Percutaneous Selective Endoscopic Discectomy and Thermal Annuloplasty for the Treatment of Lumbar Discogenic Pain

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Introduction

The history of low back pain and sciatica date back to ancient times. Domenico Cotugno first described "sciatica" in its classic terminology in 1764 and believed that pain was generated by the nerve itself. The big three V's: Valliex, Virchow and Von Luschka introduced the possibility of structure referred pain in the 1800's. With the advent of x-rays one hundred years ago, imaging of spinal anatomy allowed correlation of anatomic findings to conditions that explained the origin of low back pain.

The "Dynasty of Disc" began in the 1930's when Mixter and Barr demonstrated that radicular pain was associated with disc herniation. Attempts were later made to minimize the paradoxical effects of invading the spinal canal by utilizing smaller incisions and image magnification. Although the overall result was not altered, minimally invasiveness did reduce the morbidity of traditional approaches.

Each change required a learning curve that initially was more difficult for the surgeon, but ultimately was embraced by surgeons because it was better for the patient. Endoscopic spine surgery continues this trend, but recent experience has revealed a much greater benefit that will ensure and secure the role of endoscopic spine surgery for the diagnosis and treatment of discogenic back pain.

This quantum leap from open decompression (Lumbar Laminectomy) to micro-decompression with Endoscopic Spinal Surgery finally solved the problem of traumatizing spinal muscle and ligament, destabilizing the spine, and creating epidural and peri-neural scarring. This rapid advance was further aided by the parallel evolution of radiologic imaging such as CT and MRI.

Endoscopic Spine Surgery: What is its role?

Few physicians question arthroscopic surgery's role in advancing our understanding of knee and shoulder pain and the treatment options arthroscopy affords. Endoscopic spinal surgery is poised to serve the same role. Introduced in the United States by Kambin, the procedure has evolved from a nucleotomy and targeted fragmentectomy to a surgical technique that has the potential to offer a minimally invasive approach to spinal conditions currently without a viable surgical alternative.

The favorable efficacy of endoscopic lumbar discectomy compared to open discectomy, in a prospective randomized study, was published by Hermantin, Peters, Quartaro and Kambin in 1999. Endoscopic spine surgery, through the selective endoscopic discectomy technique, expands the endoscopic restrictions described in the article and does not exclude difficult cases at L5-S1 or

extruded, migrated, recurrent, or sequestrated disc herniations. The technique also provides minimally invasive access to degenerative conditions of the lumbar spine.

Endoscopic Spine Surgery: The Posterolateral Approach
The posterolateral approach allows access to spinal structures such as the superior articular process, the pedicle of the superior and inferior vertebra, the traversing and exiting nerve root, and the annulus in the area of the foramen.

A newly developed spinal endoscopy system by Richard wolf Surgical Instrument Company, the Yeung Endoscopic Spine System, (YESS) features a multi-channel scope and special access cannulas that allow spinal probing in a conscious patient, diagnostic endoscopy, and "tube surgery" with very little surgical morbidity. This technique revolutionizes the old concept that all disc surgery is really decompressive nerve surgery. It brings in a new era that will allow true "disc surgery" and a more focused surgery at the tissue level such as contracting and sealing annular tears, annular reinforcement and artificial discs.

The recent introduction of IDET (Intradiscal Electrothermal Annuloplasty) provides another tool for treating patients who suffer from back pain caused by annular tears, but IDET is another non-visualized technique that will be noted for historical purposes as we now have the ability to do a "visualized IDET" under direct visual control. The history of minimally invasive spine surgery supports the view that a visualized endoscopic procedure will eventually advance a "blind" technique whose success is dependent on very strict inclusion criteria, and its eventual demise through "over utilization" by less experienced and lesser trained clinicans. The role of IDET may be further defined by data gathered from visual imaging of annular tears and correlating it with our current imaging studies.

Team Approach
Due to the complexity of back pain, it is important to treat the whole person. The medical team interfaces with the surgical team to obtain the best possible response and outcome for the patient. With the endoscopic spinal techniques described, the ability to identify the tissue pain generator is available through spinal probing. Furthermore, a multidimensional treatment algorithm can be devised that will lead to improved outcomes and better patient selection for surgery.

