Rothman-Simeone The Spine, 5th Edition

Section VIII. Thoracic and Lumbar Disc Disease

Chapter 57. Percutaneous Lumbar Surgery (Draft)

Christopher P Kauffman, MD

Christopher A Yeung, MD

Anthony T Yeung, MD

Introduction

Throughout much of the late twentieth century numerous surgical specialists have pursued less invasive techniques for the treatment of surgical problems. The specialties of interventional radiology, laproscopic general surgery, arthroscopic orthopaedic surgery and minimally invasive vascular surgery have seen such rapid growth that there are now fellowships in each field. The patient benefits from these less invasive techniques have been well documented throughout the literature and the gold standard for numerous procedures has changed significantly within the last twenty years.

The development of endoscopic surgery for the spine has paralleled advances in optics, miniaturization of instruments and improvements in fluoroscopic equipment. Improvements and ease of mobility have made the fluoroscope or C-Arm one of the most important tools in orthopaedics. It has revolutionized fracture management and allowed for rapid intra-**operative** visualization of skeletal structures. Advances in optics and **joint specific** scope size have allowed for equally rapid advances in the ability to perform arthroscopy on shoulders, elbows, wrists, hips, knees and ankles. The use **of endoscopes and specially designed surgical tools** has allowed for equal advances in the development of minimally invasive spinal procedures.

Percutaneous spinal surgery has not met with the same peer recognition as the other fields. Yet the advances in the ability to perform endoscopic discectomy have been just as great. Technology at this time allows for discectomy and decompression of traversing and exiting nerve roots. **Anterior and posterior interbody fusions are possible through percutaneous approaches.** With the advent and FDA release of rhBMP for spinal fusion we are on the verge of being able to perform percutaneous interbody fusion with a high fusion rate. The progress made on percutaneous discectomy **and decortication of the endplate** will lead the way for future progress in percutaneous fusion. **Future advances in the use of biomaterials and gene therapy may open the door to endoscopic nucleus replacement, annular reinforcement, tissue repair, tissue regeneration , anterior column stabilization by disc arthroplasty, and other alternatives to fusion for pain reduction.**

While endoscopic spinal surgery has not enjoyed the wide spread acceptance of minimally invasive procedures in other fields; there are definite advantages for certain procedures within the lumbar spine. Endoscopic spinal surgeons will have to be well versed in the use of both the C-arm and **endoscopy.**

The future of spine surgery will certainly involve a mix of endoscopic and traditional open procedures. Studies comparing open and endoscopic procedures will have to be performed to find which **conditions** will be best treated by minimally invasive procedures.

History

The basis for percutaneous lumbar disc procedures came from accepted percutaneous biopsy techniques of the lumbar vertebrae. These procedures were initially performed with the use of a Craig needle to perform a posterolateral biopsy for neoplastic conditions. References 30,31,32. All of the procedures are based on using a needle from the posterolateral approach and coming through the safe triangular working zone **when the posterolateral approach is used for disc surgery.**

Anatomy

Percutaneous lumbar surgery is performed through what has been named the triangular working zone or Kambin's triangle. ***Figure 1 – lateral of triangular working zone***. This triangular zone is defined by the exiting nerve root or spinal nerve. The nerve makes up the hypotenuse of the triangle and therefore defines the anterior and superior safe working margins. The nerve makes an angle of 40^o with the dura as it exits under the pedicle. The hypotenuse is an average of 23mm long. The longer leg is defined inferiorly by the superior endplate of the distal vertebrae and measures 18.9mm on average. The shorter leg of the triangle is defined by the superior articular facet of the distal vertebrae and usually measures 12.3 mm. From cadaveric measurement it was determined that cannulas ranging from 4mm to 10mm could be safely used in the triangular working zone. Reference 1,2,3,39. A thorough understanding of the three dimensional anatomy is necessary to understand and perform posterior percutaneous lumbar surgery.

