

**Techniques and Applications of Endoscopic Spine Surgery. Part I: Overview of
Current Techniques**

Kai-Xuan Liu, MD, PhD

Atlantic Spine Center

West Orange, New Jersey 07052

Corresponding author: Kai-Xuan Liu

Address: Atlantic Spine Center, 475 Prospect Avenue, West Orange, NJ 07052

Fax: (732) 4941255

Phone: (732) 4941655

E-mail: doc@atlanticspinecenter.com

ABSTRACT

Background

Spinal pain is a serious health and social-economic problem. Endoscopic spine surgery as a treatment option for spinal pain has gained tremendous attention and growth in the past 2 decades, and a variety of endoscopic techniques have been invented to treat a wide range of spinal conditions.

Purposes

The purposes of this 2-part review article are to 1) overview the published techniques of endoscopic spine surgery, 2) summarize the applications of these techniques in treating various spinal conditions, and 3) evaluate the clinical evidence of the safety and effectiveness of these endoscopic techniques in treating some of the most common spinal conditions. The first part of the review article provides an overview of currently most commonly used techniques.

Methods

We searched the PubMed database for publications concerning endoscopic spine surgery and reviewed the relevant articles published in the English language.

Results

Discectomy and foraminotomy are the most common types of spine surgery that can currently be done endoscopically. Endoscopic techniques have been used to treat a wide range of spinal disorders located in the lumbar, cervical, as well as the thoracic regions of the spine.

Key Words: Endoscopic spine surgery, minimally invasive spine surgery, herniation, stenosis, failed back surgery syndrome

INTRODUCTION

Chronic pain is a serious health problem. Among chronic pain disorders, spinal pain caused by herniated discs and degenerative spinal diseases constitutes the majority of the problems. The lifetime prevalence of spinal pain has been reported ranging from 54% to 80%.¹

Treatment of spinal pain generally starts with conservative options, including exercise, antipain and antiinflammation medications, physical therapy, chiropractic care and traction, acupuncture, and steroid injections. Many patients experience pain relief after receiving these treatments. But because conservative treatments target the symptoms, not the source of the pain, the pain relief resulted from conservative treatments is often temporal.

If conservative treatments fail to produce satisfactory pain relief, surgery may be considered. Open spine surgical procedures are conventional surgical options for treating patients with spinal pain that does not respond well to conservative treatments. However, open techniques are often associated with tissue damage, relatively high complication rates, and long recovery. The drawbacks of open techniques compelled surgeons to search for less invasive surgical alternatives. The advances in visualization technology, surgical tools and instruments, and surgical techniques eventually made minimally invasive endoscopic spine surgery a reality.

The objective of the first part of this 2-part review article is to overview the most commonly used techniques of endoscopic spine surgery. In the second part of the article, we'll summarize the applications of these techniques in treating various spinal conditions, and evaluate the clinical evidence of the safety and effectiveness of these techniques in treating some of the major spinal conditions. Endoscopic spine techniques also play important roles in diagnosing spinal diseases and visualizing pain resources, but because of word limitation, this review article focuses on only the role of endoscopic spine techniques as a surgical treatment option.

METHODS

We searched the PubMed database for publications concerning endoscopic spine surgery and reviewed the relevant articles published in the English language.

RESULTS

Among varied endoscopic techniques reported in the medical journals, discectomy and foraminotomy are the most common types of spine surgery that can currently be done endoscopically. Because the majority of spinal conditions causing spinal pain are located in the lumbar and cervical regions of the spine, most of the peer-reviewed publications on endoscopic surgical techniques focus on lumbar and cervical regions of the spine. Only a few publications recently reported the feasibility of endoscopic techniques for the thoracic spine. Our literature review suggested that currently the most common endoscopic techniques for the lumbar spine include posterior interlaminar, and posterolateral and lateral transforaminal approaches, and that the most common endoscopic techniques for the cervical spine include anterior transdiscal and posterior laminoforaminotomy approaches.

Endoscopic Lumbar Discectomy

Posterolateral transforaminal endoscopic lumbar discectomy

Posterolateral transforaminal endoscopic lumbar discectomy appears to be the most commonly performed endoscopic spinal procedure for treating radicular pain caused by spinal disc herniations, tears, and bulges.²⁻⁶ During the operation, the endoscope and surgical instruments are introduced through a cannula that is inserted into the back between the traversing and exiting nerves in the area known as Kambin's Triangle.⁷ Posterolateral transforaminal approaches provide good endoscopic access to spinal structures from L1-2 to L4-5, and often L5-S1.

