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Posterolateral Arthroscopic Discectomies of the Thoracic and Lumbar Spine

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Posterolateral arthroscopic discoscopies were performed on the lumbar and thoracic spine of the cadaver of a 6-foot-tall man. The purpose of this study was to determine the anatomic relationships of the discotomies and to examine the feasibility of the procedure for thoracic discectomies. At most levels in the thoracic spine, the rib neck acted as a guide to the posterolateral disc and as a safeguard against penetration of the pleural cavity. The average distance from the dura to the disco. tomy was 0.79 cm, with this distance increasing caudally. The thoracic nerve roots were found, in general, to be at less risk of damage because of their initial posterolateral course as they entered the subcostal groove. In the lumbar spine, the average distance from discostomy to the dura was 11.5 mm. Access to the triangular working zone could be gained with angles of insertion ranging from 38^0 to 65^0. At angles less than 35^0, there was a significant risk of nerve injury. It is concluded that some thoracic discs can be safely removed through this approach and that the lumbar ventral ramii are very vulnerable to injury because of their proximity to the annulotomy.

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During the past 15 years, there has been an increasing interest in minimally invasive procedures for herniated lumbar discs, and, recently, there has been a definite acceleration of this trend. Procedures described so far include chemonucleolysis,[2] [3] [5] laser ablation of herniated discs, percutaneous discectomies,4.8, 10 and arthroscopic microdiscectomies.[7] Although there has been a proliferation of these types of procedures, there has been only a general anatomic description of the areas being operated upon. Kambin[7] described the triangular working zone bounded by the spinal nerve anteriorly, the superior facet posteriorly, and the caudal vertebral body inferiorly. He also studied the anatomic relationship of the path taken by instruments inserted into the discs percutaneously at the L3—4, L4—5, and L5—Sl levels on fresh cadavers. [6] Shepperd et al [10] made an interesting comparison between a lumbar extraforaminal area and the inside of a theater as seen from the upper circle. The procedures currently performed with this technique are quite simple, but with time, perhaps more complex conditions, such as more complicated disc herniations lateral canal stenosis, and instabilities of motion segments will be handled through this approach. As the procedures become more complex, the risk of neural damage will also increase, [ll] therefore, it is imperative that those who intend to use these procedures are thoroughly conversant with the periforaminal anatomy. The purpose of this article is to present a detailed study of the anatomic relationship of the discoscope and instruments as they are inserted into the posterolateral corner of the thoracic and lumbar discs at every level from Tl through SI; determine the safe angular range of arthroscope insertion into the lumbar discs; and study the feasibility of adopting the posterolateral approach for arthroscopic thoracic discectomy.

MATERIALS AND METHODS

The Dyonics 2.7-mm diameter VideoDiscoscope (Dyonics, Inc, Andover, MA) with accessories was used for visualization. A standard lumbar arthroscopic microdiscectomy instrument set (Smith & Nephew Richards Inc, Memphis, TN) was used for the experiment. An image intensifier was used for radiographic control of the procedure. The procedures were carried out at every level of the thoracic and lumbar spine bilaterally in the cadaver of a 6-foot-tall man.

The discoscopic technique described by Kambin[7] was used for the lumbar spine. The cadaver was in the prone position on a radiolucent table throughout the procedure. For the thoracic spine, the target disc was identified by laying a spinal needle across the back and drawing a horizontal line to replace it once the level had been found. Next, the costotransverse joint was identified by palpation, fluoroscopy, or both. For discoscopies of Tl —2 through T8—9, a 20-gauge spinal needle was inserted along the dorsal surface of the rib neck aimed at the center of the posterolateral disc. Once the disc had been engaged, the needle was replaced with a guide wire (Fig 1). The distance from the portal to the midline and the angle of insertion (as a deviation from the vertical) were measured directly. If the expansion of the rib head prevented deeper insertion of the needle, as it often did, instead of angulating the needle more medially, and thereby risking penetration of the dura, the obstruction was removed in the following manner. The needle was replaced with a guide wire and,

