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Thoracic Microendoscopic Discectomy

A Human Cadaver Study

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Study Design. Feasibility analysis of percutaneous posterolateral thoracic microendoscopic discectomy in a human cadaver model.

Objective. To describe a new, minimally invasive, posterolateral approach to the thoracic spine for the treatment of disc herniations.

Summary of Background. Thoracoscopic discectomy offers surgeons direct ventral access to thoracic disc herniations but requires entry into the chest. Many surgeons favor a posterolateral approach to the thoracic spine, thereby avoiding morbidity associated with entry into the thoracic cavity. By adapting minimal access surgical techniques to the thoracic spine, effective treatment of thoracic disc herniations should be possible and may help expedite recovery.

Methods. Two cadaveric human torsos were used. Using simple adaptations of our standard lumbar microendoscopic discectomy technique, endoscopic discectomies were performed throughout the mid and lower thoracic spine. Operative time was recorded. The extent of the discectomy as well as the extent of bony removal was evaluated using computed tomography myelography.

Results. Nine discectomies were performed in two cadaveric specimens, from T5–T6–T9–T10. Operative times ranged from 46 to 77 minutes (mean 60 minutes). The procedure required removing 3.4 mm (±1.9 mm) of the ipsilateral facet, which amounted to 35.4% (±17.5%) of the facet complex. Canal decompression averaged 73.5% (±7.9%).

Conclusions. Thoracic microendoscopic discectomy allows for a posterolateral approach to thoracic disc herniation without entry into the chest cavity that consistently gives access to the majority of the canal while requiring only a minimal amount of bone removal. This technique provides an approach angle similar to that obtained with other posterolateral discectomy techniques while limiting the morbidity associated with exposure.

Key words: minimally invasive surgery, disc herniation, endoscopic decompression, thoracic spine, cadavers. **Spine 2005;30:1226–1231**

Thoracic disc herniations have been treated by a variety of surgical approaches including thoracotomy, thoracoscopic, lateral extracavitary, costotransversectomy, and transpedicular.[1–7] Thoracotomy is beneficial because it allows a direct, ventral approach to the herniated disc and excellent visualization of the disc space for complete decompression.[6,7] Unfortunately, thoracotomy is associated with many complications related specifically to the approach such as pulmonary contusion, atelectasis, pleural effusion, hemothorax, and chylothorax.[6,8,9] Additionally, significant perioperative and postoperative pain may result from rib resection and retraction.[8,10,11] Thoracotomy associated morbidities are not uncommon and tend to prolong the need for hospitalization. A less invasive alternative to this procedure, thoracoscopic discectomy, was developed to decrease morbidity associated with open thoracotomy. However, entry into the chest cavity and the need for postoperative chest tube drainage is still associated with an increased risk of pulmonary complications as compared with the posterior alternatives.[5,12]

For these reasons, a number of surgeons have advocated posterolateral approaches for thoracic disc herniations.[13–15] Posterolateral approaches provide an oblique view of the spinal canal and avoid morbidities associated with entry into the chest. A number of different variations of this approach have been described, each of which requires extensive muscle dissection and a variable amount of rib resection.[2,13–16]

Herein we describe a novel minimally invasive technique for posterolateral treatment of thoracic disc herniations using a human cadaver model. With aid of a tubular retractor system and endoscope, minimal destruction of muscle and bone is necessary to access the disc space. Comparison of our technique with other thoracic discectomy techniques is discussed.

Materials and Methods

Study Design. Two embalmed human cadavers were used in the study. Myelograms and postmyelogram axial computed tomographic (CT) images of the spine were obtained before the procedures were performed to document the anatomy of the spine. With the cadavers in the prone position, thoracic discectomy was performed on alternating sides using our microendoscopic discectomy (MED) technique. In total, nine levels were

