Endoscopic Spine Surgery

Yu-Po Lee, MD, Christopher A. Yeung, MD, Michael Oh, MD, and Nitin Bhatia, MD

LEARNING OBJECTIVES: After participating in this CME activity, the spine surgeon should be better able to:
1. Describe endoscopic decompression techniques.
2. Evaluate the limitations and benefits of endoscopic spine surgery in selected patients.

Key Words: Endoscopic spine surgery, Minimally invasive spine surgery, MIS

Minimally invasive surgery (MIS) of the spine is an essential component of spine care. Studies have shown that MIS can reduce risks, shorten recovery time, and result in equivalent outcomes as traditional open surgical procedures. One type of MIS is endoscopic spine surgery, which allows surgeons to use a percutaneous approach to treat spinal pathology rather than the wide-open surgical exposure. This article discusses current endoscopic decompression techniques and review the limitations and benefits of endoscopic spine surgery. Currently, endoscopic spine surgery is used to treat lumbar disc herniations and lumbar stenosis. There are also endoscopic spine procedures being performed in the cervical and thoracic spine, but the safety and utility of these operations are still being evaluated.

The most commonly used system in endoscopic spine surgery is the percutaneous endoscopic system. This technique was developed in the mid-1980s and has become the standard for endoscopic spine surgery. This system involves the use of a working channel endoscope, a percutaneous approach to the spine, and the use of a monopolar approach with continuous saline irrigation. In most cases, a transfemoral approach is used, which refers to a posterolateral percutaneous approach to the disc or epidural space through a foraminal window. This approach provides direct access to the spinal canal and eliminates the need for a large skin incision, wide muscle retraction, unnecessary bone resection, and general anesthesia.

An alternative to the transfemoral approach is an interlaminar approach, which is characterized by a percutaneous posterior or interlaminar approach to the spinal canal. General spine surgeons are familiar with this approach because it is similar to that of open microscopic lumbar/thoracic decompression. The decompression processes are also similar to those of open microscopic decompression.

RATIONALE FOR ENDOSCOPIC SPINE SURGERY

The main objective of endoscopic spine surgery is to minimize tissue trauma while achieving equivalent results to open spine surgery. There are a number of benefits to endoscopic spine surgery over traditional open spine surgery. First, the procedure involves less tissue trauma due to a smaller skin incision, less tissue dissection, and less bone removed to access the spinal canal. Second, local anesthesia or conscious sedation can be used due to less tissue trauma. These benefits can result in fewer complications, reduced operative time, and a shorter length of stay. Other benefits include a quicker recovery due to less tissue damage, less use of narcotic medication after surgery, fewer wound complications, and quicker return to work. Because of these benefits, endoscopic spine surgery may be a practical alternative for elderly or medically compromised patients who are high-risk candidates for traditional open surgery under general anesthesia.

Endoscopic spine surgery is not without limitations. For example, there may be some complications specific to endoscopic
spine surgery, including ventral dural tears and nerve root injuries.\(^5\)\(^7\) There also is a steep learning curve, which is further complicated by the problem that most surgeons have limited opportunities to learn endoscopic spine surgery during residency or fellowship. In addition to these limitations, some pathologies that are not suitable for endoscopic spine surgery, such as a calcified disc or severe stenosis. Therefore, appropriate patient selection is essential. With higher patient demands, there is the risk of extending the surgical indications of endoscopic spine surgery. It is in these cases that complications are most likely to occur, and thus, strict indications are critical to favorable patient outcomes.

**PATIENT SELECTION**

As with any spine surgery, patient selection is key to the success of endoscopic spine surgery. The most common causes of failed endoscopic spine surgery are either intraoperative complications or incomplete decompression. In a patient with significant motor weakness, endoscopic spine surgery is usually contraindicated.\(^8\)\(^9\) In a patient with a conjoined nerve root in the neural foramen, a transforaminal endoscopic procedure should be avoided.\(^8\)\(^9\) The location of the disc herniation or stenosis, degree of canal compromise, severity of adhesion, risk of dural tear, calcification of the disc, and degenerative changes should be evaluated in the preoperative planning process.\(^8\)\(^9\) For proper patient selection and clinical success, surgeons should keep in mind the technical limitations of endoscopic spine surgery and match these with the patient’s anatomy and radiologic findings.

