Endoscopic thoracic microdiscectomy

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Object. The purpose of this investigation was to evaluate surgical and neurological outcomes in thoracic disc surgery in a prospective fashion.

Methods. Quantifiable outcome data such as operating time, blood loss, duration of chest tube drainage, narcotic drug use, length of hospital stay (LOS), and long-term follow up of neurological function and pain-related symptoms were collected prospectively.

In patients with myelopathy there was an improvement of two Frankel grades in the thoracoscopic discectomy group and one Frankel grade in the patients treated with thoracotomy; however, patients in the thoracotomy group were significantly worse preoperatively. None of the patients experienced worsened pain, and pain related to radiculopathy was improved by 75% in the thoracoscopic group.

Conclusions. Thoracoscopic discectomy yields acceptable surgical results and has several distinct advantages, with reduced postoperative pain, morbidity, and LOS.

KEY WORDS • disc herniation • endoscopy • thoracic spine • thoracoscopy • thoracotomy

Treatment of thoracic disc herniations is problematic for the spine surgeon because of the low incidence of this entity and delays in diagnosis that are often due to a lack of classic clinical characteristics.^{2–5,10,32,33,38,52,53} Previous literature on thoracic disc surgery was often collected in a retrospective fashion, spanning many years, and data on patients were often pooled, making it difficult to interpret the patient's initial clinical presentation and their neurological outcomes.^{5,7,8,12,14,18,27,31,32,42,44,48,50,55} As a result, there is a lack of quantifiable surgical data as well as information on overall neurological outcome after surgical treatment for these difficult-to-reach lesions. The purpose of this investigation was to establish criteria for outcome measurement in thoracic disc surgery. We report our results based on quantifiable operative data as well as findings of neurological outcome obtained in a prospective manner at one institution.

CLINICAL MATERIAL AND METHODS

Patient Population

Information about the clinical presentation, patient selection process, surgical techniques, outcomes, and complications in patients with symptomatic thoracic disc lesions was collected in a prospective nonrandomized fashion. All patients underwent thoracoscopic discectomy procedures performed by the senior author (J.P.J.).

Abbreviations used in this paper: LOS = length of hospital stay; MR = magnetic resonance; OPLL = ossification of the posterior longitudinal ligament; VB = vertebral body.

Patients were treated at the University of California at Los Angeles Medical Center and affiliated hospitals between March 1995 and February 2001 for thoracic disc lesions that included soft and calcified herniations, OPLL, and discitis.

There were 47 patients treated with thoracoscopic discectomy (21 men and 26 women) whose mean age was 53.5 ± 6.1 years (mean $\pm$ standard deviation, range 27–77 years). The number of thoracic levels affected and the location and type of lesion are noted in Table 1. The presenting clinical symptoms included myelopathy (26 patients) and radicular pain (21 patients), and the mean symptom duration in months was 8.3 (range 2–34) and 13.7 (range 2–60), respectively. All patients in our study experienced either neurological symptoms from compression of the spinal cord or radicular pain in the thoracic spine that was refractory to medical management.

Selection for Thoracoscopic Discectomy or Open Thoracotomy

The presenting symptoms or type of lesion (soft or calcified disc lesions) were not factors in the selection for thoracotomy or thoracoscopy. Patient selection was based on the number of spinal levels involved, and the presence of OPLL. All 47 patients with one- or two-level thoracic disc herniations underwent a thoracoscopic discectomy; all patients in the thoracoscopic discectomy group underwent a one- or two-level procedure.

