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The transfacet pedicle-sparing approach for thoracic disc removal: cadaveric morphometric analysis and preliminary clinical experience

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A number of operative techniques have been described for the treatment of herniated thoracic discs. The transfacet pedicle-sparing approach allows for complete disc removal with limited spinal column disruption and soft-tissue dissection. Fifteen cadaveric spinal columns were used for evaluation of exposure, development of thoracic microdiscectomy instrumentation, and establishment of morphometric measurements. This approach was used to remove eight thoracic discs in six patients. Levels of herniation ranged from T-7 through T-11. Preoperatively, all patients had moderate to severe axial pain, and three (50%) of the six had radicular pain. Myelopathy was present in four (67%) of the six patients. Through a 4-cm opening, the ipsilateral paraspinal muscles were reflected, and a partial facetectomy was performed. The disc was then removed using specially designed microscopic instrumentation. Postoperatively, the radiculopathy resolved in all patients. Axial pain and myelopathy were completely resolved or significantly improved in all patients.

The minimal amount of bone resection and muscle dissection involved in the operation allows for: 1) decreased operative time and blood loss; 2) diminished perioperative pain; 3) shorter hospitalization time and faster return to premorbid activity; 4) avoidance of closed chest tube drainage; and 5) preservation of the integrity of the facet-pedicle complex, with potential for improvement in outcome related to axial pain. This technique appears best suited for the removal of all centrolateral discs, although it has been used successfully for treating a disc occupying nearly the entire ventral canal. The initial experience suggests that this approach may be used to safely remove appropriately selected thoracic disc herniations with good results.

Key Words * thoracic spine * thoracic disc * intervertebral disc herniation * discectomy

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Symptomatic thoracic discs constitute between 0.15% and 1% of patients requiring disc operations.[1-7,9,13,17,18,20,25,35,37,40-42] A number of operative techniques have evolved in the treatment of herniated thoracic discs, including the transthoracic,[10,12,14,15,28-30,33,34,37-42] lateral extracavitary,[16,23,26,40-42] and transpedicular approaches.[24,31,32,40-42] These procedures have allowed surgeons to safely remove herniated discs, including central osteophytes and intradural fragments. Results with all three procedures for treatment of myelopathy and radicular pain have been excellent. The transthoracic and lateral extracavitary procedures are formidable operations that require more extensive bone removal than the transpedicular approach and are generally combined with an interbody fusion.[26,40-42] Despite these considerations, the transthoracic and lateral extracavitary approaches have superior back pain results compared to the transpedicular approach.[26,31,40,41]

We have developed the transfacet pedicle-sparing approach as a simpler alternative to the more extensive anterolateral and lateral procedures. The essence of this procedure is that a safe and effective microdiscectomy may be performed through a limited partial facetectomy, without removal of the corresponding pedicle. We have found that this keyhole bone removal does not sacrifice the exposure achieved with the transpedicular approach, and it may diminish the potential for chronic localized back pain arising from disruption of the facet, pedicle, and disc. Prior to clinical application of this technique cadaveric analysis was performed in 180 thoracic vertebral segments to evaluate the extent of exposure, to aid in developing special thoracic microdiscectomy instruments, and to establish morphometric measurements used to enhance the surgeon's orientation.

CLINICAL MATERIAL AND METHODS

Morphometric Investigation

Fifteen formalin-fixed human adult thoracic spines involving 180 thoracic levels were obtained for morphometric analysis. The spines were manually stripped of the paraspinous musculature and soft tissue, as necessary to make important landmarks easily identifiable. The measurements that improve orientation between the facet joint and the disc space include (Fig. 1): column A, sagittal distance from the inferior articular facet to the disc; column B, vertical distance from the bottom of the inferior articular process to a point on the facet overlying the center of the disc; and column C, width of the disc space.

