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The Endoscopic Approach to Lumbar Discectomy, Fusion, and Enhanced Recovery: A Review

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Abstract

Study Design: Review.

Objectives: To review the current state of endoscopic spine surgery with regard to discectomy, interbody fusion, and combination with Enhanced Recovery After Surgery programs in order to evaluate its relevance to the future of spine care.

Methods: A review of the literature and expert opinion is used to accomplish the objectives.

Results: The greatest strength of endoscopic spine surgery lies in its adherence to the basic tenets of minimally invasive surgery and its innate compatibility with Enhanced Recovery After Surgery programs, which aim to improve outcomes and reduce health care costs. The greatest challenge faced is the unique surgical skill set and significant learning curve.

Conclusions: Endoscopic spine surgery strives to achieve the core goals of minimally invasive surgery, while reducing cost and enhancing quality. In a healthcare market that is becoming increasingly burdened by cost and regulatory constraints, the utilization of endoscopy may become more widespread in the coming years.

Keywords
endoscopy, spine, minimally invasive surgical procedures

Introduction

The trend toward minimally invasive surgery (MIS) is widespread among all surgical specialties, including spine surgery. The reasons for this are numerous. In general, MIS strives to offer equivalent or better surgical outcomes compared to open surgery, while minimizing the surgical "footprint." True minimally invasive spine surgery approaches should not only minimize incision size but also reduce the extent of underlying tissue disruption and blood loss. The cascade of events following a minimally invasive approach should ultimately reduce postoperative pain, minimize narcotic reliance, encourage early ambulation, reduce the incidence of complications, and reduce hospital length of stay (LOS). The overarching effect should thereby be improved clinical outcomes and a reduced economic burden on patient and society by expediting return to normal daily activities, and reducing healthcare costs, respectively.

Endoscopic spine surgery as it is today, represents the culmination of approximately 50 years of surgical innovation, beginning with the work of Parvis Kambin and others in the development of the percutaneous nucleotomy in the early 1970s[1-5] With both the advancement of technology and our understanding of anatomy (ie, Kambin's triangle), the endoscope has found its place in spine surgery. We will review the strengths and challenges faced by spinal endoscopy, its role in decompression and fusion procedures, and keenly suited adjunctive perioperative programs in an attempt to quantify its potential long-term impact on our field.

Open/Tubular Microdiscectomy Versus Percutaneous Endoscopic Discectomy

The true potential of endoscopic spine surgery lies in the fact that it adheres to the tenets of MIS, including minimal

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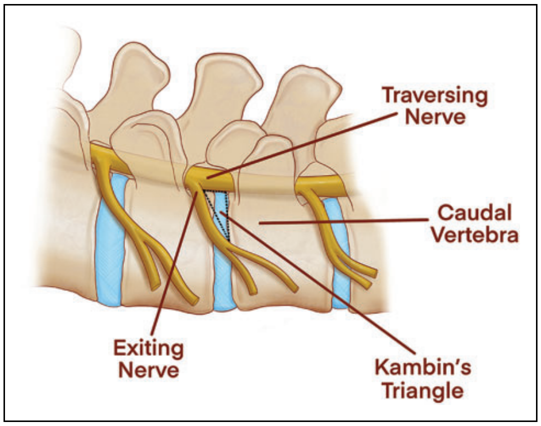

Figure 1. Kambin's triangle. The triangle is bordered by the exiting nerve root (hypotenuse), the traversing nerve root (height), and the superior end-plate of the caudal vertebral body (base). The medial-most portion of the triangle provides the greatest window for safe access to the intervertebral disc.