Techniques for Thoracoscopic Spine Surgery

A detailed description of thoracoscopic spine surgery is beyond the scope of the paper and is discussed else-

TABLE 1

Number of thoracic levels affected and type of lesion in patients with disc disorders treated with thoracoscopic discectomy

Characteristic	No. of Ops
level of lesion	
T3–4	0
T4–5	0
T5–6	14
T6–7	23
T7–8	2
T8–9	6
T9–10	6
T10–11	0
T11–12	6
no. of op levels	
one	40
two	7
three	0
four	0
five	0
mean	1.3
type of lesion	
soft disc herniation	
single-level	28
multilevel	0
calcified disc herniation (or OPLL)	16
discitis	3

where,^{15–17,26,42–46} we discuss only the most salient portions of the surgical procedure. The patient is placed in a lateral decubitus position; the ventilated lung is in a dependent position on the operating table that provides maximum exposure of the ipsilateral thoracic cavity (Fig. 1). Standard anesthetic monitoring protocols and operating room set-up for thoracic endoscopic procedures and thoracotomy are used. The patient is also prepared for a thoracotomy in the event that conversion to this procedure is needed. Thoracotomy and thoracoscopic spinal procedures require induction of general anesthesia and an anesthesia team capable of performing double-lumen endotracheal tube placement with fiberoptic endoscopic guidance. The dou-

ble-lumen endotracheal tube allows collapse of the ipsilateral lung so that the spinal procedure can be performed within the empty chest cavity while the contralateral lung receives mechanical ventilation.

Following precise localization of the disc space, the procedure begins with resection of the parietal pleura over the distal 2 cm of the rib head and adjacent disc space by using endoscopic scissors attached to a high-frequency electrocautery device. The proximal portion of the rib and the disc space are linear and help to orient the surgeon during the entire procedure (Fig. 2A and B). The proximal 2 cm of the rib is removed using a high-speed drill to expose the lateral surface of the pedicle, neural foramen, and underlying disc (Fig. 2B). The neural foramen contains epidural fat and is relatively small, with the segmental nerve and vessels coursing under the rib. The adjacent segmental vessels are usually not divided because they are located in the midportion of the VB, but they can be mobilized and divided if necessary. The dura mater of the lateral spinal cord is then exposed by removing the pedicle with the high-speed drill, which also orients the surgeon during the remainder of the procedure (Fig. 2C).

The drilling of the VBs adjacent to the disc space is a crucial step in the procedure for achieving adequate bone removal to decompress the spinal canal, and there is the potential for injuring the exiting nerve root or spinal cord during these steps. The decompression requires drilling across the posterior aspect of the VBs adjacent to the disc space and endplates that essentially undermines the floor of the spinal canal and creates a tunnel. The cortical bone on the ventral aspect of the spinal canal should remain intact until the drilling is completed, because it protects the spinal cord. Beginning at the site where the pedicle was initially removed, the floor of the spinal canal is then removed with either small Kerrison rongeurs or sharp curettage (Fig. 3A). This often requires pulling soft disc material or cracking calcified disc into the defect created by the bone decompression. This procedure completely decompresses the ventral aspect of the spinal canal from a ventrolateral endoscopic exposure (Fig. 3B).

Fig. 1. Illustration showing the patient placed in a lateral decubitus position with the ventilated lung facing downward and the deflated lung facing upward.

Fig. 2. An artist's illustrations showing steps in the procedure. A: A rib head and adjacent intervertebral disc space with pleura resected. B: The rib head is removed, demonstrating the underlying pedicle and disc. The thoracic levels (T1–10) and the head of the rib articulate with the same vertebra and the intervertebral disc space superior to the head of the rib. C: Beneath the spinal canal the pedicle and endplates are shown during drilling.

Clinical Evaluation, Follow-Up Examination, and Statistical Methods

Data on the operating time, blood loss, and duration of chest tube drainage were collected for each patient. All patients underwent postoperative neuroimaging to ensure that the decompression was successful. Follow-up clinical and neurological evaluations were conducted at 1, 3, 6, and 12 months postoperatively. The Oswestry Pain Scale²⁰ questionnaire was administered to the patients with radicular pain by a third-person interviewer, and a Frankel grade²² was assigned to patients with myelopathy to assess their neurological function.

RESULTS

The surgical and hospital data were compiled and are presented in Table 2.

