

# Advantages and disadvantages of posterolateral approach for percutaneous endoscopic lumbar discectomy

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**Background:** Percutaneous endoscopic lumbar discectomy (PELD) is one of the less invasive treatments for lumbar disc herniation (LDH), and has 3 different operative approaches. This study focused on the posterolateral approach (PLA) and investigated the appropriate operative indication.

**Methods:** PLA was performed in 29 patients with foraminal and extraforaminal LDH. The height and width of the foramen, LDH type, and positional relationship between LDH and the foramen were radiologically evaluated. Foraminoplasty was also performed in 12 cases including those combined with intra-canal LDH or osseous foraminal stenosis. Pre- and postoperative status was evaluated using Numerical Rating Scale (NRS) scores.

**Results:** Patient mean age was 56.8 years; there was single-level involvement at L3/4 (13 cases) and at L4/5 (13 cases). The mean pre- and postoperative NRS scores were 6.1 and 1.8, respectively. Early recurrence developed in a patient who was found to have local scoliosis at the corresponding vertebral level.

**Conclusions:** PLA can be safely used to treat foraminal and extraforaminal LDH with foraminal height  $\geq 13$  mm and foraminal width  $\geq 7$  mm. The procedure is effective for preserving the facet joint; however, we should carefully consider the indications when local scoliosis and/or instability are present.

**Keywords:** Percutaneous endoscopic lumbar discectomy (PELD); lumbar disc herniation (LDH); posterolateral approach; foraminoplasty; minimally invasive

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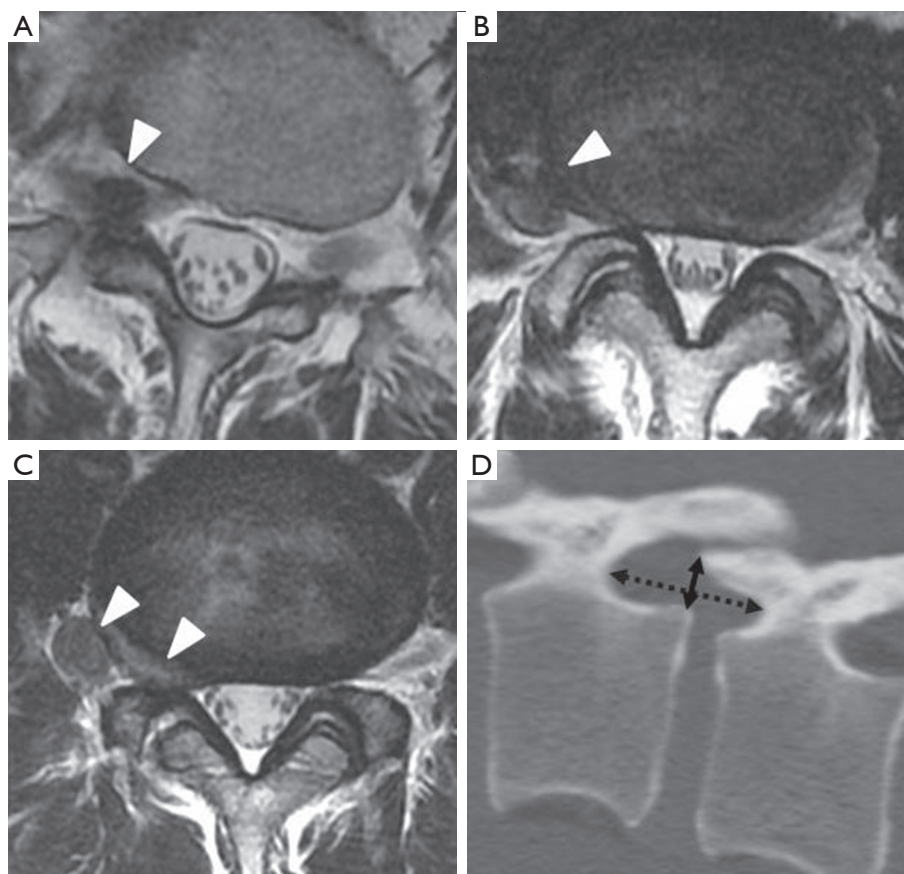
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## Introduction