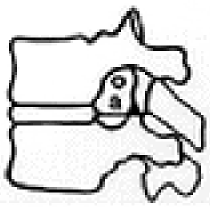
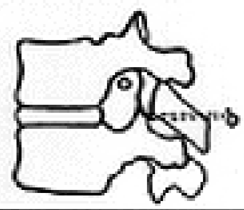
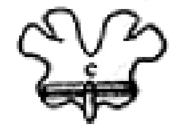
	A	B	C
LEVEL	FACET TO DISC (mm) 	INFERIOR ARTICULAR PROCESS TO DISC CENTER (mm) 	DISC SPACE WIDTH (mm) 
T1-2	15.2 +/- 2.1	0.3 +/- 0.8	31.6 +/- 2.1
T2-3	14.8 +/- 1.9	0.3 +/- 0.7	31.8 +/- 3.4
T3-4	14.6 +/- 1.6	0.8 +/- 1.1	30 +/- 2.4
T4-5	14.5 +/- 1.7	1.2 +/- 1.4*	28.6 +/- 3.8
T5-6	14.7 +/- 1.4	1.6 +/- 1.2*	30.8 +/- 4.8
T6-7	14.8 +/- 0.9	2.0 +/- 1.2*	33.2 +/- 5.6
T7-8	14.8 +/- 0.9	3.5 +/- 1.7*	34.6 +/- 4.6
T8-9	15.1 +/- 0.8	4.5 +/- 1.5*	35.8 +/- 5.8
T9-10	15.2 +/- 1.4	5.3 +/- 1.8*	38.4 +/- 6.0
T10-11	16.3 +/- 1.6	6.5 +/- 1.7*	40.2 +/- 6.8*
T11-12	19.2 +/- 2.6*	7.7 +/- 2.1*	42.2 +/- 7.0*
T12-L1	21.8 +/- 2.8*	10.3 +/- 3.2*	46.2 +/- 6*

Fig. 1. Chart showing cadaveric morphometric measurements for thoracic discs. Each measurement was performed in 15 cadavers, using both sides of the same level for 30

measurements. Asterisk indicates a significant difference between a certain level compared to the initial level at T1-2 ($p < 0.05$) using Student's t-test. +/- represents standard deviation. Column A: The distance from the facet to disc remained constant over varying vertebral body levels except at T11-12 because of increased thickness of the facet joints at these levels. Column B: The vertical distance from the inferior articular process to the point on the facet directly over disc center increased with increasing levels. Column C: The width of the disc remained constant at all levels until T10-11.

Surgical Technique

With the patient prone, an anteroposterior (AP) fluoroscopic image is used to identify the involved disc space (Fig. 2 left). A 4-cm incision is made, centered over the disc space (Fig. 2 right). The muscle on the side of the herniation is reflected laterally, exposing the posterior elements from transverse process to transverse process.

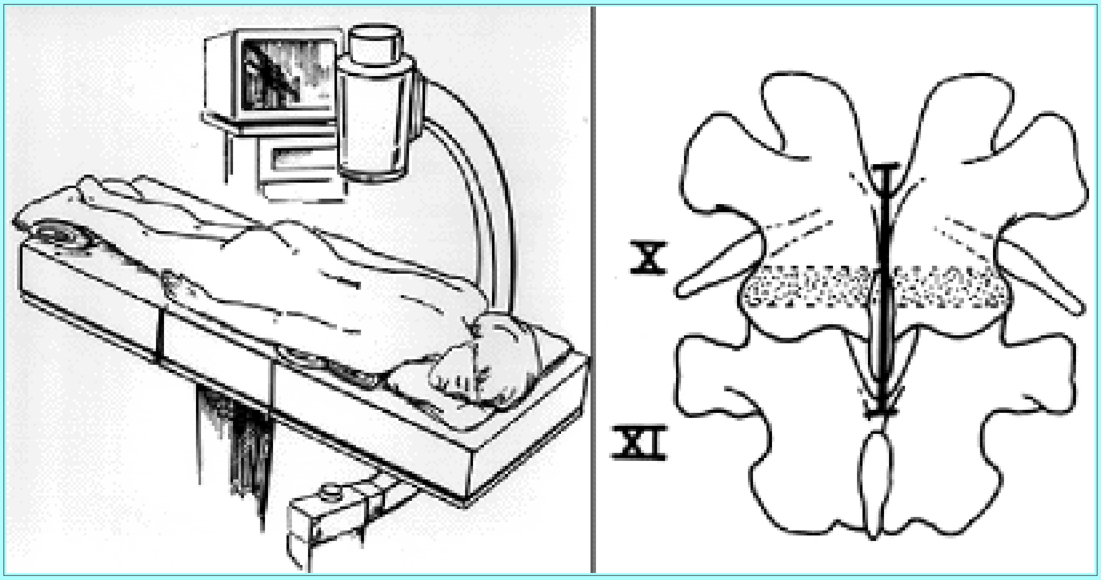


Fig. 2. Drawings showing the use of fluoroscopic guidance for localizing the incision. Left: The patient is placed prone on radiolucent chest rolls and secured with tape so that the table may be rolled away from the surgeon during the disc removal. Right: A small incision is centered over the appropriate disc space using fluoroscopy. Fluoroscopy is more desirable than plain films because it can be readily repeated to plan the skin incision, determine the portion of facet to be removed, and evaluate the extent of disc removal.

