

Research Article

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Endoscopic Identification and Treating the Pain Generators in the Lumbar Spine that Escape Detection by Traditional Imaging Studies

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Abstract

Introduction: The ability to identify and treat pain generators in the lumbar spine is helped by incorporating diagnostic and therapeutic injections, followed by visualizing the pain generator with an endoscope. Although improvements in imaging are getting very sophisticated, visualization of the source of the pain generators is currently only possible with an endoscope. This has opened the door to more options for cost effective surgical treatment in staged manner by treating the pain source.

Materials and methods: An FDA approved system endoscopic system and technique developed by A. Yeung in 1997, using a multichannel endoscope for the transforaminal approach to visualize the disc and foramen, is featured. After anesthetizing the disc foramen, and targeting the axilla of the foramen in the vicinity of the exiting and traversing nerve, known to spine surgeons as the "hidden zone" of MacNab, the technique has evolved to surgically provide pain relief for stratified conditions for patient selection. The standard translaminar approach to the disc and the spinal segment will usually miss visualizing the patho-anatomy of pain in this "hidden zone", an area harboring common causes of "failed back surgery syndrome". Recent minimally invasive techniques of decompression and fusion may help resolve the pain source, but fusion has its surgical morbidities and high costs. A less invasive highly successful transforaminal endoscopic method with 25-year data supports this technique.

Discussion: Transforaminal Endoscopic Spine Surgery, the YESS™ technique, is effective using mobile cannulas to visualize and target the pain source. New instrumentation, techniques, specially configured endoscopes with different size working channels; facilitate effective surgical treatment of the pain generator. Incorporating visualization of the disc cavity to treat painful annular tears adds to the effectiveness of the procedure. The surgeon can also treat spinal stenosis with foraminoplasty by decompressing the ventral facet of the superior articular process as well as the axilla containing the exiting and traversing nerve. The purpose of this study is to demonstrate that the physiology of pain can be visualized as a pain generator. Patho-anatomy is identified and surgically decompressed. Diagnostic and therapeutic injections also aid in identifying pain generators by epidurography performed with the transforaminal approach.

Conclusion: Interventional pain management, often the first line of minimally invasive treatment, provides pain relief only by targeting injections to block nerves. Visualizing the patho-anatomy with an endoscope targeting the patho-anatomy by the same interventional needle trajectories, however, provides a surgical option to decompress and ablate the pain generators.

Keywords: Pain generators; Lumbar spine; Spine surgery; Foraminoplasty

Introduction

A review of 10,000 surgical cases from a personal database of surgical reports documented with embedded images provides information for this clinical research article. Diagnostic and therapeutic injections are used to help predict the efficacy and success of the endoscopic transforaminal procedure through the foramen. While imaging studies are getting very sophisticated, visualization of the source of the pain

generators with an endoscope has opened the door to more options for cost effective treatment [1].

Materials and Methods

An IRB approved endoscopic technique was developed by A Yeung in 1997, visualizing disc cavity and the foramen known to surgeons as the "hidden zone" of MacNab. The emphasis on visualizing the disc cavity and using instrumentation for discectomy and intradiscal therapy, including foraminoplasty, provides the minimally invasive surgical solution for a wide spectrum of painful conditions of the lumbar spine. Anatomic Research by Wolfgang Rauschning with Cadaver Cryosections serves a partial basis for the material in this article (Figures 1-4).

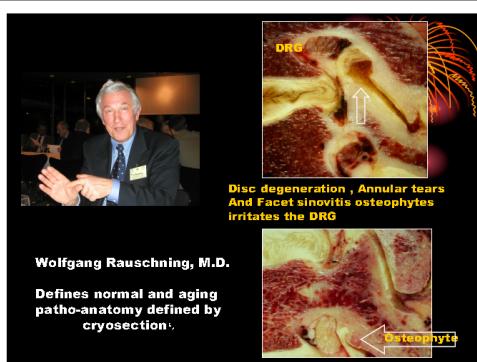


Figure 1: Wolfgang Rauschning's Cryo-anatomy (His findings provide anatomic evidence of the pain generators in Cadaveric specimens that is undisputed).

