ACCSCIENCE PUBLISHING

Orthopedics and Tissue Engineering

ORIGINAL RESEARCH ARTICLE

Technical aspects and preliminary clinical outcomes of unilateral biportal endoscopic surgery via a far-paraspinal approach for thoracic disc herniation

Ziqiao Liu[1], Ying Xiao[1], Yuhao Yang[1], Hao Wu[1], and Lekhang Cheang[2]*

[1]Department of Orthopaedics, The First Affiliated Hospital of Jinan University, Guangzhou, Guangdong, China

[2]Department of Orthopedic Surgery, Centro Hospitalar Conde de São Januário, Macao, China

Abstract

Thoracic disc herniation (TDH) is a relatively uncommon spinal disorder, and its surgical management remains technically challenging because of the complex regional anatomy and the risk of neural injury. This study evaluates preliminary clinical outcomes of unilateral biportal endoscopic (UBE) discectomy via the far-paraspinal approach (FPA) for TDH and details key surgical technical nuances. A retrospective analysis was conducted on five patients with TDH who underwent UBE-FPA discectomy between December 2024 and April 2025. Preoperative neurological examinations showed varying degrees of muscle weakness, sensory deficits, and reduced tendon reflexes in corresponding spinal segments. The lateral offset of FPA was adjusted based on segmental anatomical differences. Intraoperative parameters (operative time, treated level) and postoperative outcomes (hospital stay) were recorded. Clinical efficacy was assessed using the visual analog scale (VAS), Oswestry Disability Index (ODI), and thoracic Japanese Orthopaedic Association (JOA) score. All five surgeries were completed successfully, with an operative time of 60–80 min (mean, 67.5 min). No intraoperative complications or postoperative adverse events occurred. All patients were followed up for 6–12 months (mean, 9.4 months). Postoperative thoracic magnetic resonance imaging confirmed complete resection of herniated nucleus pulposus and adequate neural decompression in all cases. VAS and ODI scores showed sustained decreases, while JOA scores increased progressively at all postoperative time points (all $p < 0.001$). At six months postoperatively, the VAS score decreased from 6.8 ± 0.8 to 1.2 ± 0.4, the ODI improved from 56.0 ± 5.7% to 9.0 ± 8.5%, and the JOA score increased from 4.6 ± 1.1 to 10.4 ± 1.7. Neurological reassessments during follow-up revealed substantial improvements in sensory disturbances and muscle weakness. With its unique anatomical trajectory, UBE-FPA discectomy offers distinct advantages by preserving spinal stability and reducing nerve injury risk, providing a novel therapeutic option for TDH management.

Keywords: Thoracic disc herniation; Unilateral biportal endoscopy; Far paraspinal approach; Discectomy; Minimally invasive spinal surgery

***Corresponding author:**
Lekhang Cheang
(cheanglekhang@yahoo.com.hk)

Citation: Liu Z, Xiao Y, Yang Y, Wu H, Cheang L. Technical aspects and preliminary clinical outcomes of unilateral biportal endoscopic surgery via a far-paraspinal approach for thoracic disc herniation. *Orthop Tissue Eng.* 2026;1(2):025480021. doi: 10.36922/OTE025480021

Received: November 24, 2025

Revised: February 24, 2026

Accepted: February 25, 2026

Published online: April 8, 2026

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1. Introduction

Thoracic disc herniation (TDH) is a clinically rare condition, with an incidence of approximately 1 per million population, and accounts for only 0.25–0.75% of all disc herniations.[1,2] It primarily affects middle-aged and elderly individuals aged 40–60 years, and thoracic discectomy constitutes 0.15–4% of all disc herniation surgeries.[3] TDH is characterized by heterogeneous, complex, and nonspecific clinical manifestations, including thoracic back pain, sensory dysfunction, myelopathic features (e.g., limb weakness), hyperreflexia, muscle spasticity, and urinary/bowel dysfunction; most patients experience progressive symptom deterioration over time.[4,5] Surgical intervention is generally indicated for patients with definitive myelopathic signs, intractable radicular pain, or failed conservative management. Historically, laminectomy and fusion were the main surgical methods for TDH, but are now rarely used due to severe complications such as spinal cord ischemia and increased mortality.[6]

With the widespread adoption of minimally invasive surgical principles, the technology behind unilateral biportal endoscopic (UBE) surgery has matured. UBE discectomy has shown comparable efficacy to microscopic discectomy and percutaneous endoscopic lumbar discectomy.[7–9] However, the literature on UBE for TDH remains limited, both domestically and internationally. The UBE-far-paraspinal approach (FPA) discectomy described in this study uses a unique angular trajectory and dual-channel synergy to achieve high-resolution intraoperative visualization, enabling precise lesion exposure and meticulous surgical manipulation while minimizing the risk of nerve injury. In contrast, the traditional UBE translaminar approach may be limited by suboptimal operating angles and carries an inherent risk of spinal cord retraction when treating central TDH. To address these limitations, we integrated the concept of long-distance lateral access from percutaneous transforaminal endoscopy into UBE, developing FPA for TDH. This approach aims to achieve direct intraspinal decompression without spinal cord retraction by maximizing the lateral angle of the working channel. The present study comprehensively describes the surgical technique of UBE-FPA for TDH and preliminarily evaluates its early clinical efficacy and safety, offering a novel minimally invasive alternative for TDH treatment.

2. Methods

2.1. Patient selection criteria

Inclusion criteria included (i) patients meeting the diagnostic criteria for TDH proposed by Dützmann *et al.*[10]; (ii) patients with single-segment spinal involvement; (iii) patients with recurrent symptoms refractory to rigorous conservative treatment (including non-steroidal anti-inflammatory drugs, physical therapy, etc.) for at least three months; and (iv) patients with severe symptoms significantly affecting daily activities, with a strong willingness to undergo surgery and acceptance of UBE-FPA discectomy.

Exclusion criteria included patients with (i) concurrent spinal tumors or infections; (ii) ligament ossification or thoracic spinal canal stenosis; (iii) previous thoracic spine surgery or severe thoracic spinal deformity; (iv) soft tissue or skin infection at the intended surgical site; (v) coagulopathy or bleeding disorders; and (vi) preexisting surgical contraindications (e.g., severe cardiopulmonary insufficiency, inability to tolerate anesthesia).

This study was approved by the Scientific Research Ethics Committee of the First Affiliated Hospital of Jinan University (Approval no.: KY-2026-022) and was performed in accordance with the Declaration of Helsinki. The ethics committee above exempted the requirement for informed consent for this retrospective study.

2.2. General data

Five patients (one male [20%], four females [80%]) with TDH admitted to our institution between December 2024 and April 2025 were included in the analysis. The age range was 50–80 years (mean, 60.0 ± 10.3 years), and the disease duration was 6–12 months (mean, 8.0 ± 2.2 months). Lesion levels included T11/12 (three cases), T8/9 (one case), and T9/10 (one case). According to the classification system proposed by Farber *et al.*[11], three patients (60%) had Type 1 TDH, one (20%) had Type 2, and one (20%) had Type 3. Two patients (40%) had comorbidities (hypertension and diabetes mellitus), which were adequately controlled preoperatively (Table 1).

