Transcostal Microendoscopic Discectomy for Central Thoracic Disc Herniation Causing Myelopathy: A Technical Note

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Abstract:

Introduction: Minimally invasive surgical treatment of myelopathy caused by central thoracic disc herniation (TDH) is challenging to carry out because reaching the herniation site is difficult and the thoracic spinal cord is fragile. In this study, using the posterior-lateral approach for central TDH with myelopathy, we present a novel procedure of transcostal microendoscopic discectomy (TCMED).

Technical Note: The patient was operated in a prone position under general anesthesia. At a preoperatively determined distance from the midline, an 18-mm-long longitudinal incision was conducted, and using a 25-degree microendoscope, the operation was carried out. The endoscope was placed at an inward angle of approximately 50 degrees in the vertical direction. The ribs adjacent to the disc were identified, and the disc was exposed by resecting the ribs using a surgical high-speed drill while preserving the cortical bone of the ribs on the pleural side. The herniation was identified by drilling the ventral side of the disc and was then successfully removed. After discectomy, the dura mater expanded ventrally.

Three male patients (mean age, 47.3 years) were treated, with 20 weeks of follow-up on average, 237.7-min mean operative time, and 26.7-mL mean blood loss. The average preoperative modified Japanese Orthopedic Association score was 5.2/11, which improved to 9.5/11 postoperatively, with a 75.6% average recovery rate. The 10-s step test score improved from an average of eight times preoperatively to 20 times postoperatively. No serious perioperative or postoperative complications or residual rib pain were observed.

Conclusions: The proposed TCMED approach for treating central TDH that causes myelopathy allows for safe access to the level of the posterior vertebral wall using the rib as a landmark for resecting the rib head without opening the chest. Using the angled microendoscope and curved surgical instruments, the central TDH, located ventral to the spinal canal, can then be safely and effectively resected without spinal cord retraction.

Keywords:

transcostal approach, thoracic microendoscopic discectomy, central thoracic disc herniation, minimally invasive spine surgery, myelopathy, rib resection

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Introduction

Even though disc herniation occurs at a frequency of 40-50 per 100,000 people, thoracic disc herniation (TDH) is rare, with an estimated frequency of 1 per million[1,2]. Surgery for TDH accounts for only 0.15%-4% of all herniated disc surgeries[3]; surgical treatment of TDH is generally challenging because of the technical difficulties involved and the risk of serious and difficult-to-treat complications[3]. To overcome these issues, several surgical approaches have been proposed to treat TDHs. These are broadly divided into posterior[4-7] and anterior[8-10] approaches. Furthermore, excellent minimally invasive endoscopic techniques have recently been reported for the posterior[11-14] and anterior[1,15,16] approaches with good results.

Nevertheless, surgical treatment for myelopathy caused by TDH has shown poor recovery of motor function, even with these treatment strategies[17,18], which indicates that treating this pathology is challenging. The reasons for this include the anatomic characteristics of the herniation being located centrally in patients with TDH-causing myelopathy, which hinders access to the lesion which is located almost com-

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Figure 1. In the thoracic spine magnetic resonance images (MRI) sagittal image of a 40-year-old man with muscle weakness in both lower extremities, a T2-weighted image shows a central herniation with high intensity in the spinal cord at the T5/T6 level (a). In the axial image at T5/T6, the thoracic cord is compressed by a central herniation (b).

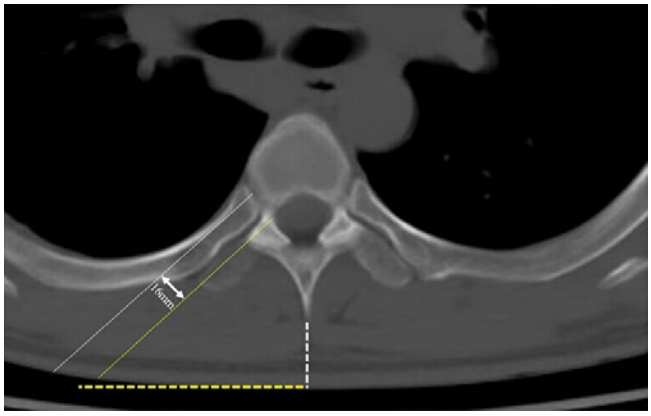

Figure 2. In plain computed tomography (CT) of the thoracic spine, no ossification or calcification lesions are seen. An entry point for the microendoscopy was pre-drawn on CT. Two parallel lines (white and yellow solid lines) show the diameter of the microendoscopic cylindrical retractor, 16 mm wide; the white solid line was drawn along the cortical bone on the thoracic cavity side of the rib, at approximately 50 degrees inward to the perpendicular line. The distance (length of yellow dashed line) from the midline (white dashed line) to the location of the microendoscopic cylindrical retractor was measured.