Enzymatic Discectomy

Dr. Lyman W. Smith pioneered the use of chymopapain for the enzymatic degradation of the nucleus pulposus and coined the term chemonucleolysis. After getting permission from the FDA in 1963, Smith reported his first 10 patients results in 1964. Following this, two of the next twenty patients treated sustained paralysis. References 4,5,6. Following its introduction chymopapain has been used on a consistent basis. The FDA released a new formulation of the drug, Chymodiactin, in 1982. Despite satisfactory results of 82%, media attention focused on 55 patients out of 100,000 who had catastrophic complications, six of them resulting in paraplegia secondary to acute transverse myelitis. **Closer review and study of these reports have identified injection techniques, poor needle placement, and the injection of chymopapain outside the confines of the disc annulus as the primary cause of complications. The**

development of a pre-operative test for antigens to chymopapain has eliminated these devastating complications, and physicians with extensive experience with chymopapain still use chymopapain as part of their surgical armamentarium. The use of chemonucleolysis has **since** remained relatively steady at approximately 3000 patients per year despite an initial decline following the negative media attention. Reference 4.

Chymopapain is the only percutaneous modality to date to undergo prospective double-blind randomized trials. The longest follow-up comes from an Australian study comparing chymopapain with saline injection with a 10-year follow-up. At 10 years the patients remained blinded to which treatment they had received. The results showed that 80% of the patients receiving chymopapain considered their surgery successful compared with only 34% of patients receiving saline injection. Twenty percent of the chymopapain went on to have open surgical intervention vs. 47% of the patients receiving saline. Reference 7. There have been several other studies comparing chemonuceolysis with placebo injections reporting success rates from 71-80%. References 8,9,10 .

There have been large indirect comparisons of open discectomy and chemonucleolysis the literature but few direct comparison. One small study prospectively compared the two. There were 46 patients in each group. Early results favored surgery, although at one year the two groups showed no statistically significant difference. One significant difference was that nine patients receiving chymopapain went on to have surgical intervention and only one of the surgical group required re-exploration. Reference 11. In a review of 45 clinical studies involving over 7000 patients, Norby reported an average success rate of 76% for chemonucleolysis vs an average of 88% for laminectomy and discectomy. In a Meta analysis of 43, 662 patients treated with chemonucleolysis the overall complication rate was 3.7% with only 0.45% being severe complications. The study also looked at 2051 surgical patients with an overall complication rate of 26% and severe complication rate of 4.2%. Reference12.

Automated Percutaneous Lumbar Discectomy

Onik introduced automated percutaneous lumbar discectomy or APLD in 1985, after developing an automated nucleotome. The procedure involved introduction of an 8-inch nucleotome (Surgical Dynamics, Atlanta, GA) with a blunt end into the center of the disc space. There were three available diameters, 2.0mm, 2.5mm and 3.5mm. The nucleotome had a cutting blade and suction. It was driven by nitrogen gas and operated under fluoroscopic control. There was no direct visualization of the disc space or neural structures. It was operated in the disc space for approximately 10 minutes. References 13, 14.

The results of APLD have been mixed in the literature with few authors other than Onik being able to achieve his reported results. Initial results showed 80% good to excellent but only had six-month follow-up. Reference 15. There is a single multi-center study, which reported a 75% success rate when proper inclusion criteria were met. Reference 16. The difficulty comes in interpretation of the imaging studies and contained disc herniations as many of the failures were determined to be in non-contained herniations. In retrospectively reviewing his own results at five-year follow-up one of the lead investigators found his success rate to be 59%. Reference 14.

Chatterjee performed a randomized prospective trial comparing APLD and microdiscectomy for contained herniations. The herniations could be no larger than 30% of the canal size. The results of this study showed a success rate of 29% for APLD vs. 80% for microdiscectomy. Overall conclusions were that APLD was not as successful for small-contained herniations as previously reported. Reference 17. In a separate study out of the United Kingdom, Grevitt reported on the long-term follow-up of initially successful APLD patients. The original study group had a 72% good to excellent result Reference 18. However on long-term follow-up, 55 months, 33% of patients deteriorated into a fair or poor group making the overall success rate 45%. Reference 19. Another study of long-term results showed that 38% of patients required subsequent open surgery within the next five years. Reference 20.