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Received April 10, 2017; **Accepted** April 19, 2017; **Published** April 21, 2017

Citation: Yeung A, Yeung CA (2017) Endoscopic Identification and Treating the Pain Generators in the Lumbar Spine that Escape Detection by Traditional Imaging Studies. J Spine 6: 369. doi: [10.4172/2165-7939.1000369](https://doi.org/10.4172/2165-7939.1000369)

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Rauschning's work has generated great interest and acceptance by spine surgeon's worldwide, but most surgeons are unable to use his research for their surgical procedures because the traditional translaminar approach cannot visualize the pain source directly. As a result, the surgical option followed by most spine surgeons favor translaminar decompression, dynamic stabilization, disc replacement, or fusion. Yeung's transforaminal approach has the ability to perform discectomy and annuloplasty much earlier in the painful traumatic and degenerative process with excellent results that has spanned up to 25 years (Figure 5).

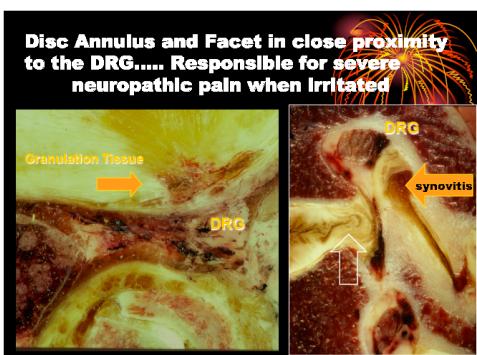


Figure 2: The disc annulus and facet joint can be a source of pain that creates pain by irritating the dorsal root ganglion.

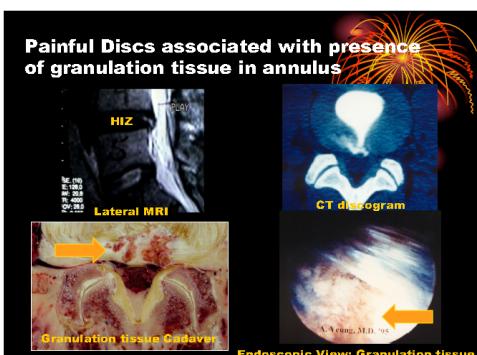


Figure 3: Correlating imaging with cadaver patho-anatomy and Endoscopic visualization of painful granulation and inflammatory tissue serves as evidence that endoscopic surgical techniques can treat spinal pain.

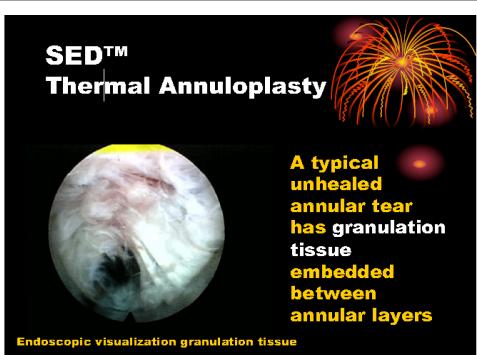


Figure 4: Surgical treatment with endoscopic thermal annuloplasty of the visualized granulation tissue in the painful annular tear (The granulation tissue can be ablated to allow the tear to heal. Longer lasting results can be anticipated if there are an abundance of intact annular layers after ablation of the granulation tissue).

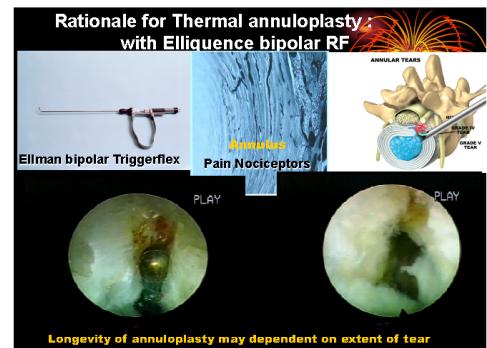


Figure 5: The rationale and technique of thermal annuloplasty. (The embedded and interposed nucleus causing the annular tear is known as "toxic" annular tears. By removing the disc material and thermally modulating the granulation tissue with a bipolar high frequency low temperature flexible trigger flex® probe, a very high success rate is obtained. This RF probe by Ellquence has power controls that mitigate thermal injury).