**PROCEDURE**

Endoscopic spine surgery is based on the principle of minimizing tissue trauma while achieving results equivalent to open spine surgical procedures. This is accomplished through a few important principles. First, the approach should be carried out percutaneously with a small working cannula, which serves two important purposes. This allows the use of local anesthesia or conscious sedation, thereby minimizing anesthesia risks and minimizing tissue damage. Second, access to spinal pathology should be gained via a working window to permit the endoscope and cannula to pass through to the spinal canal. Additionally, endoscopic visualization can provide a clear view of the spinal pathology. Special instrumentation is available to remove disc or bone that is causing nerve root compression.

**Transforaminal Approach**

Transforaminal percutaneous lumbar discectomy was initially used on soft lumbar disc herniations.\(^4\) Given the advancement in endoscopic technology, its practical application in the spine surgical procedures. This is accomplished through a few important principles. First, the approach should be carried out percutaneously with a small working cannula, which serves two important purposes. This allows the use of local anesthesia or conscious sedation, thereby minimizing anesthesia risks and minimizing tissue damage. Second, access to spinal pathology should be gained via a working window to permit the endoscope and cannula to pass through to the spinal canal. Additionally, endoscopic visualization can provide a clear view of the spinal pathology. Special instrumentation is available to remove disc or bone that is causing nerve root compression.
application has widened, and now includes migrated, recurrent, foraminal, extraforaminal, and even partially calcified disc herniations.\(^{5,7}\) This technique uses the intervertebral foramens as a working channel to address spine and disc pathology.

The procedure begins with administration of preoperative antibiotics. The patient is placed in a prone position on a radiolucent table and made comfortable with the use of pillows or a Wilson frame. The procedure is typically performed under local anesthesia or conscious sedation. A posterolateral transforaminal lumbar approach is performed under fluoroscopic control, with the approach needle inserted into the herniated disc through the foraminal window. Patient feedback is important in avoiding the exiting nerve root. The landing point should be as close as possible to the disc herniation and as far as possible from the exiting nerve root. A guidewire is placed through the needle, and then a scalpel is used to make a small incision along the needle. Dilators are used to expand the entry point and allow a working cannula to be inserted over the cannulas. Following this step, the working channel endoscope is inserted, and a selective discectomy and epidural decompression can be performed (Figure 1). Identification of disc material is often performed using indigo carmine. First, the anatomical layers, including the herniated disc, annular fissure, posterior longitudinal ligament, and neural tissues, should be identified. The herniated disc fragment should be freed from the annulus and then removed entirely. At the end of the procedure, it is important to evaluate the nerve roots and the thecal sac. The nerve roots should be mobile and free of adhesions and the thecal sac should show pulsations (Figure 2).

Decompression procedures also can be performed via a transforaminal approach. In some patients, hypertrophy of the superior articular process can result in stenosis of the lateral recess and the neuroforamen, which compress the traversing nerve root and exiting nerve root, respectively. The transforaminal endoscopic approach can be suitable for treatment of the lateral recess/foraminal stenosis in these cases by resection of the hypertrophied superior articulating process.

Unlike a percutaneous endoscopic discectomy approach, the working cannula is usually docked within the foramen, not in the disc space. The safety docking zone of the working cannula is the caudal surface of the superior articular process and pedicle. The tip of the superior articular process may be removed by a bone trephine or endoscopic burrs. After sufficient removal of the bony stenosis, the exposed ligamentum flavum can be removed by micropunches or forceps. For lateral recess stenosis, the caudal part of the neuroforamen and the traversing nerve root are decompressed. For foraminal stenosis, the cranial portion of the foramen and the exiting nerve root are decompressed. Part of the pedicle also can be resected if further decompression is needed.

**Interlaminar Approach**

For lumbar disc herniations at the L5–S1 level with high iliac crest, a transforaminal approach is difficult or even impossible. In these patients, the interlaminar percutaneous lumbar discectomy is ideal. This technique uses a posterior interlaminar approach with the small working cannula in the epidural or intradiscal space. This approach can be used to access other levels by using endoscopic punches or drills to enlarge the interlaminar space. Once the spinal canal is accessed, the cannula and endoscope are used to identify, free, and remove the disc fragment.