Percutaneous endoscopic lumbar discectomy (PELD) is one of the most sophisticated operative procedures for the treatment of lumbar disc herniation (LDH) (1-3). However, PELD has an anatomical limitation for endoscope insertion, and there are 3 different operative approaches: interlaminar, transforaminal, and posterolateral. Among these, the posterolateral approach (PLA) is most suitable for foraminal and extraforaminal LDH. Furthermore, PLA is most safely performed through “Kambin’s triangular working zone” (4); therefore, PELD beginners should first

try this approach.

Foraminal and extraforaminal LDH frequently occur simultaneously. Furthermore, extraforaminal LDH sometimes combines with intra-canal LDH, with subsequent development of 2 radiculopathies (5). This pathological state is difficult to treat with a one-stage operation or an operation without facetectomy. PLA for PELD has a potential advantage in these complicated cases (3,6). However, the complications and limitations of PLA have not been fully described. We therefore analyzed cases treated with PLA for PELD in our hospital and provide useful information regarding the indications and limitations.



**Figure 1** Preoperative radiographic findings regarding the location and type of LDH. LDH is classified into 3 types according to the location of herniation on axial MRI: foraminal (A), extraforaminal (B), and combined (C). White arrowheads indicate herniated nucleus. The foraminal height (dotted line) and width (solid line) were calculated on sagittal view of preoperative CT (D).