pletely ventral to the spinal cord, and the fragility of the thoracic spinal cord[19]. The anterior endoscopic approach for this difficult pathology is limited by the transthoracic approach and the use of special instruments[15]. Nevertheless, Perez-Cruet et al. and Isaac et al. described a microendoscopic technique via the facet using a posterolateral approach[11,14]. Nevertheless, whether this approach can allow safe and reliable access to lesions that are located almost completely ventral to the spinal cord is uncertain. Thus, a gold standard minimally invasive surgical technique for central thoracic disc herniation remains to be established. Given the need for a more lateral approach to access the anterior spinal cord using the posterior method, we developed a new transcostal microendoscopic discectomy (TCMED) method for central TDH-causing myelopathy. This article introduces this new technique and evaluates its clinical outcomes.

Technical Note

We developed the following procedure for a case of central TDH at the T5-T6 level (Fig. 1). TCMED was carried out by a board-certified microendoscopic spinal surgeon approved by the Japanese Orthopedic Association. The entry point of the microendoscope was determined using computed tomography (CT) before the surgery (Fig. 2). Under general anesthesia, the patient was placed in a comfortable prone position on a Relton-Hall frame under intraoperative spinal cord monitoring. An 18-mm-long longitudinal skin incision was made (approximately 8 cm to the right lateral to the midline in this case), and the fascia was incised. A dilator was inserted subsequently, and a 25-degree microendoscope (METRx endoscopic system; Medtronic Sofamor Danek, Memphis, TN, USA) was placed at an inward angle of approximately 50 degrees (Fig. 3). After blunt dissection and identification of the sixth rib and transverse process, using a surgical high-speed drill, the dorsal and ventral sides of the transverse process were resected (Fig. 4a). The costotransverse joint was identified (Fig. 4b) and resected using

a drill. On the more ventral side, the T6 superior articular process, the superior margin of the pedicle, and the exiting nerve root were identified (Fig. 4c). The T5/T6 intervertebral disc and ventral side of the dura mater were identified by drilling the costal head and the outer margin of the superior articular process and superior aspect of the pedicle partially. Disc herniation was identified by drilling a portion of the disc on the ventral side of the dura (Fig. 4d), and the herniated mass was removed (Fig. 4e). The dura mater expanded ventrally through the herniation resection (Fig. 4f). Using the C-arm to be in the proper position to remove the central herniation, the micro-rongeur was confirmed (Fig. 5). The wound was thoroughly washed, a drain was placed, and closed layer by layer. Postoperative magnetic resonance images showed that spinal cord decompression was achieved with sufficient herniation removal, and CT showed complete preservation of the right facet joint (Fig. 6).

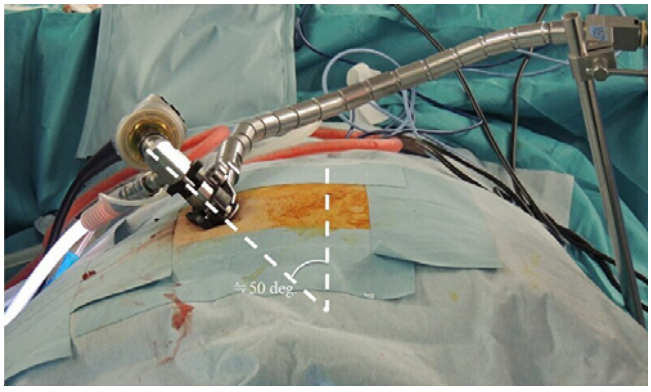

Figure 3. Exterior of the microendoscopic system and surgical field.