The microscope is brought into the operative field, and the facet complex is partially removed with a high-speed drill (Fig. 3 left). The extent of facetectomy is determined by an intraoperative AP view prior to drilling; this view defines where the disc space is in relationship to the facet. The foraminal soft tissue is coagulated using bipolar cautery and the lateral annulus is exposed (Fig. 3 center). The lateral annulus is then incised with a microknife and the disc is removed (Fig. 3 right).

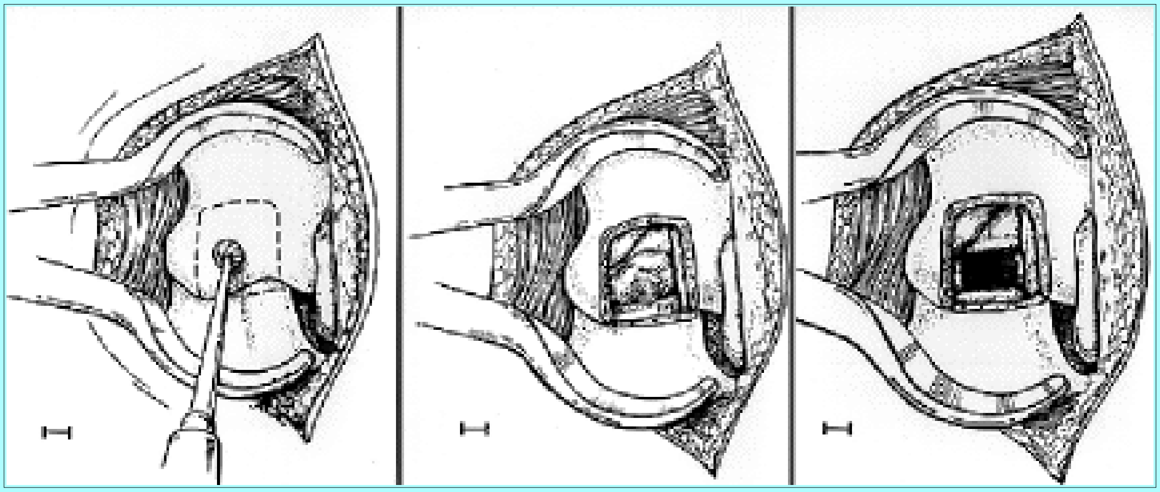


Fig. 3. Diagrams showing steps in removal of disc using the transfacet pedicle-sparing approach. The scale bar represents 0.8 cm = 1 cm. Left: Before beginning the partial facetectomy, we reintroduce the fluoroscope for anteroposterior imaging, specifically to evaluate where the disc space is in relationship to the dorsally situated facet complex. This determines the boundaries of the partial facetectomy that is then performed. Center: After drilling of the facet, the dorsal portion of the neural foramen is entered. The foraminal soft tissue may be coagulated with bipolar cautery. The lateral margins of the annulus are identified. A large herniation can be identified along with the dura (situated medially), and the cephalad nerve root. Right: The lateral margin of the annulus is incised and the disc removal is performed using specially designed instrumentation. Diagram illustrates the postdiscectomy appearance.

Specially designed microangled stomping curettes permit disc removal without injuring the spinal cord medially (Fig. 4). Endoscopy may be used to monitor disc removal directly or inspect the extent of disc decompression. No fusion is performed.