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Fig 1. Anteroposterior view of the T10-11 disc with guide wire and cannulated obturator in situ. Note that the rib articulates below the disc, whereas articulation at the T8-9 level involves the disc and the adjoining vertebral bodies.

after making a stab incision around it, the cannulated obturator was inserted over it. The universal access cannula was inserted and the wire obturator assembly was removed. The trephines were then used to excise the obstructing rib through the access cannula. Once the obstruction was removed, the procedure proceeded as de-

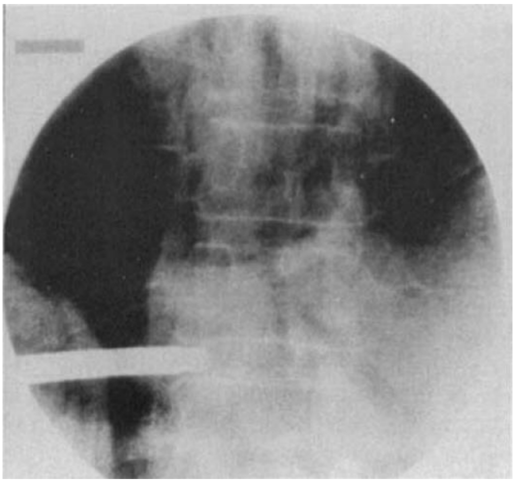
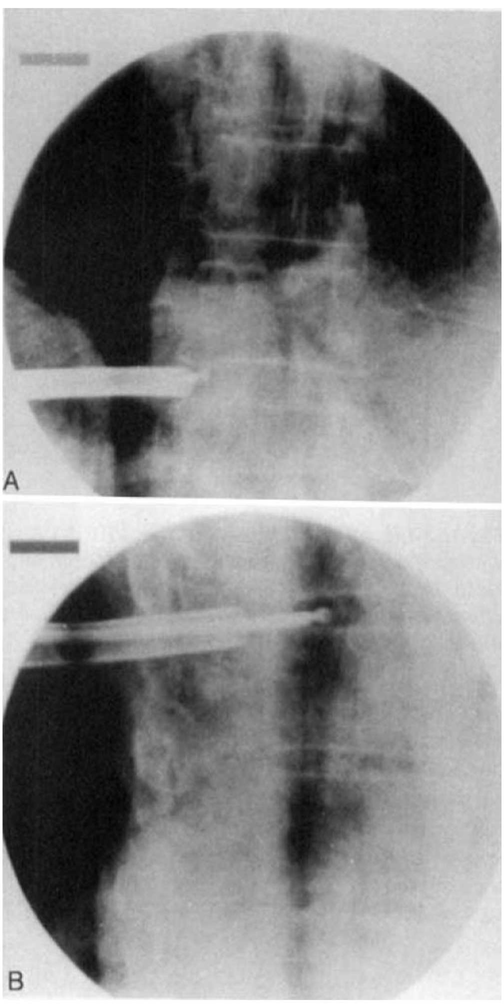


Fig 2. Anteroposterior view of the T10-11 disc shows a trephine in situ.



Figs 3A and 3B. Anteroposterjor and lateral view of the T10-11 disc showing a cup forceps in situ.

scribed for the lumbar disc by Kambin. After advancing the cannula to the annulus, trephines were used to make the annulotomy (Fig 2) and cup forceps were used to remove the disc fragments (Figs 3A and 3B). At T9—10 through Tl 2—L1 levels, the procedure was performed in a fashion similar to that of the lumbar discoscopies; however, care was exercised to insert the needle in the plane of the posterior surfaces of the adjoining rib necks to avoid penetration of the pleural cavity, with insertions lateral to the rib angles. Laminectomies were then performed from Tl to Sl level. The foraminal heights were measured before excision of the facets to remove the roof of the foramina at every level from Tl to S l. The exposure was extended laterally far enough to expose the discotomy site and the ventral ramus at all levels (Figs 4A, 4B, 5A, and 5B). The distance measurements were taken with a pair of calipers. In addition to foraminal heights, the distances measured were: the medial edge of the discotomy portal to the lateral edge of the dura; the superior edge of the discotomy to the inferior surface of the spinal nerve; the horizontal distance from the midpedicle line to the lateral dural edge; and the distance from the medial edge of the costovertebral joint to the dural edge at three levels (Figs 6 and 7).