Clinical results

Table 1 summarizes the patient demographics. Three male patients with a mean age of 47.3 years and a mean BMI of 31.8 kg/m^2 underwent the procedure. The mean follow-up duration was 20.0 weeks. All patients had TDH in the mid-thoracic spine. Table 2 summarizes the perioperative and final clinical outcomes. The mean operative time was 237.7 min, the mean blood loss was 26.7 mL, and the mean hospital stay was 9.7 days. We evaluated the following: 1) modified Japanese Orthopedic Association scoring system for the evaluation of cervical compression myelopathy (mJOA score) (Table 3) and the 10-s step test by Ogawa et al. before surgery and at the final observation[20] (total score for a healthy individual, 11); 2) recovery rates using Hirabayashi's method: (postoperative mJOA score−preoperative mJOA score)×100/(11−preoperative mJOA score); and 3) perioperative and postoperative complications. The mean preoperative mJOA score was 5.2/11, which improved to 9.5/11 postoperatively, with an average recovery rate of 75.6%. The 10-s step test score improved from an average of eight times preoperatively to 20 times at the final observation. No serious perioperative or postoperative complications were observed. None of the patients complained of rib pain during breathing or coughing at the last observation. This is the first report of transcostal-access MED for central TDH with myelo-

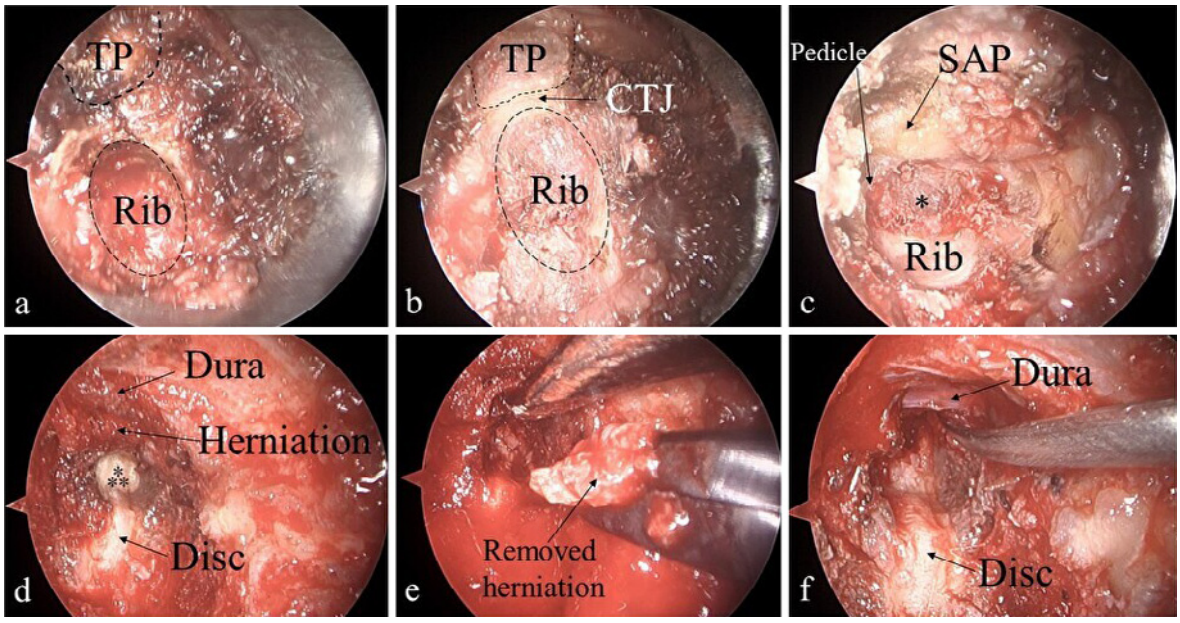

Figure 4. Microendoscopic images taken during surgery. Bone resection of the ribs was carried out in a manner that preserved cortical bone on the thoracic side, gradually reaching a deeper level (a–c). The foramen (asterisk) was observed in the area surrounded by the SAP, pedicle, and rib (c). When the rib heads had been resected, the vertebral bodies and the disc at T5/T6 were exposed; however, the central disc herniation could not be observed at this point (d). The herniation lesion was confirmed by resecting the posterior portion of the disc with a 4-mm-diameter high-speed drill (asterism). The herniation was removed until the ventral expansion of the dura mater was seen (e, f).
TP, transverse process; CTJ, costotransverse joint; SAP, superior articular process