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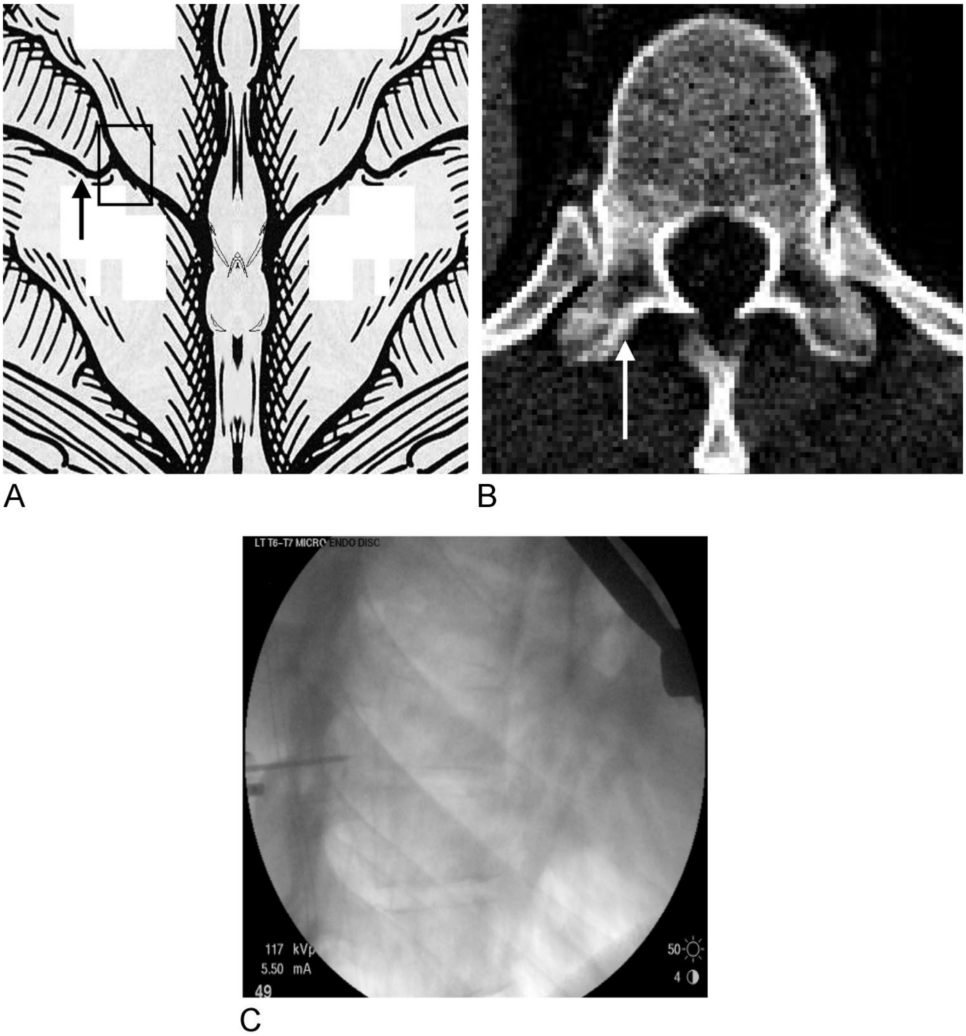

Figure 1. Target region for thoracic microendoscopic discectomy (TMED). **A**, The arrow identifies the docking point for initial exposure. This lateral trajectory helps to prevent entry into the spinal canal and thoracic cavity and provides an advantageous line of sight of the ventral spinal canal. The black square represents the region of ultimate bony removal, exposing the lateral aspect of the dura, exiting nerve root and lateral aspect of the intervertebral disc space. **B**, Preprocedure CT scan. The white arrow identifies the docking point for initial dilation. **C**, Lateral fluoroscopic image demonstrating docking of the guide pin on the transverse process at its junction with rib head.

decompressed throughout the mid and lower thoracic spine by two surgeons between T5-T6 and T9–T10. The side of discectomy was alternated between cadavers by level (*i.e.*, right T8–T9 discectomy in cadaver 1 and left T8–T9 discectomy in cadaver 2). After completion of the procedures, axial CT images of the spines were obtained at 1-mm intervals. Computer-assisted analysis of the CT images was done to measure the extent of decompression of the spinal canal and the proportion of facet joint removed. The software employed for the analysis was OSIRIS 4 Freeware (Digital Imaging Unit, University Hospital of Geneva, Geneva, Switzerland). Measurements were reported as the average value of independent measurements made by two different observers. Both cadavers were then subjected to a complete laminectomy and thorough examination of the thecal sac and nerve roots to look for evidence of dural or root injury. Statistical analyses were done using the Student *t* test.