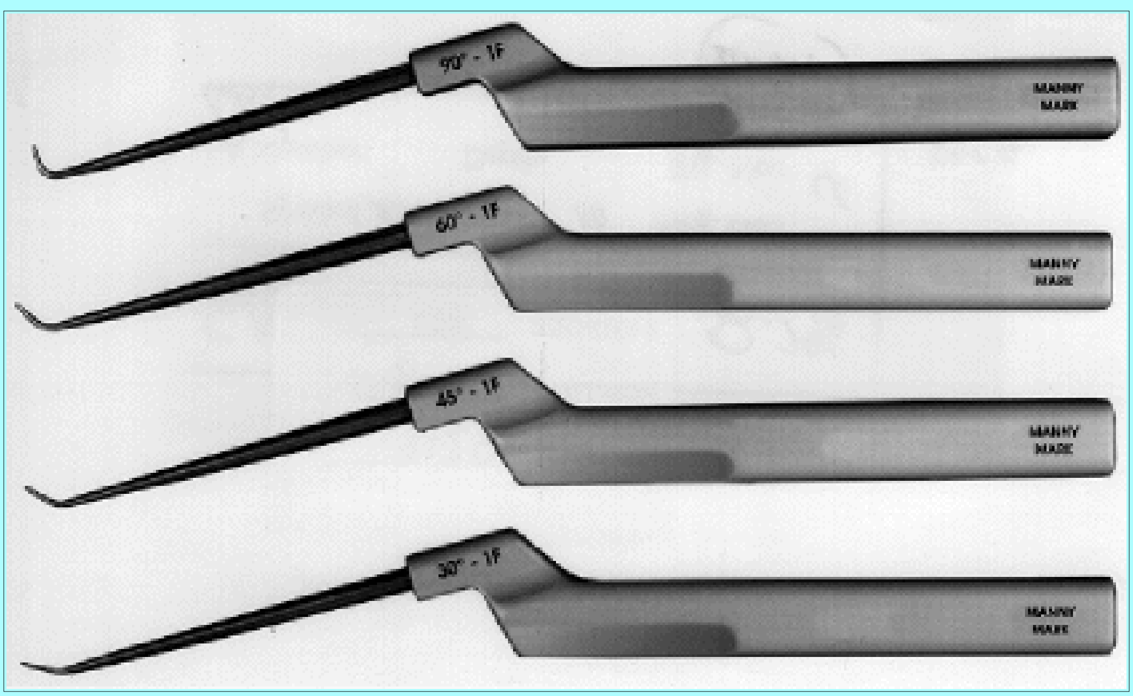


Fig. 4. Photograph of the Manny-Mark microdiscectomy instruments that were designed to facilitate disc removal without injuring the mesially situated spinal cord.

RESULTS

Morphometric Measurements

The sagittal distance from the center of the facet joint to the underlying disc space did not change except from T11-L1, reflecting the increased thickness of the facet joint at these levels (Fig. 1 column A). The vertical distance from the bottom of the inferior articular process to a point on the facet overlying the disc center increased through the thoracic spine (Fig. 1 column B). The width of the disc space increased at lower vertebral levels (T10-L1, Fig. 1 column C).

Clinical Results

Using the transfacet pedicle-sparing approach, we have successfully removed eight thoracic discs in six patients. Levels of herniation ranged from T-7 through T-11. The majority of discs were centrolateral in location; one patient had a disc that filled nearly the entire ventral aspect of his spinal canal. Half of the discs were calcified. Two patients had multiple, radiographically significant herniated thoracic discs (Table 1).

TABLE 1
THORACIC DISC CHARACTERISTICS IN SIX PATIENTS UNDERGOING OPERATION FOR HERNIATED DISCS

Case No.	Consistency	Location	Operated Levels
1	soft	centrolat	T8–9/T9–10
2	partially calcified	centrolat	T10–11
3	soft	entire ventral canal	T10–11
4	calcified	lat	T9–10
5	calcified	centrolat	T8–9/T10–11
6	soft	centrolat	T10–11

There were four men and two women, with ages ranging from 31 to 62 years old, and a mean age of 46 years. All patients had severe axial pain preoperatively. Three patients (50%) had an accompanying radiculopathy. Preoperative myelopathy was seen in four (67%) of six patients. Follow up ranged from 7 to 23 months, with a mean of 12.9 months. Postoperatively, myelopathy and axial pain significantly improved or resolved in all patients. The radiculopathy resolved in all patients. There were no complications or disc recurrences in these initial six patients (Table 2).

TABLE 2
CHARACTERISTICS OF SIX PATIENTS UNDERGOING OPERATION FOR HERNIATED THORACIC DISCS*

Case No.	Age (yrs), Sex	Axial Pain		Myelopathy		Radiculopathy		Disc Recurrence
		Preop	Postop	Preop	Postop	Preop	Postop	
1	47, F	yes	resolved	yes	resolved	yes	resolved	none
2	53, M	yes	sig improved	no	NA	no	NA	none
3	62, M	yes	sig improved	yes	resolved	yes	resolved	none
4	31, F	yes	sig improved	no	NA	yes	resolved	none
5	36, M	yes	resolved	yes	resolved	no	NA	none
6	63, M	yes	resolved	yes	improved	no	NA	none

* Abbreviations: sig = significantly, NA = not applicable.

Illustrative Case

This 62-year-old man initially presented with thoracic back pain, T-10 radiculopathy, and myelopathy. On magnetic resonance (MR) imaging, a large extruded centrolateral soft-disc herniation with spinal cord deformity at T10-11 was seen (Fig. 5 left and center). He underwent a transfacet pedicle-sparing approach for removal of his thoracic disc herniation. Postoperative MR imaging showed decompression of the spinal cord (Fig. 5 right). The patient had resolution of his myeloradiculopathy and significant improvement in his back pain.

