Endoscopic Discectomy and Foraminal Decompression
In
Interventional Spine: an algorithmic approach

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I. INTRODUCTION

Endoscopic disc surgery is evolving rapidly because of improvements in surgical technique, endoscope design, adjunctive surgical tools, and instrumentation. New endoscopes and complementary surgical devices enhances the endoscopic spine surgeon's ability to also probe spinal anatomy in a conscious patient. The surgeon can then evolve his diagnostic and surgical skills with this newly found ability to evaluate pathologic, anatomic, and physiologic processes causing the patient's pain. Now that diagnostic spinal endoscopy can be performed, conditions previously not even considered for surgery may be probed, evaluated and surgically treated with greater accuracy. Our understanding of discogenic back pain is enhanced, as endoscopic visualization of pathologic lesions not previously seen, intradiscally and in the "hidden extra-foraminal zone[1] is increasing our understanding of the pain generators in the lumbar spine.

Spinal endoscopy is poised to parallel the development and evolution of knee, shoulder, and ankle arthroscopy.[2] Without endoscopy, spine surgeons must depend heavily on imaging systems that, while extremely sensitive in identifying pathologic conditions, does not always correlate that condition with the patient's pain.

Interventional Pain Management Complementing Endoscopic Surgery

Foraminal epidurography and foraminal therapeutic injections can be performed using a needle technique that mimics the surgical approach to the foramen and spinal canal.[3] The approach differs from traditional interventional pain management "down the tunnel" approaches because it is the same far lateral approach used by endoscopic spinal surgeons to access the foramen for endoscopic surgery. If the non-ionic contrast agent (ie. Isovue 300) is injected to outline the foramen, it should be able to identify the location and position of the traversing and exiting nerves that cross each spinal level.

(Fig 1. Foramino-epidurography) Anomalous configurations such as conjoined nerves or furcal nerves provide additional information on the patho-anatomy in the lumbar spine. Diagnostic and therapeutic Information gleaned from these modified injection procedures can be used by the surgeon to better select patients for surgical intervention. Patients with symptomatic disc protrusions, annular tears, and foraminal stenosis may first be diagnosed by discography followed by foramino-epidurography, then get relief with the therapeutic foraminal injection. If the response is favorable but short lived, the diagnostic and therapeutic process will help the surgeon with patient selection. As a bonus, just performing the epidurogram will help determine the ease and feasibility of endoscopic surgery because it gives him a trial needle placement to the foramen before surgical intervention. By performing epidurograms, the surgeon can get additional information on the anatomy of the foramen, the outline of the traversing and exiting nerves, and the therapeutic response afforded by the epidural injection.[3] A foraminal injection at L5-S1 will also help the surgeon determine whether surgical access is appropriate or possible at this level due to anatomic considerations.

Endoscopic surgery following Injection therapy

Patients who find temporary relief with injection procedures directed toward the pain generator may find more lasting and definitive relief with the surgical correction or endoscopic correction of the patho-anatomy. When the pain pattern does not always match the anatomic dermatome, endoscopy, aided by discography, epidurography and therapeutic injections, will provide visual information that will help the surgeon diagnose and treat spinal conditions not considered desirable or feasible with the more invasive

open surgical techniques.[3] The technique first depends on directing a needle to the pain generator, desensitizing or anesthetizing it, dilating a path that will allow a tubular retractor to be inserted, followed by an operating endoscope. With this capability, we will gain a better understanding of the pain in specific individuals. It is also is well known that while a spinal structure is capable of pain, spinal pathology on imaging studies do not always correlate with the debilitating pain in a particular patient. These conditions are often resistant to non-surgical management. Because of these inflammatory conditions, what may be very painful in one person may be well tolerated or painless in another. Evocative discography™ is helpful in identifying the disc as a pain generator in axial back pain and sciatica.[4] When spinal endoscopy and probing complements discography performed with the patient in an aware state, the pathoanatomy and normal anatomy can be visually correlated with imaging studies. In the author's experience, new information or information different from the MRI interpretation occurs 30 percent of the time.[4]

INDICATIONS

Any pathologic lesion accessible, visible, treatable, or requiring endoscopic confirmation through the foramen may ultimately become an indication for diagnostic and therapeutic endoscopy.[5] Patient selection for pain and radiculopathy from disc herniation is similar to selection criteria for traditional spine procedures, but endoscopic surgical indications may be dictated by the limitations of the surgeon's skill and experience with the endoscopic procedure itself or with respect to the patient's anatomic considerations.[6] At L5-S1, anatomic restrictions may cause the surgeon to opt for the posterior transcanal approach. For herniations from T-10 to L4, the foraminal approach

provides excellent access to the disc and epidural space. **(Figure 2 Cadaver dissection of the foraminal approach)** As surgeon experience increases, previous contra-indications became relative, dependent partly on the surgeon's ability to endoscopically access the pathologic lesion. Restrictions are dictated only by anatomic considerations in accessing the patient's spinal pathology and the rationale of the endoscopic procedure itself. As the surgeon's experience increases, former contra-indications became relative, dependent on the surgeon's experience, and his ability to address the spinal condition to be treated.[7] Anatomic structures within reach of the spine endoscope transforaminally is illustrated **(fig. 3. The Dome: structures accessible with spinal endoscopy)**

1. **Disc herniation**

Symptomatic disc herniation is the obvious indication, with surgical decompression limited only by the accessibility of endoscopic instruments to the herniated fragment.[8, 9] The postero-lateral foraminal approach is ideal for a far lateral, extraforaminal disc herniation. Traditional approaches to far lateral, extraforaminal disc herniations are more difficult, requiring a paramedian incision through the vascular intertransverse ligament. This surgical area is often called the "hidden zone" for traditional surgeons[1]. Although a traditional spinal surgeon can access the lateral zone of the disc with a paramedian incision, it is easier to access the extraforaminal zone endoscopically via the posterolateral portal. A typical foraminal view of nucleus pulposus extruded past the posterior annulus **(figure 4)** is shown. Through this approach to the disc, relatively easy access is possible from T-10 to L4. This is also the preferred approach for disc herniations in the upper lumbar and lower thoracic spine since the

transcanal approach will require more extensive laminectomy that may destabilize the spinal segment if the herniation is above L3-4.

