Endoscopic Decompression for Lumbar Spinal Canal Stenosis: A Technical Note

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Abstract
Laminectomy and fusion were surgical options to decompress neural structures and provide more space for the spinal cord in a stenosis patient with severe leg pain and progressive neurologic signs, such as numbness and weakness. The evolution of endoscopic spinal surgery techniques has created advantages for patients who require a laminectomy. The authors present a unique technique for endoscopic access to the central and lateral recess pathology as a minimally invasive procedure, which provides a good visualization. We performed two cases of endoscopic spinal surgery for single-level and consecutive three-level lumbar spinal canal stenosis using an 8 mm outer diameter, 5.5 mm working channel, 10° angled lens spinal endoscopic system (percutaneous stenoscopic lumbar decompression, MaxMore Spine Company,Unterföhring, Germany). Optimized endoscopic drills, forceps, and Kerrison punch were used to remove bony pathology and ligamentum flavum under direct endoscopic visualization. The first case had a narrow canal space in the L4/L5 segment with severe numbness at the same dermatome and did not respond with adequate conventional treatment. The second case had three-level canal stenosis with severe back pain and leg weakness. The purpose of this paper is to describe the technique, the efficacy, and feasibility of unilateral endoscopic laminectomy and bilateral decompression via posterior approach in lumbar spinal canal stenosis. Moreover, in this article, we present the technical details on endoscopic procedures and the prevention of complications and management during operation for spinal canal stenosis.

Keywords: Endoscopic spinal surgery, percutaneous stenoscopic lumbar decompression, spinal stenosis

INTRODUCTION
Spinal stenosis is the progressive deterioration of spinal discs, and facet joints due to wear and tear with aging can also produce narrowing of the spinal canal, causing pain, numbness, weakness in the legs.1,2 As the world is becoming an aging society, there is an increasing incidence of spinal stenosis in aged people.3 Another problem for elderly patients can be associated with a progressive loss of functional reserve in all organ systems and can bring many medical issues. The physiologic changes in old age impact the anesthetic process, increasing susceptibility to anesthetic drugs, especially a long operation time of conventional open spine surgery.4

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Conservative treatment should be the initial option of treatment for stenosis. Medications and physical therapy can be helpful to relieve symptoms before considering surgical treatment, but if there is no improvement with these conservative measures, surgical treatment should be considered.

Microscopic laminectomy or fusion surgery was one of the most common operative procedures for the treatment of lumbar spinal canal stenosis under general anesthesia. As spinal endoscopy developed, various surgical approaches were tried and introduced under local anesthesia, and spinal stenosis also became an indication of endoscopic surgery. This technical report will describe surgical techniques, decompress neural elements in the narrow interlaminar window using spinal endoscopy, and manage the complications in detail that may arise during operation for endoscopic beginners.

A large 5.5 mm working channel endoscope with an outer diameter of 8 mm was used in this report to perform a unilateral laminectomy, bilateral decompression in a narrow interlaminar window in lumbar canal stenosis.

CASE 1

A 67-year-old woman presented with lower left leg pain (both L5 dermatomes) and neurogenic claudication for 2 years. Neurological examination revealed an apparent ankle weakness on the right side that was resistant to medical treatment and nerve root block. Lumbar magnetic resonance imaging (MRI) revealed a severe narrow spinal canal without foraminal stenosis at the L4/5 disc level. Computed tomography demonstrated a narrow interlaminar bone window and thickened ligament flavum.

SURGICAL PROCESS

Ipsilateral decompression

The procedures were performed under epidural anesthesia without sedation. The patients were placed in the prone position on the radiolucent Wilson frame in a flexed position. The skin entry point was just beside the spinous process, a 7 mm scalpel was used to make a stab wound. The dilator was inserted down to the laminar surface via lateral fluoroscopic view to determine the landing point. A 8.5 mm working sleeve was inserted through this dilator to create space to introduce endoscopic systems. Endoscopy was placed over the surface of the lamina through the working sleeve. A flexible radiofrequency (RF) was used for bleeding control, and a 4 mm diamond drill, a 45° angled 2 mm, 5 mm Kerrison punch were used for laminectomy and removal of ligament flavum. The landing point was on the lamina surface vertically, not interlaminar space, that was easy to process with laminectomy from the lower part of the upper lamina and is easier to reach ligament flavum from uppermost to lowermost with 45° angled Kerrison punch also. Once endoscopic systems land on the surface.
of the lamina vertically, tilted the endoscopy to interlaminar space, that way can keep the vector of power between 45° Kerrison punch and laminar angle from starting point to the endpoint well and is easy to remove ligament flavum all in a short operation time [Figure 3a-c].