Patients not responding to standard conservative methods who may or may not be candidates for invasive surgery now have an opportunity for pain relief with endoscopic spine surgery. The endoscopic procedure, coupled with discography and spinal probing under local anesthesia, allows the patient to participate in his or her care.

Current Imaging Methods
When compared with conditions diagnosed by spinal endoscopy, imaging studies are only about 70 % accurate and specific. Conditions such as annular tears, rim tears with associated endplate separation, and various other discogenic pathologies are missed almost a third of the time. Tears that are in the ventral aspect of the disc are routinely missed by MRI studies. Small disc herniations that protrude beyond the outer fibers of the annulus may be missed.

This is because the fragment may be flattened against the posterior longitudinal ligament or nerve, looking like a swollen or enlarged nerve. On the MRI subligamentous herniations may appear as a thickened or bulged annulus. When the nerve is inflamed the MRI may not be able to distinguish

the enlarged nerve from a conjoined nerve, an anomalous branch, or a nerve with an adherent piece of disc.

Spinal endoscopy has allowed the endoscopic surgeon to identify the actual pathologic lesion, correlating it with the imaging study, and making the clinician more aware of the pitfalls of relying too much on imaging alone. It is imperative that the patient be examined with all theses possibilities in mind to avoid labeling the patient a "head case".

Clinical Presentations Correlated with Endoscopic Findings
When the disc tissue is in direct contact with the nerve, chemical irritation occurs and an inflammatory membrane forms. Even a large epidural venous plexus that is inflamed can contribute to back pain and sciatica. When an inflammatory membrane is present ventral to the traversing and or exiting nerve root, the clinical picture may not be clear.

Spinal Endoscopy has confirmed "non-dermatomal" pain in multiple patients with proximal thigh, buttock and groin pain at levels distal to the root origin of the anatomic area. These also include patients which are considered to have spine pain by "non-organic" physical signs.

Inclusion Criteria
All disc herniations are amenable to selective endoscopic discectomy in a skilled endoscopic surgeon's hands. Each surgeon will select his patient dependent on his level of skill. Discogenic pain from internal disc disruption and annular tears may benefit from thermal and chemical modulation of the disc.

Ideal Indication
Perhaps the ideal lesion for selective Endoscopic Discectomy is the far lateral, extra-foraminal disc herniation. This type of herniation is the most difficult for most spinal surgeons. A skilled spinal surgeon can access the lateral zone of the disc with a paramedian incision, but the posterior approach utilized by most traditional surgeons requires the removal of a significant amount of facet to actually reach the herniation. This approach also causes extensive tissue trauma due to the dissection, which is quite vascular.

Our experience suggests that it is easier to access the extraforaminal zone with the endoscope. Endoscopically it is also more difficult than a contained herniation, but the approach is much less traumatic for the patient. It is very important to remember that the success of any surgical procedure depends on proper patient selection, surgeon skill, the correct use of treatment modalities, as well as the combined diagnostic and surgical skills of the treatment team.

We have found that diagnostic endoscopy confirms valuable information to the team on predicted pain generators to actual sites. This approach may also alleviate the need for a surgical approach that is potentially destructive to muscle and adjacent soft tissue when a less invasive or conservative treatment is available.

Other validated indications include excisional biospy of spinal structures and tissue. A prime example is discitis. Currently treated with long term antibiotics, discitis is much more effectively treated with endoscopic debridement and excisional biopsy of infected tissue. The initial clinical data result are promising, suggesting endoscopic excisional biopsy and debridement offers the optimal treatment option for this condition.

Alternatives to Fusion

Fusion has traditionally been reserved for spinal instability and deformity. More recently with the development of fusion cages, patients have been offered fusion for discogenic back pain without leg pain. The pain generators have been discovered to arise primarily from the annulus, but can also involve the endplates and facet joints.

Patients with debilitating lumbar pain are currently being offered surgical fusion as a treatment option to stabilize the motion segment. Pain nociceptors from the annulus which are innervated by branches of the sinu-vertebral nerve, have been shown to be deformed by heat at least 42 degrees Celsius. When the heat is increased to 65 degrees Celsius, type one collagen of the annulus contracts and thickens. Thermal therapy has been utilized to tighten stretched ligaments and unstable joints.

