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A new surgical method to treat intracanal lumbar disc herniation using the unilateral biportal endoscopic transforaminal approach: patient series

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BACKGROUND Unilateral biportal endoscopic lumbar discectomy (UBELD) is a new minimally invasive spine surgery. The purpose of this study is to describe a new surgical method to treat intracanal lumbar disc herniation (LDH) using the unilateral biportal endoscopic transforaminal approach (UBE-TFA). The first 15 patients who had undergone UBELD for single-level LDH were included in this study. Operative time, intraoperative blood loss, postoperative stay, and intraoperative complications were recorded. The Oswestry Disability Index (ODI), numeric rating scale (NRS) score for leg pain, and modified MacNab criteria were assessed at 3 months postoperatively.

OBSERVATIONS The mean operative time was 52.0 ± 13.8 minutes. The mean intraoperative blood loss was 10.5 ± 10.2 mL. The mean postoperative stay was 1.1 ± 0.3 days. There were no complications. The postoperative mean ODI was significantly improved from 44.9 ± 14.4 to 7.7 ± 11.2 at the final follow-up ($p < 0.001$). There was a significant decrease in the postoperative mean NRS score for leg pain, from 6.1 ± 1.9 to 0.8 ± 1.3 at the final follow-up ($p < 0.001$). Based on the modified MacNab criteria, good to excellent results were obtained in 86.7% of the patients.

LESSONS We considered UBELD-TFA as not only one of the promising surgical methods for UBELD, but also a new surgical implementation of the TFA.

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KEYWORDS unilateral biportal endoscopic spine surgery; unilateral biportal endoscopy; transforaminal approach; lumbar disc herniation; full endoscopic discectomy

In recent years, the number of unilateral biportal endoscopic (UBE) spine surgeries recognized as a new minimally invasive spine surgery (MISS) has been increasing in East Asia.[1,2] UBE spine surgery is different from conventional endoscopic spine surgery, especially in terms of its approach through the two different portals. The technique is easier to use with the use of a 30° oblique endoscope, which provides a wider field of view and allows both hands to move freely. The use of two portals allows for sufficient bone and soft tissue work and technical flexibility comparable to that with a conventional uniportal technique. Many advantages and good clinical outcomes in UBE spine surgery have been reported.[1–4] There are currently two main approaches in UBE lumbar discectomy (UBELD): an interlaminar approach (ILA) and a paraspinal or extraforaminal approach. The former is widely used to treat intracanal lesions.[1] The latter is used to treat extracanal lesions such as foraminal stenosis.[3]

A uniportal full endoscopic discectomy (FED) is the representative transforaminal approach (TFA) to treat intracanal lumbar disc herniation (LDH) and is considered a less invasive surgical approach because of its ability to preserve surrounding structures of

ABBREVIATIONS BMI = body mass index; CT = computed tomography; FED = full endoscopic discectomy; ILA = interlaminar approach; ITL = intertransverse ligaments and membrane; LDH = lumbar disc herniation; LSS = lumbar spinal stenosis; MED = microendoscopic discectomy; MISS = minimally invasive spine surgery; MRI = magnetic resonance imaging; NRS = numeric rating scale; ODI = Oswestry Disability Index; PLL = posterior longitudinal ligament; SAP = superior articular process; TFA = transforaminal approach; UBE = unilateral biportal endoscopic; UBELD = unilateral biportal endoscopic lumbar discectomy.

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the posterior spine.[5,6] Previous studies have shown that the FED-TFA can avoid complications such as dural injury by preserving the ligamentum flavum.[7–9] Other studies have reported that the prevention of epidural adhesions and arachnoiditis resulted in a decrease in failed back surgery syndrome, postoperative lumbar spinal instability, and accelerated lumbar degeneration.[10–12] However, there have been no reports of UBELD to treat intracanal lesions through a TFA. Therefore, we developed the UBELD-TFA as a new surgical method with reference to the FED-TFA. In this study, we describe a new surgical method to treat intracanal LDH using a UBE-TFA.

Study Description

Data Collection

All cases were performed by a single surgeon (T.S.). Prior to clinical application of the UBELD-TFA, the surgeon had performed more than 1,000 cases of microendoscopic discectomy (MED), FED, and UBE laminotomy for bilateral decompression.

