

Endoscopic Spinal Surgery: What Is Its Future?

Introduction

Few physicians question arthroscopic surgery's role in advancing our understanding of knee pain and shoulder pain, and the surgical advancements that have developed since its introduction. Endoscopic spinal surgery, at a crossroads similar to where arthroscopic knee surgery was in the 1970's, is poised to serve the same role.

The two most common spine surgical procedures, discectomy and fusion, at best addresses only spinal instability, some back pain, and radiculopathy. Biologically and biomechanically, both procedures eventually worsen the condition of the disc(s), leading to further degeneration.

Traditional Spine Surgery as the Gold Standard

Traditional indications for spinal surgery are rightfully rigid because of the paradoxical effects of spinal surgery. Just the invasion of the spinal canal destabilizes the spinal segment and creates scarring in and around sensitive spinal nerves. The morbidity of the approach has limited our use of surgery as an early treatment option, especially since surgical treatment can produce conditions that become painful. In order to decrease surgical morbidity, surgeons have attempted to minimize surgical trauma by using smaller incisions and microscopes for magnification. This approach, however, has not been proven to better the outcome or alter the morbidity of surgically breaching the spinal canal.

Endoscopic Spine surgery: The posterolateral Approach

Alternative approaches, such as the posterolateral or foraminal approach, may address the problem of invading and destabilizing the spine. This alternative surgical portal may limit the paradoxical effects of traditional surgery^{4,5}. The spinal structures accessible via the posterolateral portal (figure 1) include the facet joints, the pedicles of the superior and inferior vertebra, the traversing and exiting nerve roots, and the disc annulus. The epidural space is also accessible with flexible instruments and special cannulas. This approach can avoid the spinal canal if desired, and does not require the stripping of muscle or ligament to access the disc. Third generation systems such as the Yeung Endoscopic Spine System (YESS)⁴ include a cannula set with slotted openings that allow instruments to exit the cannula for surgical work, while a protruding tongue protects and retracts adjacent structures. The beveled cannula allows visualization of the disc and epidural space at the same time, facilitating the removal of subligamentous, extruded, and sequestered disc fragments. The foramen can also be enlarged by foraminoplasty to decompress central and lateral recess stenosis. Adjuvant tools and therapies such as radiofrequency, chymopapain, and laser can be employed for tissue modulation or ablation when the visualized spinal pathology^{4,5} dictates its use.

The evolution of Spinal Endoscope

Just as it was for the early endoscopic knee surgeon, endoscopic techniques are evolving, and spinal endoscopy is poised to be the technique that parallels joint arthroscopy. Unlike the knee or shoulder, however, the spine lacks a natural cavity that allows visual inspection in a fluid medium. Surgeons must then depend heavily on imaging studies to correlate findings with symptoms. The endoscopic spine surgeon, with the systems now

available, can perform spinal endoscopy similar to joint arthroscopy. The ability to perform spinal probing with the patient in the aware state may help close the diagnostic gap between imaging studies and the painful condition. This ability will then bring to the surgeon a wider spectrum of therapeutic options. It will be possible to evaluate, diagnose, and treat spinal conditions previously not even considered with the more invasive open surgical techniques^{4,5}.

We may have a relatively good understanding of the biology of back pain and sciatica, but the patho-anatomy and pathophysiology of pain in the spine is still poorly understood¹. Kuslich² has improved our understanding of the pain generators in our spine through spinal probing under local anesthesia, but it is also well known that while a spinal structure is capable of pain, spinal pathology on imaging studies do not always correlate with pain. What may be very painful in one person is well tolerated or painless in another³. When spinal probing is accomplished with the patient in an aware state, the painful and non-painful anatomic parts can be visually correlated with imaging studies. Our increased knowledge of back pain and the alternative treatment options it brings will give the patient more treatment options, and justifies the growing interest and enthusiasm for endoscopic spine surgery.

Conservative 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, non-surgical techniques are first tried, using physical therapy and injection methods for pain relief. These techniques, while therapeutically beneficial, are also limited in their ability to actually correct the painful condition. Patients not responding to standard conservative methods now have an opportunity for more lasting pain relief with endoscopic spine surgery directed toward the pain generator. This minimally invasive procedure, coupled with discography and spinal probing under local anesthesia, also allows the patient to participate in his or her care. When properly performed, the experience is no more traumatic than arthroscopic knee surgery under local anesthesia.