However, when the iliac crest is high, it is challenging to approach the L5-S1 via posterolateral transforaminal approaches as the L5-S1 disc space is located deep in the pelvis.

Depending on how the pathology is approached, posterolateral techniques can be classified into “inside-out” and “outside-in” techniques. The inside-out techniques such as the YESS technique starts working within the disc.^{8,9} If needed, the working system can be repositioned so that the tip of the working cannula is located in the foramen or the spinal canal. The inside-out techniques are suitable for treating internal disc disruption, disc tears and bulges, and pathologies located in the foramen or spinal canal. But for minor disc pathologies, especially when the pathology is not located within the disc, inside-out techniques may cause too much damage by removing normal disc tissue. In addition, it may not always be easy to determine whether or not the pathology is located within the disc, especially when a discography of a properly hydrated herniated disc shows certain degree of global degeneration.

For the outside-in techniques, the opening of the working cannula is initially positioned in the foramen or epidural space and then pushed to the inside the target disc, if needed.^{10,11} The outside-in techniques work well when treating foraminal disc herniations, and it is technically possible to use outside-in techniques to remove extraforaminal disc herniations.¹² But the techniques may demand an aggressive cut of the facet with sharp tools to reach centrally located disc herniations at L5-S1, posing risk of damaging the nerves and dura. For both inside-out and outside-in techniques, it is challenging to treat spinal pathologies located at L5-S1 level, especially in male patients because of the interference of the iliac crest.

Lateral transforaminal endoscopic lumbar discectomy

As an extension of the posterolateral approach, endoscopic lumbar discectomy through a lateral transforaminal access has been performed since the 1990s to treat lumbar disc herniations located

inside the spinal canal.¹¹ During such a procedure, a blunt cannula is inserted through the foramen and directly toward the spinal canal. The goal is to achieve a tangential reaching of the spinal canal. If the intervertebral foramen does not permit direct entry into the spinal canal, bone resection may be needed to enlarge the foramen. Lateral transforaminal endoscopic lumbar discectomy is indicated for central and paracentral disc herniations. But it cannot be used to address pathologies located at L5-S1 level because of the iliac crest. For technical clarity, it is worth noting that published reports on lateral techniques seem to show the instruments were a little bit oblique, instead of truly transversal as the names of the techniques indicate.

Posterior interlaminar endoscopic lumbar discectomy

For interlaminar approaches, the patient lies in the prone position and the skin incision is made as nearly medially in the craniocaudal middle of the interlaminar window as possible.¹³ A blunt dilator is inserted to the lateral edge of the interlaminar window before a working cannula is inserted toward the ligamentum flavum. For the opening of the cannula to reach the spinal canal, an incision of 3-5 mm in the ligamentum flavum is needed. In cases that the interlaminar window does not allow direct access to the spinal canal through the ligamentum flavum, some bone resection may be needed.

Interlaminar approaches work well for treating central, paracentral, sequestered herniations, lateral recess stenosis, and central spinal stenosis. But it is challenging to address foraminal and extraforaminal pathologies through interlaminar approaches. And the approaches may pose high risk of nerve and dura injury.

Endoscopic Cervical Discectomy

Anterior transdiscal endoscopic cervical discectomy

This technique is indicated for central, paracentral, and foraminal cervical disc herniations. It avoids posterior laminectomy-related neck pain but may decrease the height of the intervertebral disc space, damage the end plate, and cause possible access-related injury to the carotid artery, esophagus, vertebral artery, and nerves.

Anterior transdiscal endoscopic cervical discectomy is generally performed under general anesthesia with the patient lying down in the supine position. A small incision is made in the front of the patient's neck either from the right side or the left side depending on the patient's pathology and clinical symptoms. Gentle, blunt dissections are then made in the safe zone so that a guiding needle and later a dilator can reach the middle of the anterior disc space. The dilator is positioned according to the location of the pathology, and is aimed and subsequently advanced toward the pathology through the intervertebral disc. After sequential dilations are performed, a working cannula is inserted into the disc space near the pathology, and the ideal position is confirmed with fluoroscopic guidance. At this point, the pathology is clearly visible endoscopically, and the herniated disc material is removed using appropriate tools.¹⁴

Posterior laminoforaminotomy endoscopic cervical discectomy

This technique involves resection of the medial joint segments and the lateral ligamentum flavum. The bone resection may be extended toward lateral or craniocaudal if needed depending on the location and size of the pathology.¹⁵ Compared with anterior transdiscal approaches, posterior laminoforaminotomy approaches do not pose risk of injury to anterior cervical structure and do not require the removal of healthy disc material. Furthermore, posterior endoscopic procedures appear not to be associated with neck pain and technique difficulties related to bleeding, which are frequently encountered with traditional key-hole foraminotomy. However, these posterior

approaches may carry a risk of spinal nerve and spinal cord injury. This technique is indicated for lateral and foraminal disc herniations.