2. Discitis

Endoscopic excisional biopsy and disc space debridement is ideal for surgically debriding infectious discitis.[10] **(Figure 5**) Currently treated with immobilization and parenteral antibiotics, discitis is much more effectively treated when augmented by endoscopic debridement. The surgeon will not have to be overly concerned about creating dead space for the inflamed or infected disc material to spread into the dead space created by a posterior approach. The clinical results are dramatic, and tissue biopsy is more accurate than needle aspiration in identifying the cause of discitis. Even sterile discitis will benefit from intradiscal debridement and irrigation.

3. Lateral recess and central stenosis

Endoscopic foraminoplasty by endoscopic techniques is also possible for experienced endoscopic surgeons. [6, 11, 12] Although trephines, rasps and burrs can be utilized, The Ho:Yag laser has enhanced the procedure technically as laser is a very precise cutting tool for visually controlled soft tissue and bone ablation. Endoscopic laser foraminoplasty (ELF) is further validated by research studies by Osman and Panjabi demonstrating that decompression through the foramen can be as effective as posterior decompression, but will not produce further instability.[13] **(Figure 6. Endoscopic Foramino-plasty)** The foramen can be enlarged up to 45.5% vs the 34.2% attainable with the standard posterior technique of removing only the medial 1/3 of the facet. Posterior decompression of the lamina with removal of the medial 1/3 of the facet will produce increased extension and axial rotation postoperatively. [13] Endoscopic

foraminal plasty has not been shown to cause increased instability even in spondylolisthesis. [12] The technique is most useful for lateral recess stenosis, a condition that is responsible for atypical leg pain and sciatica that is differentiated from intermittent claudication of central spinal stenosis. In central spinal stenosis, when there is concomitant posterior disc protrusion, decompression of the spinal canal can be effectively accomplished by resecting the bulging annulus in a collapsed disc, thus lowering the floor of the foramen without destabilizing the spinal segment. In isthmic spondylolysthesis, when there is more leg than back pain, this is usually due to impingement on the exiting nerve by the pars pseudoarthrosis defect. The goal is then to decompress the compromised exiting nerve by elevating the dome formed by the inferior facet and lamina without further destabilizing the spinal segment. **(Fig 7. Illustration of Laser foramino-plasty)**

In degenerative spondylosis, endoscopic decompression and thermal annuloplasty of associated disc protrusion can also provide back and leg pain relief.

4. Recurrent disc herniation

Recurrent disc herniation is one condition that may be underestimated by surgeons confronted with patients who complain of recurrent sciatica within three months of a successful transcanal or transforaminal discectomy. The natural tendency is to blame the recurrent sciatica on “scar tissue”. Small recurrent herniations may cause pain out of proportion to the size of the herniation due to direct contact of the nucleus pulposus to the nerve that causes an intense inflammatory response or due to the traversing nerve being tethered to the epidural scar resulting in the inability of the nerve to give way to the disc fragment. The results of endoscopic decompression for previous transcanal or

endoscopic discectomy is as good as the original index procedure[12, 14]. In endoscopic discectomy especially with indigocarmine staining, the fragment is readily visible for extraction through the foramen.

Exclusion Criteria

There is really no absolute exclusion criteria for spinal endoccopy, but only relative contra-indications dependent on the surgeon's skills and experience. The authors have even treated cauda equina syndrome successfully with the foraminal approach, as any timely decompression of the spinal canal will help. If the patho-anatomy can be accessed, spinal endoscopy and spinal probing can be used for diagnostic purposes in a very difficult or confusing clinical problem. Therefore, since spinal endoscopy is helpful for diagnostic purposes, exclusion criteria may depend mainly on the accessiblilty of the spinal pathology and the endoscopic skills of the surgeon. The risks and benefits of the procedure must be weighted against the need to use this fluoroscopically guided procedure under local anesthesia or sedation.

III. TREATMENT PLANNING

Patients with chronic back pain and atypical sciatica are the most difficult to treat. Traditional methods of non-surgical treatment are often not effective or very transient, and the patient is often labeled drug seeking or psychologically unstable. In this situation it is extremely helpful to utilize a multi-disciplinary team approach. Psychologic profiling, behavioral modification, active exercise, and manual therapy helps the patients overcome their pain and focus on becoming functional. The team approach with psychologists, physiatrists, addictionologists and pain management specialists who are working with each other and agree on the overall treatment plan has helped rescue many

chronic pain sufferers from total disability and reliance on salvage procedures. Around the disc, foraminal epiduroscopy and foraminal epidural blocks will help determine the ease of reaching the disc and epidural space. A good temporary therapeutic response to a foraminal epidural injection is a good indicator that a foraminal approach to the pathologic lesion might respond longer term to an endoscopic surgical procedure. With the ability to directly address the pain generator minimally invasively, some of the old concepts of mandatory non-surgical treatment such as physical therapy before surgical intervention must be carefully re-evaluated before becoming a rigid algorithm for treatment.

Current Imaging Methods

In the author's experience, our imaging studies are only about 70% accurate and specific for predicting pain.[5, 12, 14-17] Conditions such as lateral annular tears, rim tears, endplate separation, small subligamentous disc herniations, anomalous nerves in the foramen and miscellaneous discogenic conditions are cumulatively missed about 30% of the time. These conditions are diagnosable and often treatable with spinal endoscopy. Tears that are in the lateral and ventral aspect of the disc are sometimes missed by MRI studies. Very small disc herniations that protrude past the outer fibers of the annulus are also missed since the fragment may be flattened against the posterior longitudinal ligament or nerve, appearing on the MRI as a thickened or bulged annulus, but really containing a subligamentous herniation. When the nerve root is "swollen" or enlarged, the MRI is not always capable of distinguishing a swollen nerve from a conjoined nerve or a nerve with an adherent fragment of disc. Both of these conditions have been diagnosed and treated. When the disc tissue is in direct contact with the nerve, the nerve

can be irritated and a painful inflammatory membrane forms. Even an epidural venous plexus that is inflamed can contribute to back pain and sciatica. Anomalous nerve branches known as furcal nerves are never seen on MRI but can be visualized with spinal endoscopy in the "hidden zone" or far lateral zone of the foramen.[1, 18, 19]