Percutaneous Laser Discectomy

The use of the laser, light amplification by stimulated emission of radiation, depends on the ability of the laser to ablate tissue and control hemostasis. Lasers have been used extensively throughout multiple surgical specialties with success. There are several types of lasers used in medicine including infrared, light and ultraviolet lasers. Lasers that have been used successfully in the lumbar spine include the CO2, KTP, Holmium:YAG, and neodymium:YAG. **Only the KTP laser and the Holmium:YAG laser is FDA approved.**

The underlying principle of laser lumbar surgery was that through tissue ablation intradiscal pressure could be substantially lowered. This was based on the work of Hirsh and his postulated relationship between intradiscal pressure, disc herniation and low back pain. It was hypothesized that lowering this pressure in an injured disc would prove to be efficacious in the relief of sciatica. Reference 21. Based on this and early results of chymopapain and APLD, studies were performed to see how much disc could be ablated with the laser. Multiple studies showed decreases in intradiscal pressures of 50% or greater. References 22,23,24.

The results of laser discectomy fall within a similar range to that of chemonucleolysis and early results of APLD. Using the potassium-titanile-phosphate, KTP laser, Davis published a success rate of 80%. In a larger study Choy looked at 333 patients with herniated discs diagnoses by MRI or Ct scan and treated with percutaneous laser discectomy. At an average follow-up of 26 months he reported a 78.4% overall success rate. Reference 25.

Percutaneous laser discectomy, like its predecessors was a fluoroscopically guided non-visualized procedure performed either with a laser guide or partially visualized with smaller endoscopes. The inability to consistently see the decompressed nerve or the targeted patho-anatomy has limited its use. At this time, with newer operating spine endoscopes, the laser is used mainly as an adjunctive tool during endoscopic lumbar procedures.

Endoscopic Lumbar Discectomy

Endoscopic surgery developed out of percutaneous procedures that initially used **working cannulas with modified instruments designed for disc removal.** The first surgeon credited with percutaneous nucleotomy was Hijikata in 1975. Reference 26. The evolution of endoscopic technique followed a series of transitions**. Initially, an arthroscope was used to inspect the disc and annulus intermittently through the cannula. The introduction of a biportal approach allowed for direct visualization of instruments introduced through a cannula**

inserted into the disc from the opposite posterolateral portal. The later development of an operating spine scope with a working channel subsequently allowed for direct visualization of surgical removal of disc material and foraminal anatomy.

All of the initial procedures were done using cannulas and fluoroscopic guidance only. With the use of the arthroscope the disc and surrounding structures could be checked periodically by placing the scope down the working cannula. The first chance to visualize while working in the disc came with the advent of biportal technique. The development of a working channel scope did not come until the mid 90's.

Parviz Kambin performed the first true endoscopic lumbar procedures. The first use of the arthroscope was an attempted interbody fusion through a biportal technique. Reference 27 The arthroscope was a non-working channel scope and was used **after** docking the cannula on the annulus. The scope was used for identification of the annulus and periannular structures. Once the cannula was safely within the disc, the nucleotome, an arthroscopic shaver, and pituitary rongeurs were passed through the cannula to perform mechanical disc removal. Kambin reported the results of his first 100 patients and showed an 88% success rate. References 28,29

The early endoscopic procedures were limited by the absence of a working channel arthroscope. This led Kambin to the development of a biportal technique in which the scope was inserted on one side and the working cannula on the opposite side. Kambin's indications for biportal approach include large sub-ligamentous herniations, extra-ligamentous herniations and for arthroscopic interbody fusion. Reference 3. In later studies, Kambin reports results from both uniportal and biportal together. Overall results ranged from 85- 92% satisfactory results at a minimum two-year follow-up. There is no differentiation made in the results of uniportal vs. biportal approaches. References 33,34,35.

Kambin's first prototype of the working channel scope was not fully developed and was not successfully marketed. The problems with the initial scope included **fragility**, limited degree of angulation for the working instruments, and the inability to establish adequate inflow or outflow for adequate visualization. Reference 36. Yeung developed the first working channel endoscope to become widely available. The scope was developed in 1997 and was approved for use by the FDA in March of 1998. The YESS (Yeung Endoscopic Spine Surgery) system (Richard Wolf Surgical Instruments, Vernon Hills, Illinois) **modifications of the scope by adding multi-channel integrated irrigation, specialized cannulas, a two hole obturator, and newly designed discectomy tools have allowed for constant real time visualization with a uniportal technique**. Reference 37.

