

The Evolution of Percutaneous Spinal Endoscopy and Discectomy: State of the Art

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Abstract

Objective: The author relates his 7 years' experience with endoscopic spine surgery for lumbar disc herniations and conditions previously treated only with more invasive methods.

Materials and Methods: Five hundred (500) patients were treated with the Yeung endoscopic spine system, which features an endoscope with a 2.8 mm operating channel. The protocol included preoperative or intraoperative discography in all cases. Adjuvant therapies were employed in various clinical conditions when dictated by the visualized spinal pathology — KTP laser (Laser-scope, San Jose, CA) in 100 patients, radiofrequency by electrothermal probe in 400 patients, chymopapain in 50 cases, and intraoperative steroids in 100 cases. A newer slotted tube system allowed for foraminoplasty and removal of osteophytes or extruded fragments.

Results: Good-to-excellent results were recorded in 432 of the 500 patients (86.4%). Separate analysis was made of the first 100 cases when the KTP laser was in use.

Conclusions: The 2.8 mm operating channel scope produced clear visualization of annular tears, disc fragments, foraminal osteophytes, and the epidural space. Monitoring of the microinstruments in the disc space and spinal canal was readily accomplished. The quality of the imaging provided by discography improved the definition of the disc pathology. Adjuvant use of lasers, radiofrequency, chymopapain, and intradiscal steroids and the newer slotted tube system, have contributed to the advances in minimally invasive technique for endoscopic discectomy. **Key Words:** Herniated lumbar disc, endoscopic discectomy, chymopapain, radiofrequency, discography, inflammatory membrane, thermal modulation, annular tear.

Introduction

BEFORE THE ADVENT OF percutaneous techniques, the only surgical treatment for herniated lumbar discs was posteromedial laminectomy, or laminotomy and discectomy. In an attempt to decrease surgical morbidity, the microscope was employed in conjunction with smaller incisions to minimize operative trauma to the bone and soft tissue. The earliest percutaneous methods concentrated on lateral approaches to the intervertebral disc and avoided breaching the spinal canal. With endoscopy came the ability to observe the disc space pathology, monitor removal of nucleus pulposus, and control adjuvants such as laser and radiofrequency. Nevertheless, a number of problems arose, including the need for expensive, nondisposable endoscopes and lack of size standardization. With smaller and disposable flexible

endoscopes and equipment, visualization of the nerve root was enhanced. Thereafter, specialized instruments were developed to perform foraminoplasty and remove osteophytes.

Materials and Methods

Yeung Endoscopic Spine System (YESS)

Five hundred patients were treated by the author between November 1991 and December 1998. Most of the cases had a variety of symptomatic disc protrusions, including recurrent, extruded, migrated, and sequestered disc fragments within reach of the YESS instruments. A subgroup with discogenic back pain due to annular tears was studied prospectively. In this group, selective endoscopic discectomy was combined with thermal discoplasty as an alternative to fusion.

Every patient underwent targeted endoscopic discectomy. Even when there was extruded foraminal and extraforaminal disc tissue in the path of the operative cannula, the "inside-out

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technique” decompressed the disc and created a working cavity within the disc. With this staging area accomplished, the visualized pathology was addressed, aided by adjuvant therapy.

This third-generation of instruments featured reusable, durable equipment. Multichannel inflow and outflow ports allowed suction through the working port and provided quality imaging (Fig. 1). The posterolateral portal was bordered by the superior facet of the inferior vertebra dorsally, the exiting nerve root ventrally, and the superior end plate of the inferior vertebra caudally (Fig. 2). The slotted cannula system protected neural tissue while allowing access to the pedicle and facet (Fig. 3A). Foraminoplasty was possible with trephines, rasps, burrs, and use of the laser (Figs. 3B and 3C).



Fig. 1. Illustration of YESS endoscope with multichannel inflow and outflow ports, and forceps extending through distal end.