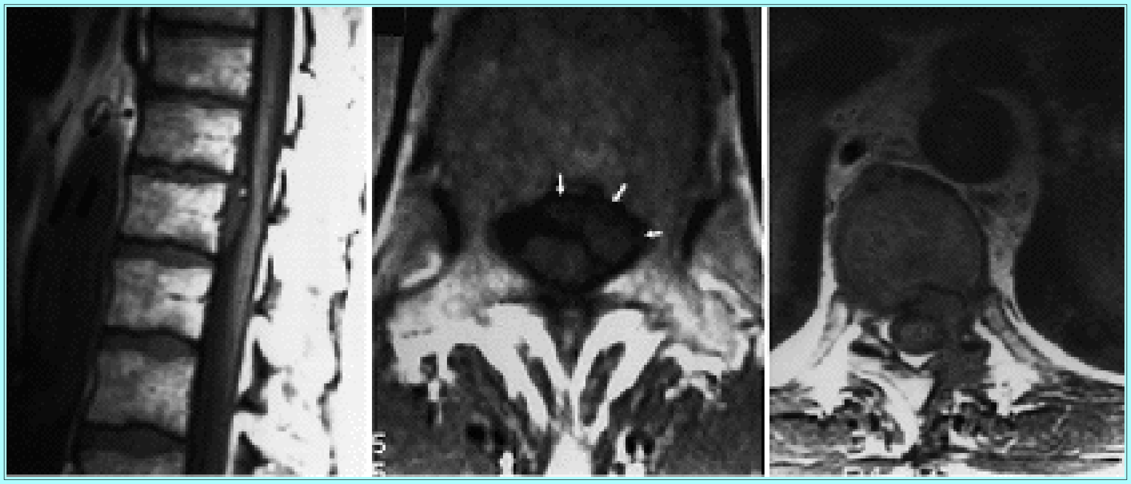


Fig. 5. Case 3. Magnetic resonance (MR) images revealing a large extruded T10-11 disc in a patient presenting with pain and myelopathy. Left: Preoperative T_1-weighted sagittal MR image demonstrating a large ventral lesion with dorsal displacement of the spinal cord. Center: A T_1-weighted axial view. The ventral spinal canal is nearly entirely occupied with the disc. Arrows depict the extruded disc. Right: Postoperative gadolinium-enhanced MR image, axial view, obtained to assess the extent of disc removal. No intracanalicular disc material is present, and only normal postoperative changes are seen. The spinal cord has returned to its normal location and configuration.

DISCUSSION

Comparison of Transfacet Approach With Other Techniques for Thoracic Disc Removal

The exposure to the disc space provided by the anterolateral[10,12,14,15,28,33,34,38,40-42] and lateral (lateral extracavitary)[14,22,23,26,40-42] approaches is excellent (Fig. 6 left and center). These approaches are best suited for calcified central discs (transthoracic) or calcified centrolateral discs (lateral extracavitary approach) (Table 3). They enable total disc removal with good results in improving myelopathy, radicular pain, and localized thoracic back pain.[23,26,40] However, they are extensive procedures from the standpoint of operative time, perioperative pain, and physiological stress to the patient. A significant amount of spinal column disruption resulting from removal of the proximal rib, a portion of two vertebral bodies, and unilateral pedicle and facet joint generally necessitate the placement of an interbody graft following disc removal (Fig. 6 center).[23,26,40-42]

TABLE 3
SURGICAL APPROACHES FOR THORACIC DISCECTOMY

Approach	Primary Indications
transthoracic	T4–11; densely calcified central disc
lat extracavitary	T6–12; calcified centrolat disc
transfacet pedicle-sparing	all levels; soft central disc; calcified centrolat disc
transpedicular	all levels; soft central disc; calcified centrolat disc