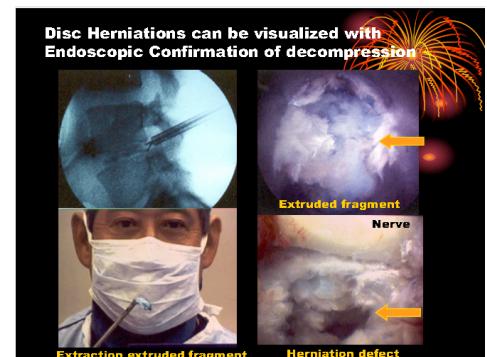


Figure 6: Surgical discectomy of disc herniations coming from the foramen. (The herniation is either targeted directly or removed from within the disc cavity with the inside-out technique).

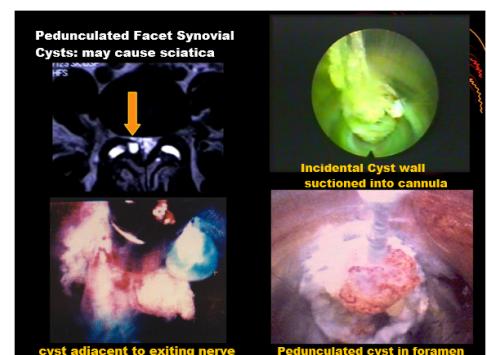


Figure 7: Endoscopic visualization of synovial cysts causing sciatica. (Synovial cysts are often pedunculated and not identified on MRI unless the section of the MRI is directly identified on the cut as a high intensity zone).

Intradiscal decompression of contained and extruded disc herniations can be successfully treated by very experienced and skilled surgical hands with a complication rate that is less than with open translaminar decompression. The clinical success rate is at least equal, but mostly better because no muscle is denervated or traumatized by the surgical approach (Figure 6).

Other patho-anatomic lesions, such as synovial cysts, osteophytes, or foraminal nerves, called furcal nerves can be visualized, decompressed, excised, or ablated (Figures 7-9).

A very common condition, foraminal and spinal stenosis, is a consequence of aging. It is readily treated minimally invasively by foraminotomy and foraminoplasty. Foraminoplasty is not the same as foraminotomy, or just the decompression of the ventral aspect of the superior articular process. Osmon has described Foraminal decompression in the early 1990's, but foraminoplasty involves removal of the tip of the superior articular process to decompress the axilla between the traversing and exiting nerve (Figure 10).

Foraminoplasty differs from foraminotomy by also removing the

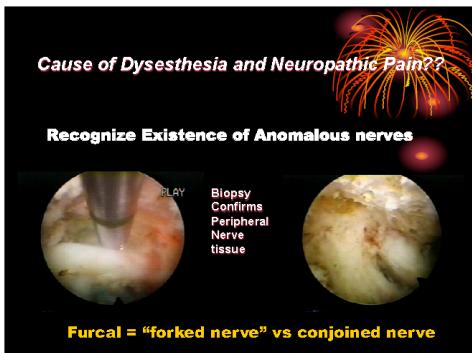


Figure 8: Normal and anatomic variations of spinal nerves have branches. (These nerves are also known as "furcal" of forked nerves or seen as conjoined nerves).

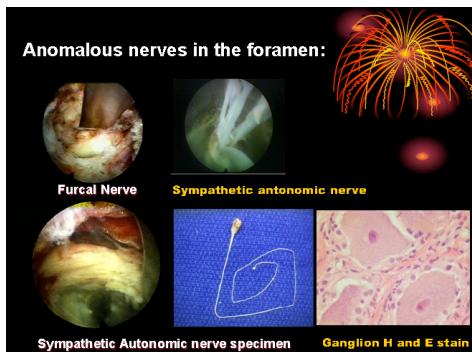


Figure 9: Visualization of anomalous and sympathetic nerves documented by surgical specimens and H and E slides of the specimens. (These nerves can cause post-op dysesthesia, but are usually transient).