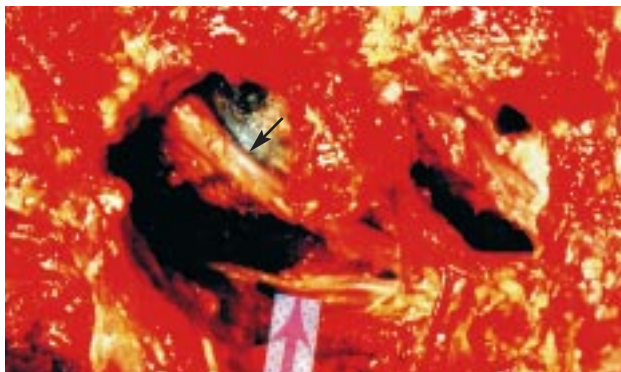


Fig. 2. The femoral-geital nerve (red arrow), found along the psoas muscle is in close proximity to the exiting nerve root (black arrow).

Discography

Indigocarmine dye 1 cc was mixed with 4 cc of iopamidol 41% and injected into the nucleus

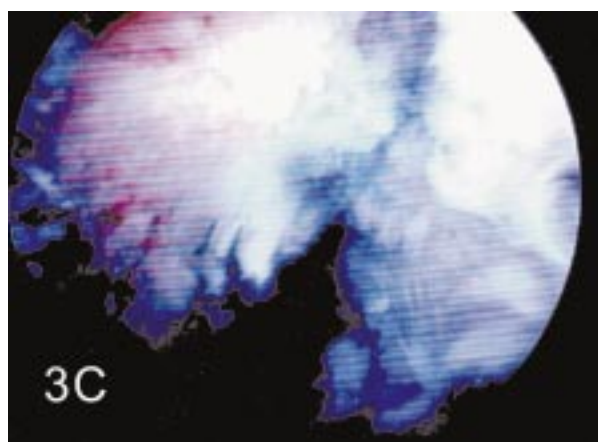
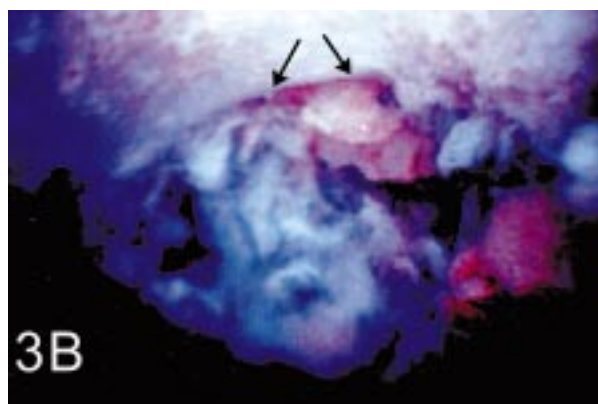
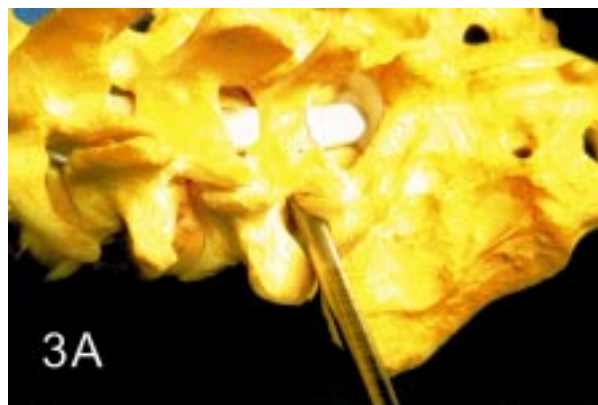


Fig. 3 (A) Slotted cannula placed under the superior facet of S1. (B) Superior facet (arrows) after foraminal enlargement at L5-S1. (C) Note absence of facet removed as part of foraminoplasty to relieve lateral recess stenosis.

pulposus. Degenerative structures within the disc were stained. Normal disc tissue was firm and resilient, would not stain, and could easily be distinguished from the “crab meat” consistency of abnormal nucleus pulposus (Fig. 4). The presence or absence of leg pain (visual analog scale 1–10) and the endoscopic findings were correlated with the preoperative MRI on an Image Manager, a computer database, which prepared a comprehensive report including the intraoperative