Table 1. Baseline data and surgical characteristics of patients (*n* = 5)

Variables	Detailed data
Gender, *n* (%)	
Male	1 (20%)
Female	4 (80%)
Age (years)	50–80 (60.0 ± 10.3)
Disease duration (months)	6–12 (8.0 ± 2.2)
Comorbidities, *n* (%)	
Hypertension	1 (20%)
Hypertension + diabetes	1 (20%)
None	3
Lesion level, *n* (%)	
T11/12	3 (60%)
T8/9	1 (20%)
T9/10	1 (20%)

(*Cont'd...*)

Table 1. (*Continued*)

Variables	Detailed data
[a]TDH classification, *n* (%)	
Type 1	3 (60%)
Type 2	1 (20%)
Type 3	1 (20%)
Operative time (minutes)	60–80 (67.5 ± 7.5)
Hospital stay (days)	5–10 (6.4 ± 1.9)
Follow-up duration (months)	6–12 (9.4 ± 2.3)
Intra/Postoperative complications, *n* (%)	None: 5 (100%)
Recurrence, n (%)	None: 5 (100%)

Notes: [a]TDH classification was based on the criteria proposed by Farber *et al.*[11], which defines subtypes as follows: Type 0: Small (<40%) herniation without compression/symptoms (observation only, no need for calcification identification); Type 1: Small (<40%) paracentral herniation compressing nerve root/spinal cord (calcification identification required to assess surgical difficulty); Type 2: Small (<40%) central herniation with symmetric spinal cord compression (myelopathy present, calcification identification required); Type 3: Large (>40%) paracentral herniation with severe spinal cord displacement (obvious symptoms, calcification identification required to determine surgical approach); and Type 4: Large (>40%) central herniation with significant spinal cord compression (calcification status directly affects anterior surgical strategy). Data presented as range (mean ± standard deviation), unless stated otherwise.
Abbreviation: TDH: Thoracic disc herniation.

2.3. Statistical methods

The Statistical Package for Social Sciences (version 26.0) software was used for data analysis. Continuous variables (age, disease duration, operative time, visual analog scale [VAS], Oswestry Disability Index [ODI], and thoracic Japanese Orthopaedic Association [JOA] scores) are presented as range and mean ± standard deviation. Categorical variables (gender, comorbidities, TDH classification, and complications) are reported as case counts with constituent proportions (*n*/%). Before paired sample *t*-tests, the Shapiro–Wilk normality test was conducted on the paired differences (preoperative vs. six-month postoperative) for each efficacy indicator (VAS, ODI, JOA). A significance level of $\alpha = 0.10$ was used; $p > 0.10$ indicated that the normality assumption was not violated. Paired sample *t*-tests were used to compare indicator differences between preoperative and postoperative time points, with $\alpha = 0.05$ and $p < 0.05$ considered statistically significant.

2.4. Surgical technique

Under general endotracheal anesthesia, the patient was placed prone on a radiolucent operating table with appropriate padding to maintain abdominal suspension, and intraoperative neuroelectrophysiological monitoring was initiated. The responsible spinal segment was localized using anteroposterior fluoroscopy with a C-arm X-ray machine (WG-CA, Weigao Group, China); lateral fluoroscopy confirmed that the target intervertebral space was perpendicular to the ground—this optimization facilitates intraoperative manipulation and reduces the risk of wrong-level surgery. The surgeon's position and incision site were selected on the side with the more severe neural compression. Taking a T11/12 TDH patient with right-sided compression as an example: the caudal portal was designated as the observation channel, and the cephalad portal as the working channel. UBE-FPA was used to sequentially establish dual channels. Due to downward migration of the herniated disc to the T12/L1 segment, two 8-mm skin incisions were made 5 cm lateral to the midline at the T12/L1 level, spaced 2.5–3 cm apart. The skin and deep fascia were sequentially incised, and graduated soft tissue dilators were inserted to bluntly dissect the paraspinal muscles. The cannula tips were aligned at the T12 vertebral arch isthmus, and fluoroscopy was repeated to confirm accurate localization of the intervertebral space responsible for the lesion (Figure 1).

After establishing dual channels, unobstructed irrigation outflow and high-quality visualization were ensured. A plasma radiofrequency probe (AC/RC, BONSS MEDCAL, China) was inserted through the working channel to coagulate and resect soft tissues around the vertebral arch isthmus, gradually exposing the L1 superior articular process, intervertebral foramen, and disc space. The endoscope's multiplanar range of motion and angled field of view provided sufficient working space in all directions, enabling clear identification of the L1 transverse process base inferior edge, superior articular process lateral margin, and intertransverse membrane. Under direct endoscopic visualization, a 2-mm diameter burr was used to thin the L1 transverse process base inferior edge (≈2 mm in extent) and a portion of the L1 superior articular process ventral bone. After initial foraminoplasty, the ventral exiting nerve root became visible. Following identification of the exiting nerve root and dissection of adherent surrounding soft tissues, the herniated disc tissue was confirmed to be anterior to the exiting nerve root. Further working space expansion was performed as follows: first, a high-speed burr thinned the lateral aspect of the T12 inferior articular process (resection limited to ≤1/3 of the articular surface to prevent iatrogenic spinal instability); subsequently, a Kerrison rongeur partially resected the T12 inferior articular process lateral portion, exposing the L1 superior articular process tip, which was then precisely excised. Throughout bony resection, real-time endoscopic visualization confirmed the extent of bone removal, ensuring only the facet joint portion overlying the disc space was resected to avoid pedicle and dural