Surgical Technique. With aid of fluoroscopy, a K-wire was inserted approximately 3 cm off midline through the posterior thoracic musculature and docked on the transverse process caudal to the disc level of interest (Figure 1, A-C). In the AP plane, the K-wire was directed to the junction of the transverse process and rib head, just inferior to the desired disc level. Sequential dilation followed using the METRx tubular retractor system (Medtronic-Sofamor-Danek, Memphis, TN). A 18-mm tubular retractor was then inserted over the largest dilator and fixed to the flexible arm assembly on the table. Before the introduction of the endoscope, the working channel was angled superiorly, such that the interspace between the two ribs and their associated transverse processes were exposed (Figure 2).

Residual muscular tissue within the tubular retractor was removed. With the lateral aspect of the lamina, facet complex, and transverse processes visualized, entry into the foramen was achieved by removing the lateral aspect of the facet complex (Figure 1A). The medial transverse process at the caudal level and lateral most aspect of the facet complex was thinned with a high-speed drill (MedNext, Medtronic, Sofamor-Danek, Memphis, TN). It is not necessary to remove the dorsal aspect

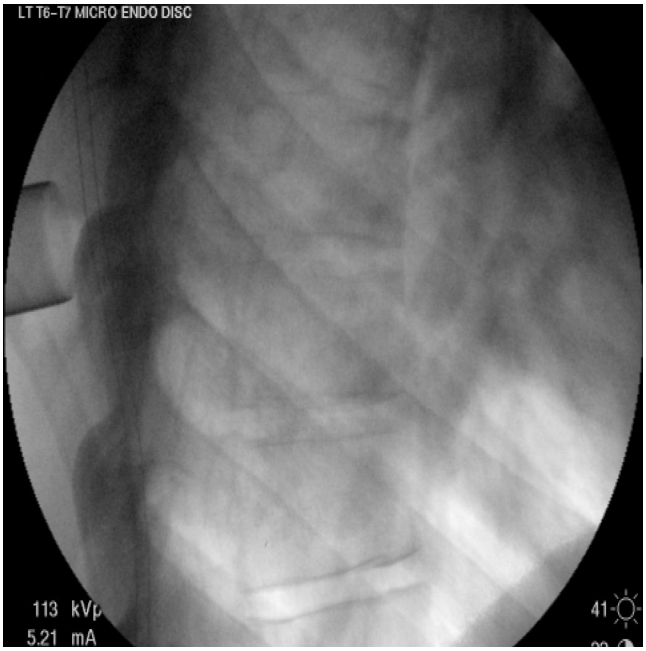

Figure 2. Lateral fluoroscopic image demonstrating angling of the working channel rostrally and medially to optimally expose the facet and lateral aspect of the lamina.

of the rib, but it may be thinned to help seat the working channel. A small angled endoscopic Kerrison rongeur was then used to complete bone removal, allowing visualization of the exiting nerve root and lateral aspect of the thecal sac. Visualization of the dura is important for safe and complete removal of disc fragments, even in cases of far lateral disc herniation. Working within the space defined by the exiting nerve root rostrally, medially by the dural sac, and caudally by the pedicle below, a defect was then created ventrally in the intervertebral disc space and adjacent vertebral bodies. The ruptured disc fragment could then be displaced into the defect and removed using pituitary rongeurs. A Scofield curette facilitated the establishment of a plane between the dura and the posterior longitudinal ligament and displacement of the intervening disc material ventrally (Figure 3).