During a laminectomy, preservation of facet joint is essential to prevent instability postoperatively. A MaxMore, 10° lens angle percutaneous stenoscopic lumbar decompression (PSLD) endoscopy is easy to observe ipsilateral lateral recess can play an essential role for preserving bony structures include facet joint [Figure 4]. After sufficient laminectomy, the endoscopic system can reach the uppermost ligament flavum and start clearing away the ligament flavum from the top to the bottom using the Kerrison punch [Figure 5a]. Once the total ligament flavum was adequately removed, the drill was utilized to grind away the lateral recess and to decompressed the nerve root at the proximal foramen [Figure 5b and c]. If discectomy is required, the root retractor is helpful to retract the nerve safely [Figure 5d]. An irrigation pump is used to maintain continuous water irrigation. As water pressure 40–60 mmHg, water permeates the epidural space, making more space between ligament flavum and dura.

**Contralateral decompression**

After tilting the endoscopic system to the opposite side, ventral subspinous and sublaminar drilling was performed to create a corridor for decompression of the central canal, the contralateral area [Figure 6a]. When the opposite ligament flavum is exposed, creating the interspace between dura and ligament flavum is essential to prevent damage to the neural structures [Figure 6b]. The surgeon should be careful not to damage the dura and contralateral nerve root caused by the Kerrison punch during removal of ligament flavum at midline and contralateral side. Sufficient contralateral decompression includes superior articular process resection and can provide the traversing root release like the ipsilateral side [Figure 6c]. After bleeding

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**Figure 3:** Yellow dot line: (a) Landing point on the lamina; (b) Tilt endoscopy to interlaminar space to start laminectomy; (c) Tilt endoscopy to reach uppermost ligament flavum

**Figure 4:** Ipsilateral bone work using the diamond drill, 10° lens angle endoscopy is easy to see ipsilateral facet joint and can help to prevent facet violation

**Figure 5:** Ipsilateral decompression; (a) Kerrison punch is used to remove a ligament flavum from uppermost to the lowermost; (b) Lateral recess drilling; (c) Confirm full ipsilateral decompression; (d) Nerve retractor is useful for discectomy
control at the bone and epidural vein, insertion of drain to prevent postoperative hematoma is the final procedure [Figure 6d]. Postoperative MRI revealed complete bilateral decompression, and the symptoms improved [Figure 1d-f]

**CASE 2**

A 66-year-old male presented with low back pain, bilateral leg numbness, and claudication that started 1 year ago. These symptoms were resistant to medical treatment. Neurological examination revealed weakness on the knee and ankle flexion on both the lower limb. Lumbar MRI revealed severe spinal canal narrowing at L2/3, L3/4, and L4/5 segments with root redundancy. The patient is placed prone on the radiolucent operating table, slightly flexed by placing Wilson’s frame under the epidural anesthesia. A 8 mm skin incision was made, just beside the spinous process in the middle segment at the level of L3/4. After introducing endoscopic systems, L3 unilateral laminectomy, bilateral flavectomy, and trimming of facet to decompress lateral recess increased L3/4 the spinal canal space. The next upper and lower level follows the same procedure using the Jumping technique. In three-level consecutive canal stenosis, the jumping technique [Figure 7] helps decompress all three-level through a single skin port using the skin's elasticity. In this technique, after completing one level, the working sleeve was moved cranially or caudally to the next target, using skin retraction within the same skin incision under image guidance. A new fasciotomy was made at each segment to place endoscopic systems on the lamina. The same process as the unilateral endoscopic laminotomy with bilateral decompression was performed for the remaining lumbar stenosis. After the procedures,
a suction drain was placed at each surgical segment to prevent postoperative hematoma [Figure 8a and b].

**DISCUSSION**

Conventional decompressive laminectomy is performed worldwide as an effective surgical technique for spinal canal decompression in stenosis.\[^9\] However, normal anatomical structures, paraspinal muscle, and facet joint damage are indispensable in conventional open surgery.\[^10,11\]

With the advent of endoscopic science and technology in the recent era, the sorting between microscopic and endoscopic operation in the field of spine surgery is disappearing. Finally, endoscopic spine surgery as a more minimally invasive technique is now being performed globally to treat all spine disorders, including fusion surgery with significant efficacy and safety.\[^12\] The importance of endoscopy and its instrument is emerging as a major issue lately. Since spinal endoscopy aims to provide direct visualization, it dramatically increases the area and quality of visualization as an object lens gets close to the surgical site. Various endoscopic instruments industries are trying to cope with the demand for more functional advanced instruments that can yield safety and great efficiency [Figure 9]. One of the tricky tasks during endoscopic decompression can be ipsilateral decompression. The lamina slope angle, the hypertrophic facet joints, and narrow lamina in the stenosis patients are the factors that create surgical difficulties to access the ipsilateral area in the canal.\[^13\]

Endoscopic decompression with the narrower-angle lens (10°) makes it easy to see the ipsilateral anatomical structures and allows to work closer to the surgical site during the procedure than a wider-angle lens. This can avoid damage to the ipsilateral facet joints and thus maintain spinal stability. Large-caliber endoscopic systems make it challenging to land on the lamina and also increase the possibility of facet violation. With the 8 mm diameter endoscopic systems, it is easy to dock on the lamina of interest for ipsilateral decompression and tilt, and decompression on the contralateral side remains very feasible.