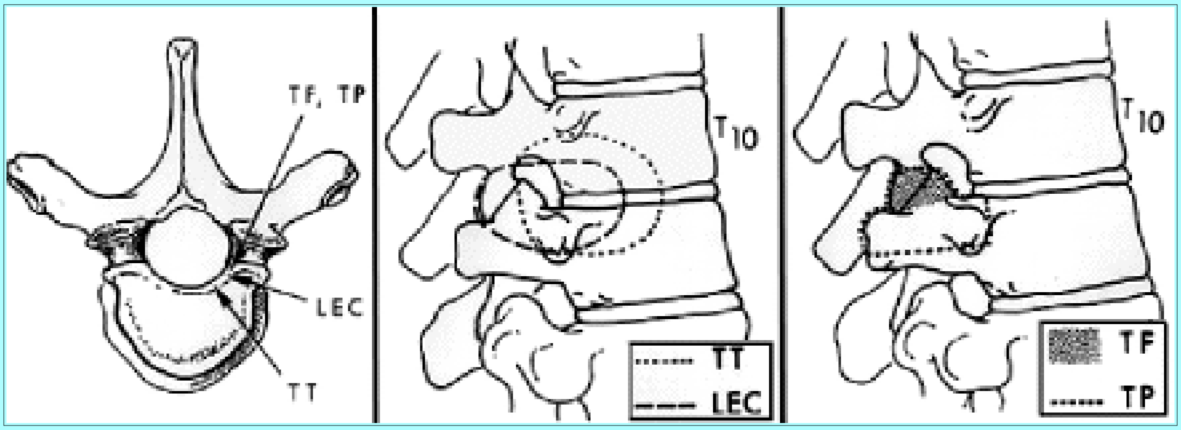


Fig. 6. Drawings depicting common approaches for discectomy. Left: Axial view demonstrating the trajectories used for the major thoracic discectomy procedures. Both the transfacet (TF) pedicle-sparing and transpedicular (TP) approaches use a posterolateral approach to thoracic discs. The transthoracic (TT) approach provides a more anterior orientation, whereas the lateral extracavitary (LEC) approach affords more direct access to the anterolateral thoracic spine. Center: Lateral view demonstrating the degree of bone removal for the TT and LEC approaches. In both approaches, a significant portion of vertebral body, pedicle, and facets are removed, generally requiring fusion. Right: Lateral view demonstrating degree of bone removal for the TF pedicle-sparing approach versus the TP approach. In addition to removal of the pedicle, the TP approach entails a more extensive facetectomy than does the TF approach.

A simpler operation with fewer risks is often desirable, especially for the high-risk patient. An alternative technique must not sacrifice safety or outcome. This "limited" approach should also diminish the length of surgery, blood loss, spinal column manipulation, and hospital stay.

Currently, two simpler operations for thoracic disc removal are available. The first option is the use of thoracoscopy for video-assisted disc removal. Although appealing, this procedure is experimental and needs further refinement before offering an advantage over more conventional "limited" approaches.[19,21,36]

Another more limited operation for thoracic discs is the transpedicular approach, first described by Patterson and Arbit.[32] The transpedicular approach allows for a posterolateral trajectory to thoracic discs and may be used for soft central discs and calcified centrolateral discs at all levels (Fig. 6 left and right, Table 3). Recently, Patterson[31] has reported his experience using this approach in 31 patients, and Le Roux, et al.,[24] have recently reported experience with 23 thoracic discs in 20 patients. Both of these series documented good results with myelopathy and radicular pain. It has been pointed out, however, that "outcome in patients with pain alone has not been entirely satisfactory."[31] From the standpoint of localized axial pain, "not all patients obtained the hoped for relief of symptoms."[31] The reason for this is unclear and perhaps relates to the loss of mechanical integrity from disruption of the facet-pedicle and disc[27] (Fig. 6 right). Of note is the fact that large series using the more extensive approaches in conjunction with fusion do not report this problem of localized pain.[19,26,40,41]

Development of and Indications for the Transfacet Pedicle-Sparing Approach

To improve localized back pain reported for the transpedicular approach and provide selected individuals with a simpler, less risky operation than the transthoracic or lateral extracavitary procedures, we have developed the transfacet pedicle-sparing approach. Like the transpedicular, the transfacet pedicle-sparing approach allows removal of thoracic discs from a posterolateral trajectory (Fig. 6 left and right). It may be used for removal of calcified centrolateral and soft central thoracic discs at all levels (Table 3). Laboratory and clinical experiences have demonstrated that the removal of the ipsilateral pedicle is not necessary for removal of selected discs. Moreover, limiting the extent of bone removal and muscle dissection minimizes the perioperative pain and may decrease the chance of chronic back pain (Fig. 6 right).

Cadaveric morphometric analysis improved orientation to the disc and enabled the development of special instrumentation. We have found that the disc space is cephalad to the bottom of the inferior articular process, and this distance increases moving down the thoracic spine. This anatomical consideration has allowed us to pinpoint the facetectomy so that a limited amount of joint resection is performed (Fig. 1 column B). Additionally, the facet-to-disc distance increases in the sagittal dimension moving caudally (Fig. 1 column A). This increased distance results from increasing thickness of the articular facets and is not secondary to a significant increase in the diameter of the neural foramen. Therefore, at the thoracolumbar junction more bone removal is necessary to drill through the facet. The disc space width also increases from T10-L1 (Fig. 1 column C). Thus, this information may be useful in guiding the extent of disc removal.