RESULTS

Thoracic Spine

Because of the structures of the shoulder girdle and transition from thoracic kyphosis to cervical lordosis, accurate insertion of the needle and the scope at T 1—2 and T2—3 levels was found to be very difficult. The small sizes of the first two thoracic vertebrae, and the large size of the discoscope and instruments, allowed easy penetration into the superior mediastinum. The average distance of the arthroscope portal from the midline was 5.78 cm (range, 4.4—8 cm) with a gradual increase caudally (Table l). The average angle of arthroscope insertion was 42^0 (range, $35—52^0$). When

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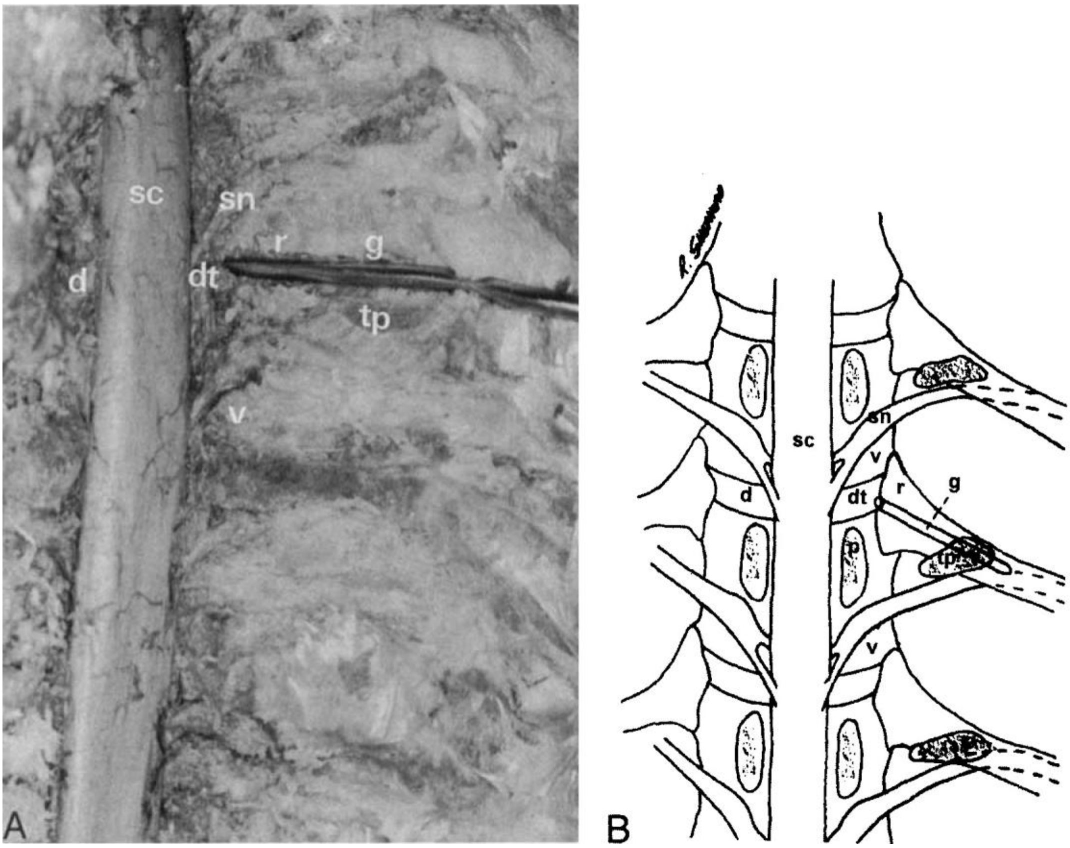


Figs 4A and 4B. (A) A segment of the thoracic spine with the dorsal bony elements removed. A probe is shown lying in the T7-8 discotomy portal and a groove in the dorsum of the rib neck and the transverse process prepared during the discoscopy at that level. (B) Schematic illustration of structures in the photograph showing: T7-8 disc (d); discotomy portal (dt); groove in the rib neck and head (g), reamed out for insertion of the discoscope; pedicle (p); spinal cord (sc) with dural covering intact; spinal nerve (sn; note its rostrat direction); the anterioiateral fragment of the transverse process left after excision of its base and dorsal cortex (tp); and the vertebral body (v).