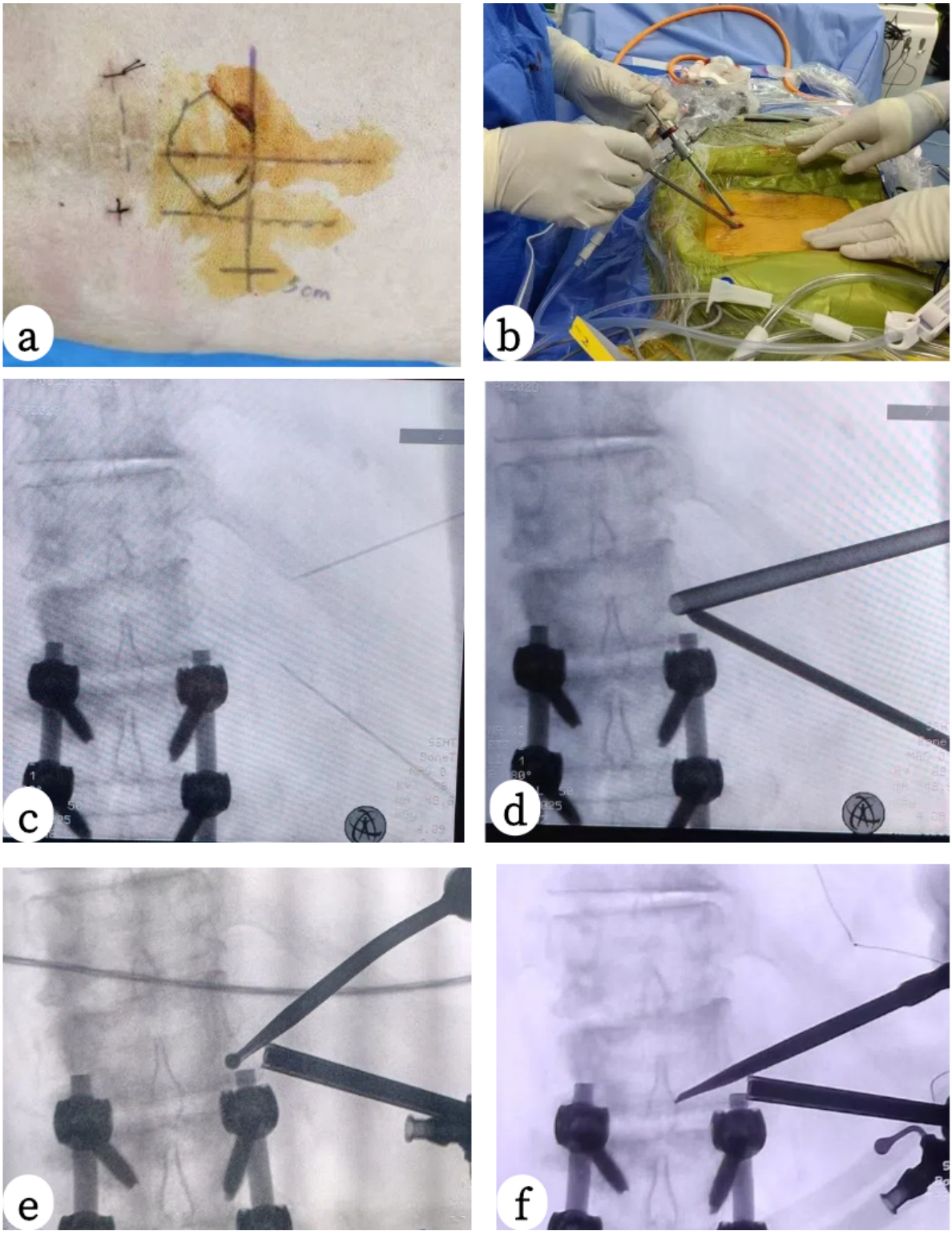


Figure 1. Intraoperative incision design and fluoroscopic images of channel placement. (a) Schematic diagram of intraoperative incision design for discectomy. (b) Illustration showing the surgeon's position and operative field setup during the procedure. (c,d) Fluoroscopic images demonstrating the placement of working channels. (e,f) Intraoperative fluoroscopic images confirming accurate localization of the responsible intervertebral space.

sac injury. Finally, the ligamentum flavum adjacent to the intervertebral foramen was resected to fully expose the intervertebral foramen and lateral spinal canal, allowing unobstructed visualization of herniated disc tissue and dural sac lateral margin without spinal cord retraction.

Without spinal cord retraction, the annulus fibrosus was incised with a sharp knife, and a portion of the nucleus pulposus was resected using angled forceps. The herniated disc tissue was then removed with a dissector, and an endoscopic probe confirmed the absence of residual disc compression anterior to the spinal cord and nerve roots (Figure 2).

Before completing the procedure, thorough hemostasis was achieved with a plasma radiofrequency probe; bone wax was used to control osseous bleeding. After hemostasis, the irrigation inlet was closed, and a water-tight test ensured adequate hemostasis. A surgical drain was placed under endoscopic guidance; instruments were withdrawn, and the incision was sutured in layers and covered with sterile dressings.

2.5. Postoperative management and efficacy evaluation indicators

Postoperatively, patients received intravenous parecoxib sodium (40 mg every 12 h for three days) for analgesia, intravenous mannitol (125 mL twice daily for three days) for edema reduction, and oral mecobalamin (0.5 mg three times daily) for neuroprotection. The surgical drain was removed 24–48 h postoperatively. Patients were encouraged to ambulate with thoracic brace immobilization starting on the third postoperative day. Postoperative thoracic computed tomography (Somatom Definition Flash, Siemens, Germany) and magnetic resonance imaging (Magnetom Verio 3.0T, Siemens, Germany) were used to assess the completeness of disc resection and neural decompression. VAS, ODI, and thoracic JOA scores were recorded preoperatively and at one day, one month, three months, and six months postoperatively. Postoperative complications were closely monitored, and patient recovery was evaluated via serial neurological examinations.

3. Results

Prior to statistical analysis of efficacy indicators, the Shapiro–Wilk normality test was performed on the paired differences (preoperative vs. six-month postoperative) for VAS, ODI, and JOA scores to verify the applicability of the paired sample *t*-test. The results showed that all paired differences conformed to a normal distribution ($p > 0.10$), meeting the statistical test conditions (Table 2).

All five patients underwent successful surgery, with an operative time of 60–80 min (mean, 67.5 ± 7.5 min), a hospital stay of 5–10 days (mean, 6.4 ± 1.9 days), and a follow-up duration of 6–12 months (mean, 9.4 ± 2.3 months). No intraoperative complications (e.g., nerve injury, dural tear) or postoperative adverse events (e.g., infection, symptomatic hematoma, aggravated neurological deficit) were observed, and no recurrence was documented during follow-up. Postoperative thoracic magnetic resonance imaging confirmed complete resection of the herniated nucleus pulposus and adequate neural decompression in all patients; consistently, VAS and ODI scores showed sustained decreases, while JOA scores increased progressively at all postoperative time points (Table 3). Paired sample *t*-test results showed statistically significant improvements in all three efficacy indicators at six months postoperatively compared to preoperative values (all $p < 0.001$): VAS score decreased from 6.8 ± 0.8 to 1.2 ± 0.4 ($t = 14.568$), ODI improved from 56.0 ±

Table 2. Normality test results of paired differences of efficacy indicators

Efficacy indicators	Paired differences (six-month postop–preop)	Shapiro–Wilk statistic	*p*-value	Normality compliance
Visual analog scale (points)	−5.8, −6.0, −5.0, −6.0, −5.0	0.902	0.556	Yes ($p > 0.10$)
Oswestry Disability Index (%)	−40.0, −50.0, −46.0, −52.0, −47.0	0.867	0.381	Yes ($p > 0.10$)
Japanese Orthopaedic Association score (points)	5.0, 6.0, 6.0, 6.0, 6.0	0.935	0.742	Yes ($p > 0.10$)

Table 3. Statistical analysis of efficacy indicators at different time points

Efficacy indicators	Preoperative	Postoperative duration				[a]*t*-value	*p*-value
		1 day	1 month	3 months	6 months		
VAS score (points)	6.8 ± 0.8	3.8 ± 0.8	2.2 ± 0.4	1.2 ± 0.4	1.2 ± 0.4	14.568	<0.001
ODI (%)	56.0 ± 5.7	36.0 ± 6.1	22.8 ± 6.7	13.4 ± 7.9	9.0 ± 8.5	11.324	<0.001
JOA score (points)	4.6 ± 1.1	5.6 ± 0.8	7.6 ± 1.1	8.2 ± 1.3	10.4 ± 1.7	−10.876	<0.001

Notes: [a]Test statistic was derived from a paired sample *t*-test (preoperative vs. six-month postoperative). The negative *t*-value for the JOA score indicated a higher score at six months postoperatively than preoperatively.
Abbreviations: JOA: Japanese Orthopaedic Association; ODI: Oswestry Disability Index; VAS: Visual analog scale.