This approach is being applied to annular tears with favorable results. This type of lesion can not always be imaged, even with the most sophisticated techniques. However, provocative discography has demonstrated its ability to diagnose such pathologies. Furthermore, when imaging studies identify these lesions as a high intensity zone (HIZ), there is a high incidence of positive confirmation by provocative discography.

Spinal endoscopy allows direct visualization of annular tears, identifying inter-positional disc tissue as the single most common finding preventing annular tears from healing. This approach may provide a possible alternative to fusion as a first line of surgical treatment for discogenic pain with origin from annular tears.

Provocative Discography

Our clinic utilizes discography as an integral part of the surgical workup. The literature supporting discography is currently considered controversial in some circles. The controversy presents because of the high inter-observer variability by discographers in reporting the patients subjective pain. However, if the surgeon works closely on a team with an experienced discographer, and there is ongoing communication, we have found the two can help decrease the variability in the interpretation of the patient's response.

It is Ideal for the surgeon to perform his own discography, as he is the one that must take the responsibility for deciding whether the patient will respond to endoscopic spine surgery. Furthermore, the surgeon always repeats the discogram at the time of surgery if he uses the Selective Endoscopic Protocol that emphasizes vital dye staining of targeted tissue.

The discogram can be used to predict the presence of a collagenized disc fragment versus a soft herniation, and the extrusion of a disc fragment as a non-contained herniation. In addition, discography can diagnose the presence of the type, grade, and location of painful versus non-painful annular tears.

The senior author follows a classification for discograms based on Adams, Dallas, and Osti. The basic pattern is according to Adams: grade I to V. The radial extensions are per Dallas where grade III is the extension to the inner annulus, Grade IV up to the outer annulus and grade V beyond the outer annulus. The extension of circumferential tears is described per Osti. When this classification is used, the number of quadrants of involvement can be determined by discography

alone, and it is not necessary to do a post discogram CT scan to get enough information to determine the efficacy of endoscopic surgery.

The Revised Discogram Classification:

1. Cotton Ball Nucleus (Normal Cotton Ball Pattern)
2. Oval Nucleus and painless extension of fragmentation beyond center
3. Radial fissured extension to the inner annulus with no circumferential extension and no disc protrusion.
4. Radial extension to the outer annulus and circumferential component to 1 to 4 quadrants and disc protrusion.
5. Radial tear past outer annulus, circumferential 1 to 4 quadrants, most variable and definite disc protrusion with possible extruded fragment.

Clinically:

- Grades 1 and 2 give no Pain.
- Grade 3: Pain present at moderate pressure.
- Grade 4: Predominately back pain. Leg pain associated with central and far lateral protrusion inflammatory membrane may be present.
- Grade 5: MRI can only detect in Zone I and II, the central and foraminal zones. (may be associated with herniation.) Possible prolonged healing time up to 9 months, depending on the size of the tear.

The Technique incorporates adjunctive modalities

1. Flexible probes
2. Flexible mechanical instruments
3. Thermomodulation
    a. Radio Frequency
    b. Laser

Since 1991 the senior author has treated over a thousand patients with a wide spectrum of disc herniations endoscopically. These include extruded and sequestered fragments. The success rate in the first 500 patients is an overall 86% good/excellent by MacNab Criteria. The success rate has continued to rise concurrent with diligence in the refinement of indications, techniques and adjunctive therapy.

With the addition of a focused multi-disciplinary team that enjoys working together, it is our hope that with a coordinated team approach we can easily reach the 90 % plus, good/excellent outcome and avoid the failed spine surgery syndrome so prevalent in today's surgical environment.

Intradiscal Thermal Therapy

As of July, 2000, only one published study on the treatment of back pain using Electrothermal Therapy (IDET) has made the literature. Electrothermal Annuloplasty (IDET) involves the insertion of an electrothermal catheter into a putatively painful disc under fluoroscopic guidance. Thermal energy delivered by the catheter results in a breakdown and restructuring of collagen fibers in the annulus. Proponents offer several explanations as to why this procedure might relieve pain attributed to the disc

This may be due to a stiffening of the disc itself, it may possibly alter the annular tears, or in fact it may ablate nerve endings. Nevertheless, Saal et al. Report 80% of the patients treated with IDET noted a significant decrease in their back pain of at least two point on a 10 point analog scale, improvement in sitting tolerance, and reduction in medication usage. An SF-36 Questionnaire revealed a positive change of at least seven points. Recent information from the International society for the study of the Lumbar spine (ISSLS) were critical of IDET.