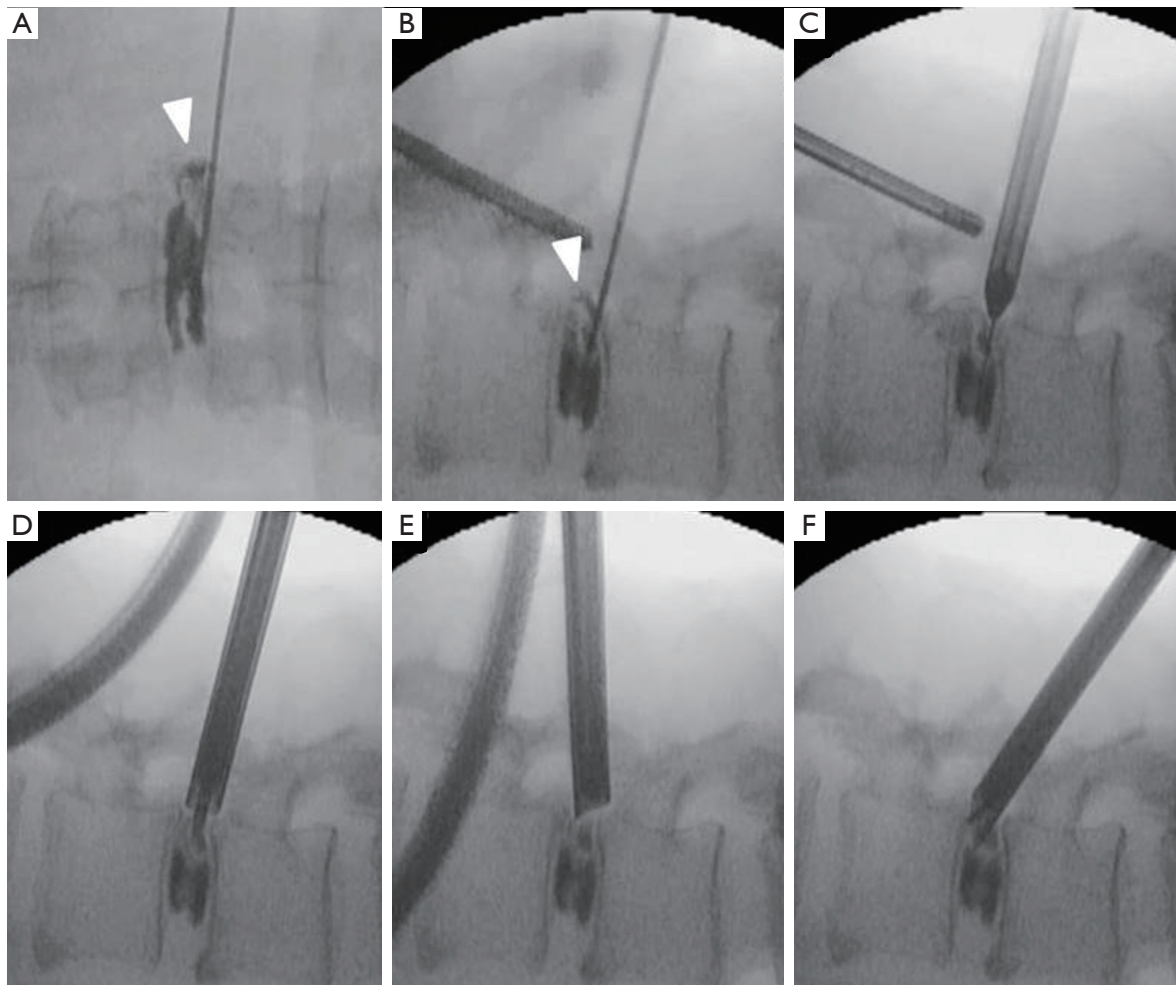
## Methods

Twenty-nine consecutive patients with foraminal and extraforaminal LDH underwent PLA for PELD using a 7-mm diameter spinal full-endoscopic system (Richard Wolf GmbH, Knittlingen, Germany) between January 2014 and April 2016. All patients had lateral radiculopathy resistant to medical treatment, epidural steroids, and/or nerve block. As PLA for PELD offers significant surgical benefit for unsuccessful cases treated using a conventional posterior approach, we did not exclude patients who previously underwent discectomy at the same vertebral level. Similarly, we did not exclude patients with combined osseous foraminal stenosis, which can be enlarged using the foraminoplasty technique (7,8).

All patients underwent PLA for PELD at only 1 vertebral level. The LDH was classified into 3 types according to the location of the herniation on axial magnetic resonance

imaging (MRI): foraminal, extraforaminal, and combined (Figure 1A,B,C). The foraminal height and width were calculated on sagittal views of preoperative computed tomography (CT) (Figure 1D). The height was measured as the maximum distance between the inferior margin of the pedicle of the superior vertebra and the superior margin of the pedicle of the inferior vertebra. The width was measured as the shortest distance between the superior edge of the superior articular process of the caudal vertebra and the posterior edge of inferior endplate of the cranial vertebra (9).

Patients were followed up for an average of 12.0 months (1–31 months) postoperatively. Pre- and postoperative leg pain was evaluated using the Numerical Rating Scale (NRS) score. Statistical analysis was performed using Student's *t*-test. P values less than 0.05 were considered statistically significant. This study was approved by ethics committee



**Figure 2** Fluoroscopic images during operative procedure (case 20). Fluoroscopic images of L3/4 disc level: (A) AP view, (B-F) lateral view. Discography with indigo carmine and a contrast medium was performed and herniated disc margin was clearly delineated (white arrowheads). Following insertion of an obturator (C), a working sheath and an endoscope were inserted (D). The herniated nucleus was removed using several types of forceps and dissectors. It is necessary to tilt the working sheath to several directions for the effective removal (E, F).

of the Iwai Medical Foundation, and informed consent was obtained from the patients for publication of this study and any accompanying images.

### Surgical technique

The patients were carefully log-rolled into the prone position. To enlarge the foramen, a pillow was placed between the operating table and anterior iliac crest. Except in an initial case (epidural anesthesia), the operations were performed under general anesthesia combined with motor evoked potential (MEP) monitoring to avoid intraoperative discomfort and postoperative piriformis syndrome (10).