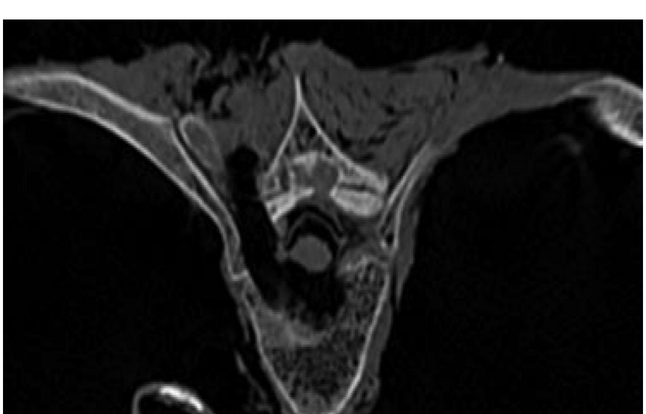

Figure 3. Typical postoperative CT image. The large defect is used to decompress disc and bony material away from the spinal canal.

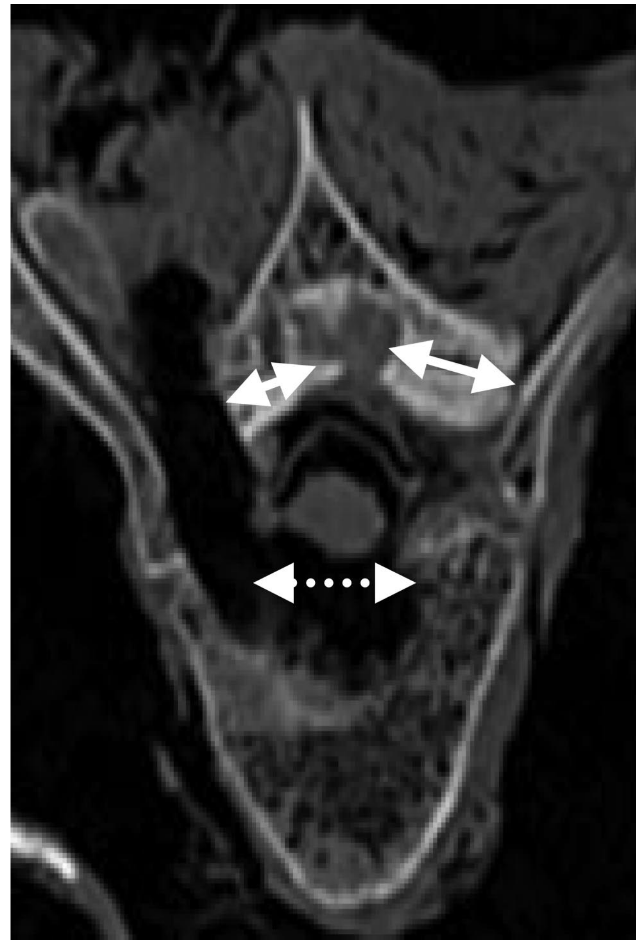

Figure 4. Measurements. The solid arrows mark the widest aspect of the facet complex bilaterally at the level of decompression. The dashed arrow marks the narrowest interpedicular distance at the level of the decompression.

■ Results

Baseline Cadaveric Measurements and Procedure

The following baseline measurements were obtained on axial CT images using the OSIRIS 4 software: interpedicular distance (minimum horizontal distance between the right and left pedicle at each vertebral level) and width of the facet (largest horizontal distance across the facet complex; Figure 4). The results are summarized in Tables 1 and 2.

Nine discectomies were performed in two cadaveric specimens, from T5–T6–T9–T10. Operative times range from 46 to 77 minutes (mean, 60 minutes), did not differ significantly between surgeons, and decreased steadily as comfort with the technique was achieved. In each specimen, CT scans were obtained following the procedures to evaluate the amount of decompression achieved by this technique.

