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The History of Endoscopic Posterior Lumbar Surgery

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ABSTRACT

Throughout its evolution, spine surgery has migrated toward less invasiveness. For posterior lumbar surgery, percutaneous techniques together with endoscopic visualization allow for the smallest surgical corridor. Initially, this approach utilized the natural entry point into the spinal canal via the transforaminal approach via Kamin's triangle. The interlaminar endoscopic technique was subsequently developed to address central disc herniations at L5-S1, where the transforaminal approach can be challenging to reach the surgical pathology. More recently, the dual portal posterior lumbar endoscopic technique provides for yet another method of performing posterior lumbar surgery, expanding its versatility, including the treatment of spinal stenosis. In addition to treating disc pathology, percutaneous endoscopic lumbar interbody fusions are now performed in select patients in the ambulatory surgery setting. Despite the dramatic advantages of advanced minimally invasive procedures, the adoption of endoscopic spine surgery in everyday practice has lagged. The main obstacle to adoption appears to be the difficult learning curve of endoscopic surgery combined with the fact that traditional microdiscectomy surgery remains one of the most successful operations in our treatment armamentarium. The successful future of endoscopic spine surgery will depend on our ability to address the learning curve problem. In the future, this problem may be addressed through the use to computer-assisted navigation, robotic assistance, and an integrated operating room suite that improves the efficiencies and ergonomics of increasingly complex surgical treatment strategies.

Special Issue

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INTRODUCTION

Spine surgery, like all other surgical treatments, continues to evolve to become less invasive as patients seek out treatments that have lower morbidity, less pain, and faster recovery to accommodate their busy lifestyles. For posterior lumbar surgery, the current state-of-the-art depends on endoscopic techniques. The treatment of degenerative lumbar conditions began in the early 1900s with the first open discectomy surgery. Some of the surgeries were performed through a transdural approach, but the collateral damage from such operations were not trivial. Over time, improvements in surgical techniques inevitably led to less invasive strategies. In the 1980s, John McCulloch developed the microdiscectomy technique in which dedicated retractor systems were employed together with the operating microscope to allow for adequate visualization through a much smaller surgical corridor.[1] Shortly thereafter, Richard Fessler, Kevin Foley, and coworkers developed a tubular retractor system that remains the gold standard for microdiscectomy surgery.[2] During this time, 2 parallel efforts were underway that would eventually join to become what is now the modern-day method for endoscopic lumbar surgery.

THE INTRODUCTION OF THE SPINAL ENDOSCOPE FOR PERCUTANEOUS LUMBAR DISECTOMY

Percutaneous treatments are commonplace in many surgical specialities, including treatments for coronary artery disease, abdominal aortic aneurysms, cholecystitis, and nephrolithiasis, among others. In the 1980s, P. Kambin, S. Hijikata, and coworkers revealed a system of needles and cannulas to be used to target a safe entry point into the spinal canal through a transforaminal approach called Kambin's triangle.[3,4] Kambin's triangle is the clear space on the posterolateral disc bounded by the traversing nerve medially, the exiting nerve laterally, and the caudal endplate inferiorly. Using intraoperative C-arm imaging, a surgeon can place a needle at Kambin's triangle and use it to guide a series of dilators and reamers to create a small surgical corridor suitable for a working cannula of about 7 to 8 mm in diameter. Through this working cannula, various instruments can be used to remove disc material along the path of this surgical corridor. Since there was no direct visualization of the surgical target site, direct removal of the herniated disc fragment was not readily achievable. The overriding strategy was to evacuate the nucleus and any

other disc material within the surgical corridor. Surgical success was usually dependent on decreasing the intradiscal pressure by removing the nucleus. From this, the percutaneous nucleotomy procedure was born. While initially popular due to its technical ease and minimal postoperative pain, the success rate of percutaneous nucleotomy in treating radiculopathy was relatively low compared to microdiscectomy.[5]

Kambin and coworkers realized that success would depend on our ability to visualize the surgical target site and confirm the removal of the herniated disc fragment. In 1983, Forst and Hauman described the nucleoscope.[6] In 1993, Kambin described the use of the endoscope to directly visualize Kambin's triangle.[7] However, it was Anthony Yeung and coworkers who developed the first fully functional endoscopic system to access the spinal canal through the transforaminal approach.