During the operation, a fluoroscope was placed across the center of the operating table to ensure appropriate positioning. An 8-mm skin and fascia incision was made 5–9 cm lateral from the midline at the target disc level under fluoroscopic guidance, and then an 18-gauge spinal needle was inserted into the disc. Discography with indigo carmine and a contrast medium was performed to stain the herniated disc material (*Figure 2A,B*). Following insertion of an obturator (*Figure 2C*), a 7-mm diameter working sheath was inserted. A 45° or 30° angled working sheath was placed on the disc surface to examine both the foraminal and extraforaminal spaces. Then, an endoscope (diameter of working channel: 4.1 mm) was inserted and the annulus,

lateral part of the yellow ligament, and superior articular process (SAP) were confirmed. Generally, the herniated nucleus is located on the ventral side of the exiting nerve; we therefore explored the sequestered nucleus using several types of forceps and dissectors (*Figure 2D,E,F*) (*Figure S1*). When we found an annular tear, we also removed the damaged nucleus located under the annulus. After complete removal, the decompressed exiting nerve root becomes visible and freely movable. Finally, the annular tear and evacuated cavities were electrocoagulated using a bipolar radio-frequency electrode system (Elliquence, Baldwin, NY, USA), followed by careful endoscopic examination for epidural bleeding and hemostasis. After decompression, the working sheath was carefully removed, and skin was closed with a single suture.

## Results

Of 29 patients registered for this study, 17 underwent PLA without foraminoplasty and 12 underwent PLA with foraminoplasty. The mean age was 56.8 years (range: 25–83 years). There were 21 male and 8 female. The most affected vertebral levels were L3/4 (13 cases) and L4/5 (13 cases). Each location of LDH predicted by preoperative MRI is shown in *Table 1*. The mean foraminal height was 17.6 mm (range, 13–23 mm), and the mean foraminal width was 8.6 mm (range, 7–13 mm). Within these ranges of foraminal size, the operative procedure of PLA was not restricted. The mean operative time was 37.1 min (range, 22–105 min), the mean postoperative hospital stay was 2.4 days (range, 1–16 days), and blood loss was negligible in all patients (*Table 1*).

The mean NRS scores improved significantly from  $6.1 \pm 2.4$  to  $1.8 \pm 2.0$  ( $P < 0.01$ ). During the follow-up period, 1 patient (case 8) has not shown any improvement in NRS score. This patient required reoperation, and we performed microendoscopic discectomy (MED) 7 months after PELD. Although intraoperative findings did not show apparent recurrence or massive residual nucleus, we carefully removed scar tissue around the exiting nerve and enlarged the foramen. After the second operation, the patient only showed slight improvement in leg pain. Although preoperative plain roentgenography did not indicate any instability, MRI and CT showed a “facet fluid sign” (11,12) and “vacuum phenomenon” (13), respectively (*Figure 3*). We retrospectively speculated that the patient’s leg pain might be due to instability at the L4/5 disc level.

We also observed early recurrence in 1 patient (case

4) who presented with local scoliosis (coronal Cobb angle =  $13^\circ$ ) (*Figure 4*). He underwent a second operation 5 months after initial surgery. In this case, we assumed that the local scoliosis participated in the recurrence, and performed lumbar interbody fusion of the L3/4 vertebrae. In the 5 months after the second operation, he has not complained of any leg pain. We have not observed recurrences in other patients during the follow-up period in this study. We also did not observe intra- or postoperative complication in any patients. Furthermore, we performed PLA for PELD in 4 patients who previously underwent spinal surgery at the same vertebral level. The operative outcome was satisfactory, even in these cases.

