomy in terms of lower postoperative day 1 VAS back and leg pain, a shorter length of hospital stays and return to work. Systematic reviews and meta-analyses comparing PELD and microdiscectomy have consistently reported no significant differences in clinical outcomes.[38,39] However, PELD demonstrated greater minimal invasiveness compared to microdiscectomy, as evidenced by a shorter hospital stay and a quicker return to work.[38,39] Choi et al.[40] demonstrated that PELD was less invasive than microdiscectomy by evaluating muscle injury through postoperative creatine phosphokinase levels and postoperative MRI findings.

Based on the findings of these previous studies, far-lateral transforaminal UBE lumbar discectomy, which employs a similar approach to PELD, might also be expected to be more minimally invasive than microdiscectomy. However, a potential disadvantage of far-lateral transforaminal UBE lumbar discectomy is the challenge associated with its surgical approach, as described in the subsection below.

5. Challenges of the Far-Lateral Transforaminal UBE Lumbar Discectomy

The far-lateral transforaminal UBE lumbar discectomy has distinctive characteristics that make it more challenging compared to the interlaminar approach. The skin incision and entry points of the 2 portals, the endoscopic and working portals, are positioned far laterally from the midline. Consequently, the corridor from the skin incision to the working space is longer than in the interlaminar approach. This extended corridor causes the endoscope and instruments to span more paraspinal muscle than in the interlaminar approach, which may limit their maneuverability. Additionally, the longer distance between the 2 portals may further limit maneuverability, as the far-lateral transforaminal UBE lumbar discectomy requires a distance of 5–6 cm compared to the usual 2.5–3 cm in the interlaminar approach. Furthermore, water outflow may be impaired due to its passage

through the long corridor, potentially resulting in muscle edema and a less clear endoscopic view. To ensure fluent water outflow, a long semitubular retractor should be inserted at the working portal, where water outflow occurs.

6. Potential Complications

In our study, a postoperative discal cyst in one patient was the only complication observed. However, far-lateral transforaminal UBE lumbar discectomy has other potential complications. The dural tear is the most common complication in UBE spine surgery.[41,42] Although no dural tears occurred in our case series, surgeons must always be mindful of this risk and take precautions. When a dural tear occurs, it can be managed with a dural sealant patch (TachoSil, Takeda Austria, GmbH, Linz, Austria), sutureless nonpenetrating vascular clips, or primary direct suturing.[43-45] In cases of large dural tears, direct suturing may be unavoidable. However, due to the long surgical corridor of the far-lateral UBE lumbar discectomy, direct suturing can be particularly challenging. In contrast, in the interlaminar approach, if direct suturing is required, conversion to an open procedure is relatively feasible. However, in far-lateral transforaminal UBE lumbar discectomy, open conversion is not possible along this trajectory, making it essential to take extra precautions to prevent dural tears.

Another potential complication is injury to the exiting root due to inadvertent penetration of the dilator through the neural foramen. When creating the working and endoscopic portals, dilators are inserted and docked at the isthmus of the upper vertebra of the index segment. However, due to the shallow insertion angle and long surgical corridor, surgeons who do not have experience with PELD and UBE paraspinal approach may have difficulty precisely docking at the isthmus, leading to discomfort or uncertainty during the procedure. Additionally, during this process, the dilator may inadvertently penetrate the foramen, resulting in injury to the exiting root. To prevent such complications, it is essential to confirm the docking position using both anteroposterior and lateral C-arm images to ensure safe and accurate placement at the isthmus.

Spinal cord infarction would also be a potential complication due to injury of the artery of Adamkiewicz. The artery of Adamkiewicz could branch from L1–2 (21.4%) and L2–4 (6%).[46,47] To prevent injury of this artery, meticulous attention is required, particularly during left-sided approaches at the L1–2 level, as this artery predominantly originates from the left side. If an injury to the artery of Adamkiewicz is suspected, diffusion-weighted MRI and spinal angiography should be obtained for accurate assessment. Postoperative fluid collection or hematoma may also occur as potential complications due to inadvertent entry of the endoscope or instruments into the retroperitoneal space.[48] To prevent these complications, we ensure the initial docking of the endoscope and instruments at the isthmus of the upper vertebra, with intermittent C-arm confirmation.

7. Limitations

This study has some limitations. First, as a retrospective case series without a comparative group, our study lacks direct comparisons to interlaminar approaches regarding postoperative segmental stability with respect to facet preservation. Although the far-lateral transforaminal UBE lumbar discectomy would preserve the facet joint, the tip of SAP should be resected in case of facet hypertrophy. Because the tip of SAP could obstruct the entrance into the neural foramen. The resection of the tip of SAP may influence the stability of the index segment. However, this study did not include long-term imaging follow-up to evaluate spinal instability. Because most patients remained asymptomatic, experiencing no exacerbation of back pain during the follow-up period, additional radiologic imaging was not obtained. Future comparative studies analyzing radiologic outcomes are warranted to evaluate whether the far-lateral transforaminal UBE lumbar discectomy can better preserve stability compared to the interlaminar approach at the upper lumbar level. Another limitation is the imbalance in the distribution of surgical levels. The L3–4 level accounts for 55.6% of the cases. This predominance is likely due to the small number of patients included in the study and the low incidence of L1–2 and L2–3 disc herniation.[1]

CONCLUSION

The far-lateral transforaminal UBE lumbar discectomy would be a viable surgical option for upper lumbar disc herniations. This approach offers advantages regarding facet joint preservation and a lower risk of neurologic deficit due to neural retraction.

NOTES

Supplementary Material: Supplementary video clip 1 is available at https://doi.org/10.14245/ns.2550058.029.

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