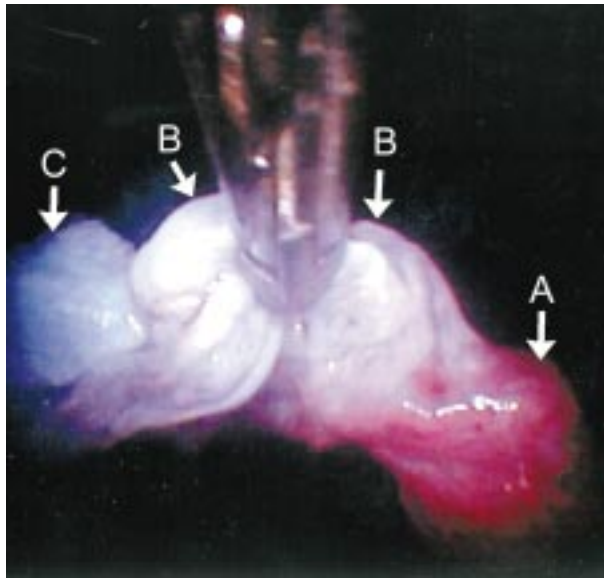


Fig. 4. Herniated disc fragment. Note inflamed portion (A) in epidural space, white portion (B) trapped in annular defect, and blue-stained portion (C) within the disc.

discogram and the endoscopic findings (Table 1). Only posterior tears are detected by MRI. Lateral tears are visualized by discography (Fig. 5) and usually produce groin and thigh pain. If localized to one or two quadrants, thermal contraction produces healing within 3–6 months. Extensive tears are more often associated with degenerative spondylolisthesis and require interbody fusion.

The severity and grading of annular tears are described in Table 1. Grades I and II never produce pain. Grade III radial tears produce pain at moderate pressures. MRI findings of a high intensity zone in the posterior annulus correlated with Grade IV and V tears, and were associated with non-dermatomal pain. Grade V tears (Fig.

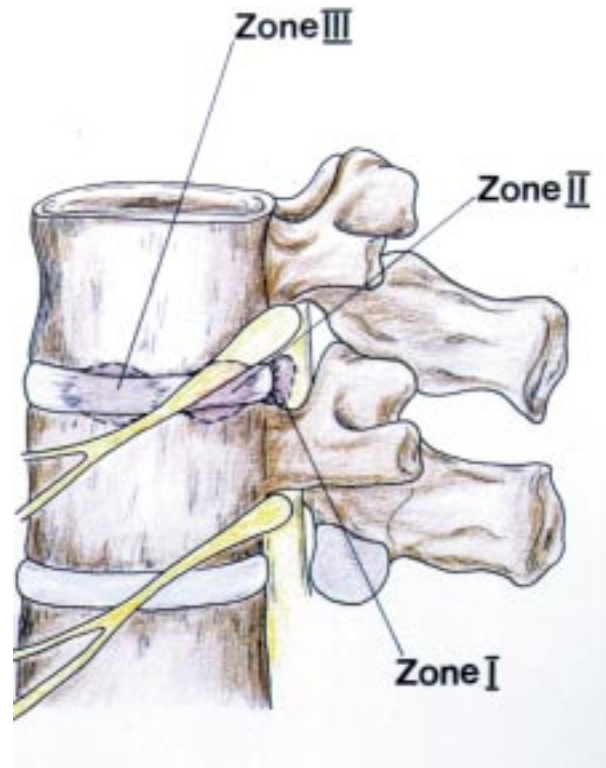


Fig. 5. Three zones of annular tear and disc protrusion. Zone I posterior tears are detected by MRI. Zone II tears directly involve the exiting nerve root. Zone III tears are best detected by evocative discography.

6) were often associated with an inflammatory membrane which spread beyond the area of tear. Far lateral and ventral tears were readily visualized endoscopically and were often associated with soft nucleus pulposus interposed between the collagen bundles of the annulus.

KTP Laser

The first 100 cases, in which the KTP laser (Trimedyn, Irvine, CA) was employed for disc decompression and ablation, were previously reported (1). The laser aided visualization by clearing the cavity of residual disc material not completely removed by instruments. Hemostasis was provided by thermocoagulation.