## Discussion

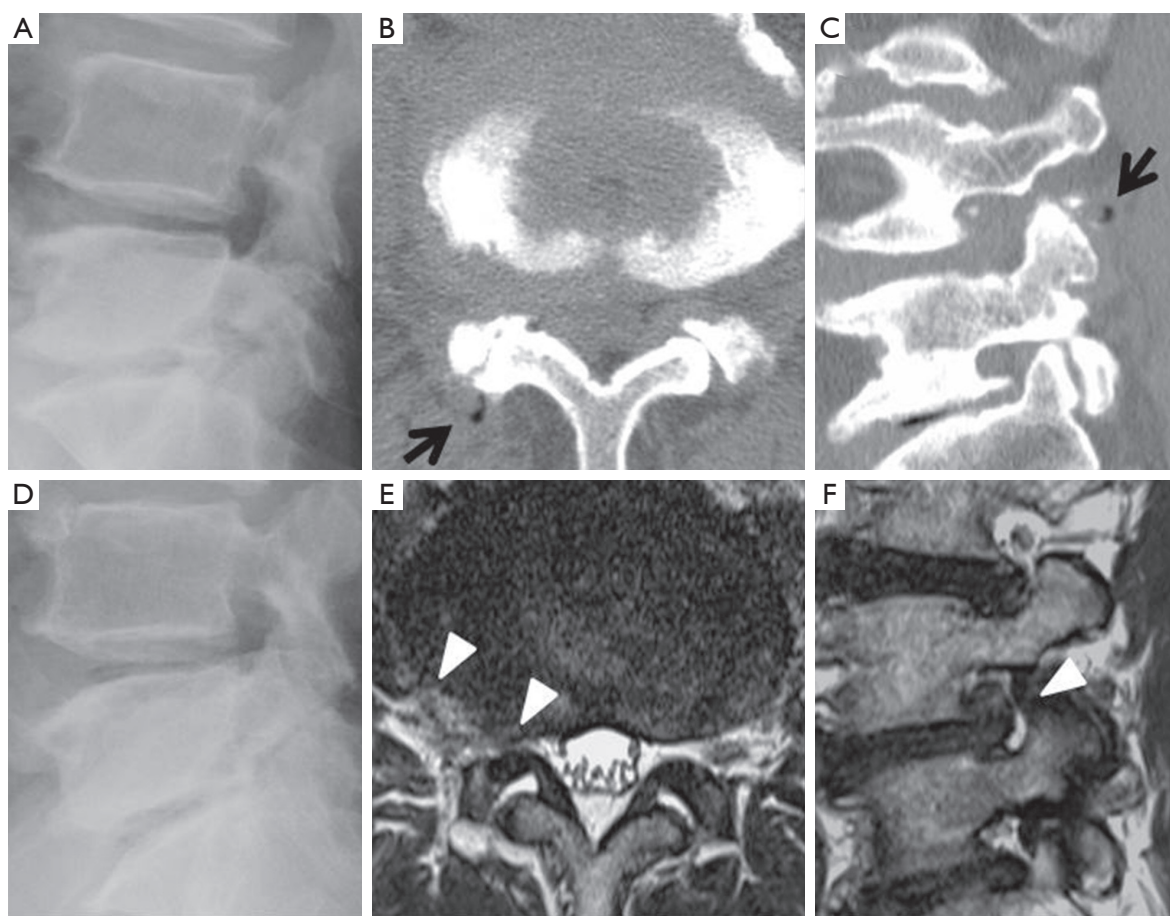
Foraminal or extraforaminal LDH extending into or beyond the foraminal zone accounts for 7–12% of all LDH cases (14,15). It has also been reported that the frequency of occurrence is nearly equal at the L4/5 and L3/4 levels (15). Furthermore, patients with foraminal or extraforaminal LDH are typically in their mid-fifties, ranging from 50–78 years of age (15). We also observed the same distributions in this study. Several different surgical techniques have been developed for foraminal or extraforaminal LDH (15,16), but PELD is the most recent and promising minimally invasive operative procedure.

Generally, facetectomy is not necessary for endoscopic removal of an extraforaminal LDH, although a small facetectomy (involving only a small part of the SAP, a so-called foraminoplasty) is occasionally a good surgical option for the endoscopic removal of foraminal or combined LDH. As foraminal or extraforaminal LDH predominantly occurs in elderly patients, and is complicated by lumbar degenerative disease such as facet joint osteoarthritis (15), removal of SAP osteophytes is sometimes required for entry of the endoscope. On the other hand, conventional open surgery occasionally requires a wider facetectomy, and the risk of postoperative instability increases (15). Anatomical cadaver studies clearly indicated that more medial access to Kambin’s triangle by foraminoplasty not only provides safe access to the intra-canal or foraminal space but also makes it possible to prevent exiting nerve injury (17). Therefore, foraminoplasty (removal of SAP from outside to medial, thereby enabling endoscopic access to the medial part of the triangle) using a surgical burr or trephine is an appropriate option in PLA for PELD. Furthermore, foraminoplasty does not increase the risk of