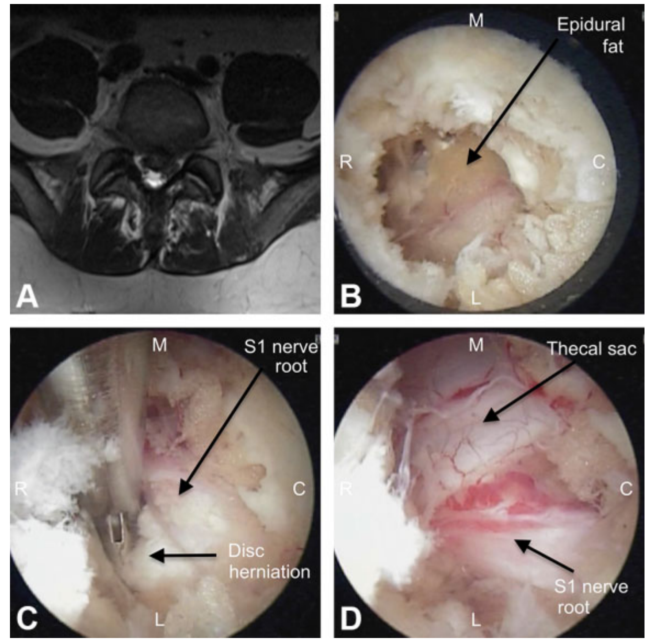

Figure 2. Left interlaminar L5-S1 percutaneous endoscopic discectomy. (A) Axial T2-weighted magnetic resonance image through L5-S1 depicts a left paracentral herniated disc. (B) Endoscopic view of epidural fat after opening a window through the ligamentum flavum. (C) Pituitary rongeur simultaneously retracting the traversing S1 nerve root, while removing herniated disc. (D) Postdiscectomy, the decompressed thecal sac and traversing S1 nerve root are clearly visualized. C, caudal; L, lateral; M, medial; R, rostral.

disruption of normal physiology, smaller incision size, reduced postoperative pain, early mobilization, and faster recovery. In addition, most endoscopic procedures may be performed without the use of general anesthesia. While the open microdiscectomy remains the gold standard for the surgical treatment of lumbar disc herniations, there are several potential issues associated with the procedure. While the incision is small, a subperiosteal dissection, laminotomy/medial facetectomy, and significant neural element manipulation is required in order to perform the procedure. As a result of the dissection, muscle weakness and/or atrophy may result.[6] Laminotomy and medial facetectomy may place the patient at risk for the development of spinal instability, and manipulation of the dura and nerve roots, may potentially result in epidural fibrosis and chronic pain. The tubular microdiscectomy, which was in fact first described by Foley et al[7] in 1997 as a tubular microendoscopic approach, attempts to focus the procedure further toward the goals of MIS by primarily replacing the classic subperiosteal dissection with a muscle-spreading technique. Apart from the approach however, the remainder of the procedure is grossly identical to the standard microdiscectomy. That being said, while the tubular approach is innovative, it is not revolutionary, and it is not surprising that functional and clinical results do not appear to vary between the 2 approaches.[8] One may argue that percutaneous endoscopic access for discectomy, foraminotomy, or even interbody fusion, does indeed represent a revolutionary step forward in MISS in that it involves (1) less muscle trauma than with the tubular approach, (2) minimal to no bone removal, (3) minimal neural element manipulation. In the transforaminal method this is accomplished by accessing the disc space through the neural foramen via Kambin's triangle (Figure 1). At the L5-S1 level, an interlaminar route is typically necessary due to the orientation of the facet joints (Figure 2).

Multiple studies have compared traditional open microdiscectomy with percutaneous endoscopic discectomy (PELD).[9-15] In summary, the literature suggests that both procedures likely have equal efficacy in the treatment of radiculopathy, with no difference in complication, recurrence, or reoperation rates. The most recent systematic review and meta-analysis of the literature comparing PELD to open and tubular microdiscectomy, including 26 studies (5 of which being randomized controlled trials), was performed by Telfeian and colleagues. They found that while open and tubular microdiscectomy appear equivalent in terms of clinical outcome and safety, PELD was associated with significant improvements in blood loss, durotomy incidence, patient-reported clinical outcomes, markers of inflammation, LOS, and time to return to work compared to open microdiscectomy.[15] While the measured differences in clinical outcomes were largely clinically insignificant, the fact that an at least equivalent complication profile, coupled with meaningful improvements in LOS and time to return to work (mean differences of 3.72 and 17.62 days, respectively), argue the advantages of PELD. Several other systematic reviews have been performed, yielding similar results.[9,12,16,17] An almost universal conclusion within the literature is that there is a need for more high-quality, prospective randomized controlled trials with larger sample sizes and longer follow-up periods to be performed before any definitive conclusions can be made. Answering this call, a multicenter, noninferiority randomized controlled trial is currently under way that will