Chymopapain

Low dose chymopapain (500 units) was used as adjuvant therapy in 50 cases of large herniations, where the configuration of the herniation indicated possible difficulty with mechanical removal of the disc from the inside. Chymopapain was incorporated when a review of the technical failures included retained fragments that

TABLE 1
Grading of Annular Tears
(Modified Dallas Discogram Description)

Grade I	normal cotton ball pattern no extension beyond central half of disc
Grade II	normal lobular pattern no extension beyond central half of disc
Grade III	fissured extension to inner annulus no disc protrusion
Grade IV	degeneration + extension to outer annulus may include disc protrusion
Grade V	degeneration past annular extension definite protrusion + possible extruded fragment

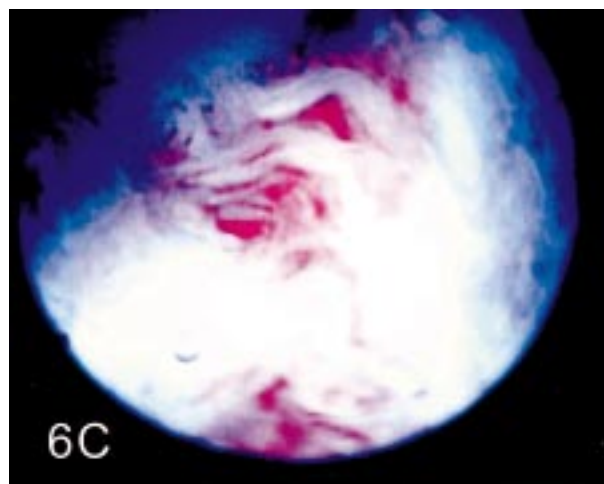
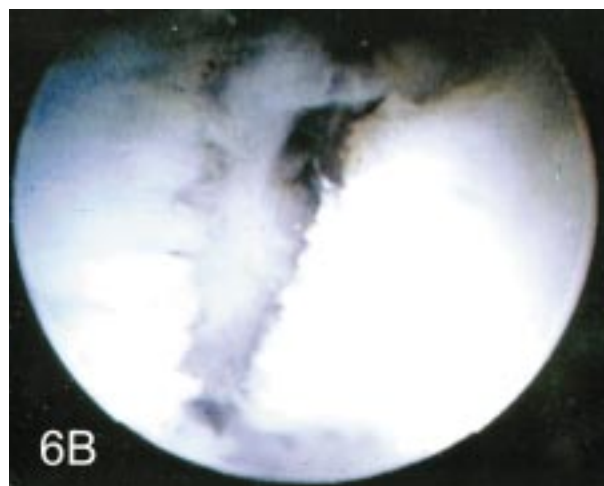
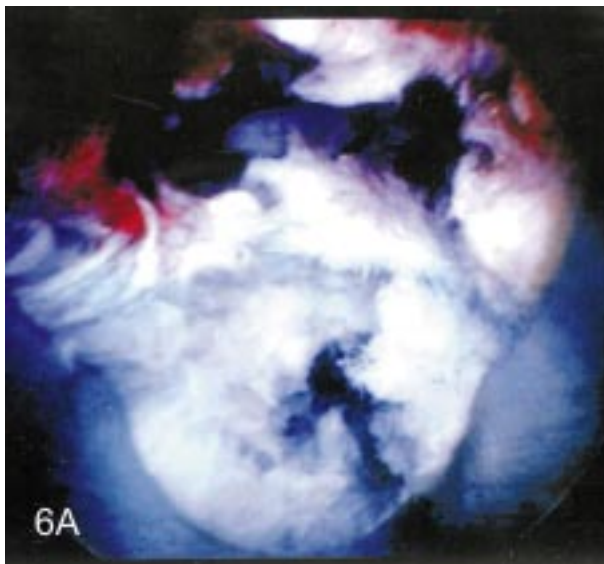


Fig. 6. Grade V annular tears. (A) Herniation extending into epidural space. (B) Interpositional disc fragment. (C) Note repair following thermal contraction.

separated from the main body of the herniation during extraction from within the disc. When disc fragments were found to be extruded and migrated behind the vertebral body or when there was a recurrent herniation, chymopapain was used to decrease the recurrence rate and dissolve the missed fragments. The patients all received cimetidine 100 mg and diphenhydramine 50 mg intravenously preoperatively. The chymopapain was injected and left in the nucleus pulposus for 5–10 minutes before fenestration of the annulus. There were no adverse reactions. When iopamidol was employed, if the contrast material was immediately absorbed into the bloodstream or entered the thecal sac, chymopapain was not injected.