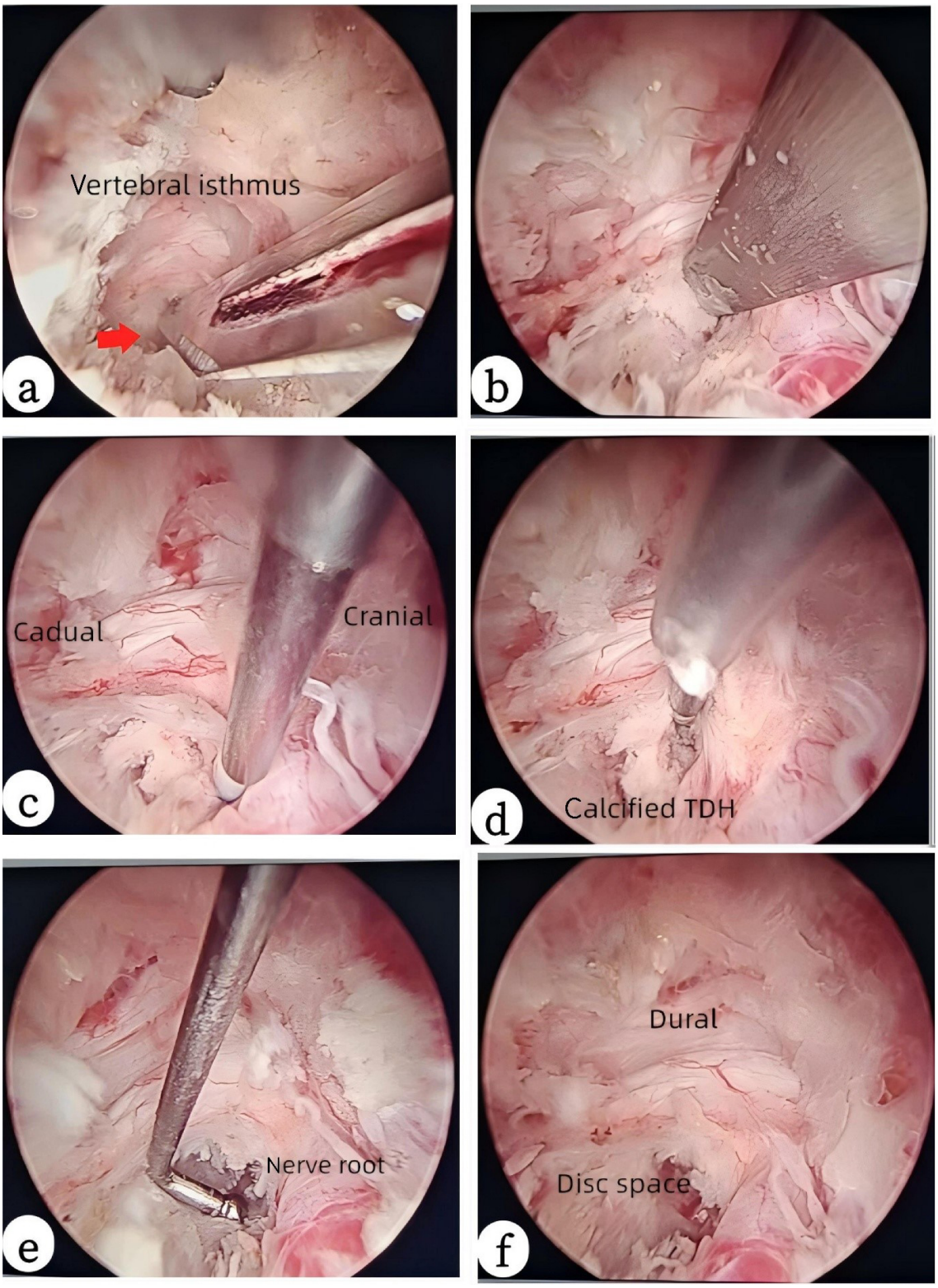


Figure 2. Serial sequence endoscopic images of the discectomy. Angling the endoscope provides an optimal view of the ventral dural sac space during the procedure. (a) After foraminoplasty, the annulus fibrosus was incised under direct endoscopic visualization. (b–d) Sequential resection of calcified disc tissue using angled forceps and a dissector to achieve complete removal of herniated fragments. (e,f) Confirmation of dural sac and nerve root relaxation following decompression, with no residual disc compression anterior to the spinal cord or nerve roots.

5.7% to 9.0 ± 8.5% (t = 11.324), and JOA score increased from 4.6 ± 1.1 to 10.4 ± 1.7 (t = −10.876). Neurological examinations during follow-up revealed that the 80-year-old female patient (Patient 1), with preoperative muscle strength grade 2, recovered to grade 3+ at six months postoperatively; the remaining patients achieved muscle strength grade 4 or higher, with significant improvements in sensory disturbances and hyperreflexia—findings consistent with the marked increase in JOA scores. Imaging findings before and after surgery further confirmed the effectiveness of decompression (Figure 3).

4. Discussion

Thoracic disc herniation is an extremely rare condition, with an estimated annual incidence of symptomatic cases of 1 per million population.[12] It primarily affects the T8–T12 segments, with the T11/12 level being the most commonly involved (26%)—a finding consistent with our study, in which three of five patients had lesions at the T11/12 level. This predilection is presumably due to increased mobility of this segment and relative weakness of the posterior longitudinal ligament at this level. Additionally, disc calcification is a characteristic feature of TDH, occurring in approximately 40% of cases.[13] TDH results from the disruption of the annulus fibrosus and the bulging or herniation of the nucleus pulposus. Compression of the thoracic nerve roots may lead to radiculopathy, while compression of the spinal cord itself can manifest as myelopathy. The clinical manifestations generally include thoracic back pain, sensory disturbance, myelopathy, hyperreflexia, spasticity, and dysfunction of the bowel and bladder. Notably, some patients with TDH present with foot drop as the initial symptom upon seeking medical attention. Through an analysis of 13 TDH patients with foot drop as the presenting symptom, Cong *et al.*[14] proposed that foot drop can serve as the initial manifestation of TDH at the T11–L1 level, particularly for calcified disc herniation.

Conservative management (exercise therapy, non-steroidal anti-inflammatory drugs, rehabilitation training, physical therapy) is sufficient for most asymptomatic patients. Surgical intervention is often necessary for symptomatic patients unresponsive to conservative treatment. The thoracic spinal canal has a significantly smaller volume than the lumbar spine, resulting in limited operating space; its proximity to critical thoracic organs (e.g., heart, lungs) also makes TDH surgery relatively high-risk.

However, with the growing emphasis on minimally invasive principles, TDH surgery has gradually shifted toward less invasive techniques, with a relative reduction in surgical risks. Current minimally invasive surgical options for TDH include video-assisted thoracoscopic thoracic discectomy[15], microscopic thoracic discectomy[16], microendoscopic thoracic discectomy[17], percutaneous transforaminal endoscopic thoracic discectomy[18], and UBE thoracic discectomy.[19] Following traditional thoracotomy, up to 50% of patients develop post-thoracotomy intercostal neuralgia, a chronic condition. Notably, 30% of patients continue to experience pain four to five years postoperatively, with some even losing their ability to work due to severe pain.[20] In a comparative study of three surgical approaches—video-assisted thoracoscopic surgery (VATS), thoracotomy, and posterior costotransversectomy—Landreneau *et al.*[21] concluded that VATS significantly reduces the incidence of intercostal neuralgia and better facilitates patients' return to normal daily life. However, VATS is associated with a long learning curve and significant respiratory complications, including pleural effusion, atelectasis, pneumonia, and pneumothorax. Microscopic thoracic discectomy involves accessing the thoracic spinal canal with greater precision through a small incision under microscopic guidance, enabling discectomy and spinal canal decompression. Bartel and Peul[16] reviewed their cases of TDH treated with VATS and microscopic minimally invasive small-incision techniques, finding that microscopic thoracic discectomy is equally effective for spinal canal decompression. This approach offers a three-dimensional surgical view similar to open surgery and features a shorter learning curve. In 2004, Perez-Cruet *et al.*[17] developed a novel minimally invasive technique for TDH: thoracoscopic microendoscopic discectomy, which represents an advancement of lumbar microendoscopic discectomy technology. The approach was performed on seven patients, with an average single-level operative time of 1.7 h and an average intraoperative blood loss of 111 mL. At a mean follow-up of nine months, the "excellent and good" rate was 85.7% according to the modified Prolo scale. No relevant complications were observed postoperatively, and most patients resumed normal life and work within three weeks. Nevertheless, thoracoscopic microendoscopic discectomy still has limitations, including a steep learning curve and limited surgical working space.