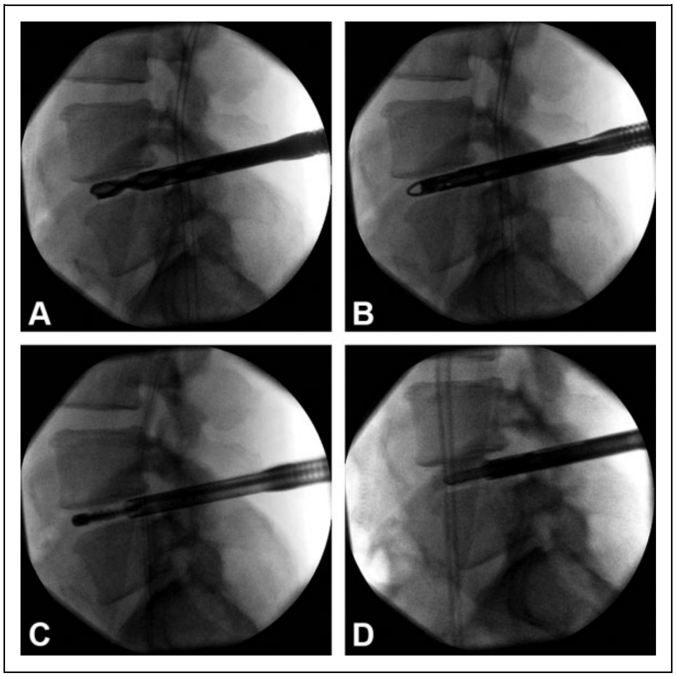

Figure 3. Percutaneous discectomy and end-plate preparation for fusion following endoscopic decompression. (A) Fluoroscopic image showing disc removal using a hand drill. (B) Fluoroscopic image showing disc removal using a specialized curette. (C) Fluoroscopic image showing final end-plate preparation using a stainless steel brush. (D) Fluoroscopic image showing sequential filling of mesh interbody implant with allograft in order to obtain the desired intervertebral height.

include 682 patients followed over 2 years in a study aiming to rigorously evaluate the efficacy and cost-effectiveness of PELD (transforaminal approach specifically) compared to open microdiscectomy.[10]

Endoscopy and Lumbar Fusion

The minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) represents an increasingly popular alternative to open lumbar fusion that provides significant reductions in blood loss and shorter hospital stays.[18] Even so, the technique remains subject to the same potential issues discussed earlier. In an attempt to reduce the surgical footprint of the MIS-TLIF even further, the endoscopic-assisted transforaminal lumbar interbody fusion was developed.[19]

The primary challenge of this procedure is being able to adequately prepare the vertebral end-plates for fusion and deliver a sufficiently sized interbody implant through an outer diameter 8-mm working channel through Kambin's triangle. Final interbody graft size is critical, as this procedure relies heavily on indirect decompression. Special percutaneous instruments including hand drills, curettes, and stainless steel brushes are necessary to adequately prepare the disc space after endoscopic decompression (Figure 3). Our practice is to use an expandable, allograft-filled mesh interbody device (OptiMesh, Spineology, St Paul, MN) that, while implantable through an

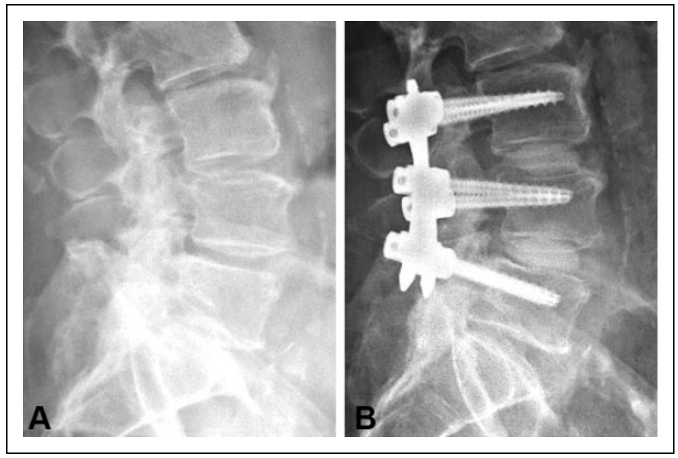

Figure 4. Representative case of L3-L5 awake endoscopic minimally invasive transforaminal lumbar interbody fusion. (A) Preoperative lateral lumbar radiograph demonstrating intervertebral settling with top-down foraminal stenosis at L3-4 and L4-5. (B) Postoperative lateral lumbar radiograph after endoscopic decompression and interbody implant placement, with restoration of intervertebral height and foraminal decompression.

8 mm working channel, may be expanded in situ to restore interbody height and provide bilateral indirect foraminal decompression (Figure 4). In addition, 2.1 mg of recombinant human bone morphogenetic protein–2 (rhBMP-2; Infuse, Medtronic, Minneapolis, MN) is implanted within the disc space to facilitate osteogenesis. Of note, the interbody implant and rhBMP-2 are used in an off-label fashion.