Endoscopic Thoracic Discectomy

Thoracic disc herniations are less common than lumbar or cervical disc herniations. And peer-reviewed publications on endoscopic thoracic discectomy from posterior or posterolateral approaches are limited. In 2002, Chiu et al ¹⁶ reported the safety and efficacy of percutaneous endoscopic discectomy for contained thoracic herniations through a posterolateral approach. Choi et al ¹⁷ recently reported the feasibility of percutaneous endoscopic techniques through transforaminal approaches for thoracic disc herniations. Choi's techniques were revised versions of his endoscopic lumbar discectomy techniques, but because thoracic intervertebral foramen is smaller than the lumbar foramen, the lateral part of the superior facet was removed to introduce the working cannula. In our own practice, we found it is not difficult to undercut facets, pedicles, and rib heads, to enlarge the foramen using a motorized burr so that the ventral epidural space can be reached, and to remove the paracentral and foraminal disc herniation.

Endoscopic Foraminotomy

Techniques of endoscopic foraminotomy can be applied to the lumbar, cervical, and thoracic regions of the spine, but most of the reported endoscopic foraminotomy operations were performed in the lumbar and cervical regions.^{15, 18} The techniques are often used to remove disc herniations or to decompress compressed spinal nerve roots.

Endoscopic posterior cervical foraminotomy

The specific techniques of endoscopic foraminotomy used in different regions of the spine can be different. For cervical spine alone, both anterior and posterior approaches have been reported. Considering that 1) most of the recent publications on endoscopic cervical foraminotomy are focused on posterior cervical foraminotomy, and 2) the advantages and disadvantages of anterior cervical foraminotomy have been previously reported¹⁹⁻²¹, in this article we mainly summarized the technique and clinical outcomes of endoscopic posterior cervical foraminotomy.

Endoscopic posterior cervical foraminotomy is generally performed under general anesthesia with x-ray guidance. The preparation work is similar to the endoscopic techniques discussed above. After the preparation work is completed, the surgeon starts the foraminotomy procedure by inserting a blunt dilator onto the target facet joint. An endoscopic instrument is then positioned and the dilator removed. Under visual guidance and continuous irrigation, the surgeon resects part of the medial joint segments and lateral fannum ligament, and identifies the lateral edge of the spinal cord and spinal nerves. The herniated disc materials are then resected and the compressed nerve is mobilized.¹⁵

Endoscopic posterolateral lumbar foraminotomy

Most of the reported endoscopic lumbar foraminotomy operations were performed via a posterolateral approach. The operation of posterolateral lumbar foraminotomy is generally performed under local anesthesia with x-ray based fluoroscopy guidance. Again, the determination of the pathology and the insertion of the dilator, endoscope, and surgical tools are similar to the endoscopic techniques discussed above. After the preparation work is completed, the surgeon starts the endoscopic lumbar foraminotomy procedure by removing part of the superior articular facet, resecting the lateral ligament flavum, and identifying the lateral edge of

the spinal cord and spinal nerves. To decompress the exiting nerve root, the tip of superior articular facet, inferior tip of the inferior articular facet, and superior foraminal ligament are removed from the lateral to the medial so that the axilla of the exiting nerve root can be reached.

Endoscopic lumbar foraminotomy can be used to undercut facet hypertrophy, and to remove disc herniations, perineural scars, synovial cysts, hypertrophic ligaments, and bone grafts from previous surgery. The goal of the technique is to make room for the exiting and transverse nerve roots compressed because of disc space narrowing, facet hypertrophy, and other foraminal pathologies.

ACKNOWLEDGMENT

The author thanks Yanni Wang, PhD, consulting medical writer and editor of International Biomedical Communications, LLC, Maryland, USA, for her assistance in revising the manuscript. Dr. Wang can be reached at dr.yanni.wang@gmail.com.