**Table 1** Summary of preoperative radiological findings and surgical outcomes in 29 cases of PLA

Case No.	Age (year)	Sex	Level	R/L	Type of MRI	Foraminal width (mm)	Foraminal width (mm)	Foraminoplasty	Entry point (cm)	Operation time (minutes)	Postoperative hospital stay (days)	Follow up period (months)	Perope NRS score	Postope NRS score	Previous operation
1	61	F	L4/5	L	Extraforaminal	13	9	Yes	7	30	1	8	7	4	
2	66	F	L4/5	L	Combined	19	8	Yes	7	36	2	8	9	2	L4/5 laminectomy
3	25	M	L5/S1	L	Combined	22	9	No	5.5	34	2	9	5	0	
4	46	M	L3/4	R	Combined	14	7	Yes	7	28	1	1	10	0	
5	73	M	L4/5	R	Extraforaminal	15	7	Yes	6	27	2	10	8	0	
6	69	M	L4/5	R	Combined	18	7	No	5	23	2	10	3	1	
7	37	M	L2/3	R	Combined	22	9	No	5	22	2	11	5	3	
8	68	M	L4/5	R	Combined	20	8	Yes	7.5	43	1	7	3	3	
9	61	M	L3/4	R	Combined	16	7	Yes	5	33	2	13	8	1	
10	46	M	L4/5	R	Combined	18	9	No	5	26	1	14	4	0	
11	49	M	L4/5	R	Combined	13	9	No	7	24	2	14	3	0	
12	46	M	L3/4	L	Combined	18	9	No	5	45	1	15	7	0	
13	66	M	L3/4	L	Combined	19	11	No	5	45	3	15	7	0	L3/4 discectomy
14	63	M	L3/4	R	Combined	15	9	No	6.5	44	3	16	7	4	
15	46	M	L3/4	L	Combined	18	8	No	7	38	1	16	8	0	
16	72	M	L4/5	L	Combined	16	13	Yes	6	43	2	16	3	1	
17	49	M	L3/4	L	Extraforaminal	18	9	No	6	32	3	19	10	3	
18	50	M	L3/4	R	Combined	20	8	No	8	46	1	22	7	0	
19	58	M	L3/4	R	Combined	22	7	No	9	47	1	23	5	3	
20	55	M	L3/4	L	Extraforaminal	23	7	No	9	105	3	24	3	0	
21	53	F	L3/4	R	Combined	19	8	No	8	45	1	31	5	3	
22	65	F	L5/6	R	Combined	14	9	Yes	6	34	3	7	2	1	
23	78	M	L4/5	R	Combined	13	10	Yes	6	40	3	6	3	1	L4/5 laminectomy
24	83	F	L3/4	R	Combined	15	9	Yes	6	32	2	6	8	5	
25	29	M	L3/4	R	Combined	21	7	Yes	6	25	1	6	8	6	
26	47	F	L4/5	R	Extraforaminal	13	9	Yes	7	45	2	6	7	0	
27	73	M	L4/5	R	Extraforaminal	19	7	No	6	22	3	5	7	0	
28	57	F	L4/5	R	Combined	17	10	No	7	29	3	5	8	3	
29	57	F	L4/5	R	Extraforaminal	19	9	No	7	34	16*	4	9	7	L4/5 XLIF

\*, in this case, the muscle weakness in the corresponding leg improved immediately after surgery. The patient required prolonged hospitalization for training to walk without a cane. MRI, magnetic resonance imaging; NRS, numerical rating scale; XLIF, extreme lateral interbody fusion; L, left; R, right.