Another major change, which allowed for advancement in the field of endoscopic spinal surgery, was the emphasis **on placement of the cannula closer to the epidural space and the base of the targeted disc herniation.** Previous percutaneous modalities all focused on entry through Kambin's triangle and working **within the nucleus pulposus with the cannula anchored inside the disc annulus.** The cannula was advanced past the annulus and remained there under fluoroscopic control. Matthews described a transforaminal approach for microdiscectomy. Reference 38. **This approach allowed for routine visualization of the epidural space, and greater access to the traversing nerve.**

The development of a working channel scope and use of the transforaminal approach utilizing **beveled and slotted cannulas** changed the practice of endoscopic lumbar surgery. Using this approach surgeons were now able to operate under full visualization throughout most of the procedure and could now follow the neural structures into the epidural space. **The specialized cannulas provided greater access to pathology and also served to protect sensitive anatomy such as the exiting nerve and the sensitive dorsal root ganglion.**

Yeung has reported his initial results using the YESS system in his first 307 patients **with disc herniations that were candidates for transcanal microdiscectomy.** The study included intracanal and extracanal herniations. Recurrent herniations and patients with previous surgery at the same level were not excluded. Results were reported with 1-year follow-up. The overall patient satisfaction was found to be 90.7% and **patients** would undergo the same procedure again if faced with same diagnosis. The overall complication rate was found to be 3.5%. Reference 40. Tsou and Yeung separated out a subgroup of 219 patients with non-contained herniations and reported results at 1 year. Patient satisfaction was 91.2%. Reference 41. These initial results showed that endoscopic surgery could provide equivalent results to reported results of open microdiscectomy, even with noncontained herniations. Others have reported 85% satisfactory outcome for transforaminal percutaneous discectomy for far lateral and foraminal disc herniations as well. Reference 42.

There have been two studies comparing traditional microdiscectomy and percutaneous endoscopic discectomy. Hermantin performed a prospective randomized study with 30 patients in each group. The mean duration of follow-up was 31 months. Patient satisfaction was 93% in the open surgical group and 97% in the endoscopic group. The endoscopic group had shorter duration of narcotic use and shorter time out of work compared with the open discectomy. This led the authors to conclude that arthroscopic discectomy was useful in the treatment of herniated discs for surgeons who have received training in this technique. Reference 43. Mayer performed a randomized prospective study in 1993 with 20 patients in each group. Mayer chose return to previous occupation as his measurement of success. The results of this study showed a significant difference in this measure. In the percutaneous group 95% of patients returned to their previous profession while only 72.2% of the microdiscectomy group returned to their previous profession. Reference 44.

Kambin and Knight (NEED REFERENCE) have independently shown that the transforaminal arthroscopic approach is also useful in the treatment of foraminal and lateral recess stenosis. Kambin reported an 82% success rate for the treatment of lateral recess stenosis and foraminal herniations using an oval cannula with two portals and the transforaminal approach. Even though they were working next to the exiting nerve root they reported no neurovascular complications in their series. Reference 45. Knight **(I believe Knight had 29% temporary dysesthesia that he may not have reported In his paper, but told me in a personal communication and at the AAMISMS 3rd world congress)**.

Access to the L5/S1 disc space can be challenging depending on the patients' pelvic anatomy. In order to obtain more direct access to the L5/S1 disc space some authors have considered the creation of channels in the iliac wing. Reference 46.

The ability to effectively remove pathology using endoscopic surgery has been validated by post-procedure imaging studies. Casey et al. looked at group of patients who had immediate post-operative CT Scan. In these imaging studies 88.9% of patients undergoing biportal endoscopy had significant reduction in the amount of canal compromise. The results of uniportal, extraforaminal and foraminal herniations showed only mild to moderate change in canal diameter. They concluded that arthroscopic discectomy had a high rate of canal clearance and removal of disc fragments. Reference 47.

