Surgical removal of Foraminal and Extraforaminal Herniated Lumbar Disc via Paramedian approach

A Thesis Submitted for Partial Fulfillment of M.D. Degree in Neurosurgery

By

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Lumbar disc herniation (LDH) is a common cause of low back pain and sciatica. The number of patients with LDH is increasing with the aging population. However, epidemiological studies have demonstrated that intervertebral disc disease is also increasing among all the populations including the young. This phenomenon may be due to the lack of physical activity, sedentary lifestyle and increasing car and air travel. Approximately 70-85% of people have experienced at least one episode of low back pain with or without leg pain during their lives, and it is the second most common reason for doctor visits. **(Andersson, 2008).**

Lumbar disc herniation may be at the central canal, subarticular zone, foraminal zone or extraforaminal zone. The clinical syndrome of far lateral (Extraforaminal) lumbar disc herniation was initially described by Abdullah, et. al., in 1974, It is typified by radicular symptoms attributable to involvement of the rostral nerve root exiting at the adjacent neural foramen. Depending on the reported series, far lateral herniation represent up to 11% of all lumber herniated discs. **(Abdullah et al., 1974, O'Hara and Marshall, 1997).**

Extraforaminal lumbar disc herniation (EFLDH), a herniated disc outside the confines of the spinal canal, has been also named as far-lateral, extreme-lateral, and extracanalicular disc herniation. **(Viswanathan et al., 2002).**

Foraminal lumbar disc herniation (FLDH), a herniated disc inside the confines of neural foramen, has been generally considered as an isolated and different disease entity from EFLDH. **(Chang et al., 2006, Epstein, 2002)**

However, lumbar disc herniation can occur in simultaneous foraminal and extraforaminal locations in significant numbers of patients **(Porchet et al., 1999).**

In both lesions the posterior root ganglion is frequently involved resulting in more severe and medically refractory pain syndromes than those usually seen in patients with more common paramedian, intracanalicular disc herniation**. (Lew et al., 2006)**

With wider availability of modern imaging methods such as high resolution CT and MRI scans, the frequency of diagnosis for EFDH is on the rise. Despite increased awareness about its existence, the optimal treatment for this disease entity is still a matter of contention. Conventional posterior laminectomy may not provide good access to a herniation that lies lateral to the lateral margin of the pedicle. Some reports have mentioned extended facetectomy (partial or complete) or even complete resection of the pars to remove these EFDHs. **(Tessitore and de Tribolet, 2004)**

Boelder demonstrated that posterior midline approach to the lumbar spine may cause atrophy of the para-vertebral muscles and that it correlated with persistent low back pain after surgery and also, he studied the para-vertebral muscle innervations and concluded that the correspondent branches may be stretched and damaged if the muscles are retracted laterally to the articular processes, a required procedure in the posterior midline approach, thus the paramedian (PM) approach, besides providing a better angle of vision, is less likely to endanger the para-vertebral muscles and their innervations.**(Boelderl et al., 2002)**

Wiltse et al. popularized the paraspinal sacrospinalis-splitting approach to the lumbar spine. In his original report on this procedure, Wiltse described the approach as passing “trans-sacrospinals”. The sacrospinalis is split about two-finger breadths lateral to the midline. He noted further “the muscle fibers do not split cleanly since at this level they run in various directions.”Wiltse argued that this approach offered a more direct route to the transverse processes and facets of the lumbar spine, with less bleeding. **(Wiltse, 1973)**

Nevertheless, the exact location of the sacrospinalis muscle requiring splitting remain unclear despite Wiltse’s description. Vialle et al., proposed, on the basis of cadaver studies, that the splitting should be done at the natural cleavage plane between the multifidus and the longissimus part of the sacrospinalis. We prefer the term “modified muscle –sparing approach”. **(Vialle et al., 2006).**

The benefits of this minimally disruptive approach might include decrease damage to the paraspinal musculature, which in turn could lead to improve outcomes. Several authors have described paraspinal muscle damage seen after conventional midline approach. Higher levels of inflammatory mediators have been demonstrated in patients undergoing conventional midline microdiscectomy as opposed to paramedian approach. **(Suwa et al., 2000, Sasaoka et al., 2006)**

Abdullah AF, Ditto EW, 3rd, Byrd EB, Williams R (1974) Extreme-lateral lumbar disc herniations. Clinical syndrome and special problems of diagnosis. *J Neurosurg,* **41,** 229-34.

Andersson GB (2008) Epidemiological features of chronic low-back pain. *Lancet,* **354,** 581-5.