Outcomes in Patients With Radiculopathy

Based on a comparison of pre- and postoperative Os-

westry Pain Scale scores, patients with radiculopathy experienced a 75% improvement in terms of pain status. The mean preoperative pain score was 60 (range 40–80) and the mean postoperative score was 14 (range 0–40). All patients experienced some improvement in radiculopathy symptoms, and three patients experienced only limited improvement; however, these three patients were satisfied with the result and would undergo the procedure again. No patient experienced worsened status postoperatively.

Neurological Outcomes in Patients With Myelopathy Treated With Thoracoscopic Discectomy

The neurological outcomes for these patients were mostly improved, as reflected by postoperative Frankel grades (Table 3). Myelopathy improved in 18 (38%) of 47 patients as indicated by a mean improvement of two Frankel grades. Myelopathy was unchanged in 27 patients (58%), including only one whose disease remained categorized as Frankel Grade C after surgery, who had a 4-year history of chronic myelopathy.

Fig. 3. An artist's illustrations showing later stages of the procedure. A: Illustration showing exposure of the intervertebral disc space site after completion of drilling and exposure of the herniated disc. B: Illustration showing a completed discectomy and decompressed spinal dura.

TABLE 2

Operative and postoperative data obtained in 47 patients with thoracic disc herniation treated with thoracoscopic discectomy

Factor	Value (range)
op time in mins	216 (102–384)
blood loss in ml	227 (100–600)
chest tube drainage in days	1.4 (0–18)
narcotic usage in mg/day for 3 days	6.4 (4–11)*
LOS in days	3.1 (1–21)

* Estimated as milligrams equivalent of morphine sulfate.

As a result, myelopathy was unchanged or improved in all but one patient (98%) in the thoracoscopic discectomy group, whereas one patient (2%) worsened from a Frankel Grade C to B. This patient had suffered longstanding paraparesis for 30 years after undergoing a laminectomy for a large calcified thoracic disc herniation; he had been paraplegic for 1 year following laminectomy. He experienced worsening paraparesis and spastic gait and underwent thoracoscopic discectomy that was noted for removal of an intradural calcified disc that resulted in a cerebrospinal fluid leak. The leak was resolved successfully by using a muscle graft, fibrin glue, lumbar subarachnoid drainage, and by maintaining the chest tube without suction postoperatively.

Complications Related to Surgery

Minor and major complications occurred in 24% of patients who underwent thoracoscopic discectomy (Table 4). Most of these complications were transient and not life threatening. Intercostal neuralgia was the most frequent transient complication in both groups, although this had resolved in nearly all patients treated with thoracoscopic discectomy at 3 months postsurgery. One patient who continued to experience intercostal neuralgia up until 6 months postsurgery subsequently attained partial improvement after undergoing intercostal nerve blocks and a radiofrequency rhizotomy. This patient was treated early in the series, when we were using hard plastic ports; no cases of permanent neuralgia have occurred since we began to use the soft, flexible ports. All cases of pneumonia resolved after antibiotic therapy and pulmonary toilet.

Recurrent disc herniation occurred in an obese young woman who underwent thoracoscopic discectomy for pri-

TABLE 3

Preoperative and postoperative Frankel grades obtained in patients who underwent thoracoscopic discectomy

Frankel Grade (preop)	Frankel Grade (postop)				
	A	B	C	D	E
thoracoscopy group					
A					
B				4	
C		1*	3	4	6
D				14	4
E					10

* Patient was worsened postoperatively.

marily chest wall pain and a mild myelopathy. Thoracoscopic reexploration was converted to an open thoracotomy procedure, and the disc was removed uneventfully, resulting in improvement in her pain symptoms. Chylothorax developed in one patient in the thoracoscopy-treated group, although no leak had been noted at surgery. There was a persistent high output of chyle from the chest tube. The patient was treated by withholding oral feedings and received elemental total parenteral nutrition therapy for 2 weeks, which resolved the leak.