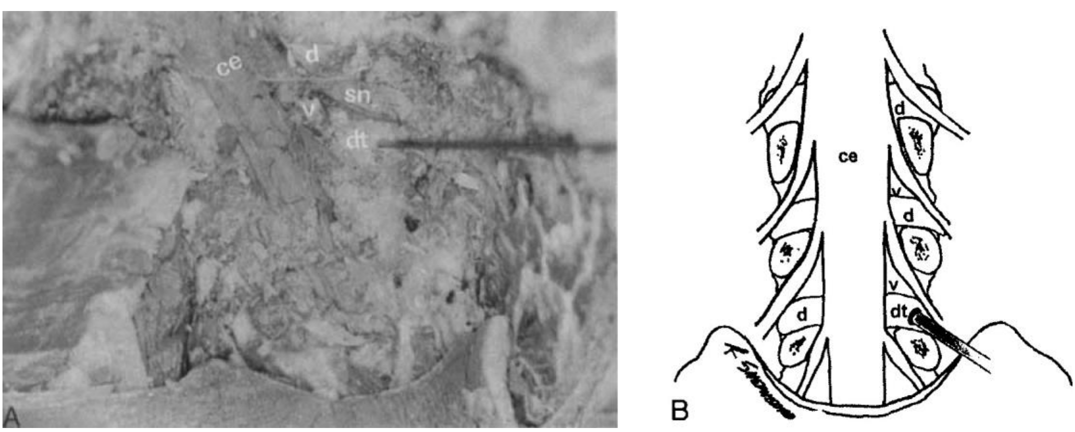
more horizontal insertions were attempted lateral to the rib angles at T9—10 and T 10—1 1, the pleural cavity was violated. The discotomy to dural edge averaged 0.79 cm with a range of 0.5— 1.2 cm. The average distance of the spinal nerve to the superior edge of the discotomy was 3.46 mm (range, 2—4 mm). A notable difference between the thoracic and lumbar spinal nerves was that, although the latter descended caudally and ventrally as it left the foramen, the former ascended slightly rostrally and dorsally as it approached the groove of the rostral rib (Figs 4A and 4B). This rendered the thoracic nerves less likely to be pinched against the disc or vertebral body. The distance from midinterpedicular line to dural edge averaged 5.65 mm (range, 4—8 mm). This distance gradually increased caudally. The vertical heights of the foramina measured at the pedicular bases averaged 8.9 mm (range, 6— 12 mm). About 50% of the rostral half of the space was occupied by the neurovascular structures, and the lower half was mainly filled with fibrofatty tissue. The distance from the dorsal (medial) edge of the costovertebral joints, measured at T6—7 through 9—10 levels, averaged 9.5 mm (range, 8—11 mm), and the distance widened caudally. At the T3—4 and T4—5 levels, the discotomies were slightly superior to the rib heads. At T5—6 to T7—8, the rib heads/necks and the transverse processes had been reamed out during the earlier use of the trephines, whereas only slight grooving of the dorsal surfaces occurred at the T8-9 and T9-10 levels (Figs 4A and 4B).

Lumbar Spine

The distance from the arthroscope port to the midline averaged 8.89 cm (range, 8—10 cm) for the intervals between T 12 and S l . A more lateral insertion at the T12—Ll level was restric ted by the caudally inclined 12th rib. The average angle of insertion was 49.2^0 (range, 35—60^0). Reinsertion at different angles, after removal of the foramina roof, revealed that, with the portals made 7.5— 10 cm from the midline, discoscopies could safely be performed in the triangular zone in the angular range of 38—60^0 at T12—L3, and in the angular range of 40—65^0 at L3— Sl levels. Insertion at smaller angles risked skewering the ventral ramus or passing latera] to it. At larger than 65^0 angles, there was an increased risk of dural injury. The average distance of the ventral ramii from the discotomy was 2.3 mm (range, 2—3 mm) (Fig 7). The average distance from the discotomy to the dural edge was 11.5 mm (range, 8— 14 mm) and the average midinterpedicular line to dural distance was 9.8 mm (range, 8— 12 mm). The vertical foraminal height averaged 14.8 mm (range, I I — 20 mm).