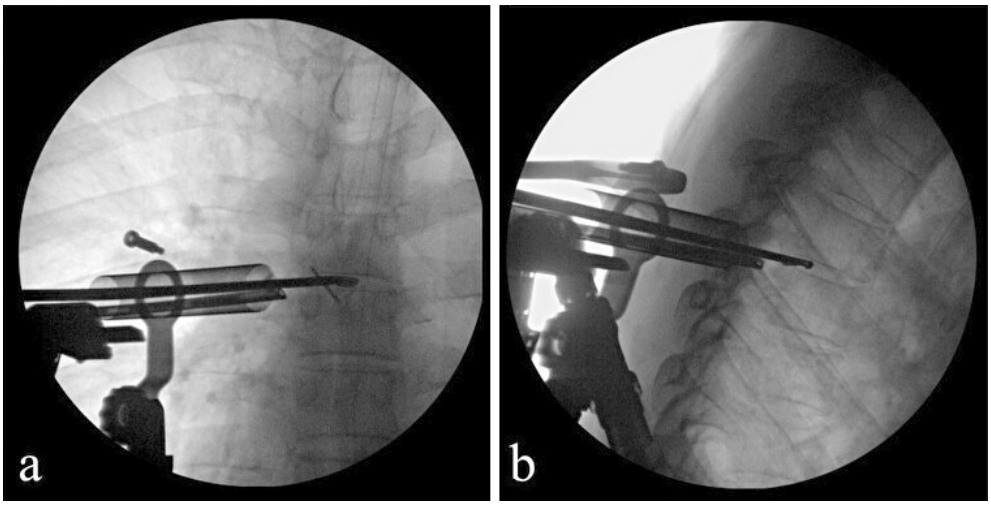

Figure 5. Radiographs of the frontal (a) and lateral (b) view by the C-arm show that the micro-rongeur is inserted in the proper position to remove the central herniation.

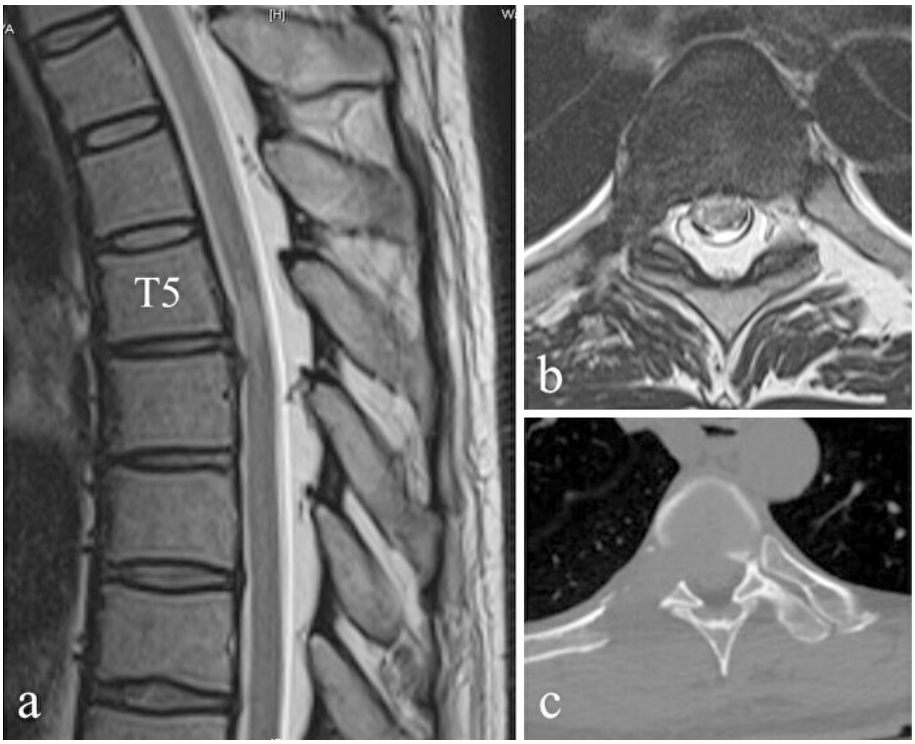

Figure 6. Postoperative magnetic resonance images show adequate removal of the herniation (a, b), and computed tomography shows bone resection on the preoperatively planned course with almost complete preservation of the right facet joint (c).

pathy, which demonstrates good clinical outcomes.