Current Imaging Methods

When compared with conditions diagnosable with spinal endoscopy, our imaging studies are only about 70% accurate and specific⁵. In the author's experience, conditions such as annular tears, rim tears, endplate separation, small disc fragments, anomalous nerves (figure 2) and miscellaneous discogenic conditions are cumulatively missed about 30% of the time. Tears that are in the lateral and ventral aspect of the disc are routinely missed by MRI studies. (figure 3) 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 contains 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. 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 are never seen on MRI but can be visualized with spinal endoscopy.

When an inflammatory membrane is present ventral to the traversing and/or exiting nerve root, the patient's pain response can be confusing. Physicians who cannot accept less than a textbook description in a single known dermatomal distribution frustrates himself as well as his patient. 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^{4,5}.

Inclusion Criteria

Perhaps the ideal lesion for Selective Endoscopic Discectomy is the far lateral, extraforaminal disc herniation. Although a skilled spinal surgeon can access the lateral zone of the disc with a paramedian incision, the posterior approach utilized by most traditional surgeons require the removal of a significant portion of the facet to reach the herniation. The approach also necessitates extensive soft tissue dissection to reach the nerve and herniation, a region that is very vascular. It is easier to access the extraforaminal zone with the endoscope. As a bonus, extensive tissue dissection is not needed. Due to this fact, for the spinal endoscopist, the ideal surgical approach for extraforaminal herniations is visualized Selective Endoscopic Discectomy^{4,5} through the postero-lateral portal. For the skilled spinal endoscopist, diagnostic endoscopy will augment or confirm traditional imaging studies. The author has utilized spinal endoscopy to inspect a spinal nerve suspected to be irritated by orthopedic hardware and to inspect annular tears. He will see that most tears that don't heal are too extensive or caused by interpositional disc tissue keeping the tear open. Other indications include excisional biopsy of spinal structures and tissue. A prime example is discitis. Currently treated with parenteral antibiotics, discitis is much more effectively treated when augmented by endoscopic debridement and excisional biopsy of infected tissue for laboratory analysis. The clinical results are dramatic, and tissue biopsy is more accurate than needle aspiration. Endoscopic removal of disc herniation is only limited by the accessibility of endoscopic instruments to the herniation site. While many will consider only contained disc herniations as an indication for endoscopic disc decompression, experienced and skilled surgeons have demonstrated the ability to extract protruded, extruded, and sequestered fragments. Even central and foraminal spinal stenosis in selected patients will respond to foraminoplasty by endoscopic techniques.

In knee and shoulder arthroscopy, more detailed findings are possible with arthroscopic probing and imaging of joint anatomy than MRI. The same is true with spinal endoscopy.

Alternatives to Fusion for the Treatment of Back pain

Axial back pain has long been considered a normal consequence of man's evolution to a biped being. Back pain was an accepted condition: one to be tolerated as a price for walking on two legs. Surgical solutions focused on various fusion methods that often made the person worse if not successful, or gave patients only temporary pain relief until the next spinal segment deteriorated. Fusion has traditionally been reserved for spinal instability and deformity, but more recently, with the development of fusion cages, patients have been offered fusion for discogenic back pain without leg pain. The surgical morbidity of all fusion procedures have caused surgeons to reconsider treatment recommendations. Discogenic pain has been discovered to arise primarily from the annulus², but can also involve the endplates(intranuclear herniations), facet