DISCUSSION

The distance and angular measurements in this study were obtained from the cadaver of a 6-foot-tall man; variations, particularly with regards to the distances, should be expected in subjects with differing heights and weights. For instance, in a taller subject, the vertebrae are likely to be taller; hence, the foraminal heights and subneural (spinal nerve to the lower pedicle) distances would be expected to be larger. The converse is true for a smaller subject. The distances of the skin ports from the midline are expected to be shorter in smaller and leaner subjects because of differences in the width of the vertebral bodies and the amount of the subcutaneous fat, respectively. The distances between the discotomy and the dura would vary according to the breadth of the pedicle, which in turn varies with the size of the vertebrae. Therefore, these figures should be taken only as a rough



Figs 5A and 5B. (A) A segment of lumbosacral spine shows a probe in the discotomy portal at L5Sl on the right. (B) A schematic illustration of the structures in the photograph shows: cauda equina (ce); disc (d); discoscopy pon (dt); spinal nerve (sn); and vertebra (v).

guide and appropriate adjustments should be made to address individual variations.

A thoracic disc below the level of T3— 4 avails itself of posterolateral arthroscopic discectomy much like the lumbar spine. The rib necks and the costovertebral articulations above the level of TIO act as perfect guides to the intervertebral discs while offering protection against penetration of the pleural cavity. Staying close to, or even excising, the dorsal part of the joint would ensure discotomy at a site away from the dural edge. The parameters obtained from this study indicate that there is a reasonably wide margin of safety against damaging the dura. TIO to Ll levels are similar to the lumbar discs in that the ribs do not articulate

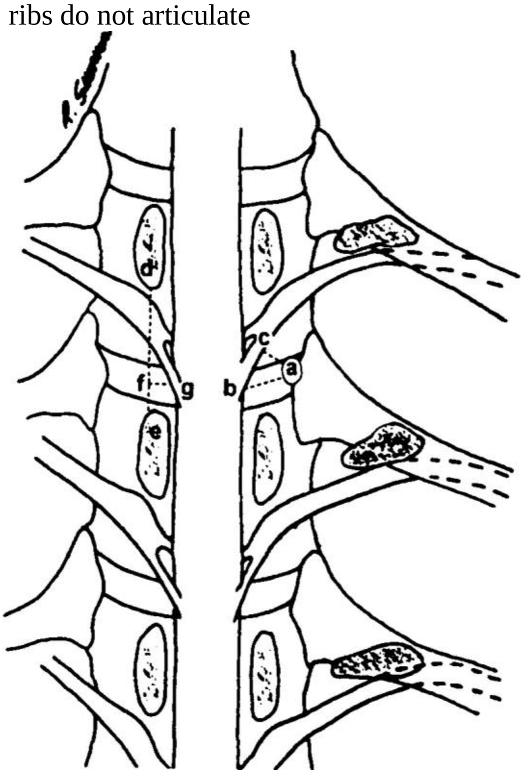


Fig 6. A diagram of the thoracic spine shows measured distances. ab = discotomy to lateral dural margin; ac = discotomy to the spinal nerve; de = foraminal height measured at the bases of the pedicles; and fg = midinterpedicular line to dural edge.

at the disc levels; however, the degree of horizontal insertion is still limited by the direction of the rib necks. Insertion lateral to the rib angle increases the risk of penetration of the pleural cavity. The thoracic spinal nerves pose fewer problems than do the lumbar nerves. Their distances from the discoscopy tracks are generally larger than that of the lumbar nerves, and they track posterolaterally away from the disc as they approach the ribs, thereby decreasing the risk of injury. Also, damage of spinal nerves at the thoracic level does not have as serious an implication as does lumbar nerve damage.