When an inflammatory membrane is present, the patient's pain pattern can be confusing. Diagnostic spinal endoscopy has confirmed "non-dermatomal" pain in scores of patients with proximal thigh, buttock and groin pain at levels distal to the root origin of the anatomic area. Removal of the source of irritation will resolve or improve the patient's pain

Evocative Discograms

Discogenic pain as determined by evocative discography™ may implicate the disc as a pain generator when there is a question whether the Mri shows enough mechanical compression to affect the patient's back pain and sciatica. Some disc herniations are relatively asymptomatic and others are extremely painful with low pressure discography. Discogenic pain from a sensitized lumbar disc due to internal disc disruption, degenerative disc disease, and annular tears with or without a disc protrusion is a different entity from compressive sciatica of mechanical origin. Axial back pain and sciatica may be identified, and correlated visually with patho-anatomic conditions in the disc, annulus, and foramen in the far lateral foraminal zone. Controversy in the literature has arisen because of the lack of a good spectrum of therapeutic surgical treatments once the pain is confirmed, and because of the plethora of articles pointing out the pitfalls of false interpretation. [20, 21]

The Role of intra-operative Evocative Chromo-discography™

If a vital dye is used to effect differential staining in the disc and epidural space intra-operatively, it is easier to recognize degenerative nucleus pulpolsus from normal nucleus, and the annulus and from facet capsule[4]. The epidural space with its epidural vessels and fat is easy to differentiate and recognize. I trademarked evocative chromodiscography™ as an integral part of spinal endoscopy. The process of removing the indigocarmine dye labeled nucleus was trademarked selective endoscopic discectomy™ to describe the technique. [12] **(fig 5 nucleus pulposus stained with indogocarmine dye)**

Future Considerations

It is not inconceiveable that the spine scope will eventually be used for all conditions where endoscopic visual inspection is desired. The author has utilized spinal endoscopy to inspect a spinal nerve suspected to be irritated by orthopedic hardware adjacent to the pedicle, to remove suspected recurrent or residual disc herniations that do not show up on imaging studies, to decompress the lateral recess by endoscopic laser foraminoplasty, to remove osteophytes and facet cysts that cause unrelenting sciatica, and to locate painful lateral annular tears or small disc herniations not evident on physical examination or on MRI. Some of these correctable lesions are responsible for Failed Back Surgery Syndrome (FBSS), especially with recurrent disc herniations and with lateral recess stenosis. The lateral "hidden" zone is rarely visualized by surgeons. It has been demonstrated that with endoscopy, it is possible to do isolated disc and annulus surgery using a visualized thermal modulation procedure, **(Figure 8a, 8b, 8c, 8d)** challenging the old concept that disc surgery is merely nerve decompressive surgery. For

example, discogenic pain from annular tears are currently being evaluated and correlated with the patho-anatomic conditions visualized. [18, 22-32]

Non-Operative Treatment

With endoscopy, conservative treatment should be labeled non-operative treatment. Physicians specializing in spinal medicine, rehabilitation and pain management are becoming more sophisticated in their ability to identify the tissue source of back pain. Once the source is identified, physical therapy and diagnostic and therapeutic injection methods are used for pain relief. These techniques, such as foraminal epidural blocks and selective nerve blocks, are therapeutically beneficial, but they may also be limited in their ability to ultimately correct the painful condition. The endoscopic spine surgeon is still needed to address surgically amenable lesions, but his effectiveness is enhanced by incorporating the help of a multi-disciplinary team

The world literature on conservative treatment has presented strong evidence that a multi-disciplinary approach to the surgical treatment of back pain, coupled with behavorial modification and exercise therapy, gives the best results. With spinal endoscopy, a new concept for surgical treatment, with the ability to more specifically diagnose and treat a painful condition in the lumbar spine make early surgical intervention the more "conservative" approach in some painful conditions.

TECHNIQUE

Endoscopic Spine surgery: The posterolateral Approach

The current technique utilized by the author has evolved over a 13 year period beginning in 1991 after learning arthroscopic discectomy from Parviz Kambin. Previously the author had experience in the use of chymopapain, automated percutaneous

discectomy, laser discectomy, and discography. The current technique combines the best features of each endoscopic procedure into a visualized method that is described as selective endoscopic discectomy™ and thermal discoplasty and annuloplasty. It continues by incorporating endoscopic foraminoplasty techniques for degenerative conditions of the lumbar spine. The foraminal approach is refined further by a standardized surgical protocol that helps decrease the learning curve.

PROBLEMS AND COMPLICATIONS

As with arthroscopic knee surgery, the risks of serious complications or nerve injury are low—about 1%-3% in the author's experience.[33] The usual risks of infection, nerve injury, dural tears, bleeding and scar tissue formation are always present as with any surgery spine surgery. Fenestration past the anterior annulus is a potential hazard creating a bowel or vascular injury. Although this is a rare complication because the thickness of the anterior annulus will usually prevent fenestration, it must be recognized as a potential risk if the annulus is weakened or fenestrated by an anterior disc herniation. This risk is also present with the posterior approach. One limitation of the endoscopic technique is the need to use some instruments in a "blind" fashion. That is, the size of shavers, pituitary rongeurs , and basket forceps are too large to fit in the working channel of the endoscope, and must be monitored with fluoroscopy. The surgeon must be cognizant of the depth of his instruments and develop a feel for the working instruments while in the disc. The cannulas are designed to protect vital structures by utilizing windows as surgical portals. Spinal nerves may be adherent to the disc and annulus, and can be extracted along with the disc or annulus by shavers or cutting instruments. In addition, the author has identified anomalous autonomic and peripheral

nerves in the foramen (furcal nerves), buried in the annular fat, that connect with the sacral plexus or the traversing nerve. These nerves are described in the medical literature and can be symptomatic, but has never been documented endsocopically. **(fig 9 furcal nerve)** The inflammatory membrane may contain tiny nerves and blood vessels that contribute to severe discogenic pain **(Figure 10)**