Decompression of central or lateral recess stenosis in the lumbar spine also can be performed via an interlaminar approach. The patient is placed in a prone position under general or epidural anesthesia. The initial target point is the lateral edge of the interlaminar window. After serial dilation, the final working cannula is placed on the lamina surface. Endoscopic laminotomy is performed from the medial border of the superior facet using an endoscopic burr and punches. With the interlaminar approach, one major concern is a dural tear. To prevent a dural breach, the practitioner should differentiate the dural sac, traversing nerve root, and exiting nerve root during tissue dissection. Any tissue adhesion should be dissected and released during the discectomy or laminotomy procedure. In the event of intraoperative bleeding and decreased visibility, complete hemostasis should be confirmed before instrumental decompression. Adequate hemostasis can be achieved through the combination of bipolar coagulation, high-water pressure, and hemostatic agents.

Decompression of the central spinal canal and lateral recess is accomplished by performing a laminotomy, medial facetectomy, and removal of the ligamentum flavum. If bilateral decompression is indicated, further decompression of the contralateral side is needed after ipsilateral decompression. The endoscope and the working cannula are directed toward the contralateral side, dorsal to the dural sac. At this point, it is better to leave the ligamentum flavum intact to protect the dural sac during the contralateral laminotomy. An endoscopic burr can be used to remove any bone causing compression and the remaining ligamentum flavum can then be completely removed using endoscopic punches.

**DISCUSSION**

The evidence shows that endoscopic spine surgery can be an effective adjunct to open spine procedures. In a study by Yeung and Tsou,\(^{7}\) the authors performed a retrospective review of 307 patients who had a posterolateral endoscopic discectomy. At 1 year, 90.7% of the respondents reported that they were
satisfied with their surgical outcome and would undergo the same endoscopic procedure. The combined major and minor complication rate for these patients was 3.5%. These results are comparable with that of traditional open microdiscectomies. Similar results were found in a meta-analysis by Kim et al\textsuperscript{10} of percutaneous endoscopic discectomies versus conventional open discectomies.\textsuperscript{10} Seven articles with 1254 total patients were selected and the authors concluded that the results between endoscopic discectomy and open microdiscectomy were similar, with endoscopic discectomy showing better results with respect to pain at final follow-up. Other studies have also shown good outcomes with endoscopic discectomy via an interlaminar approach at L5–S1. In a study by Choi et al,\textsuperscript{11} the authors performed a retrospective review of 67 patients who underwent an interlaminar discectomy at L5–S1 and observed that 90.8% of the patients reported good results. The mean hospital stay was 12 hours and average time to return to work was 6.79 weeks. Complications included 2 cases of dural injury with cerebrospinal fluid leakage, 9 cases of dysesthesia that were transient, and 1 case of recurrence. While there was no evidence of infection in any patients, 2 patients required conversion to open procedure at the initial operation. This study supports the notion that not all L5–S1 discectomies can be treated via an interlaminar approach, but rather a substantial number of L5–S1 discectomies can be successfully treated via an endoscopic approach.

Lumbar stenosis has also been treated by endoscopic spine surgery. In a study by Dowling et al,\textsuperscript{12} the authors performed a

\begin{figure}[h]
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\caption{Endoscopic discectomy at L2–L3 above a previous L3–L5 fusion. A, Initial visualization of facet capsule/lateral extent of the ligamentum flavum at the top, epidural space in the middle with epidural vessels/fat and the herniated nucleus pulposus coming out of the annulolotomy. B, Use of the bipolar radiofrequency to ablate the flavum/facet capsule/epidural veins to enlarge the foramen. C, Pituitary rongeur used to grasp the largest HNP fragment and pull it out. D, Use of the Ho:YAG side-firing laser to vaporize the flavum/facet capsule/undersurface of the facet bone to enlarge the foramen and alleviate foraminal stenosis. E, Evaluation of the area of the decompressed exiting nerve. There is a lot of epidural fat in the axilla of the exiting nerve and actually some surrounding the nerve itself. This is why the nerve is not totally distinct. F, Anteroposterior fluoroscopic image of the same view as in panel E, showing the position of the cannula. G, The same view as in panel A, but at the end of the procedure after decompression of both the herniated nucleus pulposus and the undersurface of the superior articular process.}
\end{figure}
A retrospective review on 249 patients who had spinal stenosis treated by either a transforaminal or interlaminar approach. The minimum follow-up time was 24 months. The authors reported excellent results in 47 patients (18.9%), good results in 178 patients (71.5%), fair results in 18 patients (7.2%), and poor results in 6 patients (2.4%).

