Rhode Island Hospital's Contribution to the Field of Endoscopic Spine Surgery

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ABSTRACT

The first academic program in endoscopic spine surgery in the United States opened its doors at Rhode Island Hospital in 2012. Published advances in the field since its inception have included treatments for a myriad of pathologies including lumbar and thoracic disc herniations, spondylolisthesis, spine tumors as well as treatments for complications of other spinal procedures including spinal fusion, kyphoplasty, and total disc replacement. In this issue of the *Rhode Island Medical Journal* we summarize the history of the procedure as well as some of the interesting progress going on in this field in Rhode Island.

KEYWORDS: endoscopic discectomy, minimally-invasive, transforaminal

INTRODUCTION

"Necessity is the mother of invention," is a proverb that dates back to 16th century England and describes well the challenge that faces those practicing medicine today and the generation who follow us. With health care costs rising, how will we face the upcoming challenge of providing care to our patient population?

Patients who would have had open-heart surgery in the past, are now candidates for outpatient interventional cardiology procedures. Complex intracranial vascular pathologies and skull base tumors that would have been treated with lengthy intracranial surgeries in the past are now treated with interventional radiology procedures and stereotactic radiosurgery. But what is being done in the field of spine surgery? For the answer to that question, much of the world looks to the research coming out of the institution that is at the center for publishing the latest advances in endoscopic spine surgery: The Department of Neurosurgery at Rhode Island Hospital and Warren Alpert Medical School of Brown University.

PERCUTANEOUS LUMBAR ENDOSCOPIC DISCECTOMY — THE HISTORY

The natural history of surgical techniques seem to be an evolution of "big to small." But the history of endoscopic spine surgery is really an evolution of "small to big." Early practitioners developed needle-based procedures to try to decompress the disc nuclear material to relieve back and radicular symptoms. Needles got bigger and the first endoscopic views of a herniated disc were published by Kambin in 1988,[1] and the first reported introduction of a modified arthroscope into the intervertebral disc space was reported by Forst and Hausman in 1983.[2]

In 1990, Parvis Kambin described a triangular safe zone bordered by the exiting root anteriorly, the traversing root medially, and the superior endplate of the lower lumbar vertebra inferiorly.[3] The anatomic description of this safe zone allowed the advancement of the field of endoscopic spine surgery to outgrow the technique of percutaneous nucleotomy which was limited by the use small needle-like instruments. Kambin's triangle was a working corridor that allowed the introduction of larger instruments and working channels to be introduced even closer to foraminal pathology without injuring the exiting nerve.

With the idea of a safe working triangle between the exiting and traversing roots in the foramen, the field of endoscopic spine surgery started to leave the safety of the indigo carmine blue stained nucleus and explore the foramen. An angled lens scope was used by Mayer and Brock in 1993 that allowed more dorsal visualization of annular pathology.[4] Foraminoscopy was described by Mathews in 1996[5] and Ditsworth in 1998.[6] Kambin and Zhou in 1996 described lumbar nerve root decompression by annulectomy and decompression of lateral recess stenosis with the use of forceps and trephines.[7] Schubert and Hoogland in 2005 described their technique for transforaminal endoscopic removal of a sequestered disc fragment using reemers to expand the foraminal window by removing the ventral portion of the superior articular process.[8] Multichannel endoscopes with larger working channels were introduced by Tsou and Yeung in 1997[9] and Reuten et al in 2007.[10] What would follow would be multiple reports of the clinical success of direct endoscopic decompression of foraminal pathology: Yeung and Tsou in 2002,[11] Reutten el al 2007,[10] Reutten et al 2008,[12] Jasper et al 2013.[13]

THE CLINICAL SUCCESS OF ENDOSCOPIC SURGERY

Seven papers published between 2013 and 2014 on awake endoscopic spine surgery indicated the possible efficacy of this procedure performed through a 5 mm incision for the

treatment of Lumbar radiculopathy.[13-19] For patients with single level disc disease, the success rate reported was an 84% reduction in pain, and for patients with multi-level pathology, the average pain relief was 70%.[13] In a series of 50 consecutive patients over the age of 75, over 80% of patients described either a "good" or "excellent" outcome: many of these patients were offered fusion surgeries at other centers before being considered for endoscopic surgery.[15] Patients who underwent endoscopic treatment for radicular symptoms due to spondylolisthesis reported a 72% reduction in pain – up front instrumented fusion is currently a mainstay treatment for this pathology.[18] **Figure 1** displays in a step-by-step manner how the endoscopic technique is used to treat a patient (former NFL player) with lumbar radiculopathy in the setting of spondylolisthesis.