Dysesthesia, the most common post-op complaint, occurs about 5-15% of the time but is almost always transient. Its cause is still incompletely understood and may be related to furcal nerves the annulus, delayed nerve recovery, as it can occur days or weeks after surgery, or it may be due to irritation of the dorsal root ganglion from manipulation or post –op bleeding. This condition can not be completely avoided, as neuromonitoring with dermatomal SEP and continuous EMG, the most sensitive means of monitoring, has not identified intra-operative irritation as the major cause of dysesthesia. [34] The symptoms can be severe and similar to complex regional pain syndrome, but usually without the skin changes that accompany CRPS. Stimulation of the doral root ganglion of the exiting spinal nerve can also result in dysesthesia when foraminoplasty is performed, even with the exiting nerve clearly identified and protected. The endoscopic technique, because of its approach, may be accompanied by risk for iatrogenic injury, but it is probably safer than traditional surgery for the patient since he is awake and able to provide immediate input to the surgeon when pain is generated. I never allow my anesthesiologist to use propofol for “sedation” because the patient cannot be non-responsive even for a short period. The surgeon’s ability to perform the surgery without causing the patient undue pain will self select for surgeons who can master the technique to the extent that once mastered, the surgeon will prefer endsocopic to

traditional surgery for the same condition. Neuro-monitoring techniques and equipment previously utilized by the author helps warn the surgeon of nerve irritation with continuous EMG, even when there is no direct contact of surgical instruments with the nerve proper. About 66% of the time, there is EMG activity recorded that warns the surgeon that there is nerve irritation[34]. Neuromonitoring may make give the surgeon more intra-operative feedback, but in a subsequent study comparing surgical cases without neuromonitoring, it has been demonstrated to that is just as safe using of dilute local anesthetic and conscious sedation. It is imperative for the surgeon to insist that the anesthesiologist not use propofol, general or spinal anesthesia. I require my anesthesiologists to not use propofol, or any anesthetic that has the potential for the patient to not feel pain or eventually put the patient to sleep, no matter how brief. The patient's ability to feel pain becomes the surgeon's main safety net. I also only use a dilute solution of local anesthetic like .5% Xlyocaine or its equivalent to decrease of anesthetizing the spinal nerve. The patient being able to report pain during the procedure will also help the surgeon recognize the pain generators in the spine when he correlates the production of pain with the anatomy he is probing. When there is documented post-operative improvement in nerve conduction velocities and improvement of abnormal pre-op EMG's immediately post-op, this is clear objective evidence of clinical improvement.[34] If a patient is not improved following surgery when electrodiagnostic studies show an improvement, it is likely due to the progression of the disease process itself.

NEW HORIZONS

The future of endoscopic spine surgery is extremely bright. There will soon be an explosion of new imaging systems, endoscopes, and endoscopic instruments. Refined techniques, and image guided systems may help shorten the learning curve. Coupled with advancements in tissue regeneration and enhancement of tissue healing, and the trend toward tissue healing instead of removal, regeneration over healing, and arthroplasty instead of fusion, the spinal surgeon may no longer have to consider spine surgery as paradoxical. As a treatment modality, it will no longer be considered as a last resort in a desperate patient. There will be a paradigm shift in the way we view and approach patients with back pain, especially when endoscopic spinal surgery is further validated with outcome studies and become routinely available.

KEY POINTS

1. The endoscopic foraminal posterolateral surgical approach to the lumbar disc offers the least trauma to normal anatomy
2. Spinal endoscopy offers expanded diagnostic as well as therapeutic benefits not possible with traditional surgery.
3. Spinal Endoscopy is a complement to Interventional Pain management, and techniques are beginning to merge.
4. New terminology and concepts, evocative discography™, evocative chromo-discography™, selective endoscopic discectomy™, and thermal anuloplasty, are introduced and explained in the text.
5. The learning curve is steep, but once mastered, this approach will revolutionize the surgical treatment of the lumbar disc, and provide the delivery system for emerging technology in tissue repair and regeneration.

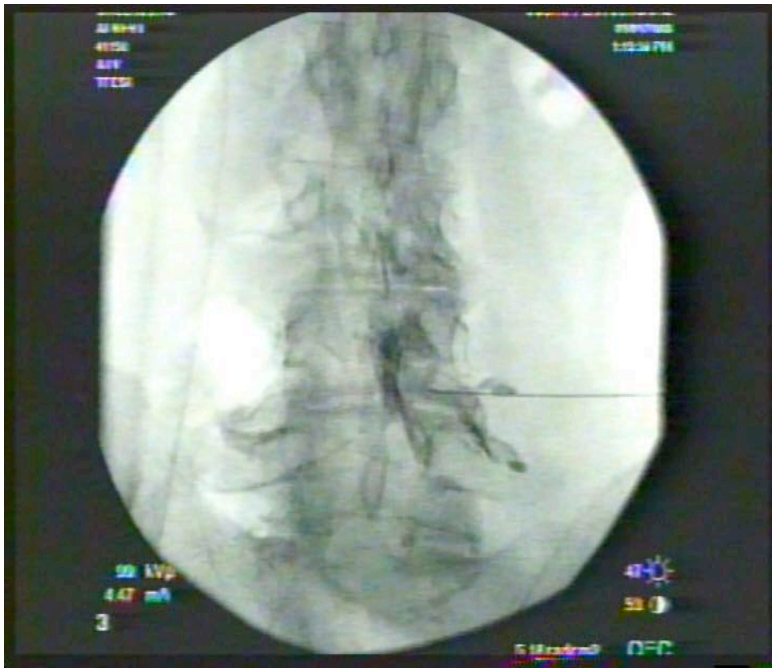
Endoscopic Surgery and Minimally Invasive Techniques