Kolcun et al[19] recently published a series of 100 consecutive patients with at least 1 year follow-up undergoing 1- or 2-level endoscopic transforaminal lumbar interbody fusion without general anesthesia (awake endoscopic MIS-TLIF). Radiographic evidence of solid bony fusion was obtained in 100% of cases and significant improvement in Oswestry Disability Index scores was achieved. Mean intraoperative blood loss was less than 75 cm^3 and average LOS was 1.4 days. Other smaller series have demonstrated similarly successful results.[20-22] In summary, while this and similar procedures remain in their infancy, the literature provides preliminary evidence that endoscopy will play a growing role in lumbar fusion.

Cost-Effectiveness and Enhanced Recovery After Surgery

Concomitant to improved surgical results and patient outcomes is a desire to maximize cost-effectiveness in spine surgery. In the United States in particular, the health care system is undergoing a major overhaul, with the future of reimbursement hinging on quality advancement, patient satisfaction, and cost reduction. Lumbar fusion surgery is perhaps the most targetable procedure through which endoscopic surgery can make a heavy impact, as these procedures are classically associated with significant soft tissue destruction, blood loss, long hospital stays, and extended postoperative recovery. That being said, Enhanced Recovery After Surgery (ERAS) programs are also ideally suited to this indication.

ERAS is a multimodal and multidisciplinary perioperative care program that was initially spawned as a "fast-track surgery" program for gastrointestinal surgery with excellent results, reducing length of stay, complication rates, postoperative pain scores, and overall cost.[23] Interest in implementing ERAS protocols in spine surgery is a relatively recent development and the literature is heterogenous in terms of patient populations, surgical procedures, and specific protocols employed.[24] Understandably, an evidence-based consensus regarding spine surgery cannot be made at this time even though official ERAS guidelines are available for a number of other surgical specialties.

To date the first and only published ERAS protocol exclusively for endoscopic spinal fusion is by Wang et al[25] and involves the awake endoscopic MIS-TLIF as described previously.[25] The perioperative protocol continues to evolve and is now being implemented for all 1- to 3-level lumbar fusions. Initial ERAS interventions include intraoperative use liposomal bupivacaine for long-acting local analgesia (Exparel, Pacira, Parsippany, NJ), intravenous acetaminophen, and daily visits from the ERAS team to assess progress. Compared with pre-ERAS controls, ERAS patients required less narcotic pain medication, had lower postoperative pain scores, ambulated a greater distance on each postoperative day, and had a shorter length of stay.[26]

This protocol continues to evolve and in an initial evaluation of acute care costs comparing awake endoscopic MIS-TLIF under an ERAS protocol to MIS-TLIF, Wang et al[27] found an average savings of $3444 (15.2% cost reduction) favoring awake endoscopic MIS-TLIF. The majority of savings stemmed from shorter operating room times, reduced length of stay, and reduced intensive care unit costs as a result of medical complications. In summary, preliminary data suggests that endoscopy, especially when combined with lumbar fusion and an ERAS protocol, has the potential to provide good clinical results while reducing overall cost.

Challenges to Endoscopic Spine Programs

The greatest challenge to the widespread implementation of endoscopic spine surgery programs is the associated learning curve. The set of technical skills required to be adept at endoscopy is different than what spine surgeons are typically accustomed to. Access is not the major issue as surgeons are comfortable and familiar with percutaneous procedures. However, the ability to successfully and safely navigate the intervertebral foramen or interlaminar space, under indirect visualization, is different from what is normally accustomed to. This is made obvious in several clinical series, with later cases requiring less procedural time, blood loss, and resulting in potentially better outcomes with fewer complications.[9,19] When first starting out, it is advisable to begin with cases that are perceived as being more straightforward. Multiple studies have attempted to define the learning curve for PELD, focusing on reductions in operative time, blood loss, and percentage of clinical success, with widely varied results spanning anywhere from 10 to 72 cases.[28,29] The only certainty is that a significant learning curve does in fact exist. Fortunately, as endoscopy becomes more popular, more surgical trainees will gain exposure to these techniques during residency and fellowship, effectively neutralizing this issue.

Conclusion

Endoscopy in spine surgery provides the least invasive means by which to surgically treat degenerative conditions of the spine. The indications for endoscopic spine surgery are growing, with applications for fusion being the newest addition. Coupled with newly developed ERAS programs, endoscopic spine surgery may represent a means by which to increase access to care, while minimizing overall cost and maximizing quality, in a health market that today is burdened by crippling cost and regulatory constraints.

Declaration of Conflicting Interests

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