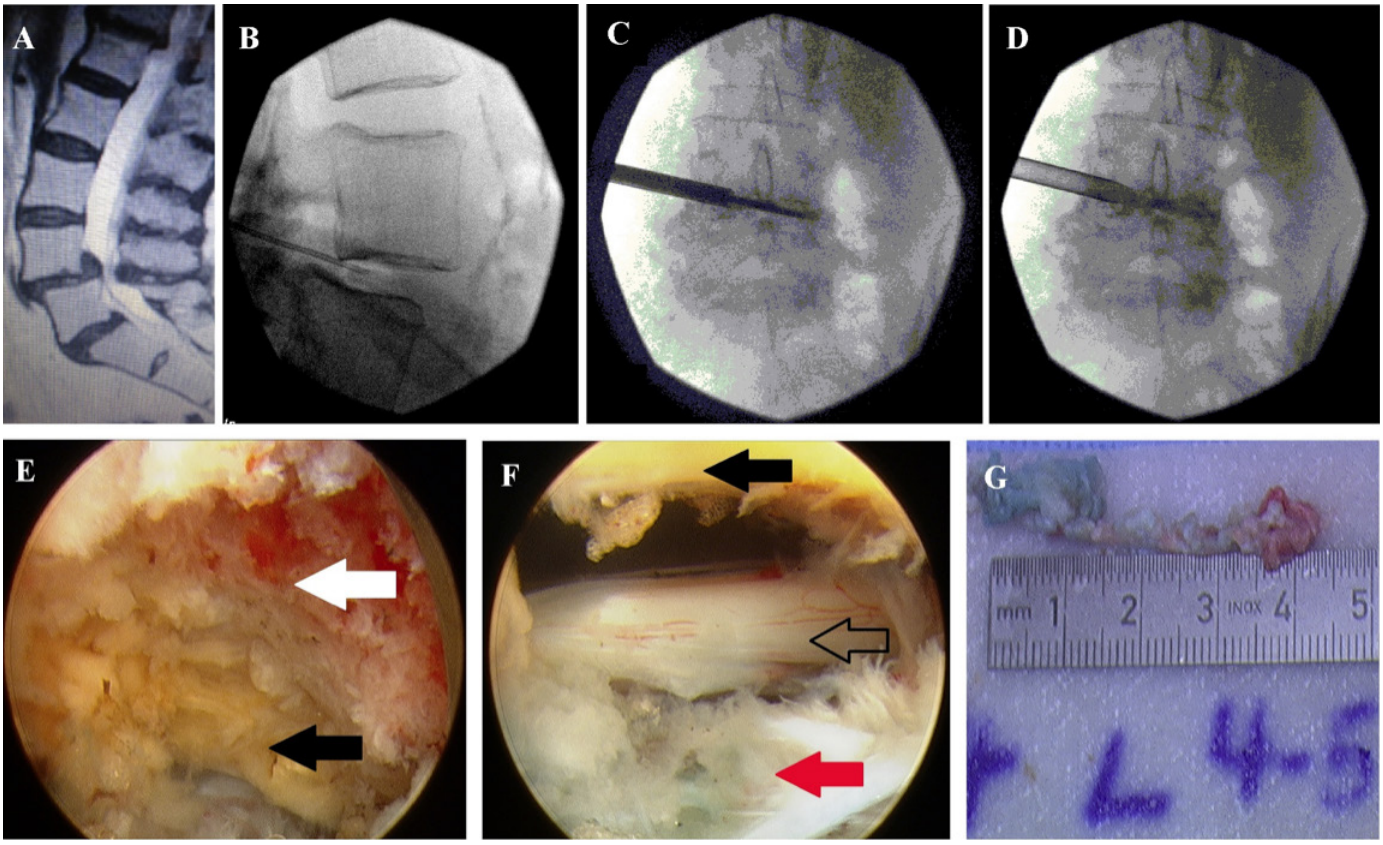
The mainstay for the treatment of lumbar degenerative pathology is conservative treatment with weight loss uniformly recommended for lumbar radicular symptomatology in the setting of morbid obesity. But the success of conservative management in reducing obesity is difficult. 82 patients in one study published showed pain reduction close to 70% for patients with BMIs between 30 and 40 but closer to 45% for patients with BMIs over 40.[19]

The first paper in the world describing the feasibility and technical steps that enable a surgeon to circumnavigate and reach into the epidural space for intracanal pathology was also published in these period, opening the possibility for treating more than routine herniated lumbar discs.[14]

FAILED BACK SURGERY

There has been a 15-fold increase in complex spinal fusion procedures in the past decade. But innovative treatment strategies for treating the complications from these procedures has lagged. In 2015 a series of 3 papers have described innovative minimally invasive treatments for herniated

Figure 1.



A. Preoperative sagittal T2 MRI showing pathology of L4-5 spondylolisthesis.

B. Spinal needle entry into L4-5 disc on lateral fluoroscopic view.

C. Small dilator and large crown reamer in L4-5 foramen during foraminoplasty on AP fluoroscopic view.

D. Bevelled working canulla in L4-5 foramen on AP fluoroscopic view.

E. Endoscopic view of the residual reamed ventral border of the SAP (white arrow) and ligamentum flavum (black arrow).

F. Endoscopic view of the ligamentum flavum (black arrow), traversing nerve root (black border arrow), and herniated disc (red arrow).