Post-Procedural Analysis

All cadaveric torsos were imaged using the same CT scan protocol. Interpedicular distance and facet width were measured and compared with the baseline values. On the intact (nonoperative) side, no discrepancy greater than 1

Table 1. Facetectomy

	Level	Facet Size	Facet Remaining	% Removed	Amount Removed
Cadaver 1	T5–T6	10	4.5	55	5.5
	T6–T7	10.3	6.9	33.01	3.4
	T7–T8	7.9	6.2	21.52	1.7
	T8–T9	9.6	6.9	28.13	2.7
	T9–T10	10.7	8.9	16.82	1.8
Cadaver 2	T5–T6	10.3	3.4	66.99	6.9
	T6–T7	7.6	5.2	31.58	2.4
	T7–T8	9.3	4.8	48.39	4.5
	T8–T9	9.6	7.9	17.71	1.7
Average				35.46	3.4
SD				21	1.861

mm was found between the average pre- and postprocedural readings, and no statistical differences were noted between the two groups.

On average, 3.4 mm (±1.9 mm) of the lateral facet was removed during the procedure. This amounted to approximately 35.4% (±17.5%) of the total facet complex. There was a tendency to remove more of the facet complex in the midthoracic spine (T5–T6 and T6–T7) than in the more distal levels, 46% *versus* 26% on average, respectively. Canal decompression, defined as the width of the defect across the canal at the level of the disc space divided by the interpedicular distance, averaged 73.5% (±7.9%). At all operated levels except one, the extent of canal decompression was consistent (between 72 and 82%). No dural tears or injuries were appreciated by direct inspection of the dura and nerve roots. Figure 1 shows typical canal decompression achieved by thoracic MED on an axial postprocedural CT image.

■ Discussion

The treatment of thoracic disc herniations has steadily evolved from posterior laminectomy, which was associated with a high morbidity and mortality rate, to posterolateral, transthoracic, thoracoscopic, and finally posterior endoscopic approaches.[9,12,14,15,17–19] Many of these approaches require extensive disruption of normal tissues and prolonged hospitalization for chest tube and pain control management. The goal of each technique has been to effectively decompress the spinal cord and nerve roots while minimizing morbidity associated with the technique. In that regard several techniques, namely thoracoscopic, transfacet pedicle-sparing and the transpedicular endoscopic, were specifically designed to minimize soft tissue destruction and speed recovery after thoracic discectomy.[12,17,18] We describe a novel posterolateral endoscopic technique in a cadaver model that allows entry into the disc space without significant disruption of the normal facet complex or entry into the thorax.

We chose to focus on thoracic levels between T5–T6 and T9–T10 to help develop a technique that was truly representative of thoracic spine anatomy and what is observed clinically. In several large series reporting on treatment of thoracic disc herniations, approximately three-quarters occurred between T5–T6 and T9–T10 levels.[13,20,21] Extrapolation of our technique can be used to treat disc herniations at all thoracic levels.

The thoracoscopic approach affords access to the anterior and central spinal canal and avoids many of the sequlea associated with a large open thoracotomy. Initial experience with this technique demonstrated that patients experienced less postoperative pain, had shorter intensive care and hospital stays, and had no post-thoracotomy pain.[5,12] Rosenthal and Dickman reported excellent clinical and neurological results using the thoracoscopic technique.[5] Compared with open thoracotomy, their operative time was shorter, and they had less blood loss, shorter duration of chest tube drainage, decreased pain medication requirements, and abbreviated hospital stays. However, the learning curve is steep for thoracoscopic procedures. Specialized training with instructional and laboratory teaching is necessary to master this technique.[22] Whether thoracoscopic or open, these techniques violate the pleural cavity and require placement of a chest tube, which increases the risk of postoperative atelectasis, pulmonary dysfunction, and infection.

Stillerman *et al*[17] described the transfacet, pedicle-sparing approach for removal of thoracic disc herniations. In this technique, a 4-cm opening is used to expose and partially remove the medial facet complex; then, with specially designed instruments, a discectomy is performed. In some cases, an open endoscope was used to aid completion of the discectomy. There is no need for a chest tube, which reduces hospitalization and potential postoperative pulmonary complications. Additionally, by preserving the facet-pedicle complex, there is a potential for improvement in outcome related to postoperative axial pain. In another report, Stillerman *et al*[13] detailed their experience in the management of 82 thoracic disc herniations. On the basis of their results, they advocated a posterolateral approach for all symptomatic soft disc herniations, including those centrally located. Use of open endoscopy and specially designed instruments aided the removal of more centrally located disc herniations. The transfacet pedicle-sparing approach was fa-