Since the first application of endoscopic spinal surgery for lumbar disc herniation in the 1980s, its indications have expanded significantly, now encompassing the treatment of cervical spinal stenosis, cervical disc herniation, and TDH.[18] Under local anesthesia, the transforaminal approach provides a safe surgical corridor to the thoracic spinal canal. Percutaneous endoscopic transforaminal thoracic discectomy is an effective method for treating TDH. However, it is constrained by limited working space, which may prevent complete disc removal and increase

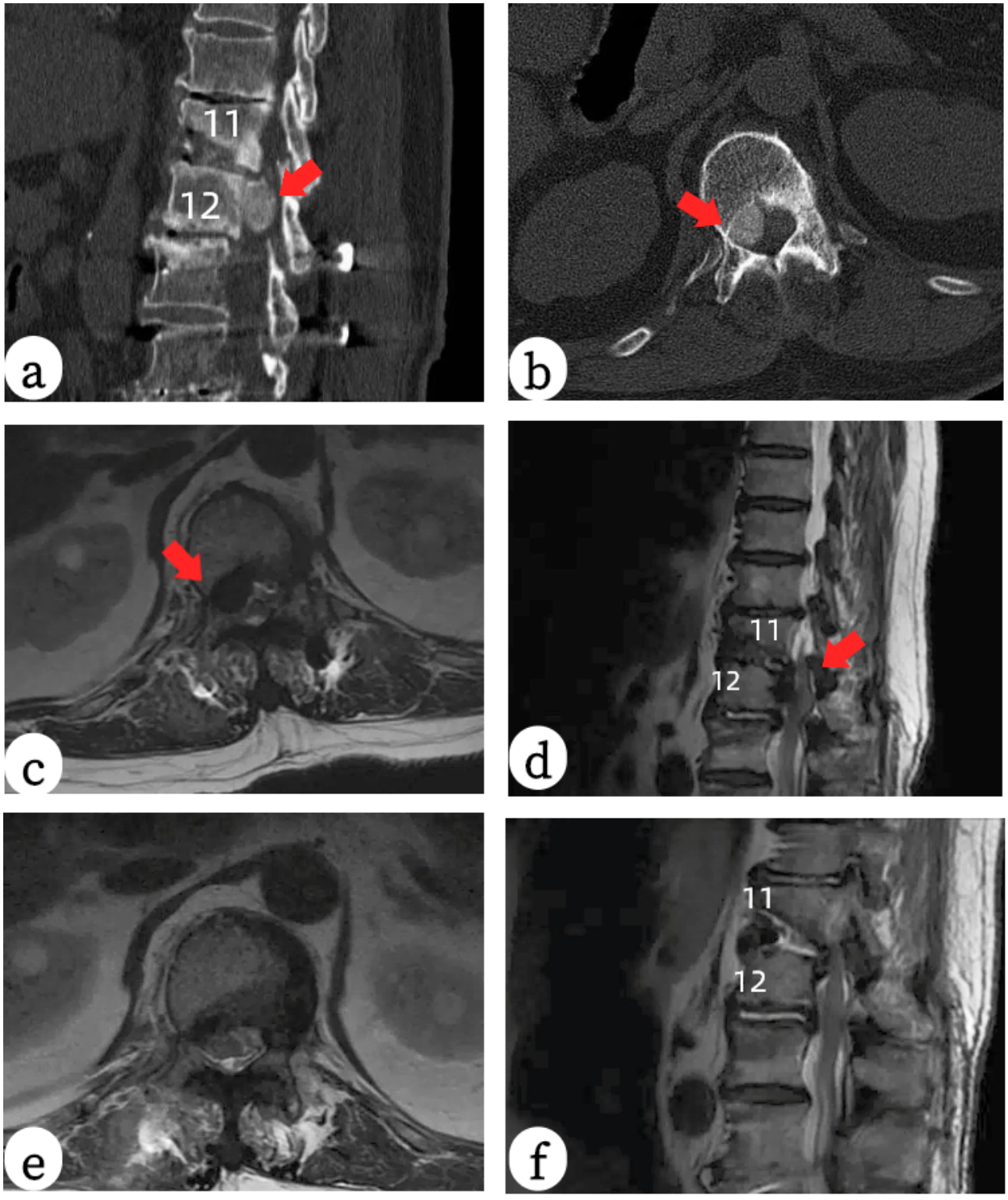


Figure 3. Preoperative and postoperative imaging findings of an 80-year-old female patient (Patient 1) with calcified thoracic disc herniation at the T11/12 level. (a,b) Preoperative computed tomography scans demonstrating calcified disc herniation protruding into the spinal canal, resulting in ventral spinal cord compression at the T11/12 level. (c,d) Preoperative T2-weighted magnetic resonance imaging (MRI) confirming severe spinal cord compression and compromised epidural space caused by the calcified herniated disc. (e,f) Postoperative T2-weighted MRI illustrating complete resection of the calcified disc fragment, adequate neural decompression, restored dural sac expansion, and no residual disc compression or spinal cord impingement at the T11/12 level.

the risk of recurrence. Furthermore, the technique poses significant challenges in managing central and calcified disc herniations. Minimally invasive approaches for TDH are also categorized as posterior, posterolateral, lateral, or anterior transperitoneal thoracoscopic surgery.[22] The anterior approach is associated with significantly higher complication rates, mortality, longer hospital stays, and increased costs due to the need to expose vital thoracic organs (e.g., lungs, heart, major arteries).[23] In contrast, the posterior or lateral approach inevitably carries risks of thoracic lung injury, spinal cord injury, paravertebral muscle damage, and excessive bone resection—complications that may lead to postoperative back pain or spinal instability.[24]

Unilateral biportal endoscopic technology is a rapidly advancing spinal endoscopic platform widely used for the treatment of lumbar degenerative diseases (e.g., lumbar spinal stenosis, lumbar disc herniation). With ongoing technological advancements, this technique has also achieved significant breakthroughs in treating cervical and thoracic degenerative conditions.[25,26] Hahn *et al.*[19] treated two patients with TDH using UBE and reported no symptom recurrence during a 27-month follow-up, concluding that UBE is a feasible and effective surgical method for TDH, providing high-precision visualization and a safe surgical field. In comparison, full-endoscopic technology for TDH is also safe and effective[18] but has a steeper learning curve than other endoscopic techniques.[27] Additionally, the limited operating space of single-channel systems may lead to residual disc tissue and recurrence risks, and these systems face greater challenges in managing central and calcified herniations. The UBE-FPA used in the present study differs from the conventional UBE paraspinal approach (which uses 1 cm vertical incisions at the midline of two transverse processes, 2 cm lateral to the pedicle margin)[28]; instead, it incorporates the design concept of percutaneous transforaminal endoscopy, featuring a larger lateral offset from the midline (>6 cm) and a more obtuse lateral angle of the working channel.[29] Hwang *et al.*[30] have effectively treated upper lumbar disc herniations using UBE far-lateral transforaminal lumbar discectomy, achieving favorable patient outcomes and demonstrating advantages in preserving facet joints and reducing the risk of neurological deficit from nerve retraction.

The ideal goal of thoracic discectomy is to achieve adequate decompression and disc removal without spinal cord manipulation, while minimizing injury to paravertebral muscles and facet joints. Therefore, the incision design for UBE-FPA in the thoracic spine is individualized. The presence of ribs and the thoracic cavity limits incision lateral offset; however, a larger channel lateral angle can facilitate access to the intervertebral foramen and minimize bony resection. Thus, when designing the thoracic surgical incision, the approximate entry site can be determined as the intersection of the line connecting the surgical target and the dorsal rib tangent point on preoperative imaging cross-sections—this technique maximizes lateral offset (Figure 4). Preoperative imaging localization (using the line connecting the surgical target and the dorsal rib tangent point) optimizes the working channel's lateral angle, directing the cannula tip toward the vertebral arch isthmus. Only minimal bony resection is required for foraminoplasty, eliminating the need for spinal cord retraction while reducing damage to paravertebral muscles and facet joints, thereby preserving spinal stability. Furthermore, the observation channel in the dual-channel system provides high-definition visualization, enabling clear identification of the anatomical relationship between the exiting nerve root and herniated disc. Combined with intraoperative neuroelectrophysiological monitoring, this further reduces the risk of nerve injury.