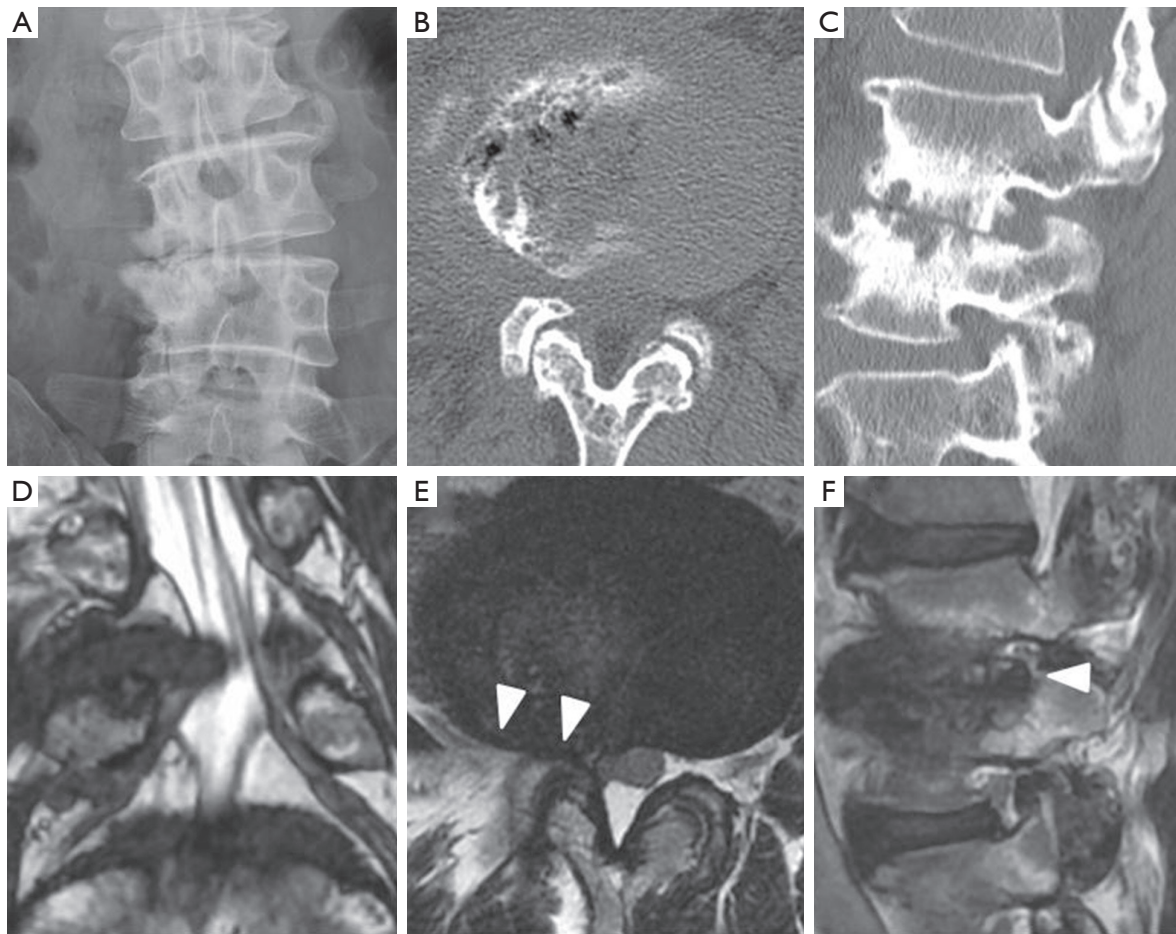
**Figure 3** Preoperative radiographic findings in a patient with persistent leg pain (case 8). Plain lateral radiographs of lumbar spine: (A) flexion, (D) extension; plain CT scan: (B) axial view of L4/5 disc level, (C) sagittal view of corresponding right foramen; T2-weighted MRI: (E) axial view of L4/5 disc level, (F) sagittal view of corresponding right foramen. Black arrows indicate a “vacuum phenomenon” in the right facet joint. We can also observe a “facet fluid sign” in both joints (E). Additional findings of facet joint osteoarthritis are also observed (sclerosis, osteophytes, and joint-space narrowing). White arrowheads indicate herniated nucleus.

instability.