Patient Population and Clinical Outcome Analysis

Twenty-two consecutive patients with single-level intracanal LDH were treated by a single surgeon at Inanami Spine and Joint Hospital from January 2023 to March 2023. They had intermittent neurological claudication or radicular leg pain refractory to conservative management for at least 12 weeks. Our study exclusion criteria were as follows: 1) high-grade migrated LDH such as zone 1 or 5; 2) the need for resection of more than 50% of superior articular process (SAP) on preoperative computed tomography (CT) or magnetic resonance imaging (MRI) examination; 3) LDH occurred with lumbar spinal stenosis (LSS); 4) spondylolisthesis with Meyerding grade >2 on simple lateral radiograph; 5) lumbar instability (motion >3 mm at the surgical level, as measured on flexion-extension radiographs of the lumbar spine); 6) history of spine tumor or infection in the lumbar spine; and 7) cases deemed unsuitable for the procedure by the surgeon.

Of the 22 consecutive cases, 3 cases occurred with LSS, 2 cases were high-grade migrated LDH, 1 case was anatomically difficult to perform, and 1 case had previously received condoliase therapy. These 7 cases were treated with MED. The remaining 15 cases were treated with UBELD-TFA (Table 1). The patients comprised 13 males and 2 females. The mean age was 43.8 ± 15.0 years (range, 18–67 years). The mean body mass index (BMI) was 22.6 ± 3.4. The operative levels ranged from L2–3 to L5–S1: L2–3 in 1 patient; L3–4 in 1 patient; L4–5 in 7 patients; and L5–S1 in 6 patients. There were 4 cases of central LDH and 11 cases of paracentral LDH. There was 1 patient (case 2) with low-grade migrated LDH. Three patients (cases 6, 8, and 14) had a history of previous lumbar spinal surgery at the same level.

Preoperative T2-weighted MRI and CT were performed to diagnose LDH and evaluate the migrated LDH. The following clinical parameters were assessed: Oswestry Disability Index (ODI), numeric rating scale (NRS) score for leg pain, modified MacNab criteria (excellent, good, fair, and poor), operative time, intraoperative blood loss, postoperative stay, and complications related to the operation. The preoperative and 3-month postoperative ODI and NRS score were compared. Modified MacNab criteria were also used to examine the clinical outcomes at 3 months postoperatively. All patients underwent follow-up for more than 3 months. All data were prospectively collected and retrospectively evaluated.

Statistical Analysis

For continuous variables, statistical analysis was performed using a nonparametric test. A p value < 0.05 was considered statistically significant. Statistical analysis was performed using SPSS statistics version 24.0 (IBM Japan, Ltd.).

Equipment Used in the UBE Procedure

During the procedures, we used a 30° oblique-viewing 2.7-mm diameter lumbar endoscope officially certified for spine surgery in

TABLE 1. Summary of patient characteristics

Case No.	Age (yrs)	Sex	BMI	Level	Side of Approach	Location of Skin Incision* (mm)	Location of LDH	Op Time (mins)
1	28	M	22.0	L5–S1	Rt	72	Central	75
2	43	M	26.3	L4–5	Lt	100	Paracentral	56
3	63	M	24.6	L3–4	Rt	70	Paracentral	60
4	62	M	27.8	L2–3	Lt	94	Paracentral	35
5	44	M	19.3	L5–S1	Lt	70	Paracentral	42
6	43	M	27.2	L4–5	Rt	95	Paracentral	52
7	67	M	20.3	L5–S1	Lt	80	Paracentral	61
8	23	M	23.1	L4–5	Rt	100	Paracentral	37
9	18	M	21.0	L4–5	Rt	80	Central	56
10	53	M	18.5	L5–S1	Lt	56	Paracentral	42
11	32	M	22.1	L4–5	Rt	80	Paracentral	69
12	40	M	24.9	L4–5	Lt	86	Central	36
13	43	F	16.0	L5–S1	Rt	60	Paracentral	47
14	54	F	23.4	L5–S1	Lt	95	Central	74
15	36	M	22.2	L4–5	Rt	80	Paracentral	38

* Distance from the midline to the skin incision.