G. Intraoperative photograph of the L4-5 herniated disc fragment removed with an endoscopic forceps during the procedure.

Figure 2.

A. Sagittal T1 MRI with gadolinium of the thoracic spine demonstrating recurrence of the ventral extradural tumor.

B. Axial T2 MRI with gadolinium showing preoperative planning for spinal needle trajectory for transforaminal approach.

C. Intraoperative AP fluoroscopic image demonstrating passage of spinal needle into the left T5-6 neural foramen.

D. Intraoperative AP fluoroscopy showing reaming of the superior articular process.

E. Intraoperative AP fluoroscopic image showing working channel within the left T5-6 neural foramen, along with ball probe passed to confirm position of T6 pedicle.

F. Intraoperative AP fluoroscopy confirms position of malleable curved grasping forcep.

G. Patient positioned prone with working channel 5cm lateral to midline and communicating author shown manipulating bendable grasper in working channel.

H. Intraoperative endoscopic view with ball probe pushing on the dorsal aspect of the tumor capsule.

I. Intraoperative endoscopic view demonstrating the bendable grasper reaching inside the tumor capsule.

discs after fusion,[20] lumbar radiculopathy after instrumented fusion,[21] and lumbar radiculopathy after interbody fusion.[22] All of these "rescue" or "salvage" procedures were performed without general anesthesia on outpatients.

SPINAL TUMORS

In the international journal Clinical Neurology and Neurosurgery in July 2015, the first report in the world of performing a resection of a spinal canal tumor endoscopically in an awake patient was reported.[23] The case was performed on a 15-year-old patient who underwent the procedure in order to avoid a complex instrumented fusion procedure. **Figure 2** shows the patient's MRI, intraoperative x-rays, a photograph from the operating room, and endoscopic images from the surgery. The NBC news story of this historic surgery was shared around the world.

THORACIC DISC SURGERY

Surgery for the treatment of thoracic disc herniations has for years meant operating through a thoracotomy to remove disc pathology and fuse the spine. In 2016 the first 2 descriptions of technical nuances for performing awake endoscopic surgery for thoracic and thoracolumbar disc herniations were published in the Journal of Neurosurgery[24] and World Neurosurgery.[25] The advances in this area were the result of a collaboration between physicians at Rhode Island Hospital and surgeons in Germany and the Netherlands.

ENDOSCOPIC SURGERY TO TREAT OTHER SPINE SURGERY COMPLICATIONS

Kyphoplasty is a treatment for painful compression fractures of the osteoporotic spine. Cement leakage can be a disastrous complication that results from the procedure because an open laminectomy and instrumented fusion can be necessary to remove the extravasated cement. This surgery is made even more complicated by the fact that these osteoporotic patients are not favorable candidates for instrumented fusion procedures. In 2016 the first paper in the world describing an endoscopic solution for this problem in an awake patient was published.[26]

Artificial lumbar discs or total disc replacement surgery is performed more popularly in Europe than in the United States because of difficulty getting this non-fusion technology approved by insurance carriers. Patients interested in this surgery in the U.S. will sometimes travel to Europe for the procedure. Approximately 10% of these surgeries ultimately go on to need instrumented fusion due to complications from the original implant. In 2016 the first endoscopic treatment for a total disc replacement surgery was published in the Journal of Neurosurgery.[27] The surgery in Germany to place the artificial disc dislodged a fragment of bone that caused nerve compression. With the patient awake, an endoscope was used to drill out the fragment to free it and then remove it. The patient was able to avoid a laminectomy and fusion and ultimately benefited from a successful total disc replacement. The future of total disc replacement surgery in the U.S. remains to be seen but certainly endoscopic surgery may have a role in treating the complications seen in this procedure.

CONCLUSION: THE FUTURE OF SPINE SURGERY

Laser spine surgery that is advertised ubiquitously is not, in fact, performed with a laser. It is, in fact, an aggressive marketing program for a minimally invasive open surgical procedure that is performed with the patient under general anesthesia. Endoscopic spine surgery is performed with a working channel rigid endoscope, high definition camera, drills, trephines, articulated graspers, and sometimes, yes, a laser. But it has at its endpoint, the same surgical goal as many more open surgical spine procedures. The essence of what makes it different and the heart of what may be at the future of spine surgery is moving the point of visualization from the surgeon's eye to the endoscopic camera, which allow us to move the "eye's" lens remotely to the site of the surgical pathology. Innovation that brings the surgeon's "eye" to within millimeters from the patient's pathology allows complex spine surgery to be performed in awake patients through a tube the size of a pencil.

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