In the early part of a learning curve, complications can be high due to a narrow spinal canal and poor endoscopic anatomical orientation, i.e., the possibility of iatrogenic facet fracture and dura and root injury.

![Figure 8:](image1.png) (a) 3 suction drainage catheter in 1 skin port, (b) 3 suction drainage catheters on X-ray

![Figure 9:](image2.png) (a) 8 mm diameter, 10° lens catheter in percutaneous stenoscopic lumbar decompression endoscopic systems. (b) Posterior approach, the skin entry point is just beside spinous process, land on the lamina. (c) Ipsilateral decompression. (d) Bilateral decompression, the end stage of procedures. (e) Contralateral decompression
One of the severe complications is dural tear that occurs when removing ligament flavum at the midline and contralateral area. One can take caution during the removal of ligamentum flavum. Before cutting the ligament flavum, it should be held and lifted with a Kerrison punch to access the underlying adhesion with the dura. The $10^\circ$ view is beneficial for early detection of dura tear underneath the thick ligamentum flavum so further dura and subsequent arachnoid damage can be prevented [Figure 10]. In the case of dura or arachnoid membrane tear, often rootlet is prolapsed outside in epidural space [Figure 11a]. Closing the water output of the endoscopy system with the fingers will increase pressure in the epidural space, push the rootlet into the intradural space, and work repositioning the rootlet in the thecal sac. TachoSil fibrin sealant patch can seal the defect by pushing into intradural space under the endoscopic view. It promotes the rapid formation of a strong bond between the dura and patch by the active ingredient substances like fibrinogen and thrombin of the TachoSil patch [Figure 11b]. Additional apply of TachoSil® patch enables the dura to stick more firmly to the opposite layer of the dura, helping to seal the dura and can prevent the CSF from leaking [Figure 11c and d].

To get a clear surgical visualization during endoscopic surgery, strict hemostasis from the epidural tissue and bone is essential. Continuous water irrigation provides constant hydrostatic pressure to the epidural venous plexus and small artery of cancellous bone, allowing bleeding control during surgical procedures. Irrigation water goes inside through the 2 mm tube of endoscopy, and water escapes outward through the 5 mm working channel. The amount of water used for 30 min is about 3000 cc with 40 mmgh pressure. Thus, the total input and output were balanced and avoided any abnormal fluid retention in the soft tissue and epidural space. If bleeding from the venous plexus still does not control with hydrostatic pressure, bipolar RF heat coagulation can be a useful way to stop the bleeding [Figure 12a]. Cancellous bone compression firmly by Kerrison punch is also the efficient alternative to control the bleeding [Figure 12b].

One of the advantages of endoscopic spine surgery for stenosis could be excellent surgical visualization that helps to reduce the possible damage and promotes safe surgery. Less tissue damage renders quick recovery. The possibility of multiple level decompression through the same single skin port is one of the most crucial additional advantages. The horizons of endoscopic spine surgery are now expanding to the majority of the lumbar and cervical spine diseases and still evolving.\cite{15}

Figure 10: $10^\circ$ lens angled endoscopic systems help look at the epidural space between dura and ligament flavum

Figure 11: (a) Dura tear is revealed with a herniated nerve rootlet under the endoscopic view. (b) Push Tachosil® into the intradural space can rootlet rearrange. (c) The amount of Tachosil® to put depending on the torn length of the dura. (d) Pressing the contact surface of the dura using forceps will stick together and close the dura

Figure 12: (a) Bipolar radiofrequency heat coagulation to stop epidural bleeding. (b) Cancellous bone compression by Kerrison punch to stop bone bleeding percutaneous stenoscopic lumbar decompression
CONCLUSIONS

Single- to multiple-level lumbar canal stenosis can be decompressed safely and effectively by a posterior approach using PSLD, an optimized spinal endoscopic system. The narrow interlaminar window can be overcome with laminectomy using a high-speed drill and Kerrison punch. With the clean endoscopic view, this method also made further decompression of lateral recess easy and safe.

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REFERENCES