In

Pain Management: A Practical Guide for Clinicians 7th Edition

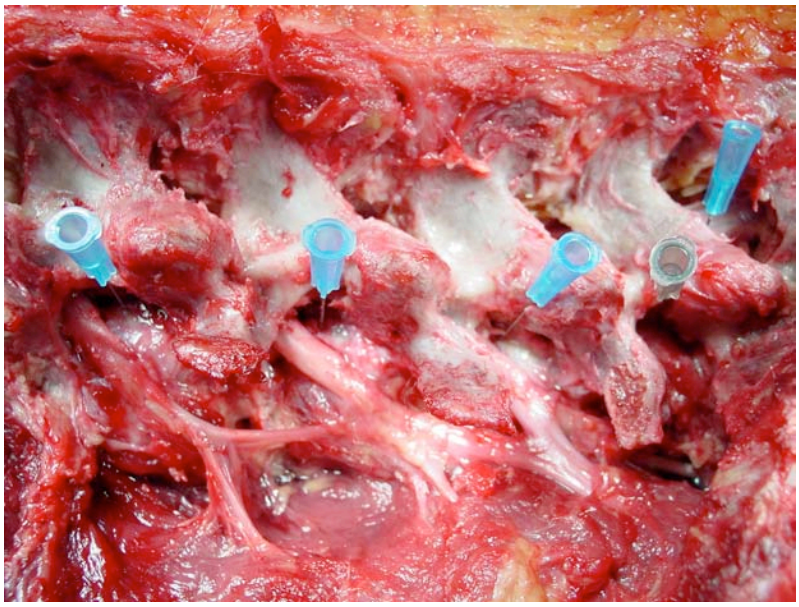
Figures

Figure 1



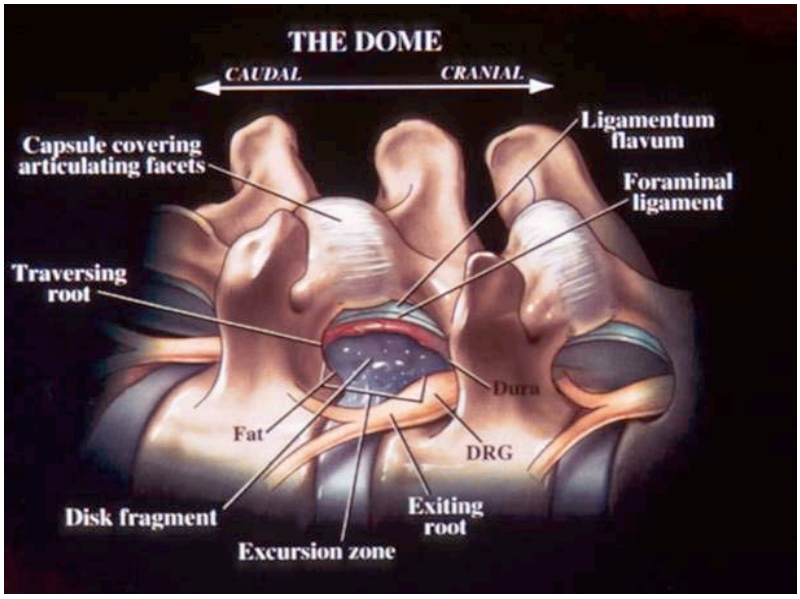
This foraminal epidural gram outlines the traversing nerve and exiting nerve. The exiting nerve is partially obstructed by a foraminal osteophyte causing lateral recess stenosis.

Figure 2



Anatomy of the postero-lateral foraminal Portal from L2 to S1. Only the L5-S1disc space is access to the spinal canal restricted due to the pelvis and the relatively wide facet. (gray hubbed needle in the L5-S1 disc) High lumbar disc herniations from L1 to L3 are easier to reach endoscopically through the posterolateral foraminal portal. L4-5 provides ample room for either approach. Note the furcal nerve branches entering the psoas muscle.

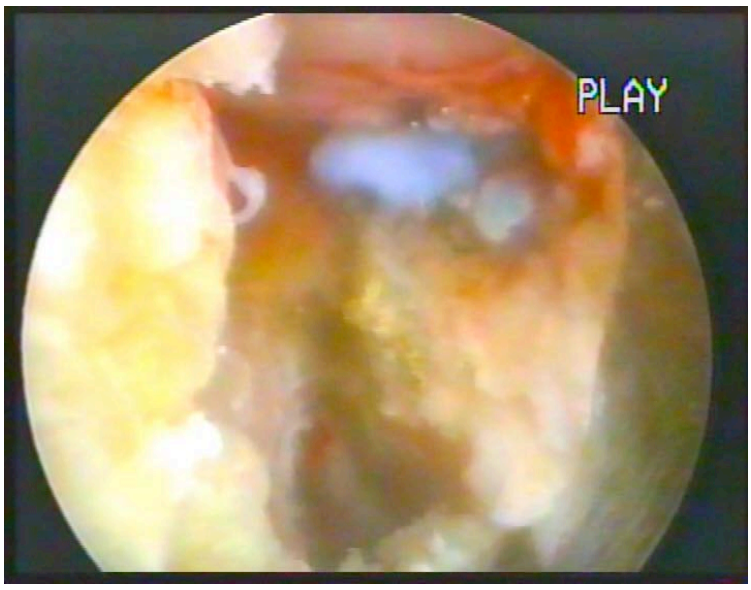
Figure 3



The Dome

Spinal structures in the foramen accessible to visualization and surgical intervention and probing via the posterolateral approach (Courtesy of Hal Matthews, M.D.).

Figure 4



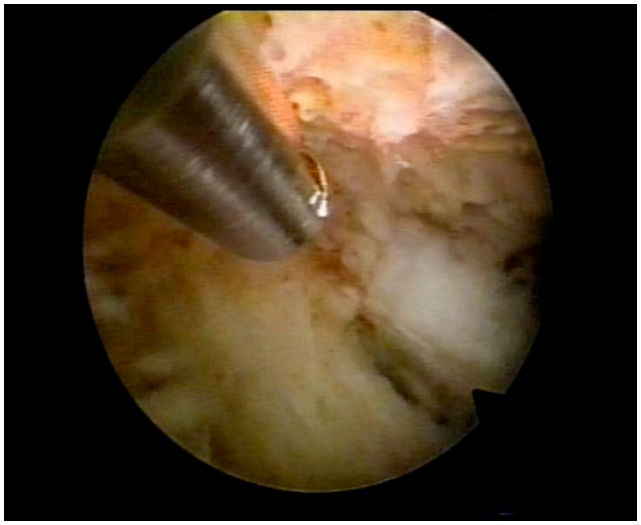
Foraminal view of an extruded subligamentous disc herniation through the

posterior annulus at L5-S1. The vital dye stains the disc fragment for easier identification and extraction. Here, the tiny herniation has clearly extruded through the posterior annulus and is under the traversing nerve. These tiny fragments are often missed on MRI if the axial cut misses the fragment.