In carefully selected cases, with the use of appropriately designed discoscopes and instruments, it is possible to perform posterolateral thoracic arthroscopic discectomy. Illumination of the operative field to the desired intensity, and the facility to magnify the endoscopic images, should make the visualization of structures, including the spinal nerve and the dura, superior to the costotranversectomy approach, and probably as good if not superior to the anterior thoracotomy approach. With current arthroscopic microdiscectomy instruments, the easiest thoracic herniation removable by this approach would be a noncalcified lateral disc. However, with flexible and curvable instruments, the first generation of which have already been produced, a noncalcified central disc could also be removed using either a uniportal or biportal approach in a fashion similar to that of the posterolateral arthroscopic discectomies of the lumbar spine.

One should always consider such new techniques as an addition to, rather than a replacement of, established and safe procedures. The indications for this technique should, therefore, be confined at first to the

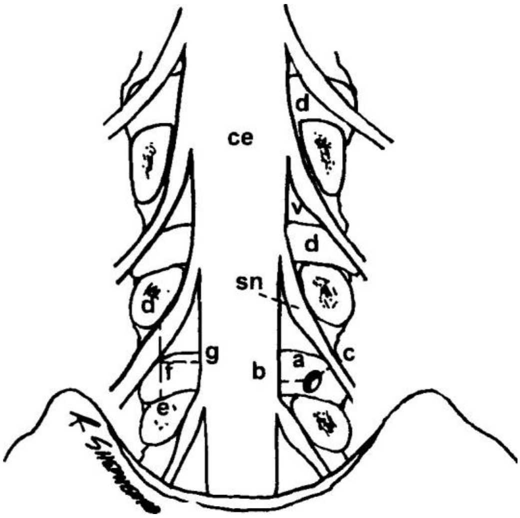


Fig 7. A diagram of the lumbosacral spine with posterior bony elements removed shows measured distances. ab = discotomy to dural edge; ac = discotomy to spinal nerve; de = foraminal height measured at the pedicular bases; fg = midpedicutar distance to the dural edge; and sn — spinal nerve.

TABLE 1. Measurements of Distances and Angles

Spine Level	Port to Midline (cm)	Angle of Insertion	Safe Horizontal Insertion Limits	Discotomy to Dura (cm)	Discotomy to Nerve (mm)	Mid Pedical Line to Dura (mm)	Vertical Height of Foramen (mm)	Comment
	4.5							
T2-3	5.5	440		1.5	3	4	7	b.
T3—4	5	420		1.2	2	4	7	c.
T4-5	4.4	440		0.9	3	5		d.
T5—6	4.5	370		0.7	3	5	7	
	5	400		0.8	4	6	10	
T7-8	5.5	470		07	3	7		
T8—g	6.5	520		0.5	4		12	h,
T9-10	6	400		0.6	4	7	11	
TIO-II	7.5	400		0.8	4	7	8	
Til-12	8	350		0.9	4	8	9	
T12-L1	9.3	350	45^0 60^0	1.1	3		11	
	8		38^0 60^0	1 .3	3		1 3	m.
1.2-3	9		45^0 60^0	0.8	2	1 .2	15	
	8	500	50^0 65^0	0.9	2	0.7	15	o.
1.4-5	10	450	45^0 65^0	1.4	2	0.8	15	p.
L5-1	9	450	45^0 65^0	1.4	2	1 .2	20	q.