Discussion

Whether the anterior or posterior method is more useful in the surgical treatment of TDH remains controversial[21-23]. In clinical practice, surgeons choose the surgical method based on the level of the TDH, its size, presence or absence of calcification, central or paracentral location, and radiculopathy or myelopathy, to choose the surgical method[17]. Patients with myelopathy caused by TDH show poor recovery of motor function[17,18], and no useful surgical procedure has been established as the gold standard. A TDH that results in myelopathy is almost always a central herniation that is challenging to reach anatomically. Therefore, a surgical approach is key to accomplishing safe and reliable minimally invasive surgery. The minimally invasive anterior methods reported in the past have disadvantages, such as the use of a transthoracic approach and the need for special long endoscopes and instruments[1,15,16]. By contrast, the posterolateral

Table 1. Patient Demographics.

Case	Age (years)	Sex	BMI (kg/m^2)	Treated level	Duration of follow-up (weeks)
1	51	Male	32.8	T7/8	27
2	40	Male	26.5	T5/6	21
3	51	Male	36.1	T8/9	12
Mean	47.3		31.8		20.0

BMI, body mass index

Table 2. Clinical Outcomes at the Perioperative and Final Observation.

Case	Operation time (min)	Blood loss (mL)	Duration of hospitalization (days)	mJOA score (_/11)			10-s step test[20]	
				Preoperative	At the final observation	Recovery rates (%)*	Preoperative	At the final observation
1	168	10	8	6	11	100	12	24
2	248	50	13	4.5	9.5	76.9	12	17
3	297	20	8	5	8	50.0	0	19
Mean	237.7	26.7	9.7	5.2	9.5	75.6	8	20

mJOA score; modified Japanese Orthopedic Association scoring system for evaluation of cervical compression myelopathy, *Hirabayashi's method: (postoperative mJOA score−preoperative mJOA score)×100/(11−preoperative mJOA score).

Table 3. Modified Japanese Orthopedic Association Scoring System for Evaluation of Cervical Compression Myelopathy (mJOA Score).

		mJOA Score
A Motor function of the lower extremity		0: Impossible to walk 1: Need cane or aid on flat ground 2: Need cane or aid only on stairs 3: Possible to walk without a cane or aid, but slow 4: Normal
B Sensory deficit	a) Lower extremity	0: Apparent sensory loss 1: Minimal sensory loss 2: Normal
	b) Trunk	0: Apparent sensory loss 1: Minimal sensory loss 2: Normal
C Sphincter dysfunction		0: Complete urinary retention 1: Severe disturbance 2: Mild disturbance 3: Normal

approach has been described as a minimally invasive posterior method[11-14]. Nevertheless, whether this approach can reach the lesion safely and reliably is questionable, considering the insertion angle of the microendoscope and the location of the lesion being completely ventral to the spinal cord. We believe that the ideal approach for central TDH that causes myelopathy is a posterior approach with maximal lateral access. This new approach makes it safer and easier to reach the anterior portion of the spinal cord, which may be the reason for the successful and favorable results. Imagama et al. reported a method for resecting a beak-type thoracic ossification of the posterior longitudinal ligament (RASPA)[24]. The RASPA is an open method of rib resection that allows for a safe anterior approach to the spinal cord. TCMED can be considered a microendoscopic procedure based on RASPA. This procedure can safely reach the posterior vertebral wall using the rib as a landmark to dig in and resect the rib head without opening the chest. Thereafter, the anterior spinal canal can be safely observed by approaching at an angle of approximately 50 degrees using a 25-degree angled microendoscope. Moreover, using the angled microendoscope and curved surgical instruments, without retracting the spinal cord, herniation anterior to the spinal canal can be safely resected (Fig. 7).

In the field of spine surgery, rib resection on the concave side of the thoracic curve has been employed to increase the