Japan (Smith & Nephew, Inc.), Ambient Super TurboVac 90° 3.75-mm RF wand as a bipolar radiofrequency probe (Smith & Nephew, Inc.), Quantum2 System (Smith & Nephew, Inc.), a 4.0-mm spherical diamond bur, serial dilators, and standard spinal discectomy instruments such as hook dissectors, Kerrison punches, and forceps (Fig. 1A).

Surgical Procedure

All operations were performed with the patient under general endotracheal anesthesia and with simultaneous motor evoked potential monitoring. Patients were placed prone on a radiolucent table to enable the use of a C-arm fluoroscope. Waterproof draping was used for all cases. A specialized drape was preferred for the lumbar endoscopic procedure. The following description assumes that the surgeon's dominant hand is the right hand. In other words, the right side was the working portal, and the left side was the endoscopic portal.

Two skin and fascia incisions were made in the extra far lateral area from the midline under posterior-anterior fluoroscopic guidance. The skin incision was 7.0 mm in length for the working portal and 5.0 mm in length for the endoscopic portal. The working portal was made necessarily parallel to the target disc level. It was normally made 7 to 10 cm lateral from the midline at the target disc level (Fig. 1B). The endoscopic portal was made approximately 25 to 30 mm cranial or caudal side to the working portal. The endoscope was finally inserted after a spinal needle, guidewire, and serial dilator were inserted through the working portal (Fig. 1C–E). When we performed the procedure at the L5–S1 level, both portals were normally made directly above the iliac crest (Fig. 1B).

The patient in case 15 underwent a right-sided approach (Table 1). Skin incision for the working portal was made 80 mm lateral from the midline at the target disc level (Fig. 1F). An 18-gauge spinal needle was inserted into the target disc through the working portal. Discography was performed with indigo carmine and a contrast medium to stain the herniated disc material. After inserting a guidewire through the spinal needle, a small serial dilator was inserted to spread the fascia, muscle layers, and a pinhole in the intertransverse ligaments and membrane[13] (ITLs; Fig. 2A and B). This process facilitates insertion of the instruments through the working portal and the avoidance of disorientation. As a result, muscle damage can be minimized. The endoscopic portal was made 2.5 to 3.0 cm on the caudal side from the working portal. A 30° oblique lumbar endoscope was inserted through the endoscopic portal after insertion of the cannula. Finally, endoscopic irrigation systems were used. Saline irrigation was performed with gravity-based pressure. After the small serial dilator was removed and the guidewire was maintained in place, a triangulation was performed with the endoscope and instruments.

When part of the muscles (from the inside, multifidus muscle, longissimus muscle, and iliocostalis muscle) on the posterodorsal side of the lumbar spine toward the foramen were detached along a guidewire, the hole made in the ITLs could be found (Fig. 2B). A