Boelderl A, Daniaux H, Kathrein A, Maurer H (2002) Danger of damaging the medial branches of the posterior rami of spinal nerves during a dorsomedian approach to the spine. *Clin Anat,* **15,** 77-81.

Chang SB, Lee SH, Ahn Y, Kim JM (2006) Risk factor for unsatisfactory outcome after lumbar foraminal and far lateral microdecompression. *Spine (Phila Pa 1976),* **31,** 1163-7.

Epstein NE (2002) Foraminal and far lateral lumbar disc herniations: surgical alternatives and outcome measures. *Spinal Cord,* **40,** 491-500.

Lew SM, Mehalic TF, Fagone KL (2006) Transforaminal percutaneous endoscopic discectomy in the treatment of far-lateral and foraminal lumbar disc herniations. *J Neurosurg,* **94,** 216-20.

O'Hara LJ, Marshall RW (1997) Far lateral lumbar disc herniation. The key to the intertransverse approach. *J Bone Joint Surg Br,* **79,** 943-7.

Porchet F, Chollet-Bornand A, de Tribolet N (1999) Long-term follow up of patients surgically treated by the far-lateral approach for foraminal and extraforaminal lumbar disc herniations. *J Neurosurg,* **90,** 59-66.

Sasaoka R, Nakamura H, Konishi S, et al. (2006) Objective assessment of reduced invasiveness in MED. Compared with conventional one-level laminotomy. *Eur Spine J,* **15,** 577-82.

Suwa H, Hanakita J, Ohshita N, Gotoh K, Matsuoka N, Morizane A (2000) Postoperative changes in paraspinal muscle thickness after various lumbar back surgery procedures. *Neurol Med Chir (Tokyo),* **40,** 151-4; discussion 154-5.

Tessitore E, de Tribolet N (2004) Far-lateral lumbar disc herniation: the microsurgical transmuscular approach. *Neurosurgery,* **54,** 939-42; discussion 942.

Vialle R, Wicart P, Drain O, Dubousset J, Court C (2006) The Wiltse paraspinal approach to the lumbar spine revisited: an anatomic study. *Clin Orthop Relat Res,* **445,** 175-80.

Viswanathan R, Swamy NK, Tobler WD, Greiner AL, Keller JT, Dunsker SB (2002) Extraforaminal lumbar disc herniations: microsurgical anatomy and surgical approach. *J Neurosurg,* **96,** 206-11.

Wiltse LL (1973) The paraspinal sacrospinalis-splitting approach to the lumbar spine. *Clin Orthop Relat Res***,** 48-57.

The aim of this study is to determine the intermuscular approach for removal of foraminal and extra foraminal lumber disc herniation as regard indication, operative difficulties, postoperative outcome and the advantage of saving the bone and the Paravertebral muscles

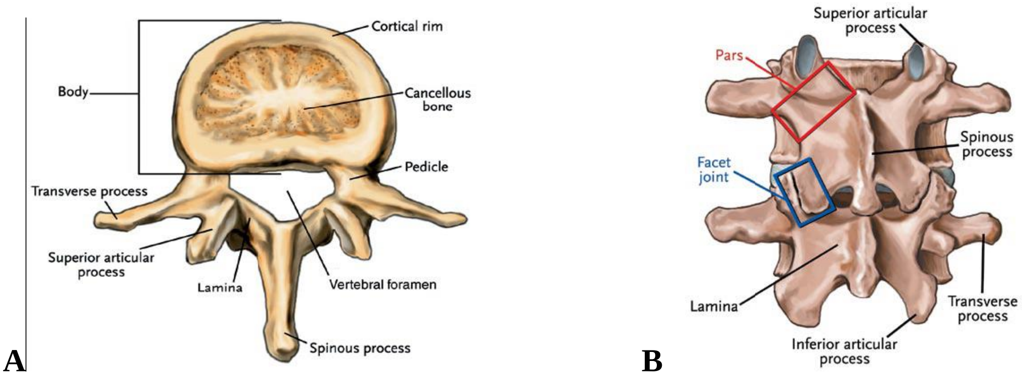
Anatomy of the Lumbar Spine

Osseous Structures:

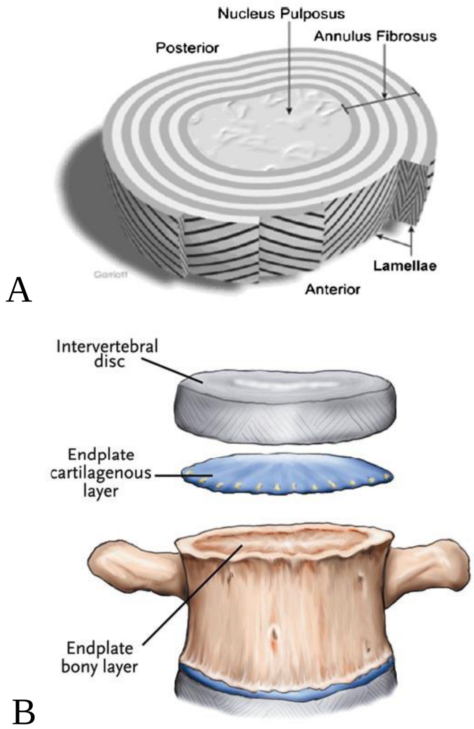
There are five lumbar vertebrae, followed by the sacrum making up the lumbosacral spine (Fig. 1 A and B). Each lumbar vertebra has 2 parts, the vertebral body and neural arch. The vertebral body; lies anteriorly, and its dimensions gradually increase from cephalad to caudal, and it is designed to bear weight. When viewed from above, the superior surface of vertebral body is wider transversely and is kidney shape. The discal surface of an adult vertebral body demonstrates on its periphery a ring of cortical bone. This ring, the epiphysial ring, acts as a growth zone in the young and in the adult as an anchoring ring for annular fibers. The hyaline cartilage plate lies within the confines of this ring. The neural arch; lies posterior to the vertebral body and consists of a pair of pedicles emerging from the posterolateral surface of the upper portion of vertebral body. These join with paired laminae, which are located further posteriorly, and are designed to protect the neural elements **(Kuroki et al., 2004).** The portion of the lamina between the superior and inferior articular processes and just below the level of the pedicle is the isthmus or pars interarticularis. This is a common site for stress fractures. From the junction of two laminae, a spinous process arises posteriorly. It is almost horizontal, quadrangular, and thickened along its posterior and inferior borders**(Panjabi et al., 1993)**.

Articulations

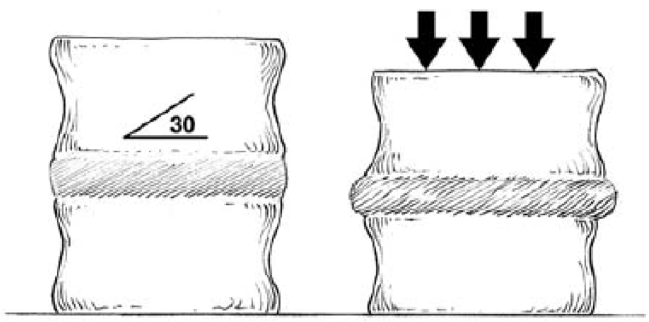
The articulations include the intervertebral disc anteriorly and a pair of facet or zygapophyseal joints posteriorly, reinforced by muscles and ligaments.



(Fig: 1) Osseous structures of the lumbar spine, A; Lumbar Vertebra. B; Posterior view of the lumbar spine **[Gallego and Schnuerer, 2003]**.



(Fig: 2 A and B) The intervertebral disc **(Devereaux, 2007).**



(Fig: 3) The annulus fibrosus is composed of layers of collagen fibers. The collagen fibers are oriented at 30^{o} relative to the endplate. The orientation alternates with each successive layer **[Belkoff SM, 2007].**

The Intervertebral Disc

Function; intervertebral discs stabilize the spine and maintain its alignment by anchoring adjacent vertebral bodies to each other. They also allow flexion, extension, and lateral bending motions between vertebrae that give the spine its flexibility, and they absorb energy and distribute loads applied to the spine. These multiple functions are made possible by the structure of discs **(Diwan et al., 2003).**

Structure; the tissue is best described as a specialized form of fibro-cartilage. The intervertebral disc is composed of three elements (Fig: 2 a and b); the central portion of the disc contains the nucleus pulposus, surrounded by the annulus fibrosus, and the cartilaginous end plates adjacent to the surfaces of the vertebral bodies **(Martin et al., 2002).**