In summary, the UBE-FPA for the treatment of TDH offers the following advantages. Compared with the interlaminar approach, it better preserves the facet joints and effectively prevents postoperative segmental spinal instability. Additionally, relevant studies[31,32] have indicated that although the contralateral approach can preserve the facet joints, it has limitations, such as the need for intraoperative thecal sac retraction, and residual herniated material may persist postoperatively, especially when treating central disc herniation. In contrast, UBE-FPA allows for the resection of paracentral or even central disc herniation without thecal sac retraction. This is because the far-lateral approach enables the endoscope and instruments to be inserted at a shallow angle, accessing the central region of the intervertebral disc through the neural foramen with only minimal thecal sac retraction. Additionally, the narrow lamina of the thoracic spine results in a short distance from the foraminal zone to the central zone, facilitating the resection of central disc herniation. Thirdly, it allows clear visualization of the ventral aspect of the thecal sac, facilitating confirmation of complete resection of the herniated material and preventing residual material. Percutaneous endoscopic transforaminal thoracic discectomy and UBE thoracic discectomy share the same advantages, including facet joint preservation, reduced neural retraction, and clear visualization of the ventral thecal sac. However, the former is a uniportal endoscopic surgery, while the latter is a biportal endoscopic surgery. The biportal design decouples the endoscope and instruments, enhancing instrument maneuverability. Meanwhile, compared with the uniportal technique, it has a less steep learning curve. Currently, there is a lack of relevant studies

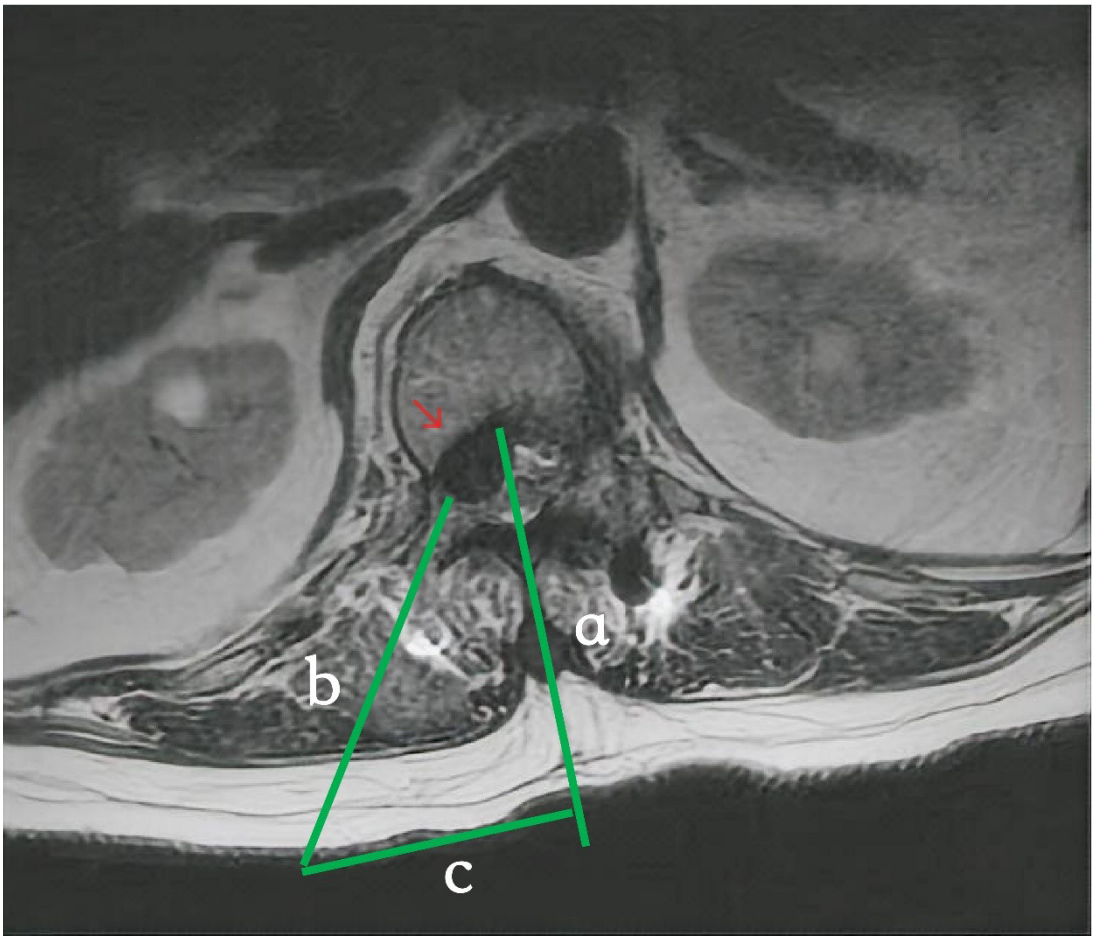


Figure 4. Preoperative radiology-based lateral offset planning diagram. The arrow indicates the herniated disc (surgical target). Line a represents the midline of the spine. Line b denotes the extension line from the connection between the surgical target and the dorsal rib tangent point to the body surface. Line c indicates the lateral offset distance from the midline to the planned incision site.

directly comparing the advantages and disadvantages of UBE-FPA and microscopic thoracic discectomy, indicating a need for such studies. However, this study is a case series and cannot realize such a comparison. Nevertheless, numerous studies have compared the uniportal technique with microscopic techniques[33–35], all of which indicate that the uniportal technique is more minimally invasive, with shorter hospital stays and faster return to work for patients. As a technique with a similar concept to the uniportal technique, UBE-FPA may also be less invasive than microscopic discectomy, but further relevant studies are still required to verify this. The absence of nerve injury complications in all five patients in the present study is attributed to the unique anatomical design and dual-channel technical advantages of UBE-FPA. It is noteworthy that one patient (an 80-year-old female) required prolonged postoperative bed rest due to individual factors, such as preoperative neurological impairment and advanced age. The patient had grade 2 preoperative muscle strength, a one-year history of low back pain with one month of worsening symptoms, and prolonged nerve compression. Although muscle strength improved to grade 3+ three days postoperatively, this was insufficient to support independent ambulation. Additionally, the 80-year-old patient had poor neurological function, impaired vascular regulation, and lower limb muscle atrophy due to prolonged bed rest; early ambulation posed a significant fall risk, leading to the clinical decision to extend bed rest until stable muscle strength was achieved.

Although the UBE-FPA offers many advantages, it has certain limitations. Since the skin incision and the entrances to the two portals (endoscopic and working) are both far from the midline, the surgical corridor from the skin incision to the working space is longer. The endoscope and instruments must pass through additional paraspinal muscles, limiting maneuverability. Additionally, the water flow must be drained through the long corridor, which is prone to poor drainage, leading

to muscle edema and postoperative lumbodorsal pain. Although no severe complications occurred in this study, UBE-FPA may be associated with the following potential complications. Firstly, an incomplete resection of the herniated disc segment, with residual nucleus pulposus tissue or secondary discal cyst formation postoperatively. This situation mostly occurs when the herniated material migrates upward beyond the inferior border of the upper pedicle or downward beyond the superior border of the lower pedicle, i.e., when the herniated material is located at the medial edge of the pedicle—a blind spot that cannot be visualized by UBE-FPA. Therefore, it is recommended to classify this scenario as a relative contraindication for the procedure. Secondly, dural tear is the most common complication in UBE spine surgery.[36,37] Although no such case occurred in this study, surgeons must remain vigilant and take preventive measures at all times. If a dural tear occurs, prompt management with a dural sealant patch, sutureless nonpenetrating vascular clips, or primary direct suturing should be performed.[38–40] However, the long surgical corridor of this approach makes direct suturing particularly challenging, and the large lateral distance from the midline prevents conversion to open surgery along the original trajectory. Thus, preventing dural tears is of utmost importance. Thirdly, caution should be exercised to avoid injury to nerve roots by dilators. When establishing the two portals, dilators need to be inserted and docked at the isthmus of the upper vertebra of the index segment. Due to the shallow angle and long corridor of the surgical approach, inexperienced surgeons are prone to inadvertently injuring the exiting nerve root. Additionally, care must be taken to prevent endoscopic instruments from entering the retroperitoneal space or thoracic cavity, which could lead to postoperative fluid collection or hematoma.[41] To avoid such complications, the endoscope and instruments should be initially docked at the isthmus of the upper vertebra, with intermittent confirmation of their position using C-arm fluoroscopy during the operation.