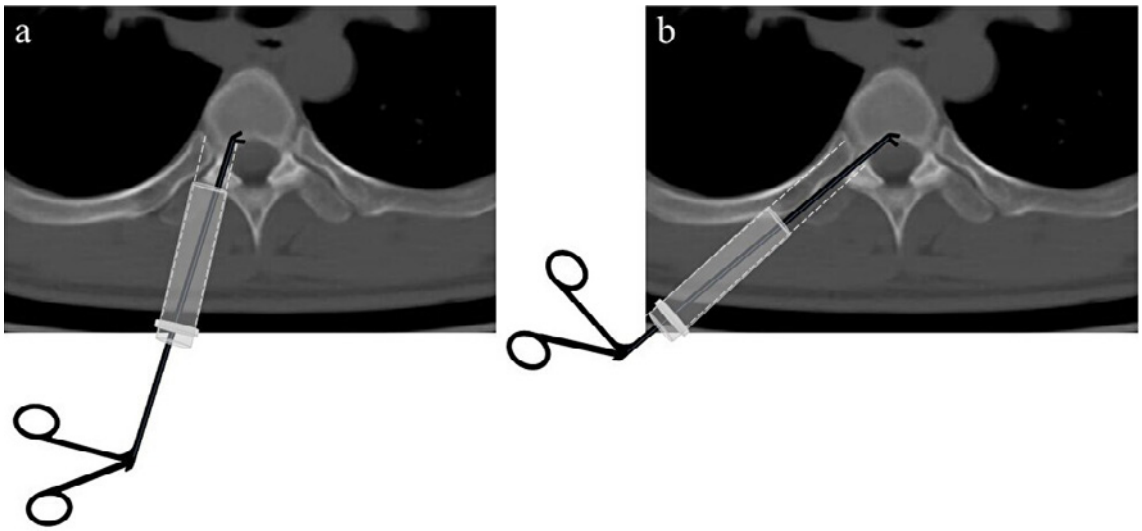

Figure 7. A schema of a conventional transfacet microendoscopic discectomy (MED) shows that reaching completely ventral to the spinal canal is difficult, even when using curved surgical instruments (a). In this approach, the spinal cord must be compressed laterally to remove the central herniation. By contrast, a schema of transcostal MED shows that the curved surgical instrument can safely and effectively reach anterior to the spinal canal without requiring spinal cord retraction (b).

rate of correction in corrective fusion surgery for adolescent idiopathic scoliosis[25]. The need for rib resection has also been described in the anterior transthoracic approach to TDH[9,26]. All patients included in the current study had mid-thoracic lesions and required almost full resection of the ribs. Moro et al. examined the relationship between the anterior approach and herniation level and stated that full resection is required for T9 and above, and that partial rib resection is required for T10 and below[27], which was consistent with the results of our study.

This study has some limitations. This was a retrospective evaluation of the clinical outcomes performed by a single surgeon at a single institution, and there was no control group. Furthermore, the number of cases was small. However, TDHs occur infrequently, and central herniations, in particular, are even less frequent[16-18]. Prospective multicenter studies are thus required to demonstrate the safety and utility of this technique. We think that this method facilitates the surgical treatment for paramedian herniation. Nevertheless, the approach and manipulation of herniation that is severely migrated to the cranial or caudal directions and calcified herniation with strong adhesion still have limitations. Despite the inclusion of obese patients with BMIs of 32.8 and 36.1 in this study, all surgeries were actually completed with only the normal scope and instruments. Nevertheless, this method may have a limitation in approach for severe obesity patients. When performing anterior decompression of the spinal canal in the thoracic spine with the use of a spinal microendoscope, there are potential risks of lung injury and intercostal nerve and vascular injuries that can result from disorientation. To avoid these complications, we believe that the transcostal procedure can provide the most reliable and safe pathway to the posterior intervertebral disc space between the superior and inferior costal facets within the rib head. The key to the success of this procedure is the drill-out of the rib leaving the outer cortical bony wall intact like an eggshell procedure of the pedicle. Additionally, surgeons must carefully plan the approach path on the CT axial images before surgery because there are some variations in the morphology of the vertebral body among patients. If the approach trajectory includes the thoracic cavity, surgeons should consider advancing at a larger angle.

Conclusions

We developed a new approach of TCMED for the treating of central TDH that causes myelopathy. This procedure can safely reach the level of the posterior vertebral wall using the rib as a landmark to dig in and resect the rib head without opening the chest. Thereafter, using an angled microendoscope and curved surgical instruments, the central TDH, which is almost completely located ventral to the spinal canal, can be safely and effectively resected without spinal cord retraction. Overall, this minimally invasive method shows good clinical outcomes for myelopathy-causing TDH.

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Ethical Approval: Because this study was a case report of three patients with central thoracic disc herniation, no approval from any IRB was required.

Informed Consent: All participants in this study provided informed consent for publication.

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