Endoscopic Treatment of Discogenic Pain

(Include work on multi-level discogenic pain by Bini and Yeung in press and Tsou and Yeung in press The Spine Journal July 2004)

Surgical Approach and Technique

Local anesthesia using 1/2% lidocaine infiltration **is supplemented by conscious sedation with Versed and fentanyl.** The patient is positioned prone on a hyperkyphotic frame, placed on a radiolucent table. Percutaneous posterolateral endoscopic LDH excision requires an unfailing ability to place the endoscope and the extraction instrument from the skin window to the foraminal annular window at the optimal trajectory. The authors use free hand, biplane c-arm guidance. Three fixed roentgenographic landmarks of the target vertebral (figure 1) are located using the c-arm: the anatomical center of the disc, the foraminal annular window centered within the medial-lateral borders of the pedicle, and the **disc's** inclination line that bisects the disc in the lateral projection. The fourth, a topographic location, the skin window, is calculated from the disc inclination. The skin window's lateral location from the midline determines the trajectory angle into the foraminal annular window. The following method of finding the four anatomical landmarks is currently used.

Orient the c-arm in the posteroanterior imaging position, use a narrow metal rod as a radio-opaque locator and ruler, and mark the midline on the skin surface. Then place the metal rod transversely across the center of the target disc. A horizontal line is drawn, bisecting the disc under evaluation . Where the transverse line crosses the longitudinal midline, locate the anatomical disc center (quadrant circle, figure 1 A). The surface marking of the anatomical disc center, identified by the line intersects is used as the first aiming reference point of that disc in the approach. The Ferguson view (tilt c-arm in PA position until beam is parallel to end plates) provides additional aiming reference when the approaching needle is within the c-arm viewing field. At the L4-5 and L5-S1 levels note the location of the foraminal annular windows, dotted circles (figure 1A).

Rotate the c-arm to the lateral projection to view the inclination of the lumbar discs (figure 1 B). Hold the metal rod, along the side of the patient, in the parasaggittal orientation equidistant between contiguous vertebral endplates of the index disc and draw disc inclination line on the patient. While holding the metal rod in the same position record the length from the center of that disc to the plane of the posterior skin surface (length of the solid line from the quadrant circle to the small dot, figure 1 B, L3-L4 level). The same length is used as the lateral distance of the skin window (open circle, figure 1 C) from the posterior midline[29]. At the point where the disc inclination line projects above the posterior skin surface, determined by the metal rod lateral position, will be taken as the skin window's cephalad-caudad location (open circles, figure 1, B and C).

The positive disc inclination (lordotic) of the L5-S1 disc is noteworthy. A steep positive inclination will position the skin window above the " high iliac crests ". A flatly inclined L5-S1disc in the presence of a high iliac crest requires a more medial placement of the skin window and sometimes resection of the lateral _ of the facet joint. The first neutrally inclined intervertebral disc is usually either L4-5 or L3-4. The approach angle for the neutrally inclined disc is therefore perpendicular to the midline. A negatively inclined disc, if present, should also be noted. The insertion angle for the negative inclined L3-4 disc is cephalad directed.

Infiltrate the skin window, subcutaneous tissue and trajectory tract using **one half** percent plain lidocaine. Insert a six inch long, eighteen gauge needle from the skin window at 60-65 degrees angle from the parasaggital plane (reciprocal of 25-30 degrees, figure 2), anteromedially toward the anatomic disc center. The superficial portion of the needle trajectory is usually outside of c-arm viewing perimeter. Once the needle tip is visible within c-arm viewing perimeter, tilt the c-arm, beam parallel to the disc inclination, the Ferguson view. Advance the needle toward the target foraminal annular window. If minor directional adjustments are necessary, use the plane of the needle bevel and hub pressure to navigate. At the first bony resistance or before the needle tip is advanced medial to the pedicle, turn the c-arm to the lateral projection. Do not advance the needle tip medial to the pedicle during the initial approach. Doing so risks inadvertent traversing root and dural puncture. Most frequently the first bony resistant to the needle advancement is due to the facet in the path of trajectory. Reduce the trajectory angle, turn needle bevel medial ward and continue the approach toward the foraminal annular window. The c-arm lateral projection should confirm the needle tip's correct annular location. In the lateral view the correct needle tip position should be just touching the posterior annulus surface (figure

1b, L5-S1 level). In the postero-anterior view the needle tip should be centered in the foraminal annular window (figure 1 c, L1-S1 level). The above two views of the c-arm confirm that the needle tip has engaged, the safe zone, the center of the foraminal annular widow. **A**dvance the needle through the full thickness of the annulus. Perform confirmatory contrast discography at this time. The following contrast mixture is used: nine cc of Isovue 300 with one cc of indigocarmine dye. This combination of contrast ratio gives readily visible radio-opacity on the discography images, and intra-operative light blue chromatization of pathologic nucleus and annular fissures.