1) The Annulus; it forms the circumferential rim of the disc .The annulus has a multilayer lamellar architecture made of collagen fibers. Within each layer, the collagen is oriented at approximately 30° to the horizontal. Each successive layer is oriented at 30° to the horizontal in the opposite direction, leading to a “crisscross” type pattern. This composition allows the annulus, and in particular the outer annulus, which has the highest tensile modulus, to resist torsional, axial, and tensile loads (Fig: 3) **(Rhee et al., 2006)**. The fibers of the annulus can be divided into three main groups; the outer most fibers attaching between the vertebral bodies and the under surface of the epiphyseal ring; the middle fibers passing from the epiphyseal ring on one vertebral body to the epiphyseal ring of the vertebral body below; and the inner most fibers passing from one cartilaginous end plate to the other. The outer and middle fibers of the annulus are most numerous anteriorly and laterally but are deficient posteriorly, where most of the fibers are attached to the cartilage plate **(Wong and Transfeldt, 2007)**. A thinner posterior annulus fibrosus and a more vertical arrangement of the fibers could account for increased incidence of posterior or posterolateral disc herniation as compared with anterior herniation **(Ebraheim NA, 2004)**. The anterior longitudinal ligament (ALL) and posterior longitudinal ligament (PLL) further strengthen the disc space. The ALL attaches more strongly to the vertebral body edges than to the annulus. The PLL is not as strong as the ALL, it strongly attaches to the annulus fibrosus, and is frequently torn in cases of free fragment disc herniation **(Martin et al., 2002)**.

2) The cartilaginous end plate is located between the vertebral body and the disc; it functions as a growth plate and transfuses nutrients from the vertebral body to the disc **(Ebraheim et al., 2004)**.

3) The Nucleus Pulposus is centrally located and comprises approximately 50% of the total disc cross-sectional area in the lumbar spine. It is composed of type II collagen strands that lie in a mucoprotein gel containing various hydrophilic proteoglycans that imbibe water. The water content of the disc varies with the age of the disc and in the normal disc ranges from 70 to 90% **(Panagiotacopulos et al., 1987)**. The nucleus pulposus provides resistance to axial compression and is the principal determinant of disc height. The nucleus also contains a cellular component of both fibroblast like and chondrocyte like cells. These cells maintain the matrix in which they exist, and they also receive metabolic nutrients that diffuse through the matrix **(Rhee et al., 2006)**.

Collagens and proteoglycans are the primary structural components of the intervertebral disc macromolecular framework.

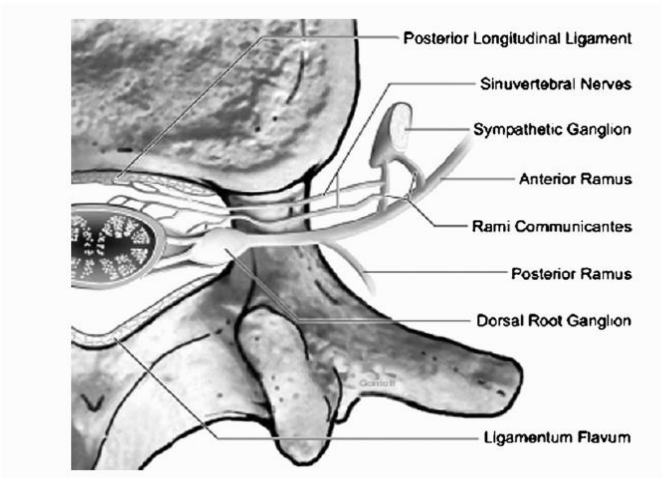
Proteoglycan and Water content; proteoglycan is a hydrophilic, negatively charged branched chain molecule composed of a protein attached to an oligosaccharide. They are also known as glycosaminoglycans and include structures such as chondroitin and collagen. The negative charge on the branched chains and the hydrophilic nature of proteoglycan internally pressurize the disc generating large hydrostatic pressure within the disc by drawing water via osmosis into the nucleus pulposus. Proteoglycans, through their interactions with water, give the tissues stiffness, resistance to compression, and viscoelasticity **(Gumina et al., 1999)**. Unfortunately, proteoglycan and water content in the disc tend to decrease with age **(Adam et al., 1996)**. Additionally the amount of hydration within the disc is inversely proportional to applied stress, suggesting that applied spinal loads lead to a loss of hydration and proteoglycan in the disc. Interestingly, proteoglycan, and water content, has also been shown to be low throughout the entire spine in patients with degenerated discs **(Martin et al., 2002). Collagen Distribution;** the intervertebral disc contains multiple collagen types, including Types I, II, III, V, VI, IX, XI, XII, and XIV, whose relative abundance changes with age. Types I and II collagen are the most abundant collagens in the disc, accounting for about 80% of the total collagen, with type VI collagen being next in abundance, accounting for 10% to 20% of the collagen. The fibrillar collagen framework of the disc is composed principally of Types I and II collagen, with the outermost layers of the annulus fibrosus possessing mostly type I collagen and the nucleus pulposus possessing mostly type II collagen. Studies of the collagen composition of the disc have revealed the importance of collagen cross links to the tensile strength and mechanical stability of the intervertebral disc**(Roughley, 2004).**

Vascularity of the Disc:

The disc is an avascular structure with a low metabolic rate and receives most of its nutrition by diffusion, which is facilitated by spinal motion. The majority of disc nutrition is supplied via the capillary beds of the cartilaginous end plate. These capillary beds receive blood flow from the distal branches of the interosseous arteries supplying the vertebral body. Vascular and lymphatic tissue is present in the annulus of patients who are as old as age 20 years; however, lymphatics and blood vessels are not present in the nucleus pulposus at any age **(Martin et al., 2002)**.