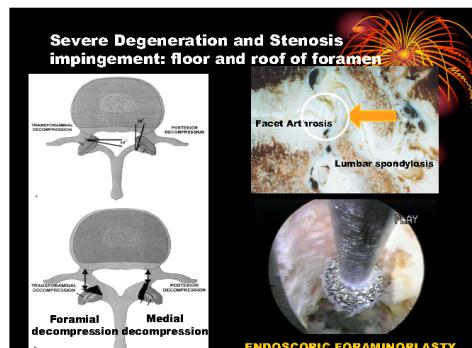


Figure 10: Foraminal decompression technique discussed by Osmon in the literature and documented by YEES™ foraminoplasty. Foraminoplasty does not just decompress the ventral facet, but targets decompression of the exiting and traversing nerve.

The Axilla of Kambin's Triangle in the Foramen

- Tip of SAP impinges on the axilla between the traversing and exiting nerve
- Site of unrecognized patho-anatomy
- Under decompressed with translaminar decompression when only the medial facet is removed

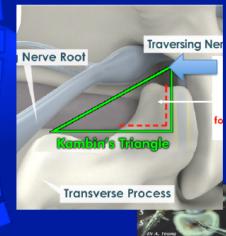


Figure 11: Foraminoplasty versus foraminotomy.

The axilla contains unrecognized patho-anatomy

Axilla of exiting and traversing nerve

Decompressed axilla



Figure 12: Visualization of the hidden zone of Mac Nab, the site of many causes of failed back surgery syndrome (FBSS).

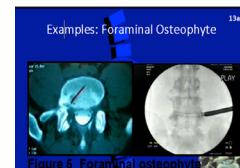


Figure 13: Endoscopic decompression of a painful foraminal osteophyte.



Figure 14: Anomalous and branches of the normal traversing and exiting spinal nerves do exist, but are mostly encountered in the foraminal approach. (Cutting small branches usually produce only transient dysesthesia, but cutting or ablating large branches may cause residual pain, numbness or weakness. This is a risk for transforaminal surgery that cannot be completely avoided, and the patient should be warned that this is a risk of transforaminal surgery that is mitigated by operating under local anesthesia).

tip of the superior process in Kambin's triangle to decompress the axilla (Figures 11-13).

Other causes of failed back surgery or under estimated patho-anatomy are readily treated by foraminoplasty. A prime example is the foraminal osteophyte. Many of the osteophytes are asymptomatic and considered a condition of lumbar spondylosis but when the osteophyte

is impinging on the exiting nerve in the foramen, it can cause sciatica not visualized by the translaminar approach, but readily identified with the transforaminal approach by decompressing and visually confirm the decompression of exiting as well as the traversing nerve (Figures 14).

Discussion

The standard translaminar surgical approach may miss causes of pain in the anatomic zone between the traversing and exiting nerve, a zone harboring common causes of failed back surgery syndrome. Recent minimally invasive techniques of fusion may help resolve the pain source, but fusion has its surgical morbidities and high costs [2,3].

Transforaminal Endoscopic Spine Surgery is effective using mobile cannulas to visualize and target the pain source. New instrumentation, techniques, specially configured endoscopes; facilitate effective surgical treatment of the pain generator, including visualization of the disc cavity and the ability to add intradiscal therapy. When a surgeon combines interventional techniques with endoscopic visualization, additional effective steps in the treatment algorithm are available. The purpose of this study is to demonstrate that the physiology of pain can be visualized as a pain generator. Diagnostic and therapeutic injections aid in identifying pain generators by epidurography performed with the transforaminal approach.

Globally, pain relief or function improvement is the reason patients go to their physicians for their spine problems. Pain is better understood with *in vivo* visualization and probing of the pain generators using endoscopic transforaminal visualization that correlates with imaging studies and further elucidation of the pain source.