joints(osteophytes and synovial cysts), and Sacro-iliac joints⁵. Patients with debilitating back pain are currently being offered surgical fusion as a treatment option to stabilize the motion segment. Patients, however, with recurrent, relatively annoying or debilitating pain from annular tears in the lumbar disc may be also be helped by electro-thermal therapy^{6, 10, 15}. Type III and IV pain nociceptors in the annulus are deformed by heat at 42-45 degrees Celsius. When the heat is increased to 65 degrees Celsius, the annulus contracts and thickens^{5, 6}. This novel approach, touted in the literature as intradiscal electrothermal therapy,(IDET) is currently being used for the treatment of back pain due to painful annular tears in the lumbar disc. Patient selection is critical, since followup studies have reported a rapid deterioration of results, even when beneficial in the early post-op period. A visualized endoscopic variation of the technique, selective endoscopic discectomy(and thermal annuloplasty,^{5, 10, 15} overcomes some of the pitfalls of the blind technique. The tear is detected by evocative discography^{5, 15}. Indigocarmine dye, mixed with a nonionic contrast material, Isovue 300, stains the degenerative disc and annular tear a light blue. The degenerative disc is removed from the posterior disc quadrant, exposing the annular tear for thermal annuloplasty. When imaging studies identify these lesions as a high intensity zone(HIZ), there is a high incidence of positive confirmation by evocative discography⁷. The author's endoscopic version of IDET has converted 80% of IDET failures to satisfactory results. Spinal endoscopy has enabled surgeons to identify interpositional disc tissue as the single most common finding preventing annular tears from healing¹⁵. Other novel approaches are currently being studied to help the tears heal⁶, since annular modulation may incorporate injection of therapeutic solutions utilizing hypertonic dextrose, glucosamine sulfate, and chondroitinsulfate. These novel approaches deserve study and may provide a viable alternative to fusion as a first line of surgical treatment for debilitating discogenic back pain from annular tears and internal disc disruption.

Provocative Discograms

The author uses discography as an integral part of spinal endoscopy. The literature on discography is currently considered controversial. It is controversial only because of the high inter-observer variability by discographers in reporting the patient's subjective pain⁸ as well as the ailing patient's ability to give a clear response, especially if pain response is altered by the use of analgesics or sedation during the procedure. The surgeon who is accomplished in endoscopic spine surgery prefers to do the discography himself in order to decrease the inter-observer variability interpreting the patient's response. When this author compares his own assessment of the patient's pain response with another discographer's report, there is often some variability diagnosis and interpretation. This variability may result in unpredictable results. False positive discography ,however, can be significantly decreased in an experienced endoscopic surgeon's hands, as the surgeon learns to correlate the patient's response to the discogram pattern of the pathology he is looking to treat when he correlates the patient's response to the pain reproduced. There is good correlation of discograms with predicted pathology and the successful treatment of the visualized condition. For example, the discogram can be used to predict the presence of a collagenized disc fragment versus a soft herniation, the extrusion of a disc fragment as a non-contained herniation, or the presence of the type, grade, and location of a painful versus non-painful annular tear^{5, 9}. The ability to relieve discogenic pain is demonstrated by a prospective study of 50 patients undergoing selective endoscopic discectomy(SED) and thermal discoplasty by the author, is 45/50(90%)¹⁵. Other methods(IDET, Coblation)

blind, have the same disadvantages of all relatively "blind" techniques.

Risks and Complications

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. 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, as it can occur days or weeks after surgery. The symptoms are like a variant of complex regional pain syndrome, but less severe, and without the skin changes that accompany CRPS.

Endoscopic spine surgery has a very high learning curve, but is within the grasp of every endoscopic surgeon with proper training. The development of surgical simulators and CD-ROM programs will also allow the surgeon to become comfortable with the technique outside the operating room. As with any new procedure, the complication rate is higher during the learning curve, and may vary with each surgeon's skills and experience. The endoscopic technique may be less forgiving for iatrogenic injury, but possibly safer for the patient who is awake 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 to traditional surgery for the same condition. For most disc herniations and discogenic pain, the experienced endoscopic spine surgeon will opt for the endoscopic approach as the treatment of choice for his patients. New neuro-monitoring techniques and equipment currently utilized by the author not only make the procedure even safer, but frequently observed improvement in nerve conduction latencies and abnormal pre-op EMG's immediately post-op can help predict the surgical efficacy of each procedure immediately post operatively.

Exclusion Criteria

Except for pregnancy, there is no absolute exclusion criteria but only relative contraindications dependent on the surgeon's skills and experience. Spinal endoscopy and spinal probing can eventually be used for diagnostic purposes in a very difficult or confusing clinical problem. At this time, spinal instability may be considered a relative contraindication, but there will eventually be advanced techniques that will encompass endoscopic stabilization of the disc. Endoscopic foraminal plasty, however, has not been shown to cause increased instability in spondylolisthesis as opposed to traditional posterior decompression for stenosis. Posterior decompression with removal of the medial 1/3 of the facet has been demonstrated to create increased motion in extension and rotation, but endoscopic foraminal decompression does not alter the biomechanics of the spinal segment.