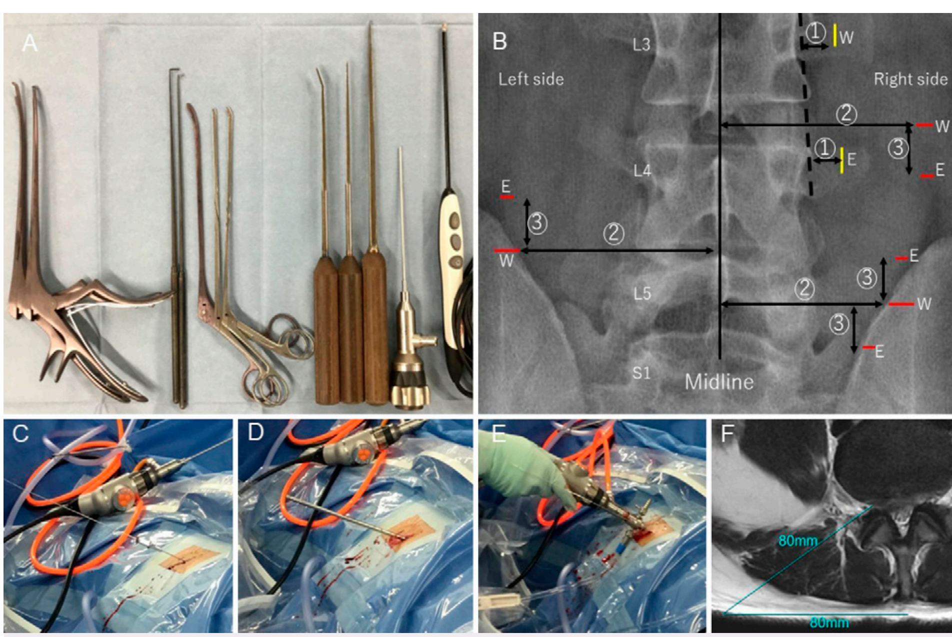

FIG. 1. Standard tools and placement of portals. **A:** Standard tools used in UBE. **B:** W denotes the working portal; E, the endoscopic portal. The *yellow vertical lines* indicate the placement of portals in the extraforaminal approach. The *red horizontal lines* indicate the placement of portals in the UBE-TFA. The *dashed line* is the lateral margin of the pedicle line. ①, ②, and ③ are distances to portals: ① is 2.0 cm, ② is 7.0–10 cm, and ③ is 2.5–3.0 cm. The working portal in the UBE-TFA is made parallel to the target disc level. The endoscopic portal is made approximately 2.5 to 3.0 cm cranial or caudal side to the working portal. **C:** Inserting a guidewire through the spinal needle. **D:** A small serial dilator is inserted to spread the fascia, muscle layers, and a pinhole in the intertransverse ligaments and membrane. **E:** Advancing the endoscope along the guidewire. **F:** In the case of a right-sided approach, the diagnosis is LDH at L4–5. Skin incision for the working portal is made 80 mm lateral from the midline at the target disc level.

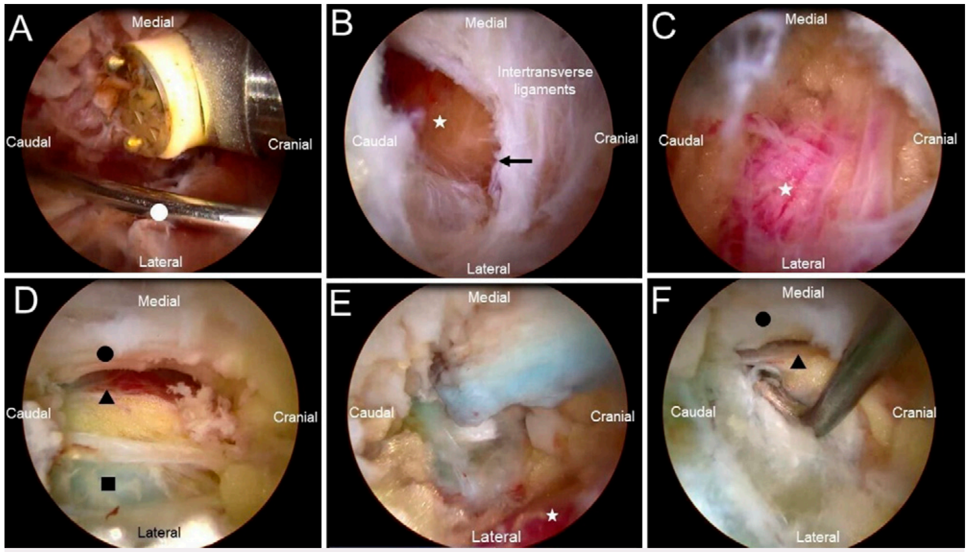

FIG. 2. The UBELD-TFA. **A:** The white circle denotes a guidewire. The surgical field is made along a guidewire. **B:** The *white star* indicates the exiting nerve root; the *black arrow*, Kambin's window. A surgeon can view the exiting nerve root through Kambin's window. **C:** The endoscope is advanced into the safety triangle while viewing the exiting nerve root (*white star*). **D:** *Black circle* indicates the ligamentum flavum; *black triangle*, the PLL; and *black square*, the contrasted annulus fibrosus. Partial resection of the ligamentum flavum is performed to confirm the PLL. **E:** The sequestrated nucleus is removed. **F:** There are no residual herniations.