DISCUSSION

Almost a century ago the concept of using an endoscope to view the thoracic cavity was proposed for lysis of tubercular pleural adhesions as an alternative to open thoracotomy.²⁵ These maximally invasive thoracotomy and posterior-lateral paraspinal procedures provided the impetus for development of minimally invasive thoracoscopic techniques for thoracic spinal lesions.^{6,15–17,26,33,42–46} The trend of minimally invasive procedures for thoracic spinal surgery has similarly evolved, with use of thoracoscopy for ventral lesions to gain adequate exposure of these anatomically challenging entities that require specialized surgical techniques.^{15–17,23,26,29,33,36,42–46,49}

Natural History and Pathophysiological Disorders of Thoracic Discs

Thoracic disc herniations are rare in comparison with those in either cervical or lumbar discs. The incidence of thoracic disc herniation is estimated to be between 0.25 and 1% of all such lesions, and population studies indicate that the overall incidence of thoracic disc herniations is approximately 1 per million patient-years.^{1,10,50} Thoracic disc herniations typically present with a variety of non-specific symptoms, frequently leading to a wrong or delayed diagnosis.^{24,33,53}

The vast majority of thoracic disc herniations are found

TABLE 4

*Surgery-related complications after thoracoscopic discectomy in 46 patients with thoracic herniated discs**

Complication	No. (%)
atelectasis	3 (6)
pleural effusion	2 (4)
pneumonia	2 (4)
intercostal neuralgia	
transient (<3 mos)	5 (11)
permanent (>3 mos)	1 (2)
recurrent disc herniation	1 (2)
chylothorax	1 (2)
hemothorax	0 (0)
wrong level	1 (2)
infection	0 (0)
inadequate discectomy	2 (4)
subcutaneous emphysema	0 (0)
neurological deterioration	1 (2)
additional neurological deficit	1 (2)
death	0
total	11 (24)

* More than one complication per patient.

in patients between the third and fifth decades of life below the level of T-7. The eighth, ninth, and 10th ribs are fused to the sternum with cartilage, whereas the 11th and 12th ribs are not attached to the sternum at all, which is thought to contribute to the greater degree of flexibility in this region. Given the biomechanical stresses on the thoracic spine, the greater degree of flexion allowable at each vertebral level corresponds to a higher incidence of nucleus pulposus herniations.⁵⁴ Interestingly, the most common level of lesion in our study in both groups was at the T6–7 disc space (Table 1).

Stillerman, et al.,⁵⁰ classified the symptoms of thoracic discs into localized thoracolumbar pain, radicular pain, and myelopathy. Surprisingly, almost 25% of their patients did not present with symptomatic pain. The most common presenting symptom was pain, which approximately 75% of their patients reported; myelopathy was actually the second most common presenting symptom. Although pain was also the most common presenting symptom in our group of patients, only four of the participants in our study did not have myelopathy.

Thoracic Disc Surgery

The surgical management of thoracic disc herniations has undergone an evolution in recent years in both diagnosis and treatment.^{15–18,21,23,26,28,29,31,37,42–46,50–52} Nonetheless, the spine surgeon is still confronted with the unique anatomy of central disc herniations in the thoracic spine and must choose the optimal approach for decompression. Myelopathy is a clear indication for surgery, but the role of surgery for radicular pain is controversial. It remains unlikely that a true randomized prospective study in which thoracotomy is compared with thoracoscopic discectomy will occur, because patients seeking minimally invasive procedures from surgeons skilled in these techniques would not agree to a thoracotomy as a primary procedure. Thoracoscopic discectomy is a minimally invasive procedure that is an alternative to traditional open thoracotomy or posterolateral transpedicular and costotransversectomy approaches. Thoracoscopic operations have been well established as the procedures of choice compared with thoracotomy because of reduced rates of morbidity.^{28,43–45}

Neurological and Surgical Outcome

In neurosurgical practice, outcome data are used to measure the efficacy of a surgical procedure. In the past, outcomes were loosely defined and there were no clear surgery-related outcome parameters. In spine surgery there are probably no pathological entities in which it is more difficult to quantify outcome than in those treated with thoracic disc surgery. The difficulties related to determining outcome in thoracic disc surgery have historically been severe. First, the natural history of the disease is not so clear, therefore making it difficult to determine which patients would actually benefit from receiving surgery.³³ Second, the incidence of thoracic disc herniation is extremely low, with an estimated incidence of 1% of all herniated discs.