Sequestered disc fragments, a relative contra-indication, can be reached by endoscopic instruments, especially if the spinal canal is anatomically accessible in the patient. Critics of endoscopic spine surgery are always from surgeons who do not do endoscopic spine surgery, or who have not mastered the technique. These same surgeons base their opinions on imaging studies that they interpret rigidly. Lacking an anatomic explanation, they sometimes attribute patient complaints as invalid, psychosomatic, or exaggerated

when both patient and doctor are frustrated. The same was said about joint arthroscopy in it's infancy.

Outcome Data

The results of percutaneous spine surgery in the literature focuses on blind techniques such as laser disc decompression and automated percutaneous lumbar discectomy. The visualized technique, however, as described by Kambin, range from 85 - 93% good/excellent in studies with a minimum two year followup^{11, 12, 13}. In a prospective manner, Kambin has also validated the visualized technique as a valuable tool in the armamentarium of a spinal surgeon. When performed in an experienced endoscopic surgeon's hands, Kambin found results equal to a traditional microdisectomy, but with less morbidity and earlier return to work¹³. The high learning curve has curtailed its universal acceptance at this time, but those surgeons willing to invest the time in learning this technique will soon earn the loyalty and acceptance of his patients and referring physicians.

The evolution of endoscopic surgery is enhanced when the physician documents his findings by video imaging and studies his tapes post-operatively. By studying the video of his surgeries in the early part of the learning curve, he will soon learn to associate visualized conditions with his ability to affect those conditions. This will help the surgeon evolve his diagnostic and surgical skills faster.

The Author's Experience with Endoscopic Spine Surgery

Since 1991, the author has utilized a rod-lens system for endoscopic disc excision through a posterolateral approach as described by Parviz Kambin. Kambin coined the term arthroscopic microdiscectomy to describe his method of disc removal from the dorsal half of the intervertebral disc using uniportal and biportal techniques. In 1997, a newly designed spinal endoscope(Yeung Endoscopic Spine System)⁴ featured a working channel and multiple inflow and outflow ports. This allowed consistent clear visualization through fluid volume and pressure control, to provide consistent hemostasis. The ability for the surgeon to visualize structures clearly and the concomitant development of flexible instruments to be utilized with slotted cannulas opened the door for true endoscopic spine surgery and spinal probing in a sedated, but awake patient. To date, the author has treated more than 1500 patients with discogenic pain, degenerative conditions of the lumbar spine, and the whole spectrum of disc herniations including extruded and sequestered fragments. The success rate in the first 500 patients was 432/500(86%) Good/Excellent using modified MacNab criteria⁵. A subsequent retrospective study¹⁴ of 219 consecutive patients with radiculopathy secondary to large intracanal noncontained lumbar disc herniations revealed a satisfactory outcome in 204(93.1%) by modified MacNab criteria, but even higher(94.8%) when patients were asked to respond to a study patient based outcome questionnaire. The evolving methodology in the treatment of discogenic back pain by selective endoscopic discectomy(is reviewed in a prospective study¹⁵ that validates SED(as an alternative for a variety of spinal conditions treated by traditional methods. The practice of minimally invasive spinal technique is summarized in a recent book with the same name, edited by Martin Savitz, John Chiu, and Anthony Yeung. A journal by the same name has been endorsed by multiple spine specialty societies to bring endoscopic spine surgery into the next millennium.

The Future of Endoscopic Spine Surgery

With today's computer technology, surgeons may no longer have to use patients for their learning curve. The learning curve in endoscopic spine is steep compared to knee surgery because surgical misadventures are unforgiving in the spine. The future may incorporate CD-ROM programs that enhance surgical skills on the computer and virtual reality surgical simulators, similar to the flight simulators that pilots and astronauts use before flying the first mission. Intensive surgical instruction with preceptorships and fellowship programs have produced increasing numbers of spinal endoscopists world- wide, and it is strongly recommended that a preceptorship be completed before attempting endoscopic spine surgery.

Conclusion

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 a paradoxical treatment modality that is considered only 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 when endoscopic spinal surgery is validated with outcome studies and become routinely available.

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Recommended Reading

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