Insert a long thin guide wire through the 18 gauge needle channel. Advance the guide wire tip, one to two centimeters deep into the annulus, then remove the needle. Slide the bluntly tapered cannulated obturator over the guide wire until the tip of the obturator is firmly engaged the annular window. An eccentric parallel channel in the obturator allows four quadrant annular infiltration using small incremental volumes of lidocaine in each quadrant, enough to anesthetize the annulus, but not the nerves. Hold the obturator firmly against the annular window surface, remove the guide wire. Infiltrate the full thickness of the annulus through the obturator center channel using lidocaine.

The next step is the through-and-through fenestration of the annular window by advancing the bluntly tapered obturator. Annular fenestration is the most painful step of the entire procedure. Advise the anesthesiologist to heighten the sedation level just prior to annular fenestration. Advance the obturator tip deep into the annulus and confirm on the c-arm views. Now slide the beveled access cannula over the obturator toward the disc. Advance the cannula until the beveled tip is deep to the annular window. The foraminal annular window is an easily identifiable c-arm and intraoperative anatomic landmark and is the starting location for endoscopic disc excision. Remove the obturator and insert the operating endoscope. Through the endoscope, the surgeon may see various amounts of blue stained nucleus pulposus. The general purpose access cannula has a bevel hypotenuse of 12 mm and outside diameter of seven millimeters. When the cannula is slightly retracted to the midstraddle position in relationship to the annular wall, the wide angle scope visualizes the epidural space, annular wall and the intradiscal space in the same field.

The endoscope trajectory from the skin window to the foraminal annular window controls the instrument accessibility to the epidural space. The 30-25 degrees trajectory in reference to the frontal plane allows extraction of intracanal noncontained herniations. Whereas the 40-45 degree trajectory is ideal for central nucleotomy. The basic endoscopic method to excise a non-contained paramedian extruded lumbar herniated disc is described here (figure 3). Use the 30-25 degree trajectory for epidural space herniation extraction. A working tunnel (open arrow, figure 3) is first created from the foraminal annular window. Extend the excavation to a location just under the apex of the herniation. An endoscopic rongeur is used to extract the blue stained material in the tunnel. Directly under the herniation apex a large amount of blue stained nucleus is usually present, likened to the submerged portion of an iceberg. The nucleus here represents migrated and unstable nucleus. The movement direction follows the path of least resistance toward the already thinned out and perforated annulus. Perform a bulk decompression by using a motorized shaver. This step requires shaver head c-arm localization before activate power. The cavity thus created is called the working cavity (solid arrow figure 3). The debulking process serves two functions. First it decompresses the disc, reducing the risk for further acute herniation. Second it removes the unstable nucleus material to prevent future reherniation.

If a non-contained extruded disc fragment is confirmed by finding blue stained nucleus material in the epidural space, additional steps are necessary before removing the epidural part of the herniation. Leave the blue stained narrow intra-annular herniation track and a thin blue dome deep to the herniation track undisturbed at this point. The blue stained intra-annular part of the herniated nucleus is a guide leading to the epidural part of the herniation. Divide the annular collar, use a cutting forcep to perform the partial annulectomy (figure 3). The side walls of this annular channel can be further widened by using a side firing Holmium-YAG laser. Any epidural bleeding encountered is controlled by using a wide sweep, radio-frequency trigger-flex bipolar probe. After performing the above described preparation, extract the subligamentous or extraligamentous components of the herniation first into the working cavity then pull out through the endoscope working channel. The reason for pulling the herniated elements into the working cavity first is more apparent in the massive midline herniation. One variant of the massive herniation is that the annular attachment at one vertebral corner is avulsed, described as an open hinged door (figure 4). Here a large amount of the nucleus has extruded into the spinal canal. The detached annulus may rotate up to 180 degrees on its remaining attachment to the other vertebral corner. When faced with this situation, again proceed to excavate the working tunnel and create a larger working cavity. Use the Holmium-YAG laser to divide the intact annular vertebral corner attachment. Once the large nuclear and annular fragments are free, pull the fragment first into the working cavity, then pull out through the cannula, together with the endoscope.