DEVELOPMENT OF DEDICATED ENDOSCOPIC SPINAL SYSTEMS

The first fully functional endoscopic discectomy system was developed by Yeung. A multichannel endoscope of 7 mm diameter was created with a working channel, along with a set of dedicated dilators, reamers, and endoscope-compatible instruments. Using small probes and rongeurs that can be used through the working channel of the endoscope, Yeung and coworkers described the successful application of this technique on patients with lumbar disc herniation with radiculopathy.[8] Yeung further described the use of a curved radiofrequency probe and the side-firing YAG-Holmium laser to coagulate blood vessels and ablate tissues under direct endoscopic visualization. His endoscopic discectomy system was bolstered by a regimented teaching program that describes his specific techniques, along with tips and tricks, to address the unique challenges of endoscopic surgery.[9] Menno Iprenberg and Thomas Hoogland developed comprehensive endoscopic spinal systems shortly thereafter.

In 2000, Sebastian Ruetten described the interlaminar approach for uniportal endoscopic discectomy.[10] Thieir approach expanded the utility of endoscopic surgery, particularly at L5-S1, where a transforaminal approach can be challenging. At the same time, several other key surgeons worked to advance our understanding of endoscopic surgery, including Sang-Ho Lee, who developed an entire hospital system to employ this technique.

RECENT ADVANCES IN ENDOSCOPIC SPINE SURGERY

The most significant advances in posterior lumbar endoscopic surgery strive to increase the versatility and breadth of applications. While the transforaminal and interlaminar lumbar endoscopic techniques are well suited to treat herniated discs, they have not been readily applicable to treating other common spinal conditions, such as lumbar stenosis and spondylolisthesis.

Biportal Lumbar Endoscopic Surgery

In an effort to better treat conditions, such as spinal stenosis, the recently described biportal technique uses separate ports for the endoscope and the working instruments.[11] More akin to knee and shoulder arthroscopy, the use of 2 separate ports allows larger, more traditional instruments, such as rongeurs, punches, nerve root retractors, and drills/burrs to perform an otherwise traditional hemilaminectomy. Dedicated instrumentation systems are currently under development.[12]

Endoscopically Assisted Lumbar Interbody Fusion

Percutaneous lumbar interbody fusion with supplemental posterior fixation has been described as early as 2010.[13] The inclusion of the spinal endoscope has allowed for direct assessment of nerve decompression and endplate preparation. James Yue, Michael Wang, Rudolph Morgenstern, Kai-Uwe Lewandrowski, and coworkers have reported good clinical results.[14—16] More recently, the dual portal endoscopic technique (UBE/BESS) has been used to perform a direct hemilaminectomy and posterior interbody fusion, allowing for a thorough decompression of the spinal canal.[17,18]

CHALLENGES TO ADOPTION OF ENDOSCOPIC SPINE SURGERY

Endoscopic spine surgery as it pertains to posterior lumbar surgery has experienced a slow but steady increase in popularity. To this day, endoscopic spine surgery is far from being a part of everyday practice. The slow adoption of this innovative and effective technique is perplexing, but it is likely due to a perfect storm of several factors. First and foremost of obstacles is the learning curve. A dreaded learning curve complication is postoperative radiculitis, marked by an increase in radicular pain sometimes accompanied by weakness.[19] Although usually temporary, the condition is distressing to both patient and surgeon. Furthermore, direct

visualization of the dural tube is limited, making it difficult to assess the decompression intraoperatively. These technical challenges are compounded by economic factors and, to a certain extent, complacency.

The endoscopic discectomy surgery seeks to replace the most successful operation in spine surgery, the microdiscectomy. Microdiscectomy is a simple operation that can be performed well by the vast majority of practicing spine surgeons, with good results that are durable and reproducible.[20] As reflected in the medical school slogan that "the enemy of good, is better," abandoning the microdiscectomy operation for a far more technically difficult endoscopic procedure is an obvious obstacle to adoption.

In the United States, adoption of endoscopic spine surgery is further hampered by poor payor coverage policies. In 2012, the T-code 0275T was introduced to the current procedural terminology (CPT) coding. The 0275T code categorizes percutaneous posterior lumbar decompressive procedures that do not involve direct visualization of the surgical anatomy with the naked eye, thereby eliminating the ability to use CPT code 63030 specifically for endoscopic transforaminal discectomy. The use of this T-code was immediately met with noncoverage decisions by nearly all payors in the United States, including the Centers for Medicare and Medicaid Services. In 2017, a new code was introduced specifically for endoscopic discectomy surgery (CPT 62380). CPT code 62380 also suffers from noncoverage policies by nearly all payors in the United States.