guidewire was finally removed. The endoscope could be advanced into Kambin's safety triangle through the hole while confirming the location of the exiting nerve root (Fig. 2C). This hole is very important to successfully perform the UBE-TFA, so we called it "Kambin's window" (Video 1). As the lateral margin of posterior longitudinal ligament (PLL) could not be observed, partial resection of the lateral margin of the ligamentum flavum was performed to confirm the PLL using Kerrison punches (Fig. 2D). Depending on the shape of the SAP, the ventral side of the SAP may be partially resected. After puncturing the surface of the annulus fibrosus, a surgeon removed the sequestrated nucleus underneath the PLL by using several types of forceps (Fig. 2E). After the removal was completed, the compressed ventral surface of the dural sac or the large space between the PLL and dural sac became visible (Fig. 2F). It is important to confirm that there is no residual disc material of herniation using standard ball probes. After careful endoscopic examination for epidural bleeding and hemostasis, the instruments and endoscope were removed (Video 2). Finally, skin incisions were closed with a single suture without inserting a drainage catheter.

VIDEO 1. Clip showing the surgical field construction and advancement into Kambin's safety triangle. Click here to view.

VIDEO 2. Clip showing confirmation of the PLL and discectomy. Click here to view.

Results

The mean operative time was 52.0 ± 13.8 minutes. The mean intraoperative blood loss was 10.5 ± 10.2 mL. The mean postoperative stay was 1.1 ± 0.3 days. There were no postoperative complications. Moreover, there was no meningeal irritation and consequent headache known as a specific complication of UBE spine surgery resulting from excessive irrigation. The mean follow-up period was 4.5 ± 1.1 months. The mean postoperative ODI was significantly improved from 44.9 ± 14.4 to 7.7 ± 11.2 at the final follow-up ($p < 0.001$). There was a significant decrease in the mean postoperative NRS score for leg pain, from 6.1 ± 1.9 to 0.8 ± 1.3 at the final follow-up ($p < 0.001$). Based on the modified MacNab criteria, results were excellent in 9 patients (60.0%), good in 4 (26.7%), fair in 2 (13.3%), and poor in 0 (0%).

Patient Informed Consent

The necessary patient informed consent was obtained in this study.

Discussion

Our new surgical procedure is a useful approach because outcomes such as the ODI, NRS score for leg pain, and modified MacNab criteria were significantly improved at 3 months postoperatively with no perioperative complications. Several MISS techniques are available for the treatment of LDH. The clinical outcomes of the UBELD-ILA, such as the ODI and NRS score, have been supported by several randomized controlled trials and reviews.[14–16] However, some reports have indicated that the UBED-ILA is not the optimal strategy for treating LDH in terms of some outcomes, such as a longer operative time and longer hospital stay.[15,17,18] Therefore, new surgical methods are needed to improve these problems.

Observations

We reported a new surgical method to treat intracanal LDH performed through the UBE-TFA. The mean operative time was 52.0 ± 13.8 minutes. The postoperative stay was 1.1 ± 0.3 days. There were no perioperative complications. Operative time is a very important factor to assess the superiority of a surgical technique. However, the UBELD-ILA has been suggested to be ineffective in reducing operative time.[18–20]

In general, it is said that the UBELD-ILA takes longer to create the surgical field. Moreover, it requires some degree of bone resection and removal of the ligamentum flavum of the posterior lumbar spine due to the ILA. On the other hand, the UBELD-TFA requires less resection of the bone and ligamentum flavum compared to the UBELD-ILA because it allows direct entry at the target disc level. Therefore, we believe that the UBELD-TFA will reduce operative time more than the UBELD-ILA.

Previous studies have reported a total complication rate of 6.7% (0%–13.8%) for the UBELD-ILA.[16] According to some detailed reports on the complications of UBELD-ILA, dural injuries often occurred during resection of the ligamentum flavum. The UBELD-ILA necessarily requires some amount of bone resection and removal of the ligamentum flavum from the posterior lumbar spine to perform the resection of intracanal LDH. In other words, the surgical process itself poses the risk of a complication because of the need to perform intracanal manipulations. On the other hand, the UBELD-TFA is a very logical way to prevent dural injuries because of minimal disruption of the spinal structures, including ligaments and bones. We believe that no intracanal manipulations can effectively reduce the risk of dural injuries.