Advantages and Disadvantages of Transfacet Pedicle-Sparing Approach

The advantages of this procedure include: 1) diminished operative time; 2) decreased blood loss; 3) limited bone removal; and 4) limited soft-tissue disruption. Compared with the transthoracic and lateral extracavitary approaches, we have seen significant improvements in perioperative pain, with shortened hospital stays, and reduced time interval before return to work. In the rare occurrence of multiple disc herniations, multilevel discectomies may be performed.[8,11] The multilevel approach was used in two of our cases without difficulty. Because the extent of bone removal is limited to only a portion of one facet, without the need to remove the corresponding pedicle, we hope that the incidence of long-term localized pain secondary to loss of mechanical integrity will be reduced. This is suggested by our preliminary results.

The disadvantages of this procedure are: 1) the limited skin incision makes it more difficult to perform a microdiscectomy in larger patients; 2) disc removal may be difficult for centrally located herniations without the use of specially designed instruments; and 3) the extent of decompression after the microdiscectomy may be difficult to evaluate. Like other researchers, we have found endoscopy useful for visualizing the ventral dura.[24,36] The use of AP fluoroscopy, with insertion of a small instrument through the annular defect across the disc space, also allows for intraoperative assessment of the extent of decompression. Moreover, accurate measurement of the disc space width (Fig. 1 column C) enables further evaluation of the extent of disc removal.

Our preliminary experience suggests that this approach may become the procedure of choice in the surgical management of all soft symptomatic herniations, lateral calcified, and centrolateral calcified thoracic discs. Results in this series using this technique have been excellent for the treatment of myelopathy, radiculopathy, and back pain. The efficacy of this approach for centrally located densely calcified discs, or for intradural herniations, remains to be proven.

References

1. Alberico AM, Sahni KS, Hall JA Jr, et al: High thoracic disc herniation. **Neurosurgery 19:**449-451, 1982

2. Albrand OW, Corkill G: Thoracic disc herniation. Treatment and prognosis. **Spine 4:**41-46, 1979

3. Arce CA, Dohrmann GJ: Thoracic disc herniation, improved diagnosis with computed tomographic scanning and a review of the literature. **Surg Neurol 23:**356-361, 1985

4. Arseni C, Nash F: Thoracic intervertebral disc protrusion. A clinical study. **J Neurosurg 17:**418-430, 1960

5. Awwad EE, Martin DS, Smith KR Jr, et al: Asymptomatic versus symptomatic herniated thoracic discs: their frequency and characteristics as detected by computed tomography after myelography. **Neurosurgery 28:**180-186, 1991

6. Benjamin V: Diagnosis and management of thoracic disc disease. **Clin Neurosurg 30:**577-605, 1983

7. Benson MKD, Byrnes DP: The clinical syndromes and surgical treatment of thoracic intervertebral disc prolapse. **J Bone Joint Surg (Br) 57:**471-477, 1975

8. Bhole R, Gilmer RE: Two-level thoracic disc herniation. **Clin Orthop 190:**129-131, 1983

9. Blumenkopf B: Thoracic intervertebral disc herniations: diagnostic value of magnetic resonance imaging. **Neurosurgery 23:**36-40, 1988

10. Bohlman HH, Zdeblick TA: Anterior excision of herniated thoracic discs. **J Bone and Joint Surg (Am) 70:**1038-1047, 1988

11. Chin LS, Black KL, Hoff JT: Multiple thoracic disc herniations. Case report. **J Neurosurg 66:**290-292, 1987

12. Chou SN, Seljeskog EL: Alternative surgical approaches to the thoracic spine. **Clin Neurosurg 20:**306-321, 1973

13. Chowdhary UM: Intradural thoracic disc protrusion. **Spine 12:**718-719, 1987

14. Ebersold MJ: Surgical management of thoracic disc disease. **Contemp Neurosurg 7:**1-6, 1986

15. El-Kalliny M, Tew JM Jr, Van Loveren H, et al: Surgical approaches to thoracic disc herniations. **Acta Neurochir 111:**22-32, 1991

16. Fessler RG, Dietze DD Jr, Mac Millan M, et al: Lateral parascapular extrapleural approach to the upper thoracic spine. **J Neurosurg 75:**349-355, 1991