Nerve supply of the Disc:

A meningeal branch of the spinal nerve, better known as the recurrent sinuvertebral nerve (Fig: 4), innervates the area around the disc space. This nerve exits from the dorsal root ganglion and enters the foramen, where it then divides into, a major ascending and lesser descending branch. The outer annular regions are innervated, but the inner regions and nucleus pulposus are not innervated. The ALL also receives afferent innervations from branches that originate in the dorsal root ganglion and from the segmental ventral ramus and sympathetic trunk. The PLL is richly innervated by nociceptive fibers from the major ascending branch of the sinuvertebral nerve **(Martin et al., 2002).** Degenerated human lumbar discs have been shown to contain more nerve tissue and to be more vascular than normal discs **(Coppes et al., 1997)**.



(Fig: 4) The Sinuvertebral nerve **(Devereaux, 2007)**

Functional Basics of the Intervertebral Disc

The lumbar spine allows for flexion, extension, axial rotation, side bending, and compression of the motion segments. These movements are performed constantly during normal activities of daily living and may be repetitively stressed during exercise or job specific activities. Chronic repetitive motions as well as traumatic events can lead to injury of the spinal elements including the intervertebral disc. The intervertebral disc functions to allow for motion between the spinal segments while dispersing compressive, distractive, sliding, and torsional forces. The disc is strongest in withstanding compression and relatively weak in torsion relying on the facet joints to limit axial rotation and sagittal translation of motion segments. Stress on the disc occurs during lumbar flexion due to anterior sagittal translation and rotation of the vertebrae. In lumbar extension, the disc is relatively protected because extension is primarily limited by bony impaction of the posterior elements. Axial rotation of the lumbar spine is resisted by the posterior elements as well as the specific directional fibers of the annulus. Compression of the lumbar spine results not only from pure body weight or an externally derived force, but a significant amount may be the result of loading caused by the lumbar spinal musculature. The paraspinal musculature lies close to the lumbar spine itself; therefore, it exerts large forces to achieve movement of the spinal motion segments especially when resisting flexion at the lumbar spine. While the disc may be at risk of injury in all fundamental planes of motion, it is particularly susceptible to flexion moments combined with torsion. Biomechanical studies have not shown injury to the disc due to isolated flexion of the lumbar spine **(Wesley et al., 2004)**.

Lumbar Facet Joints

Zygapophyseal joints are synovial joints that consist of the adjacent inferior and superior articular processes and the articular capsule. The articular surfaces are covered by hyaline cartilage, which allows sliding motion occurring in the posterior arch of the spinal column. The articular capsules are thin, and have an inner synovial and an outer fibrous membrane covered by the ligamentum flavum. In lumber region, the superior articular surface is concave and faces posteromedially, and the inferior articular surface is convex and faces anterolaterally. The facet joints lie posterolateral to the lumbar spinal canal and posterior to the intervertebral canals. These joints are sagittaly oriented in the upper lumbar spine, rotating toward the coronal plane at the lumbosacral junction and serve to limit the amount of forward shear translation and axial rotation of the motion segment **(Giles, 1999)**.

Muscles and Ligaments of the Lumbar spine

Ligaments; there are several ligaments that play an important role in stabilization of the spines as one unit (Fig. 5 A, B, and C). These include:

1) The ALL; is a strong band that attaches to the whole anterior aspect of the vertebral bodies and intervertebral discs from the skull down to the upper part of sacrum. It is thicker anteromedially and thinner laterally. Limitation of extension of the spinal column is the main function of the anterior longitudinal ligament **[Ebraheim et al., 2004]**.

2) The PLL; attaches to the posterior aspect of the vertebral bodies and discs, from the occipital bone to the sacrum. In the lumber region it is narrow over the middle of the vertebrae and broad over the discs. In the region of the intervertebral foramen, the posterior longitudinal ligament extends laterally and fuses with the lateral extensions of the anterior longitudinal ligament. The role of the posterior longitudinal ligament is to stabilize the spinal column during flexion **[Ebraheim et al., 2004]**.