Injury to the exiting nerve root is one of the major complications in FED-TFA. It has been reported in the literature that the incidence ranges from 9.3% to 26%.[21–23] The UBELD-TFA may prevent this complication by allowing a direct view of the exiting nerve root. A surgeon can confirm the location of the exiting nerve root by looking into the safety triangle through Kambin's window (Fig. 2B and C). In addition, rotating a 30° oblique lumbar endoscope allows the surgeon to observe the exiting nerve root while performing the procedure, which is effective in avoiding exiting nerve root injury. The endoscope is not required to be inserted close to the exiting nerve root in the UBELD-TFA, which prevents injury to the exiting nerve root as a secondary effect of the technique.

Our surgical procedure appears to be similar to the previously reported extraforaminal approach for treating foraminal stenosis.[3] Both portals in the extraforaminal approach are made 2 cm lateral to the lateral margin of the pedicle line on the midline of each of the two transverse processes (Fig. 1B).[3] The target points are the intervertebral foramen and the tip of the SAP. The purpose of this previously described procedure is to decompress the intervertebral foramen by removing the tip of the SAP (Fig. 3A). This is still a very effective surgical procedure to decompress the intervertebral foramen. On the other hand, the portals in the UBE-TFA and FED-TFA were made more laterally (Fig. 3B and C). The purpose of our new procedure is to treat intracanal LDH. Depending on the shape of the facet, the ventral portion of the SAP can sometimes be partially resected to ensure adequate resection of the intracanal LDH, but a partial facetectomy of the SAP is not necessary (Fig. 4A and B). Therefore, our procedure is a new surgical method that is different from the extraforaminal approach.

Lessons

The most important aspect of this procedure is whether it has achieved minimal invasiveness, including in terms of operative time. Although the postoperative follow-up period was short, the clinical outcomes were generally good. All UBE spine surgeries are prone to the muscle damages that occur during the procedure.[24] It has been reported that muscle damages in UBE spine surgery may correlate with an increased operative time but will resolve overtime.[24] Compared to the ILA, the TFA requires a greater distance to reach the target disc level, which may result in more muscle damage. Therefore, it was necessary to devise a method to directly reach the target disc level to finish the procedure in a relatively short time and avoid unnecessary muscle damage resulting from momentary indecision during the procedure. The uniqueness of this procedure is that the endoscope is advanced along a guidewire that is inserted at the target disc level. This may facilitate a shorter operative time and prevent unnecessary muscle damage caused by indecision. There were no obvious muscle changes on MRI scans at 3 months postoperatively (Fig. 4C–F). Although these results are consistent with previous reports,[24] further research is warranted to clarify the advantages of this technique.

Although inexperienced surgeons are advised to start with the ILA, which has clear anatomical indicators, patients with normal to overweight body habitus (BMI $<$ 30.0) and those with no migrated LDH except for the L5–S1 level are considered favorable cases for the described approach, particularly when first learning the TFA. In addition, considering the effective length of a bipolar radiofrequency probe and its operability, it is important that the distance from the

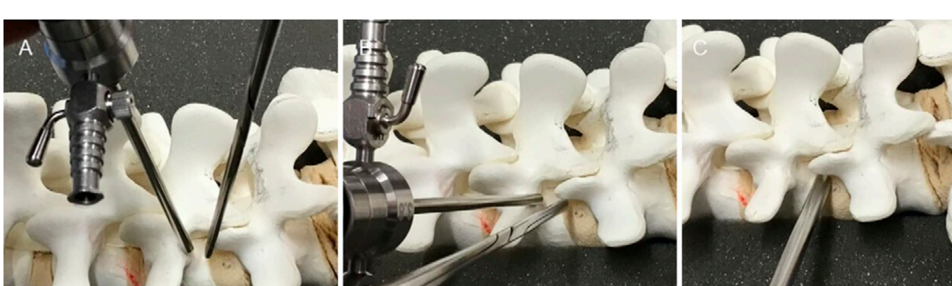

FIG. 3. The UBE approaches and the FED-TFA. The portals in the UBE-TFA and FED-TFA are made more laterally than in their respective transforaminal approaches. **A:** The UBE extraforaminal approach. **B:** The UBE transforaminal approach. The portals are made more laterally than in the UBE extraforaminal approach, but they are not made as far laterally as in the FED-TFA. **C:** The FED transforaminal approach. The portals are made more laterally than in the UBE-TFA.