17. Fidler MW, Goedhart ZD: Excision of prolapse of thoracic intervertebral disc. A transthoracic technique. **J Bone Joint Surg (Br) 66:**518-522, 1984

18. Garrido E: Modified costotransversectomy: a surgical approach to ventrally placed lesions in the thoracic spinal canal. **Surg Neurol 13:**109-113, 1979

19. Horowitz MB, Moossy JJ, Julian T, et al: Thoracic discectomy using video assisted thoracoscopy. **Spine 9:**1082-1086, 1994

20. Hulme A: The surgical approach to thoracic intervertebral disc protrusions. **J Neurol Neurosurg Psychiatry 23:**133-137, 1960

21. Krasna MJ, Mack MJ: **Atlas of Thorascopic Surgery.** St. Louis: Quality Medical Publishing, 1994, pp 206-211

22. Kumar A: Thoracic disc prolapse in calcified discs. **Orthopedics 14:**98-99, 1991

23. Larson SJ, Holst RA, Hemmy DC, et al: Lateral extracavitary approach to traumatic lesions of the thoracic and lumbar spine. **J Neurosurg 45:**628-637, 1976

24. Le Roux PD, Haglund MM, Harris AB: Thoracic disc disease: experience with the transpedicular approach in twenty consecutive patients. **Neurosurgery 33:**58-66, 1993

25. Lesoin F, Rousseaux M, Autricque A, et al: Thoracic disc herniations: evolution in the approach and indications. **Acta Neurochir 80:**30-34, 1986

26. Maiman DJ, Larson SJ, Luck E, et al: Lateral extracavitary approach to the spine for thoracic disc herniation: report of 23 cases. **Neurosurgery 14:**178-182, 1984

27. Maiman DJ, Pintar FA: Anatomy and clinical biomechanics of thoracic spine. **Clin Neurosurg 38:**296-324, 1992

28. Otani K, Manzoku S, Shibasaki K, et al: The surgical treatment of thoracic and thoracolumbar disc lesions using the anterior approach. Report of six cases. **Spine 2:**266-275, 1977

29. Otani K, Nakai S, Fujimura Y, et al: Surgical treatment of thoracic disc herniation using the anterior approach. **J Bone Joint Surg (Br) 64:**340-343, 1982

30. Otani K, Yoshida M, Fujii E, et al: Thoracic disc herniation. Surgical treatment in 23 patients. **Spine 13:**1262-1267, 1988

31. Patterson RH: Thoracic disc disease: experience with the transpedicular approach in twenty consecutive patients. **Neurosurgery 33:**66, 1993 (Comment)

32. Patterson RH Jr, Arbit E: A surgical approach through the pedicle to protruded thoracic discs. **J Neurosurg 48:**768-772, 1978

33. Perot PL Jr, Munro DD: Transthoracic removal of midline thoracic disc protrusions causing spinal cord compression. **J Neurosurg 31:**452-458, 1969

34. Ransohoff J, Spencer F, Siew F, et al: Transthoracic removal of thoracic disc. Report of three cases. **J**

Neurosurg 31:459-461, 1969

35. Reif J, Gilsbach J, Ostheim-Dzerowycz W: Differential diagnosis and therapy of herniated thoracic disc. Discussion of six cases. **Acta Neurochir 67:**255-265, 1983

36. Rosenthal D, Rosenthal R, de Simone A: Removal of a protruded thoracic disc using microsurgical endoscopy. A new technique. **Spine 19:**1087-1091, 1994

37. Russell T: Thoracic intervertebral disc protrusion: experience of 67 cases and review of the literature. **Br J Neurosurg 3:**153-160, 1989

38. Safdari H, Baker RL II: Microsurgical anatomy and related techniques to an anterolateral transthoracic approach to thoracic disc herniations. **Surg Neurol 23:**589-593, 1985

39. Sekhar LN, Jannetta PJ: Thoracic disc herniation: operative approaches and results. **Neurosurgery 12:**303-305, 1983

40. Stillerman CB, Weiss MH: Management of thoracic disc disease. **Clin Neurosurg 38:**325-352, 1992

41. Stillerman CB, Weiss MH: Management of thoracic disc herniation and spondylosis: strategy and management, in Menezes AH, Sonntag VKH (eds): **Principles of Spinal Surgery.** New York: McGraw-Hill (In press 1995)

42. Stillerman CB, Weiss MH: Principles of surgical approaches to the thoracic spine, in Tarlov EC (ed): **Neurosurgical Treatment of Disorders of the Thoracic Spine.** Park Ridge, Ill: American Association of Neurological Surgeons, 1991, pp 1-19

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