Historically, surgical outcomes for patients undergoing thoracic disc surgery were reported as the number of patients benefiting from the procedure compared with the

number with postoperative complications. Moreover, in recent studies investigators have concluded that thoracoscopic discectomy is the method preferred; however, these conclusions were based on historical comparisons that were difficult to interpret. To make the matter even more complicated, there have been small series of patients who underwent treatment of thoracic discs in which the groups were subdivided based on the approach.³⁷ Last, the surgical management of disorders in thoracic discs has become a controversial issue to a number of spine surgeons, who have proposed various surgical approaches. The optimal approach for herniated thoracic discs remains unclear, and the literature regarding the efficacy, indications, or limitations of thoracoscopic disc surgery has not been established. Today, the surgical approaches used to reach these anatomically challenging lesions are transthoracic, modified costotransversectomy or lateral extracavitary, transpedicular or transfacet, and thoracoscopic microdiscectomy.^{7,8,11,12,15–18,21,23–25,29–39,45–48,51}

In previous reports thoracoscopic discectomy was compared with open thoracotomy and costotransversectomy, and all investigators concluded that thoracoscopy is advantageous based on the lower morbidity rates.^{15,34,36,43,45} Moreover, other authors have made comparisons with cases from the 1980s and/or pooled their retrospective studies. Although they provided interesting comparisons, these lack validity because surgical and anesthetic procedures as well as postoperative management practices were vastly different for procedures performed in that era.^{5,7,8,12,14,18,27,31,32,43,44,48,50,55} For example, in a thoracotomy or costotransversectomy procedure performed today for the treatment of an uncomplicated thoracic lesion, the incision would be smaller and the operating time, postoperative pain medications, and LOS would likely be cut by 50% compared with the same procedure a decade ago. Even today, LOS and operating time vary widely between surgeons and their respective institutions (Table 5).

Patients who underwent thoracoscopic discectomy had shorter operating times, less blood loss, a shorter period of dependence on chest tube drainage, less narcotic usage, and a shorter LOS. These findings were statistically significant for shorter LOS and narcotic drug usage ($p < 0.05$). Pain related to radiculopathy was improved by 75%, and none of our patients experienced worsened pain. In patients with myelopathy there was an improvement of two Frankel grades in the thoracoscopic group.

Surgical Approaches

Anterior approaches to the thoracic spinal column have become established as standard for appropriate treatment of disc lesions primarily anterior to the spinal cord.^{9,19,26,40,41,48} Thoracotomy remains the standard open procedure that provides optimal ventral exposure of these anterior spinal lesions.^{2,5,8,11,13,19,24,33,40,41,48} Alternatively, the costotransversectomy and transpedicular techniques provide a posterolateral exposure that avoids opening the chest; however, direct visualization of the ventral spinal cord is not possible.^{11,21,28,30,31,33,35,39,51,52} With the exception of the lateral extracavitary and transpedicular approaches that follow a posterior and lateral trajectory to the disc along the rib or pedicle, respectively, the thoracotomy remains the gold standard for treatment of ventral midline lesions

TABLE 5
*Literature review of surgical outcome after thoracic disc surgery**

Authors & Year	Approach	Op Time (mins)	Blood Loss (ml)	Chest Tube (days)	LOS (days)	Narcotic Usage (mg/day)	Patient Satisfaction
Regan, et al., 1994	thoracoscopy	220	400	2	7	NR	NR
	thoracotomy	235	792	4	10	NR	NR
Rosenthal & Dickman, 1998	thoracotomy	268	683	3.5	16.2	20.4	NR
	costotransversectomy	280	350	NA	5.0	3.0	NR
	thoracoscopy	205	327	1.5	6.5	3.7	NR
present study	thoracoscopy	216	227	1.4	3.1	6.5	75% excellent, 25% good