They cited the lack of high-quality scientific evidence in favor of this treatment. Furthermore, there is no evidence in favor of IDET from randomized controlled trials, or from other published controlled about long-term safety, yet reports suggest over 20,000 patients have undergone this procedure. Caution is advised as with any procedure. These patients present with back pain without severe radiculopathy.

Patients with severe radicular symptoms due to frank disc herniations are not candidates. If there is any amount of disc protrusion or herniation, selective endoscopic discectomy would be the treatment of choice.

Visualized Thermal Annuloplasty
The Author's choice of a visualized technique over the blind technique of a thermal resistive catheter is supported by his success in converting failed IDET procedures to successful ones using the selective discectomy and visualized thermal annuloplasty technique. In our experience one of the most common findings with failed IDET is the presence of a disc fragment or inter-positional disc tissue fragment preventing the shrinkage of the annular tear. On rare occasions one is able to find necrotic disc tissue (confirmed by pathology slides) in patients who have undergone IDET treatment.

We feel strongly that direct visualization overcomes both conditions when visual control of tissue reaction to thermal energy allows the surgeon to avoid carbonization of tissue and target the annular tear directly. In the Y.E.S.S. technique inclusion of a side firing Ho:Yag laser also serves as the energy source that offers a tool that effects tissue shrinkage to the ablation of bone, just by controlling the laser setting.

Further advancement and application of these techniques will help expand the surgical capabilities of this procedure that allow for treatment of conditions in a degenerative spine that is painful, but not responding to conservative treatment.

Chymopapain
Low dose Chymopapain 500 units helps "digest" the soft herniation and treat the collagenized fragment for ease of removal. The senior author uses chymopapain when disc fragments were found to be extruded and migrated behind the vertebral body. Other applications are when there is a recurrent herniation. Chymopapain is used to decrease the recurrence rate and dissolve the missed fragments. Chymopapain is injected and left in the nucleus pulposus for up to 5 min. before endoscopic discectomy.

When Chymopapain is used as adjunctive therapy, we have had no adverse effects or allergic reactions, even when the discogram identifies leakage beyond the annular fibers into the epidural space. If the discogram demonstrates uptake by the venous plexus, if it is absorbed as soon as it is

injected, or if it communicates in any way with the thecal sac, demonstrating a communication with the disc space, we have not injected chymopapain. As a precaution against an allergic reaction, we will routinely administer Benadryl, 50 mg and Cimetidine, 300mg IV before injecting the chymopapain.

Intraoperative Steroids
Whenever an inflammatory membrane was observed, stimulation of the nerve and surrounding tissue elicited pain. When there was no inflammatory membrane, the nerve and annulus can be manipulated without eliciting pain. When there is an inflammatory membrane present, the patient's pain is often considered "out of proportion" to the imaged pathology. When there is significant inflammation noted, Depomedrol is placed intradiscally at the conclusion of the procedure.

Risks and Complications
Surgical risks and complications are real issues that need to be weighed before considering any invasive procedure. These include dural tear, nerve root damage, bleeding, or infection. The author has seen variations of nerve anatomy and distribution on the annulus, including conjoined nerves not appreciated by imaging studies and accessory nerve branches that often connect the traversing with the exiting nerve. Removal of these branches usually do not affect the patient's clinical course.

The most common adverse effect of the use of electrothermal therapy is dysesthesia. Fortunately, most dysesthesia will resolve completely, like in a second degree controlled burn. Occasionally there will be severe sympathetic pain that will challenge post-operative pain management. A multi-disciplinary team is extremely helpful to help the patient cope with the pain. Usually good pain management with selective epidurals or nerve root block, the use of long acting oral analgesics, and judicious use of Gabapentin (Neurontin) will mitigate this condition.

We have noted the presence of dysesthesia as a delayed response days and weeks after the procedure. Therefore, while we blame the use of laser and electro-thermal therapy, the actual cause of this regional sympathetic condition is still unknown. The incidence of dysesthesia is about 5%. Complications of discitis, nerve injury, dural tear and psoas hematoma total less than 1-2% overall.

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