Furthermore, meticulous preoperative planning is essential when managing calcified TDH with UBE-FPA. During intraoperative handling of calcified discs, the endoscope is angled to visualize the ventral dural space. A burr creates a space at the posterior endplate margin and within the vertebral body, facilitating direct visualization of ventral disc resection. Central or calcified disc fragments are displaced downward into the intervertebral space using a curved dissector and then removed with forceps. If severe adhesion exists between the herniated disc and dural sac, separation attempts should be avoided; instead, a burr thins the calcified disc portion adherent to the dura, leaving a posterior shell. This maneuver, referred to as the "floating technique," provides indirect and direct decompression from ventral to dorsal, effectively avoiding spinal cord contact.

The present study has several limitations. The small sample size (n = 5) and single-center retrospective design may introduce selection bias, limiting the generalizability of the results. The relatively short follow-up duration (mean: 9.4 months) prevents evaluation of long-term spinal stability and adjacent segment degeneration. The technique has limited applicability for patients with severe spinal deformity or large calcified herniations, which present significant surgical challenges. Despite the small sample size, the paired sample t-test minimized individual variability through a self-preoperative–postoperative comparison, and the Shapiro–Wilk test confirmed normal data distribution, ensuring the reliability of the statistical results. Future large-scale, multi-center prospective studies with extended follow-up are needed to further validate the long-term efficacy of this technique.

5. Conclusion

Unilateral biportal endoscopic discectomy via the FPA is a safe and effective minimally invasive procedure for TDH, offering distinct advantages such as low nerve injury risk, spinal stability preservation, and rapid postoperative recovery. This approach provides a novel minimally invasive therapeutic option for central, paracentral, and calcified TDH, particularly for patients who cannot tolerate thoracotomy or for whom traditional minimally invasive techniques are technically challenging. However, due to the small sample size and short follow-up duration of the present study, the long-term efficacy of UBE-FPA requires further validation in large-scale prospective studies.

Acknowledgments

We thank the clinical research team of the Department of Orthopaedics at The First Affiliated Hospital of Jinan University for the comprehensive implementation of this research, and the nursing staff for their meticulous perioperative care of the patients.

Funding

This work was financially supported by the Macao Medical Technology Research Association (Fund source: Macao Science and Technology Development Fund; initiated by the First Affiliated Hospital of Jinan University; grand no.: 0003/2024/RIB1). The project funding was specifically used for the clinical research of this study, including clinical data collection, sorting, and statistical analysis.

Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Ziqiao Liu, Hao Wu, Lekhang Cheang
Formal analysis: Ziqiao Liu, Yuhao Yang
Investigation: Ying Xiao, Yuhao Yang
Methodology: Hao Wu, Lekhang Cheang
Writing–original draft: Ziqiao Liu
Writing–review & editing: Hao Wu, Lekhang Cheang

Ethics approval and consent to participate

This retrospective study was approved by the Scientific Research Ethics Committee of The First Affiliated Hospital of Jinan University (Approval no.: KY-2026-022). Requirement for informed consent was waived due to the study's retrospective nature, in accordance with the Declaration of Helsinki.

Consent for publication

The Scientific Research Ethics Committee of The First Affiliated Hospital of Jinan University waived the requirement for publication consent for this retrospective study. All patient information included in the study has been de-identified to protect privacy.

Availability of data

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Arce CA, Dohrmann GJ. Herniated thoracic disks. *Neurol Clin*. 1985;3(2):383-392.

   doi: 10.1016/S0733-8619(18)31043-0

2. Rodrigo V, Corral P, Mesa-Guzmán M, *et al*. Evolution of Video Assisted Thoracoscopic Surgery for Thoracic Disc Herniation: Towards Biportal Thoracoscopic Approach. *World Neurosurg*. 2024;192:59-62.

   doi: 10.1016/j.wneu.2024.09.022

3. Whitmore RG, Williams BJ, Lega BC, *et al*. A patient with thoracic intradural disc herniation. *J Clin Neurosci*. 2011;18(12):1730-1732.

   doi: 10.1016/j.jocn.2011.04.021

4. Kang Y, Yang Y, Zhang H, *et al*. Applying ultrasonic osteotome to treat thoracic ossification of ligamentum flavum combined with thoracic disc herniation: A case report. *Asian J Surg*. 2024;47(4):1855-1856.

   doi: 10.1016/j.asjsur.2023.12.163

5. Ziechmann R, Pathak SM, Kim BS. Combined Microscopic Tubular and Endoscopic Approach for Calcified Midline Thoracic Disc Herniation: A Bridge to Endoscopic Discectomy. *Cureus*. 2024;16(8):e66948.

   doi: 10.7759/cureus.66948

6. Perot PL, Munro DD. Transthoracic removal of midline thoracic disc protrusions causing spinal cord compression. *J Neurosurg*. 1969;31(4):452-458.

   doi: 10.3171/jns.1969.31.4.0452

7. Feng ZH, Zhao ZH, Cui W, *et al*. Unilateral biportal endoscopic discectomy versus microdiscectomy for lumbar disc herniation: a systematic review and meta-analysis. *Eur Spine J*. 2024;33(6):2139-2153.

   doi: 10.1007/s00586-023-08116-2

8. Park DY, Upfill-Brown A, Curtin N, *et al*. Clinical outcomes and complications after biportal endoscopic spine surgery: a comprehensive systematic review and meta-analysis of 3673 cases. *Eur Spine J*. 2023;32(8):2637-2646.

   doi: 10.1007/s00586-023-07701-9

9. Kwon O, Yoo SJ, Park JY. Comparison of Unilateral Biportal Endoscopic Discectomy with Other Surgical Technics: A Systemic Review of Indications and Outcomes of Unilateral Biportal Endoscopic Discectomy from the Current Literature. *World Neurosurg*. 2022;168:349-358.

   doi: 10.1016/j.wneu.2022.06.153

10. Dützmann S, Rosenthal D. Thorakaler Bandscheibenvorfall [Thoracic disc herniation]. *Orthopädie*. 2024;54(1):18-25.

    doi: 10.1007/s00132-024-04585-5

11. Farber SH, Walker CT, Zhou JJ, *et al*. Reliability of a Novel Classification System for Thoracic Disc Herniations. *Spine*. 2024;49(5):341-348.

    doi: 10.1097/brs.0000000000004701

12. Quint U, Bordon G, Preissl I, *et al*. Thoracoscopic treatment for single level symptomatic thoracic disc herniation: a prospective followed cohort study in a group of 167 consecutive cases. *Eur Spine J*. 2012;21(4):637-645.

    doi: 10.1007/s00586-011-2103-0

13. Court C, Mansour E, Bouthors C. Thoracic disc herniation: Surgical treatment. *Orthop. Traumatol.-Surg. Res*. 2018;104(1):S31-S40.