Table 2. Canal Decompression

	Level	Decompression (mm)	Interpedicular Distance (mm)	% Decompressed
Cadaver 1	T5–T6	13.1	16.8	77.98
	T6–T7	12.2	16	76.25
	T7–T8	12.7	16.8	75.6
	T8–T9	13.8	16.8	82.14
	T9–T10	12.4	16.8	73.81
Cadaver 2	T5–T6	13.8	18.6	74.19
	T6–T7	11.7	15.5	75.48
	T7–T8	12	16.5	72.73
	T8–T9	8.3	15.5	53.55
Average				73.53
SD				7.98

vored over the transpedicular one because of decreased bone and soft tissue destruction and was associated with less postoperative back pain.[13,17]

Jho[18] described an endoscopic transpedicular approach for the treatment of thoracic disc herniations. Through a 2-cm incision, muscle was stripped from the lamina and facet with a periosteal elevator. The disc space and lateral dura were visualized after removal of the lateral lamina, medial facet, and a third of the pedicle; discectomy was performed with aid of a 70° endoscope. Three patients in his series of 25 had no relief of pain following discectomy. Popularization of this technique may be limited by use of a 70° endoscope, which can be quite disorienting and involves a significant learning curve to master.

Our technique differs significantly from the endoscopic approach described by Jho. First, we use a more lateral trajectory to approach the disc space. In this manner, it is unnecessary to rotate the patient, which can distort the visualization of the operative field. In addition, we use a muscle-splitting technique that maintains muscular and ligamentous attachments to the spine. We routinely use a 30° endoscope, which aids in medial visualization of the disc space but is not significantly disorienting. We expose the disc space by removal of the lateral aspect of the facet complex and avoid removal of the pedicle. Our technique is similar to that described by Stillerman et al except we perform a lateral facetectomy, and by using the tubular retractor and endoscope, the incision was decreased to 2-cm and muscle was preserved using serial dilators.[17] Finally, by approaching the spine at an oblique angle, visualization of the anterior spinal canal is optimized.

As with all posterolateral approaches, our technique is ideally suited for soft, lateral disc herniations. The treatment of central disc herniations is relatively contraindicated with this technique because of poor visualization and accessibility. Large, calcified central herniations should not be treated with the microendoscopic approach because of potential dural erosions.[21] Although use of an endoscope does not provide a 3-dimensional view of the operative field, practice helps develop comfort with the technique. Also, use of frequent intraoperative fluoroscopy provides additional visual information. For those unfamiliar with endoscopic techniques, it is best not to attempt a thoracic MED as an initial case. Mastery of lumbar MED, in which the anatomy and thecal sac are more approachable, is advisable before trying a thoracic MED. Depending on individual skill level, comfort with lumbar MED technique could be gained after a few dozen cases.

Practical considerations for applying this technique on real patients include careful patient selection and surgical planning for the case. Application of this technique is especially well suited for muscular patients who would otherwise require longer incisions and extensive muscle dissection with conventional posterior approaches to the thoracic spine.

Conclusion

Thoracic MED is an adaptation of the lumbar MED technique for the treatment of thoracic disc herniation. This method provides an approach angle similar to that obtained with other open, posterolateral discectomy techniques while significantly limiting the muscular dissection and bone removal necessary in the open approaches. Thoracic MED, as compared with thoracoscopic discectomy, avoids entry into the chest cavity and its associated complications. It is relatively easy to perform and can be completed within an hour or so. The approach provides consistent access to the spinal canal and allows for adequate decompression of the centrolateral spinal canal while minimizing soft tissue trauma. This technique offers a minimally invasive, posterolateral alternative for the treatment of thoracic disc herniation.

Key Points

- Minimally invasive treatment of thoracic disc herniations can be done without entry into the chest cavity.
- Adequate canal decompression can be achieved in the area of the lateral and centrolateral thoracic disc space.
- The technique is relatively easy to perform and with practice can be done quickly and safely.

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