Comments. a. and b.: Due to the transition from thoracic kyphus to cervical lordosis there was difficulty of insertion at Tl —2 and T23—the superior mediastinum was penetrated easily. c. and d.: Discotomy was slightly superior to rib head. f. , and g.: Rib neck/ head and transverse process were reamed during insertion. A slight grooving of the rib. i.: A slight grooving of the rib. j. and k.: Insertion lateral to the rib angle risked pleural penetration. i.: 12th rib prevented further iateral or a more horizontal insertion. ma: Less than 85^0 angle of insertion, discotomy was lateral to nerve. n,: Less than 40^0 angle of insertion; discotomy was lateral to nerve. 0,: Less than 37^0 angle of insertion: discotomy was lateral to nerve. p:. Less than 45^0 angle of insertion; discotomy was lateral to nerve.
q.. Less than 40^0 angle of insertion; discotomy was lateral to nerve.

least complicated herniations. For instance, a calcified and adherent central thoracic disc herniation is currently best handled by thoracotomy and anterior decompression. However, as more experience is gained and more sophisticated flexible instruments such as endoscopic burrs on flexible shafts are developed, more difficult discs could also be tackled safely through this approach. The morbidity after open surgery,] and even the anterior thoracoscopic approach,[9] make it imperative that this approach be developed. Its strong attractions are: (l) it is retropleural, and (2) because the operative area is small, it can be performed under local anaesthesia on an outpatient basis.

In the lumbar region, there is a consistently wide space between the edge of the discostomy and the dural margin; therefore, barring an extremely horizontal insertion, the risk to the dura is minimal. The spinal nerve, however, lies quite close to the discotomy on its lateral side and should always be considered to be in danger. The vessels generally lie superior to the spinal nerve at the level of foramen and are, therefore, less likely to be injured. There is a wide range of angles of safe insertion of the discoscope into the triangular working zone, but one should bear in mind that the ventral ramii are never far away, and that insertions at less than 40^{0} risk injuring the nerve. The discoscopic technique that is currently used is primarily that described by Kambin.[7] After insertion of the universal cannula, the tissue at the end of the cannula is examined both visually and by probing with a needle to elicit radicular pain to exclude entrapment of the spinal nerve. This has been shown to be sufficient for most cases of simple herniations. However, in view of the current finding of the close proximity of the ventral ramii to the annulotomies in the lumbar discs, the authors urge discoscopists to make every effort to inspect the extraforaminal region to determine the location of the nerve before proceeding to make an annulotomy, similar to the knee arthroscopist who carries out a diagnostic survey of the knee before proceeding to a meniscectomy. Such caution would prove particularly useful in subjects who are at the extremes of the height and weight spectra, and in situations in which more complicated procedures than a simple discectomy are contemplated.

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References

I. Bohlman HH, Zdeblick TA: Anterior excision of herniated thoracic discs. J Bone Joint Surg 70A: 1038-1047, 1988.
2, Dabezies EJ, Langford K, Morris J, Shields CB, Wilkinson HA: Safety and efficacy of chymopapain (discase) in the treatment of sciatica due to a herniated nucleus pulposus: Results of a randomized double blinded study. Spine 13:561— 565, 1988.
3. Fraser RD: Chymopapain for the treatment of intervertebral disc herniation: the final report of the double blinded study. Spine 9:815—818, 1984.
4. Hijikata S: Percutaneous nucleotomy: a new concept, technique and a 12 years' experience. Clin orthop 238:9, 1989.
5. Javid Ml, Nordby EJ, Ford LT, et al: Safety and efficacy of chymopapain (chymodiacin) in herniated nucleus pulposus with sciatica. JAMA 249:2489-2494, 1983.
6. Kambin P, Brager MD: Percutaneous posterolateral discectomy—anatomy and mechanism. Clin orthop 223:145-154, 1987.
7. Kambin P: Arthroscopic microdiscectomy. Arthroscopy 8:287-295, 1992.
8. Onik G, Mooney V, Wiltse I, et al: Percutaneous automated discectomy in the treatment of herniated lumbar discs. Radiology 165(suppl):78, 1987.
9. Regan JJ, Mack MJ, Picetti GD, et al: A comparison of video-assisted thoracoscopy (VAT) to open thoracotomy in thoracic spinal surgery. 1993 North American Spine Society Meeting, San Diego, California 84-85, 1993.
10. Shepperd JAN, James SE, Leach AB: Percutaneous disc surgery. Clin Orthop 238:43—49, 1989.
I l. Stern MB: Early experience with lateral percutaneous discectomy. Clin Orthop 238:50—55, 1989.