Figure 5

Intradiscal view of Discitis after partial debridement. Inflammatory tissue, and loose endplate cartilage are usually visualized and readily removed from the disc space with pituitary rongeurs and automated shavers. Pain relief is immediate, and abundant tissue is available for laboratory analysis. Discitis is often sterile, or non-suppurative, even when sufficient inflammatory tissue is removed for culture. The incidence of discitis following endoscopic disc surgery is about 0.3%.

Figure 6



The technique of endoscopic foraminal decompression. The superior articular process can be decompressed by rotating the open face of the cannula against the base of the facet while the ventral half of the cannula protects the exiting nerve. The decompression continues cephalad toward the tip of the facet and the exiting nerve, resecting the ligamentum flavum attachment that can impinge on the axilla, causing symptomatic lateral recess stenosis. Just resecting the capsule and releasing the ligamentum flavum may be enough to enlarge the foramen and free the traversing as well as the exiting nerve. This illustration demonstrates laser foraminoplasty next to a conjoined or bifurcated exiting nerve.

Figure 7

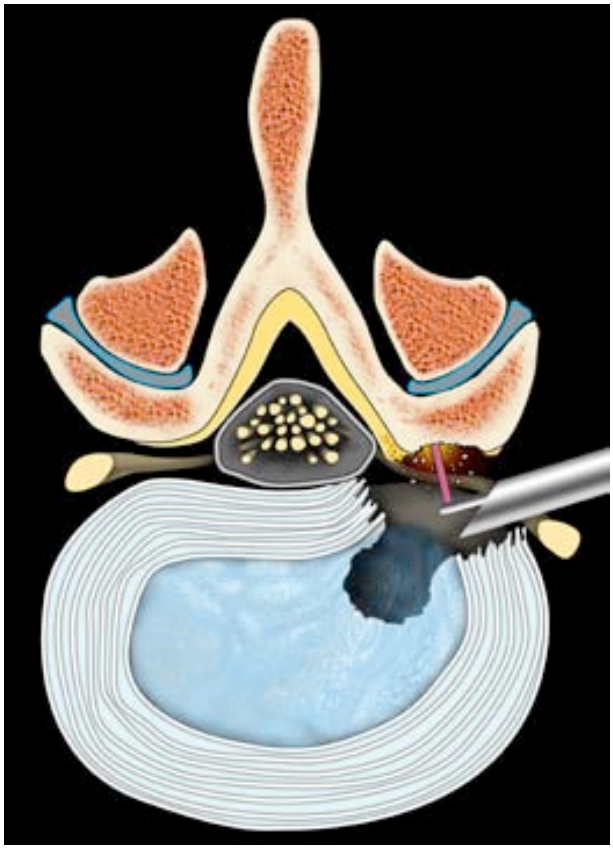


Illustration of side firing laser ablating bone under the superior articular process

Figure 8a Annular Tears

Grade V annular tears open into the epidural space, extra-foraminal zone, or psoas muscle, sensitizing the nerve and forming an inflammatory membrane that allow the ingrowth of nerves and capillaries. An inflammatory membrane next to the dorsal root ganglion of the exiting nerve, psoas muscle, or traversing nerve can cause non-dermatomal pain out of proportion to the MRI study. If patients with annular tears get relief from foraminal epidural blocks after a painful positive discogram, more lasting relief is probable with selective endoscopic discectomy and thermal annuloplasty. The procedure removes degenerative nuclear material keeping the tear open, thermally closes the tear, and allows for ablation of the inflammatory tissue.

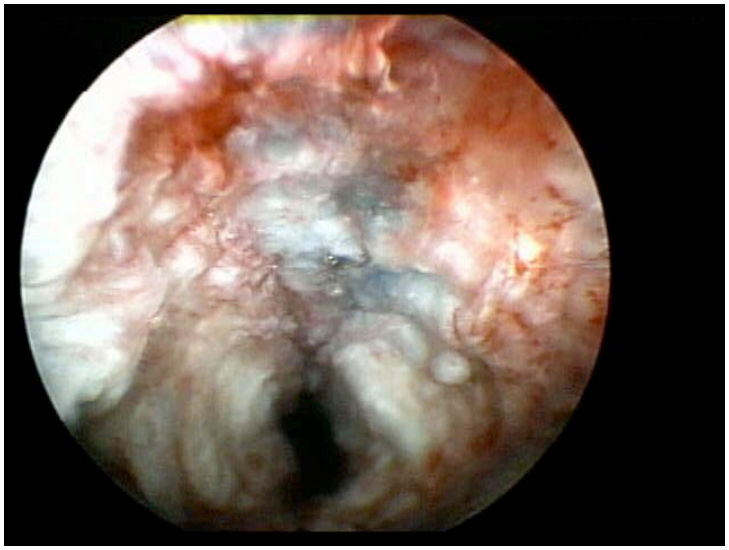
Figure 8b Grade IV Annular tear

Degenerative Interpositional disc tissue is embedded in the annulus.

The annulus is contracted by a bipolar radio-frequency flexible probe or laser, removing the interpositional disc tissue that is preventing the annular tear from

healing. Intra-operative chromo-discography will stain the degenerative disc and annulus.

Figure 8 c



Inflammatory and granulation tissue surrounds a grade IV annular tear stained by indigo carmine in the dorsal annulus.

Figure 8 d

Ellman bipolar radio-frequency trigger-flex probe thermal modulating a grade IV annular tear that has stained the outer fibers of the annulus. The more annular layers remain, the better the prognosis. If a radial tear or annular defect is large, thermal contraction sometimes causes the tear to enlarge, especially if there is an associated disc herniation. These large tears associated with large disc herniations do not create the chronic lumbar discogenic pain syndrome that is still not completely understood.