REFERENCES

1. Boswell MV, Shah RV, Everett CR, et al. Interventional techniques in the management of chronic spinal pain: evidence-based practice guidelines. *Pain Physician* 2005; **8**(1): 1-47.
2. Kambin P, Zhou L. History and current status of percutaneous arthroscopic disc surgery. *Spine* 1996; **21**(24 Suppl): 57S-61S.
3. Mathews HH. Transforaminal endoscopic microdiscectomy. *Neurosurg Clin N Am* 1996; **7**(1): 59-63.
4. Tsou PM, Yeung AT. Transforaminal endoscopic decompression for radiculopathy secondary to intracanal noncontained lumbar disc herniations: outcome and techniques. *Spine J* 2002; **2**(1): 41-8.
5. Tsou PM, Alan Yeung C, Yeung AT. Posterolateral transforaminal selective endoscopic discectomy and thermal annuloplasty for chronic lumbar discogenic pain: a minimal access visualized intradiscal surgical procedure. *Spine J* 2004; **4**(5): 564-73.
6. Ruetten S, Komp M, Merk H, Godolias G. Use of newly developed instruments and endoscopes: full-endoscopic resection of lumbar disc herniations via the interlaminar and lateral transforaminal approach. *J Neurosurg Spine* 2007; **6**(6): 521-30.

7. Kambin P, Gellman H. Percutaneous lateral discectomy of the lumbar spine: a preliminary report. *Clin Orthop* 1983; **174**: 127-32.
8. Yeung AT. Minimally Invasive Disc Surgery with the Yeung Endoscopic Spine System (YESS). *Surg Technol Int* 1999; **8**: 267-77.
9. Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: surgical techniques, outcomes, and complications in 307 consecutive cases. *Spine* 2002; **27**(7): 722-31.
10. Hoogland T, Schubert M, Miklitz B, A R. Transforaminal posterolateral endoscopic discectomy with or without the combination of a low-dose chymopapain: a prospective randomized study in 280 consecutive cases. *Spine* 2006; **31**(24): E890-7.
11. Ruetten S, Komp M, Godolias G. An extreme lateral access for the surgery of lumbar disc herniations inside the spinal canal using the full-endoscopic uniportal transforaminal approach-technique and prospective results of 463 patients. *Spine* 2005; **30**(22): 2570-8.
12. Jang JS, An SH, Lee SH. Transforaminal percutaneous endoscopic discectomy in the treatment of foraminal and extraforaminal lumbar disc herniations. *J Spinal Disord Tech* 2006; **19**(5): 338-43.
13. Ruetten S, Komp M, Godolias G. A new full-endoscopic technique for the interlaminar operation of lumbar disc herniations using 6-mm endoscopes: prospective 2-year results of 331 patients. *Minim Invasive Neurosurg* 2006; **49**(2): 80-7.
14. Liu KX, Massoud B. Endoscopic anterior cervical discectomy under epidurogram guidance. *Surg Technol Int* 2010; **20**: 373-8.
15. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic cervical posterior foraminotomy for the operation of lateral disc herniations using 5.9-mm endoscopes: a prospective, randomized, controlled study. *Spine (Phila Pa 1976)* 2008; **33**(9): 940-8.
16. Chiu JC, Clifford TJ, Sison R. Percutaneous microdecompressive endoscopic thoracic discectomy for herniated thoracic discs. *Surg Technol Int* 2002; **10**: 266-9.
17. Choi KY, Eun SS, Lee SH, Lee HY. Percutaneous endoscopic thoracic discectomy; transforaminal approach. *Minim Invasive Neurosurg* 2010; **53**(1): 25-8.
18. Ahn Y, Lee SH, Park WM, Lee HY. Posterolateral percutaneous endoscopic lumbar foraminotomy for L5-S1 foraminal or lateral exit zone stenosis. Technical note. *J Neurosurg* 2003; **99**(3 Suppl): 320-3.
19. Jho HD. Microsurgical anterior cervical foraminotomy for radiculopathy: a new approach to cervical disc herniation. *J Neurosurg* 1996; **84**: 155-60.
20. Hacker RJ, Miller CG. Failed anterior cervical foraminotomy. *J Neurosurg* 2003; **98**(2 Suppl): 126-30.
21. Saringer W, Nobauer I, Reddy M, Tschabitscher M, Horaczek A. Microsurgical anterior cervical foraminotomy (uncoforaminotomy) for unilateral radiculopathy: clinical results of a new technique. *Acta Neurochir (Wien)* 2002; **144**(7): 685-94.