Radiofrequency

In the remaining 400 cases, a radiofrequency electrode (Ellman International, Hewlett, NY) was substituted for the KTP laser. The probe was highly satisfactory for coagulating small bleeding vessels, and causing the annulus and disc material to contract. After thermal contraction, loosened soft and collagenized disc tissue was removed with manual instruments and motorized suction devices. The radiofrequency device has evolved from a straight electrode to a flexible, steerable probe with a thermal couple for temperature control.

In patients without disc protrusion but with painful Grade III + IV (Table 1) annular tears, nucleus pulposus may be observed as interpositional material between the collagen bundles and may be responsible for the tear not healing. More recently, when granulation tissue or an inflammatory membrane has been identified adjacent to grade V tears that extend to the epidural space and outer annulus, ablation has been accomplished with an electrothermal probe (Oratec Interventions, Inc., Menlo Park, CA). The annular tissue contracts with the use of the unipolar, flexible, temperature-modulated instrument, and the herniation defect is effectively closed.

Intraoperative Steroids

In 100 patients, whenever an inflammatory membrane was observed in the annulus, stimulation of the nerve and surrounding tissue elicited pain. Even when a foraminal herniation was encountered, the annulus was dilated at the base of the herniation and the fragment was pulled back into the disc space before being extracted — “inside-out technique” (Fig. 7). Depo-Medrol 80 mg in 1 cc of saline was placed intradiscally at the conclusion of the discectomy.

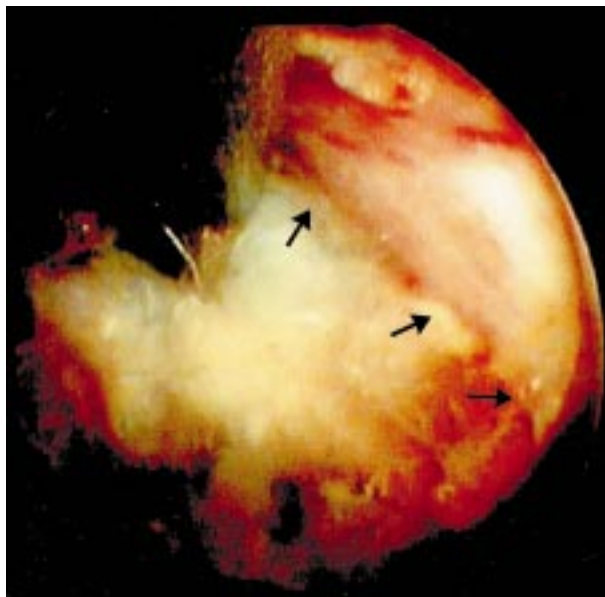


Fig. 7. Foraminal herniation (arrows) against traversing L5 nerve root.

Results

Good-to-excellent results were recorded in 432 out of 480 cases (90%); 20 patients were lost to follow-up. Of the first 100 operations, in which the KTP laser was employed, 80 patients (Table 2) were available for evaluation; good-to-excellent results were noted in 56 cases (70%) and fair-to-poor results in 24 (30%). The mean age was 42 years, with a range of 25–69 years. Good-to-excellent results occurred in 24 of the 32 patients (80%) presenting with predominant leg pain, but in only 30 of the 48 patients (63%) with pain confined to the low back. Eight patients (10%) who did not improve underwent successful open discectomy; the findings at surgery were either an extruded fragment or unrecognized foraminal stenosis.

In order to evaluate the electrothermal probe, the next 50 consecutive patients were reviewed. Forty-five cases (90%) reported pain relief. Grade III tears involving less than one-half of the dorsal annulus responded best, with pain relief occurring

between one week and 3 months after the procedure. Grade IV tears involving 50% or more of the annulus took an average of 3–6 months for back-pain relief, while Grade V tears took up to 9 months for improvement. In another preliminary prospective study of 50 patients, good-to-excellent results were recorded in 42 cases (84%).