Figure 9 Anomalous nerves

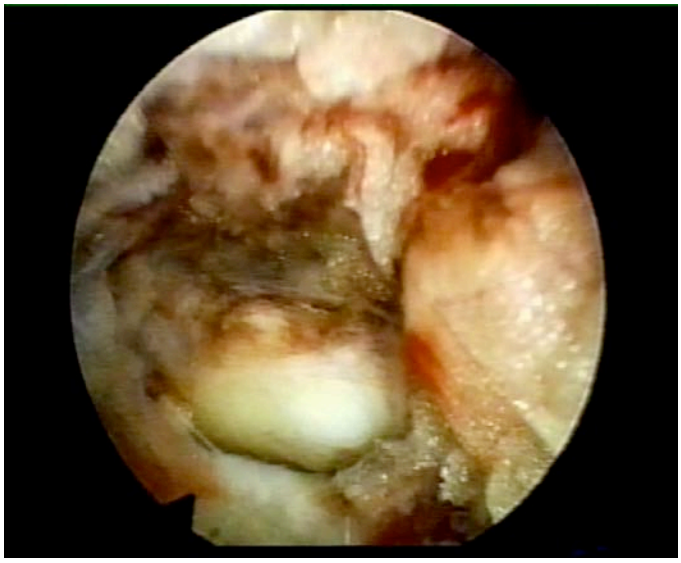


Figure 9a Furcal nerve

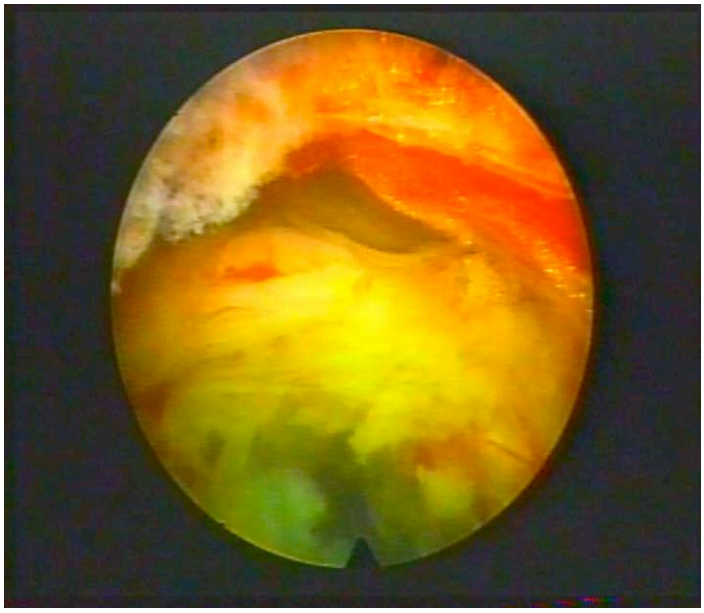


Figure 9 b Autonomic nerve

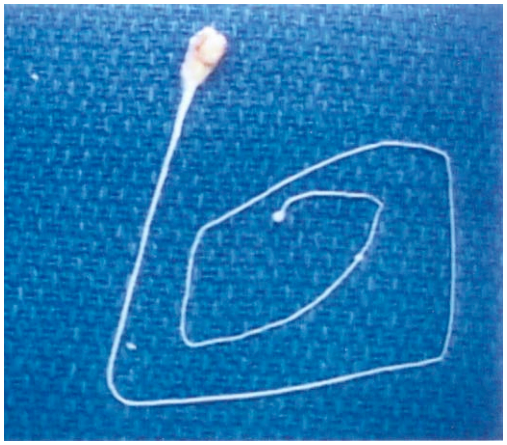


Figure 9c biopsy of automic nerve shown in 9b

Anomalous Nerves

Anomalous Nerves are seen in the annular fat in the "hidden" foraminal zone. When found in the foramen, it is considered an anomalous branch, but furcal nerves are common branches from the exiting nerve entering the Psoas muscle.These communicating branches are described as furcal nerves in the anatomy and literature. Small sympathetic nerves are occasionally seen. Ablation or resection of these nerves may be associated with dysesthesia, but removal may also decrease chronic discogenic lumbar pain.

Figure 10 b Neo-angiogenesis and Neo–neurogenesis is commonly present in the inflammatory membrane adjacent to annular tears in patients who have severe discogenic pain and sciatica, but a rather benign MRI

Bibliography

1. **Macnab, I., *Negative disc exploration. An analysis of the causes of nerve-root involvement in sixty-eight patients.* J Bone Joint Surg Am, 1971. 53(5): p. 891-903.**
2. **Yeung, A.T., *Endoscopic Spinal Surgery: What Future Role?* The Journal of Musculoskeletal Medicine, 2001. 18(11): p. 518-528.**
3. **Yeung, A.T. *Discography, Foraminal Epidurography and Therapeutic Foraminal Injections: Its Role in Endoscopic Spine Surgery*. in *International 22nd course for Percutaneous Endoscopic Spinal Surgery and Complementary Techniques*. 2004. Zurich, Switzerland January 20-30.**
4. **Yeung, A.T., *The role of provocative discography in endoscopic disc surgery*, in *The Practice of Minimally Invasive Spinal Technique*, M.H. Savitz, J. Chiu, and A.T. Yeung, Editors. 2000, AAMISMS Education LLC. p. 231-236.**
5. **Yeung, A.T. and J. Porter, *Minimally Invasive Endoscopic Surgery for the Treatment of Lumbar Discogenic Pain*, in *Pain Management: A Practical Guide for Clinicians*. 2002, CRC Press. p. 1073-1078.**
6. **Yeung, A.T. *Endoscopic Decompressive approaches to the disc*. in *North American Spine Society Annual Meeting Symposium: Minimally invasive surgical treatments of spinal pathhologies: a rational approach*. 2003. San Diego California, October 21-25.**
7. **Yeung, A.T. and S.A. Gore, *Evolving methodology in treating discogenic back pain by Selective Endoscopic Discectomy (SED).* Journal of Minimally Invasive Spinal Technique, 2001. 1: p. 8-16.**
8. **Tsou, P.M. and A.T. Yeung, *Transforaminal endoscopic decompression for radiculopathy secondary to intracanal noncontained lumbar disc herniations: outcome and technique.* Spine J, 2002. 2(1): p. 41-8.**
9. **Yeung, A.T. and P.M. Tsou, *Posterolateral endoscopic excision for lumbar disc herniation: Surgical technique, outcome, and complications in 307 consecutive cases.* Spine, 2002. 27(7): p. 722-31.**
10. **Savitz, S.I., Savitz, M H , Yeung, A T, *Antibiotic prophylaxis for percutaneous discectomy.* The Journal of Minimally Invasive Spinal Technique, 2001. 1(Inaugural): p. 49-51.**
11. **Yeung, A.T. *Endoscopic Access for Degenerative Disorders of the Lumbar Spine*. in *International Society for Minimal Intervention In Spinal Surgery-19th course for Percutaneous Spinal Surgery and Complementary Techniques*. 2001. Zurich, Switzerland January 25-26.**
12. **Yeung, A.T. and C.A. Yeung, *Advances in endoscopic disc and spine surgery: foraminal approach.* Surg Technol Int, 2003. 11: p. 253-61.**
13. **Osman, S.G., et al., *Transforaminal and posterior decompressions of the lumbar spine. A comparative study of stability and intervertebral foramen area.* Spine, 1997. 22(15): p. 1690-5.**
14. **Yeung, A.T. *Minimal Invasive Techniques in the Lumbar Spine: Evolving Methodology since 1991 (Magistral speaker)*. in *International 20th Jubilee course for Percutaneous Endoscopic Spinal Surgery and Complementary Techniques*. 2002. Zurich, Switzerland.**