In the cervical spine, some authors have published randomized trials of anterior or posterior endoscopic cervical disectomy technique. Unfortunately, there still remains a lack of high-quality randomized trials or meta-analyses. Therefore, more studies are sufficient to validate the use of endoscopic surgery in the cervical spine.

Endoscopic spine surgery is an emerging technique in the field of minimally invasive spine surgery, providing the benefits of minimal tissue trauma, low complication rates, and shorter recovery times. There are a variety of procedures utilizing this technique that vary according to the endoscopes used, approaches taken, and spinal levels treated. Among them, the transforaminal percutaneous endoscopic discectomy technique has been proven, through randomized trials and meta-analyses, as an excellent alternative surgical option. Regarding other endoscopic techniques, however, the current level of evidence is limited, and more studies are necessary to validate their clinical relevance and effectiveness.

REFERENCES
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1. A 46-year-old man has a disc herniation at L4–L5. He is interested in MIS. Which one of the following describes the benefit of MIS over traditional open spine surgery in this patient?
   - A. Less tissue trauma
   - B. Shorten recovery time
   - C. Lower infection rate
   - D. All of the above

2. Endoscopic spine surgery is used primarily in the thoracic spine.
   - A. True
   - B. False

3. A woman has a foraminal disc herniation at L3–L4. Her surgeon is planning an endoscopic discectomy. A key component of the percutaneous endoscopic system is a
   - A. working channel endoscope
   - B. percutaneous approach to the spine
   - C. monoporal approach with continuous saline irrigation
   - D. all of the above

4. A 50-year-old man has a disc herniation at L5–S1. His surgeon does not think she can use a traditional transforaminal approach. Which one of the following approaches would be a reasonable endoscopic approach?
   - A. Interlaminar
   - B. Cephalad
   - C. Foraminal
   - D. There is no alternative approach

5. An 80-year-old woman with aortic stenosis has radicular pain from stenosis at the L4–L5 level. Which of the following statements is **false**?
   - A. The procedure can be performed under local anesthesia and conscious sedation.
   - B. Endoscopic surgery would be helpful because it would avoid general anesthesia.
   - C. The patient will need to undergo general anesthesia.

6. A 50-year-old woman has a disc herniation at L4–L5. He is interested in endoscopic spine surgery. Under which of the following conditions would this patient **not** be a suitable candidate for endoscopic spine surgery?
   - A. Calcified disc herniation
   - B. Severe central stenosis
   - C. She has a foot drop
   - D. All of the above

7. A 45-year-old woman has a disc herniation at L4–L5. She is interested in endoscopic spine surgery. Under which of the following scenarios would this patient **not** be a suitable candidate for endoscopic spine surgery?
   - A. Soft disc herniation
   - B. Recurrent disc herniation
   - C. Extraforaminal disc herniation
   - D. Foraminal disc herniation
   - E. All of the above

8. A 40-year-old woman has right-sided leg pain. Which of the following conditions would be suitable for transforaminal discectomy in this patient?
   - A. Soft disc herniation
   - B. Recurrent disc herniation
   - C. Extraforaminal disc herniation
   - D. Foraminal disc herniation
   - E. All of the above

9. A 56-year-old man has lumbar stenosis and will undergo endoscopic decompression. The primary difference in this procedure, versus an endoscopic discectomy, is that the cannula is docked within the foramen versus the disc space.
   - A. True
   - B. False

10. A 50-year-old woman is undergoing decompression at L5–S1 via an endoscopic approach. Which of the following maneuvers will her surgeon perform to decompress the central canal during surgery?
    - A. Laminotomy
    - B. Medial facetectomy
    - C. Remove the ligamentum flavum
    - D. All of the above