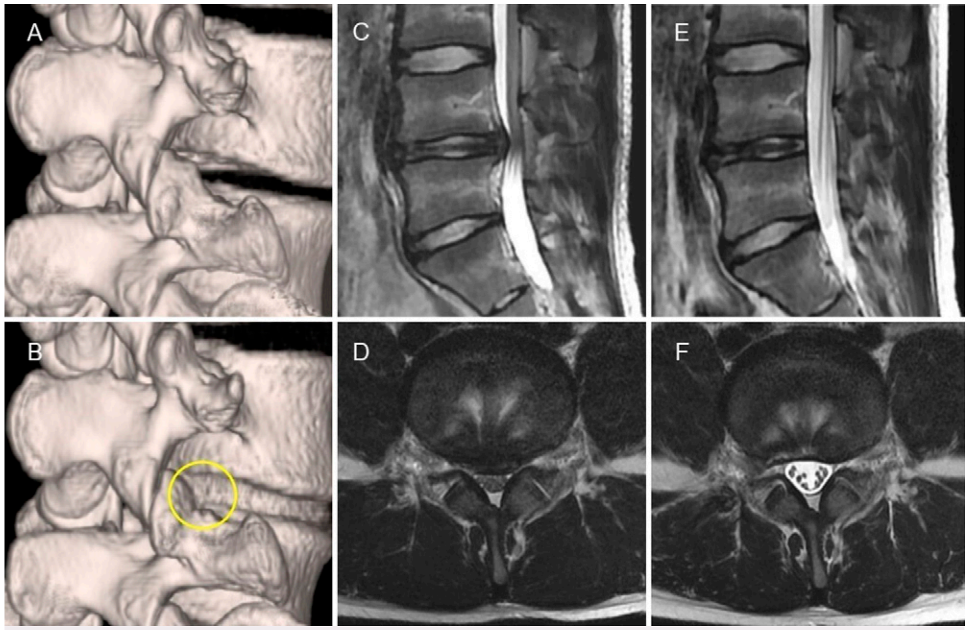

FIG. 4. Case 9. The patient underwent a right-sided approach. The diagnosis was L4–5 central LDH. MRI at 3 months postoperatively. CT image on postoperative day 1. **A:** Preoperative 3D CT image. **B:** The *yellow circle* indicates partial resection of the ventral aspect of the SAP. **C:** Preoperative sagittal MRI. **D:** Preoperative axial MRI. **E:** LDH was perfectly resected. **F:** Obvious changes were not observed in the muscle.

working portal to the target disc level does not exceed approximately 12 cm.

The procedure described in this paper encompasses a new surgical method to treat intracanal LDH through the UBE-TFA. The advantage of this procedure is that the posterior lumbar spinal tissue can be preserved and can reach the target disc level directly. We suggest that the new procedure is superior to the UBELD-ILA, especially in terms of its minimal invasiveness including operative time and length of hospital stay. However, further research is needed to conclude that this procedure is more advantageous than the UBELD-ILA.

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Disclosures

Dr. Kaneko reported personal fees from Elicence International and Smith+Nephew outside the submitted work.

Author Contributions

Conception and design: Segawa, Iwai, Taniguchi, Yanagisawa, Sasaki. Acquisition of data: Segawa, Yanagisawa, Tominaga, Nakamoto. Analysis and interpretation of data: Segawa, Yanagisawa. Drafting the article: Segawa, Yanagisawa, Sasaki. Critically revising the article: Segawa, Iwai, Yanagisawa, Sasaki, Koga. Reviewed submitted version of manuscript: Segawa, Takano, Yanagisawa, Yokosuka, Sasaki, Koga. Approved the final version of the manuscript on behalf of all authors: Segawa. Statistical analysis: Segawa, Yanagisawa. Administrative/technical/material support: Segawa, Iwai, Takano, Yuzawa, Taniguchi, Yanagisawa, Koga. Study supervision: Segawa, Inanami, Takano, Kaneko, Yanagisawa.

Supplemental Information

Videos

Video 1. https://vimeo.com/898128085.

Video 2. https://vimeo.com/898129617.

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