The adoption of posterior lumbar endoscopic spine surgery has faced a confluence of challenging circumstances: difficult learning curve, replacing the highly successful microdiscectomy, and lack of payor coverage. Despite these difficulties, interest in endoscopic spine surgery, by both patients and surgeons, continues to grow. The number of publications related to lumbar endoscopic spine surgery in 2010 was 23 (based on a PubMed search using "lumbar endoscopic discectomy"). In 2020, there were 231 publications—a 10-fold increase over 10 years. In 2010, only a few academic societies, such as the Society for Minimally Invasive Spine Surgery and the International Intradiscal Therapy Society, included sessions dedicated to endoscopic spine surgery. In 2016, 2 new societies dedicated to endoscopic spine surgery was formed: The International Society of Endoscopic Spine Surgery and the World Endoscopic Spine Society. In 2020–2021, nearly every academic spine society program contains a session dedicated to endoscopic surgery, including the North American Spine Society, the International Society for the Advancement of Spine Surgery, the American Academy of Orthopaedic Surgeons, and the Spine Section of the Congress of Neurologic Surgeons/American Academy of Neurologic Surgeons.

A NONENDOSCOPIC, MINIMALLY INVASIVE SPINE SURGEON'S PERSPECTIVE

Endoscopic spine surgery has seen slow adoption in the United States. Much of this has to do with a paucity of reasonable quality studies validating the effectiveness and outcomes of these techniques when compared to more traditional techniques. To date, much of the appeal of endoscopic surgery relates to the marketing value this provides. Although clearly less invasive than traditional open surgery, the incremental advantage that endoscopic approaches provide over current minimally invasive alternatives remain speculative. One could question whether an outpatient minimally invasive spine neural decompression using a 16-mm tubular retractor following well-validated principles is "more invasive" than its less familiar endoscopic counterpart. Endoscopic technique adoption has also been hampered by the unfamiliarity of the approach and challenges in readily identifying and clearly visualizing familiar and critical spinal anatomy. In addition, it remains to be determined whether the endoscopic procedure is applicable to a broad range of spinal pathologies or whether it has limited applications, including removing small contained disc herniations or addressing isolated foraminal stenosis. Other than anecdotal reports, it is unclear whether endoscopic approaches can accomplish the broader goals of spinal decompression, including spinal canal bony decompression, removal of extruded disc fragments, and other more complex pathologies.

Endoscopic spine surgery has also been hampered by many of the pioneers' questionable indications for this procedure. Using endoscopic debridement (with and without lasers) of the disc to treat postulated low back pain generators, such as annular fissures, for a diagnosis of "idiopathic disc derangement" remains unproven. Endoscopic foraminoplasty described to treat so-called failed back surgery does not resonate with most spine surgeons. Use of spinal endoscopy for unclear indications with nonvalidated claims of success tends to cast doubt on the field as a whole.

More recently, endoscopic-assisted lumbar fusion has been popularized. The development of

expandable cages may allow for their introduction into the disc space via smaller endoscopic cannulas. Although conceptually attractive, many questions regarding the ability to perform a thorough discectomy and end plate preparation through an endoscopic canula remain. These steps of the transforaminal lumbar interbody fusion procedure are arguably the most time-consuming but critical steps in achieving good fusion outcomes, yet they are largely ignored or minimized in the endoscopic versions of the surgeries. Modern spine surgery also emphasizes optimizing lordosis when performing fusion, which remains to be studied in endoscopic fusions. With studies documenting the ability to safely perform minimally invasive transforaminal lumbar interbody fusion in an outpatient setting, it is beholden on endoscopic proponents to prove at least equivalent and ideally superior clinical and fusion outcomes.

Despite some of the challenges endoscopic spine surgery and its early proponents have faced in the United States, these techniques are increasingly being adopted by a new generation of spine surgeons. As enabling technologies improve the ability of endoscopic surgery to address many of the aforementioned shortcomings, and as quality studies define the appropriate indications, outcomes, and complications, the field will undoubtedly advance and be increasingly incorporated into surgical practices.

SUMMARY AND FUTURE DIRECTIONS

Posterior lumbar endoscopic spine surgery remains viable through the support of a growing number of passionate and devoted endoscopic surgeons. These surgeons have conquered the learning curve and addressed payor issues to make it a part of their everyday practice. Although still few in number, their belief in the endoscopic procedure is evident at every presentation and course conducted. It is this evangelistic loyalty that continues to pique the interest of other surgeons to this technology. The future of endoscopic surgery must focus on obtaining a better understanding of the learning curve and translate such findings into actionable training programs. Concomitantly, incorporating intraoperative navigation, robotic assistance, and operating rooms configured to the needs of endoscopic spine surgery will likely increase adoption while continually improving efficacy and efficiency.

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