The “hand-down technique” proposed by Sairyo *et al.* is another option (2). In this technique, downward pressure on the proximal side of the endoscope makes it possible to observe a more interior region through the foramen, thereby enabling removal of a nucleus that is extremely protruded toward the spinal canal. As continuous downward pressure on the endoscope might compress the exiting nerve, we should only use this technique for a short time, and repeat it after a long interval. In this study, we performed foraminoplasty in 12 cases, and used the hand-down technique in all cases to at least confirm the decompression of the foraminal space. The combination of PLA with foraminoplasty or hand-down technique

seems to be appropriate for the treatment of foraminal or combined LDH.

PELD offers the advantages of small incision size (8 mm), rapid recovery, short hospital stay, limited blood loss, less destruction of surrounding tissues, and less postoperative pain (18). However, contraindications and inadequate indications have not been fully reported (19-21). In this study we showed that a narrow foramen (foraminal height  $\geq 13$  mm, foraminal width  $\geq 7$  mm) is not a limiting factor in PLA for PELD; however, we observed early recurrence in 1 patient who presented with local scoliosis (coronal Cobb angle =  $13^\circ$ ), and in 1 patient with suspected instability who showed no improvement in the NRS score. We subsequently excluded patients with local scoliosis (coronal



**Figure 4** Preoperative radiographic findings in a patient with degenerative scoliosis (case 4): (A) Plain anteroposterior radiograph of lumbar spine; plain CT scan: (B) axial view of L3/4 disc level, (C) sagittal view of corresponding right foramen; T2-weighted MRI: (D) coronal view showing bilateral L4 and L5 nerve roots, (E) axial view of L3/4 disc level, (F) sagittal view of corresponding right foramen. White arrowheads indicate herniated nucleus.

Cobb angle  $>10^\circ$ ) and signs of instability such as a facet fluid sign (11,12) and vacuum phenomenon (13) on MRI and CT, respectively.

It is important to emphasize the importance of training and surgical experience, as PELD surgery does not have a steep learning curve, in contrast to MED (22,23). Early in training, operative complications such as exiting nerve injury can easily occur (24,25). Working sleeve insertion is harder to perform in the intra-canal region than in the extra-canal region. Furthermore, operative manipulation of the endoscope and forceps require delicate surgical skills because of the narrow operative field (4.1 mm diameter) and two-dimensional visualization. PLA for extraforaminal LDH is a simpler and safer procedure than other PELD

approaches from the viewpoint of anatomy and technique. Therefore, we recommend performing PLA for PELD in the early period of training. We also recommend a short, intensive course of training on the use of the free-hand endoscope system under expert supervision to prevent intra-operative complications of PELD.

### Conclusions

Preliminary results during a short follow-up period show that PLA for PELD is feasible for the treatment of foraminal and/or extraforaminal LDH with foraminal height  $\geq 13$  mm and foraminal width  $\geq 7$  mm. The procedure is effective for preservation of the facet joint; however, the

indications must be carefully considered when local scoliosis and/or instability are present.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

*Ethical Statement:* This study was approved by ethics committee of the Iwai Medical Foundation, and informed consent was obtained from the patients for publication of this study and any accompanying images.

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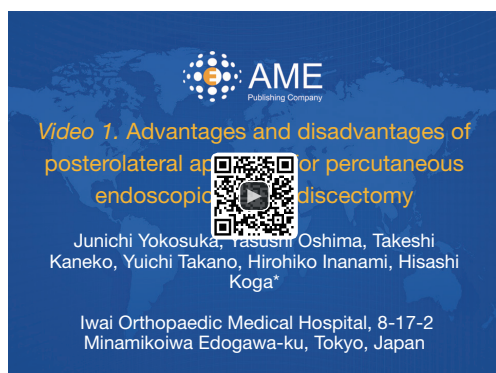


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*Contributions:* (I) Conception and design: H Koga; (II) Administrative support: Y Ishii; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: T Kaneko; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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**Figure S1** Advantages and disadvantages of posterolateral approach for percutaneous endoscopic lumbar discectomy (26). Available online: <http://www.asvide.com/articles/1158>