15. **Yeung, A.T., *The evolution of percutaneous spinal endoscopy and discectomy: state of the art.* Mt Sinai J Med, 2000. 67(4): p. 327-32.**
16. **Yeung, A.T., *Selective Discectomy with the Yeung Endoscopic Spine System*, in *The Practice of Minimally Invasive Spinal Technique*, M.H. Savitz, J. Chiu, and A.T. Yeung, Editors. 2000, AAMISMS Education LLC. p. 115-122.**
17. **Yeung, A.T. *Transforaminal Endoscopic Selective Nuclectomy and annuloplasty for Chronic Lumbar discogenic Pain: an Alternative to Fusion*. in *Spine Arthroplasty II Spine Arthroplasty Society*. 2002. Montpellier, France May 5-8.**
18. **Yeung, A.T. *Macro-and Micro-anatomy of Degenerative Conditions of the Lumbar Spine (Best Paper Presentation Award)*. in *International Intradiscal Therapy Society 16th Annual Meeting*. 2003. Chicago, Illinois April 2-5.**
19. **Yeung, A.T. *Rauschning's Anatomy for Minimally Invasive Spine Surgery*. in *Spine Across the Sea 2003 July 27-31*. 2003.**
20. **Carragee, E.J., et al., *The rates of false-positive lumbar discography in select patients without low back symptoms.* Spine, 2000. 25(11): p. 1373-80; discussion 1381.**
21. **Carragee, E.J., et al., *False-positive findings on lumbar discography. Reliability of subjective concordance assessment during provocative disc injection.* Spine, 1999. 24(23): p. 2542-7.**
22. **Tsou, P.M., A.T. Yeung, and C.A. Yeung, *Posterolateral Transforaminal Selective Endoscopic Discectomy and Thermal Annuloplasty for Chronic Lumbar Discogenic Pain.* The Spine Journal, 2004. (In press July 2004).**
23. **Yeung, A.T. *Arthroscopic Electro-thermal Surgery for Discogenic Low Back Pain: a Preliminary Report*. in *International Intradiscal Therapy Society Annual Meeting*. 1998. San Antonio, Texas.**
24. **Yeung, A.T. *Classification and Electro-Thermal Treatment of Annular Tears*. in *American Back Society Annual Meeting December 12*. 1998. Las Vegas, Nevada.**
25. **Yeung, A.T. *Annular Tears: Correlating Discogram and Endoscopic findings with Electrothermal Response*. in *International Intradiscal Therapy society and International Society for Minimally Invasive Spine Surgery Annual Meeting*. 1999. Cambridge, England August 1-5.**
26. **Yeung, A.T. *Endoscopic Thermal Modulation as an Alternative to Fusion for Discogenic Pain*. in *International Meeting for Advanced Spine Technologies*. 1999. Vancouver, British Columbia, Canada July 8-10.**
27. **Yeung, A.T. *Patho-anatomy of Discogenic Pain*. in *Minimally Invasive Spine Update*. 1999. Disney Magic Cruise Nov 5-8.**
28. **Yeung, A.T. *Thermal Modulation of Disc Pathology*. in *1st World Congress American Academy of Minimally Invasive Spinal Medicine and Surgery.* 2000. Las Vegas, Nevada Dec 7-10.**
29. **Yeung, A.T. *Thermal Modulation: SED versus IDET*. in *1st World Congress American Academy of Minimally Invasive Spinal Medicine and Surgery*. 2000. Las Vegas, Nevada Dec 7-10.**

30. **Yeung, A.T., et al., *Intradiscal thermal therapy for discogenic low back pain*, in *The practice of minimally invasive spinal technique*, M.H. Savitz, J. Chiu, and A.T. Yeung, Editors. 2000.**
31. **Yeung, A.T. and M.H. Savitz, *Treatment of multi-level lumbar disc disease by Selective Endoscopic Discectomy and thermal annuloplasty: case report.* Journal of Minimally Invasive Spinal Technique, 2002. 2(Spring 2002): p. 36-38.**
32. **Yeung, A.T. and C.A. Yeung, *Microtherapy in low back pain*, in *Minimally Invasive Spine Surgery*, M. Mayer, Editor. 2004, Springer Verlag.**
33. **Yeung, A.T. and M.H. Savitz, *Complications of Percutaneous Spinal Surgery*, in *Complications in Adult and Pediatric Spine Surgery*, A. Vacarro, Editor. 2004.**
34. **Yeung, A.T., J. Porter, and C. Merican. *SEP as a sensory integrity check in selective endoscopic discectomy using the Yeung endoscopic spine system*. in *2nd WorldCongress American Academy of Minimally Invasive Spinal Medicine and Surgery*. 2001. Las Vegas, Nevada December 2001.**