* NA = not applicable; NR = not reported.

compressing the spinal cord.^{39,40} Furthermore, the lateral extracavitary and transpedicular approaches do not provide direct visualization of lesions directly ventral to the spinal cord, which cannot always be removed safely without possible injury to the spinal cord. This is particularly true with midline calcified disc lesions that require an anterior transthoracic approach.^{40,41}

We also believe that a thoracotomy may be the best procedure in patients harboring such complex multilevel thoracic lesions as OPLL, in which the operating time and risks may exceed the perceived advantages of an endoscopic procedure. These lesions typically compress a contiguous segment of the spinal cord rather than featuring focal herniated disc lesions, and would require that several additional ports be placed, thus contributing to a longer operating time than for a thoracotomy. Although a thoracoscopy for complex multilevel thoracic lesions is indeed feasible, it may not be practical if the procedure requires a significantly longer time and potentially greater risk to the patient.

The nonrandomized nature of our study weakens our data somewhat because there is an inherent selection bias in nonrandomized retrospective studies. The indications for each technique are different; therefore, it is not possible to compare one treatment with the other. The patients who were selected for thoracoscopic spine surgery were clearly different from those chosen for thoracotomy. As a result, the physiological effects observed for each group and their respective treatments could have been influenced by patient selection.

Limitations of Thoracoscopic Surgery

The primary disadvantages of thoracoscopic spinal procedures are several very important differences in the way the procedures are performed: endoscopic visualization, even with the latest three-dimensional technology, still depends on television projections in which the depth of field does not compare with direct stereoscopic vision. The three-dimensional glasses are sufficiently inconvenient that many surgeons still use two-dimensional endoscopes. Frequent cleaning of bone dust from the endoscope during the drilling procedure significantly interrupts the flow of the operation. The ports placed in the chest wall significantly restrict the surgeon's ability to manipulate the instruments, and they act as a fulcrum as opposed to the usually unlimited degrees of motion allowed within an open thoracotomy incision. The instruments are usual-

ly longer and more awkward to use with fine dexterity than are open surgical instruments; it is also difficult for the surgeon to use instruments in each hand simultaneously to perform complex tasks with both hands, and most rely on an experienced assistant.

The need for acquiring difficult new visuomotor surgical skills is also a factor; a high level of new skills is required for the surgeon to perform this complex procedure.^{15,17,26,42,45,46} These skills remain challenging for the surgeon who performs them on a regular basis, and may be impractical for one who performs them infrequently. The learning curve is steep, as confirmed by surgeons who perform the procedure frequently, and formal training is recommended. It also seems appropriate to ascertain that a sufficient number of cases are treated annually to maintain necessary skills effectively.

CONCLUSIONS

The literature on prospective neurological outcome data for thoracic spine surgery is lacking and only a small series of retrospective studies have been published. It is essential to compare newer techniques such as thoracoscopy with those (such as thoracotomy) that are already established as the gold standard.

We conducted a prospective nonrandomized study in which we collected quantifiable operative and neurological outcomes data. Based on our experience, we conclude that one- and two-level thoracic lesions are ideally treated using endoscopic techniques, because the minimal incision-related pain and morbidity are markedly different from those associated with a thoracotomy. Patients undergoing thoracoscopic discectomy experienced reduced surgery-related pain, morbidity, LOS, and complications. The need for adequate training and consistent surgical experience are paramount for spine surgeons performing this technically demanding procedure. The alternative techniques (transthoracic, modified costotransversectomy or lateral extracavitary, and the transpedicular or transfacet approaches) clearly remain viable and effective for surgeons experienced in these procedures who have limited experience with thoracoscopic spine surgery.

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Disclaimer

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