Symptoms, aided by detailed descriptions and patient generated symptom diagrams are correlated with imaging studies. Correlating the image study with response to therapeutic injections suspected to be the source of symptoms using the same trajectory as the minimally invasive treatment will then help provide the location of the patho-anatomy responsible for the patient's pain [4,5].

Image abnormalities, or lack of imaging confirmation, however, may not explain the pain and disability experienced by each individual patient. Images do not always show variations in nerve supply and patho-anatomy, nor do they quantify the pain experienced by each individual patient, so correlation of diagnostic and therapeutic injections may be needed. The patient's pain complaints with respect to their response to these tests will require clinical acumen known as the "art of medicine". The ability to deliver results will depend on clinical acumen as well as surgical skill.

Endoscopic foraminal surgery (The YESS™) technique is summarized in these steps:

1. Needle and cannula placement for optimal instrument placement is calculated from coordinate lines drawn on the skin from the C-Arm image. The needle trajectory is utilized for diagnostic and therapeutic injections as a precursor to endoscopic surgical intervention.

2. Injection of non-ionic radio-opaque contrast to create a foraminal epidural gram and produce epidural patterns that outline foraminal patho-anatomy such as HNP, central and lateral recess stenosis.

3. Evocative chromo-discography is performed to confirm discogenic pain with abnormal an abnormal discogram pattern such as extravasstion of dye to the DRG.

4. Disc and foraminal decompression, aided by vital tissue staining.
5. Endoscopic foraminoplasty decompresses the lateral recess and

visualizes the exiting and traversing nerve in the axilla containing the dorsal root ganglion (DRG) [6,7].

6. Diagnostic surgical exploration of the epidural space.
7. Probe the hidden zone of Mac Nab under local anesthesia.
8. Using the biportal technique for inside-out removal of extruded and sequestered nucleus pulposus.
9. Dorsal visualized rhizotomy of the branches of the dorsal ramus to denervate the facet joint.

A database of over 10,000 surgical cases utilizing jpeg and MP4 video imaging illustrate the painful conditions most suitable for foraminal endoscopic surgery. This is an endoscopically visualized surgical procedure that requires specialized surgical training and not a fluoroscopically guided pain management procedure. Many different endoscope systems with other leading key opinion leaders are also marketed. Recent developments with intra operative imaging, Artificial Intelligence for robotic guidance, and image guidance, will make surgery faster, safer, and improve results.

Results

The transforaminal endoscopic technique will allow surgical access to the lumbar spine for treatment of a wide spectrum of painful degenerative conditions. The most common condition responsible for common low back pain and sciatica are from "Toxic Annular tears" These tears emanating from annular tears usually involve sensitization of the dorsal root ganglion, the (DRG).

There are conditions where the endoscopic foraminal approach has advantages over traditional surgical approaches. These conditions are:

1. Discitis.
2. Far lateral foraminal and extraforaminal HNP, especially at L5-S1.
3. Upper lumbar HNP.
4. Lateral foraminal stenosis.
5. Visualizing the pain generators responsible for FBSS.

Conditions 1-4 can be treated with traditional translaminar decompression, but FBSS has pain generators that are often missed by traditional surgeons because some causes of pain are in the "hidden zone" of MacNab between the traversing and exiting nerve.

Conclusion

Interventional pain management, often the first line of invasive treatment provides temporary relief by targeting injections to block nerves causing pain, but it only provides temporary relief that must also that depend on natural healing to mitigate pain.

Intradiscal therapy, combined with transforaminal endoscopic decompression, is effective for chronic back pain and sciatica by decompressing the patho-anatomy in the disc, and in the axilla, of the traversing and exiting nerve called the "hidden zone of Mac Nab". First focus on the disc as a pain generator, but extend the technique to the exit as well as entrance zone of the subtalar recess. These three zones of the lateral recess, can be reached with transforaminal foraminoplasty. The aging process alters spinal anatomy in these three zones.

Visualizing the patho-anatomy with an endoscope targeting the patho-anatomy by the same interventional needle trajectories has opened the door for surgical decompression and ablation of the pain generators.

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