The clinical results were rated by a combination of modified MacNab criteria and Adam's classification (2). The extent of the tear was determined by a modification of the Dallas Discogram Description (3). The tear pattern was further divided into radial and circumferential components as per Osti et al. (4). The overall purpose was to record discogram patterns and radial extension into the peripheral annular fibers, by the number of quadrants involved, but not depend on CT scan findings to rate the tear.

Complications were limited to temporary dysesthesia in 20% of patients. The cause was thermal irritation of the traversing nerve root or dorsal root ganglion. The heat of thermocoagulation may have spread through annular fissures or defects. More recent modifications in the radiofrequency probe allow for constant irrigation with cold saline. Continuing paresthesias and quadriceps atrophy occurred in two patients.

Discussion

In 1963, Lyman Smith (5) reported the effects of chymopapain on symptomatic disc herniations. The enzymatic debulking of the nucleus pulposus was validated by two large double-blind studies and a number of cohort studies (6–8). However, chymopapain was not as effective on hard collagenized fragments or sequestered and migrated fragments (9, 10). With the use of 2,000 units, systemic reactions due to vascular dispersion and injection outside the nucleus pulposus were associated with transverse myelitis and other unacceptable complications (11). Employing lower dosages (500 units) softened collagenized fragments and made extraction easier. When chymopapain was not injected, the electrothermal probe produced contraction of the annular fibers and dislodged fragments trapped in the annulus.

The intraoperative discogram has become an essential test during spinal endoscopy to confirm the pathology seen on preoperative imaging studies. The vital dye can fill the herniation defect, target degenerative material, warn the surgeon of non-containment if contrast extravasates, or simply outline the annular defect for thermal shrinkage. Classic extruded disc herniations are usually caused by collagenized fragments that are trapped

TABLE 2
80 out of 100 Patients in Follow-up Study

Level	Patients
L2–3	2
L3–4	12
L4–5	28
L5–S1	21
L4–5 + L5–S1	17

by the annulus and cannot retract back into the disc space. Herniations are often seen as a void on the discogram, as opposed to contrast material filling the protrusion. Extracted fragments can be examined in previously unappreciated detail.

Hijikata (12) and Kambin (13, 14) developed the mechanical and endoscopic approach to the lumbar disc in the early 1970s. Kambin (15) and Craig (16) refined their systems to allow for targeted fragmentectomy by uniportal and biportal techniques. Craig-type cannulas (16) were employed with manual and automated instruments to remove disc tissue from the triangular working zone between the traversing and exiting nerve roots. Initially, one cannula size and configuration allowed limited irrigation exploration. Later development of an oval cannula allowed fanning of instruments more dorsally and ventrally. When coupled with rigid patient selection, the reported surgical outcomes were comparable to those of open laminectomy (87% good-to-excellent results) (17, 18).

Without adequate evaluation of the epidural space by preoperative imaging studies, small extruded fragments and lateral recess stenosis could not be consistently ruled out and were the reported causes for clinical failure. Annular tears in the ventral and far lateral zone of the disc seen by intraoperative discography were often missed by MRI.

With newer slotted tube systems, it is now possible to remove bone, perform foraminoplasty, and excise extraligamentous disc fragments (19). Special cannulas have also been designed for inserting spinal implants and enlarging the subarticular recess. Depending on the location and size of the herniation, a uniportal or biportal technique can be used for posterolateral fragmentectomy. With the ability to visualize the spinal anatomy in a conscious patient comes the opportunity to diagnose, evaluate, and treat painful conditions that are still poorly understood.

Summary

Minimally invasive techniques offers an alternative to both conservative therapy and open surgical treatment of discogenic pain. The state of the art in percutaneous discectomy is no longer limited to contained disc herniations. Surgeons can now remove extruded and migrated fragments as long as they can reach the pathology involved. YESS gives access to the epidural space from pedicle to pedicle at each lumbar level. Development of instrumentation continues apace, with application of adjunct therapies such as discography, electrothermal probes, low dosages of chymopapain,

and intradiscal injection of steroids. Future studies are needed to evaluate prosthetic disc replacement, and tissue responsiveness and healing.

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