Endoscopic technique in the excision of LDH in patients who had prior surgical intervention at the index level requires modification of operative technique. The most common reasons for reoperations were either missed fragment or reherniation after prior surgical intervention. During endoscopic reoperation, the newly herniated nucleus can be firmly anchored to the annular herniation track and cicatrix stretched over the herniation apex. If the prior intervention was a transcanal approach, create the standard working tunnel and working cavity. Use the forceps to carry out partial annulectomy from the annular window toward the herniation fragment. By removing the intervening tissue the shape and orientation of the reherniated fragment can be acertained. If the herniated part is firmly adherent to the annular tract, use the laser as a dissecting tool. Sever the fibrosus anchorage by cutting around the base of the herniation tract just outside of the inner edge of the annular fibrosus perforation. Once the herniation base is free, slowly pull the fragment (s) out

Endoscopic Interbody Fusion

The development of a expandable Intervertebral Holder (Disc-O-Tech) has enabled preliminary studies in Isreal, Korea, and Germany for stand alone interbody fusion and 360 degree fusion supplemented with pedicle screw stabilization. (ref. Gepstein ISMISS 21st Meeting Jan 23-24, 2003) With excellent preliminary results in 125 patients. I can fax you the abstract for reference. Work is under investigation using a protein polymer injected into the enucleated disc to act as a nucleus replacement (Cryolife)

Potential Complications and Avoidance

As with arthroscopic knee surgery, the risks of serious complications or injury are low—about 1% or less in the author's experience. The usual risks of infection, nerve injury, dural tears, bleeding and scar tissue formation are always present as with any

surgery. Transient dysesthesia, the most common post-op complaint, occurs about 5% of the time and is almost always transient. Its cause is still incompletely understood and may be related to nerve recovery, operating adjacent to the dorsal root ganglion of the exiting nerve, or a small hematoma adjacent to the ganglion of the exiting nerve, as it can occur days or even weeks after surgery. It cannot be completely avoided, as even with no adverse events or irritation as detected by neuromonitoring with continuous EMG and SEP cannot completely eliminate the transient dysesthesia. The symptoms are like a variant of complex regional pain syndrome, but less severe, and without the skin changes that accompany CRPS. Dysesthesia is readily treated by foraminal epidural blocks sympathethic blocks, and the use of Neurontin titrated to as much as 1800-3200 mg /day.

Avoidance of complications is enhanced by the ability to clearly visualize normal and patho-anatomy and the use of local anesthesia and conscious sedation rather than general or spinal anesthesia.The entire procedure is usually accomplished with the patient remaining comfortable during the entire procedure and should be done without the patient feeling severe pain except when expected, such as during evocative discography or when instruments are manipulated past the exiting nerve. Local anesthesia using half percent xylocaine allow generous use of this dilute anesthetic for pain control and still allow the patient to feel pain when the nerve root is manipulated.

The future

Endoscopic spine surgery has a very high learning curve, but is within the grasp of every endoscopic surgeon with proper training. As with any new procedure, the complication rate may be higher during the learning curve, and may vary with each surgeon's skills and experience. The endoscopic technique is safer for the patient when he is conscious and able

to provide immediate input to the surgeon when pain is generated. 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 the surgeon prefers endoscopic over traditional surgery for the same condition. For most contained disc herniations and discogenic pain, the experienced endoscopic spine surgeon may opt for the endoscopic approach as the treatment of choice for his patients. Mastery of the endoscopic approach to the spine will open the door for supplemental techniques for diagnostic spinal endoscopy and provide a delivery mechanism for emerging technology utilizing gene therapy, and tissue regeneration.