    doi: 10.1016/j.otsr.2017.04.022

14. Cong M, Si M, Hou Y, *et al*. Foot drop as the initial symptom caused by thoracic disc herniation. *Eur Spine J*. 2022;31(7):1795-1801.

    doi: 10.1007/s00586-022-07254-3

15. Kim SJ, Sohn MJ, Ryoo JY, *et al*. Clinical analysis of video-assisted thoracoscopic spinal surgery in the thoracic or thoracolumbar spinal pathologies. *J Korean Neurosurg Soc*. 2007;42(4):293-299.

doi: 10.3340/jkns.2007.42.4.293

16. Bartels R, Peul WC. Mini-thoracotomy or thoracoscopic treatment for medially located thoracic herniated disc?. *Spine*. 2007;32(20):E581-E584.

doi: 10.1097/brs.0b013e31814b84e1

17. Perez-Cruet MJ, Kim BS, Sandhu F, *et al*. Thoracic microendoscopic discectomy. *J Neurosurg-Spine*. 2004;1(1):58-63.

doi: 10.3171/spi.2004.1.1.0058

18. Barber SM, Huang M. Full Endoscopic Transforaminal Thoracic Discectomy Operative Technique. *J Vis Exp*. 2024;(203).

doi: 10.3791/65951

19. Hahn BS, Park CK, Hwang JS, *et al*. Unilateral Biportal Endoscopic Discectomy for Upper Thoracic Herniated Discs (T1-2): A Case Report and Technical Notes. *J Minim Invasive Spine Surg Tech*. 2025;10:S14-S19.

doi: 10.21182/jmisst.2024.01564

20. Karmakar MK, Ho AM. Postthoracotomy pain syndrome. *Thorac Surg Clin*. 2004;14(3):345-352.

doi: 10.1016/s1547-4127(04)00022-2

21. Landreneau RJ, Mack MJ, Hazelrigg SR, *et al*. Prevalence of chronic pain after pulmonary resection by thoracotomy or video-assisted thoracic surgery. *J Thorac Cardiovasc Surg*. 1994;107(4):1079-1086.

doi: 10.1016/s0022-5223(94)70384-1

22. Sharma SB, Kim JS. A Review of Minimally Invasive Surgical Techniques for the Management of Thoracic Disc Herniations. *Neurospine*. 2019;16(1):24-33.

doi: 10.14245/ns.1938014.007

23. Yoshihara H, Yoneoka D. Comparison of in-hospital morbidity and mortality rates between anterior and nonanterior approach procedures for thoracic disc herniation. *Spine*. 2014;39(12):E728-E733.

doi: 10.1097/brs.0000000000000322

24. Roelz R, Scholz C, Klingler JH, *et al*. Giant central thoracic disc herniations: surgical outcome in 17 consecutive patients treated by mini-thoracotomy. *Eur Spine J*. 2016;25(5):1443-1451.

doi: 10.1007/s00586-016-4380-0

25. Sun HT, Zhang Q, Xu KH, *et al*. A retrospective study on safety and clinical outcomes of unilateral biportal endoscopic technique for spinal degenerative diseases. *PeerJ*. 2025;13.

doi: 10.7717/peerj.19076

26. Park MK, Park D, Son SK. Unilateral Biportal Endoscopic Decompression for Thoracic Spinal Stenosis. *J Minim Invasive Spine Surg Tech*. 2023;8(1):82-88.

doi: 10.21182/jmisst.2023.00696

27. Choi G, Munoz-Suarez D. Transforaminal Endoscopic Thoracic Discectomy: Technical Review to Prevent Complications. *Neurospine*. 2020;17(1):S58-S65.

doi: 10.14245/ns.2040250.125

28. Ahn JS, Lee HJ, Choi DJ, *et al*. Extraforaminal approach of biportal endoscopic spinal surgery: a new endoscopic technique for transforaminal decompression and discectomy. *J Neurosurg-Spine*. 2018;28(5):492-498.

doi: 10.3171/2017.8.SPINE17771

29. Telfeian AE, Wagner R. Transforaminal endoscopic thoracic discectomy: surgical technique. *J Spine Surg*. 2023, 9(2):166-175.

doi: 10.21037/jss-22-109

30. Hwang JS, Lee SH, Jeong D, *et al*. Far-Lateral Transforaminal Unilateral Biportal Endoscopic Lumbar Discectomy for Upper Lumbar Disc Herniations. *Neurospine*. 2025;22(1):14-27.

doi: 10.14245/ns.2550058.029

31. Jha RT, Syed HR, Catalino M, *et al*. Contralateral Approach for Minimally Invasive Treatment of Upper Lumbar Intervertebral Disc Herniation: Technical Note and Case Series. *World Neurosurg*. 2017;100:583-589.

doi: 10.1016/j.wneu.2017.01.059

32. Heo DH, Lee N, Park CW, *et al*. Endoscopic Unilateral Laminotomy with Bilateral Discectomy Using Biportal Endoscopic Approach: Technical Report and Preliminary Clinical Results. *World Neurosurg*. 2020;137:31-37.

doi: 10.1016/j.wneu.2020.01.190

33. Qin R, Liu B, Hao J, *et al*. Percutaneous Endoscopic Lumbar Discectomy Versus Posterior Open Lumbar Microdiscectomy for the Treatment of Symptomatic Lumbar Disc Herniation: A Systemic Review and Meta-Analysis. *World Neurosurg*. 2018;120:352-362.

doi: 10.1016/j.wneu.2018.08.236

34. Jarebi M, Awaf A, Lefranc M, *et al*. A matched comparison of outcomes between percutaneous endoscopic lumbar discectomy and open lumbar microdiscectomy for the treatment of lumbar disc herniation: a 2-year retrospective cohort study. *Spine J*. 2021;21(1):114-121.

doi: 10.1016/j.spinee.2020.07.005

35. Ruan W, Feng F, Liu Z, *et al*. Comparison of percutaneous endoscopic lumbar discectomy versus open lumbar microdiscectomy for lumbar disc herniation: A meta-analysis. *Int J Surg*. 2016; 31:86-92.

doi: 10.1016/j.ijsu.2016.05.061

36. Ju CI, Lee SM. Complications and Management of Endoscopic Spinal Surgery. *Neurospine*. 2023;20(1):56-77.

doi: 10.14245/ns.2346226.113

37. Lee SH, Seo J, Jeong D, *et al*. Clinical Outcomes and Complications of Unilateral Biportal Endoscopic Posterior Cervical Foraminotomy: A Systematic Review and Meta-Analysis With a Comparison to Full-Endoscopic Posterior Cervical Foraminotomy. *Neurospine*. 2024;21(3):807-819.

doi: 10.14245/ns.2448430.215

38. Heo DH, Ha JS, Lee DC, *et al*. Repair of Incidental Durotomy Using Sutureless Nonpenetrating Clips via Biportal Endoscopic Surgery. *Global Spine J*. 2022;12(3):452-457.

doi: 10.1177/2192568220956606

39. Nam HGW, Kim HS, Park JS, *et al*. Double-Layer TachoSil Packing for Management of Incidental Durotomy During Percutaneous Stenoscopic Lumbar Decompression. *World Neurosurg*. 2018;120:448-456.

doi: 10.1016/j.wneu.2018.09.040

40. Shin JK, Youn MS, Seong YJ, *et al*. Iatrogenic dural tear in endoscopic lumbar spinal surgery: full endoscopic dural suture repair (Youn's technique). *Eur Spine J*. 2018;27(S3):544-548.

doi: 10.1007/s00586-018-5637-6

41. Ahn Y, Kim JU, Lee BH, *et al*. Postoperative retroperitoneal hematoma following transforaminal percutaneous endoscopic lumbar discectomy. *J Neurosurg Spine*. 2009;10(6):595-602.

doi: 10.3171/2009.2.SPINE08227