Lumbar Foraminal Stenosis: Full Endoscopic Transforaminal Approach

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Introduction (Key Point and Purpose) of Approach

Open foraminal decompression with/without fusion has been performed as a standard surgical treatment for lumbar foraminal stenosis. Total facetectomy provides complete nerve decompression but often leads to spinal instability and usually requires additional fixation [1–3]. Wiltse et al. [4] reported a paraspinal approach as a method for decompression of foraminal stenosis. Because this technique preserves much of the facet joint, it is now widely used as a standard surgical treatment for decompression in patients with foraminal stenosis.

The full endoscopic transforaminal approach has less muscle trauma and less blood loss than open decompression. It can also be done under local anesthesia. Thus, reduced hospital stay, early functional recovery, and better cosmesis are shown [5, 6]. With the desire of patients and the development of endoscopic instruments, the transforaminal approach is gaining in popularity. To date, endoscopic transforaminal decompression has been predominantly performed in patients with disc herniation. For spinal stenosis, endoscopic working mobility is limited due to foraminal bony structure and exiting nerve root [7–10]. Recently reported endoscopic approach through extraforaminal landing enables working mobility after partial removal of superior articular process. After that, it was possible to approach the foraminal zone safely and to treat decompression for foraminal stenosis. We will describe this technique in this chapter.

Indication and Contraindication

Indication

This technique can be applied to patients with foraminal stenosis who do not respond to preservation therapy and whose symptoms persist. It is appropriate to perform in patients with unilateral radicular symptom.

Contraindication

This technique is not appropriate in patients with segmental instability or spondylolisthesis. In

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these cases, fusion surgery should be considered. It is also difficult to apply to patients with profound motor weakness or revision surgery. Approach is also difficult in patients with high iliac crest at L5/S1 level. Coexisting pathological conditions such as acute inflammation, infection, or tumor can also be difficult to apply.

Anesthesia and Position

Endoscopic foraminal decompression can be performed under local anesthesia. Midazolam or fentanyl may be given intravenously to relieve pain and sedation during procedure. The degree of sedation is controlled to respond to the physician's verbal command during the procedure. The patient is placed in the prone position after flexion of the knee and hip on the radiolucent table with fluoroscopic guidance. Knee and hip flexion postures provide foraminal widening to provide a wider working space during decompression.

Special Surgical Instruments

Unlike disc herniation, in patients with foraminal stenosis, the target of removal is not a soft cartilage but a bony structure or thickened foraminal ligament. Endoscopic drills, bone reamers, shavers, etc., can be used to remove bony structures (Fig. 1). And endoscopic punches or lasers are useful for the removal of thickened ligamentum flavum. Also, endoscopic scissor or endoscopic probe may be useful for dissection between the exiting nerve root and the surrounding tissue.

Surgical Steps

Preoperative MRI should be carefully checked to determine the appropriate skin entry point and approaching angle. The distance from the midline to the skin entry point can be calculated in the axial image of the MRI, usually 6–13 cm. The appropriate approach angle is determined by the location of the lesion. An angle of about 15° is recommended for the decompression of the subarticular zone and an angle of about 30–45° for the decompression of the foraminal or extraforaminal zone.

After determining the proper approach angle and skin entry point, insert an 18 gauge spinal needle under the superior articular process using a fluoroscope. Then insert the guide wire and place the obturator into the foramen. Along the obturator, the bevel-ended working cannula is introduced and placed on the undersurface of the

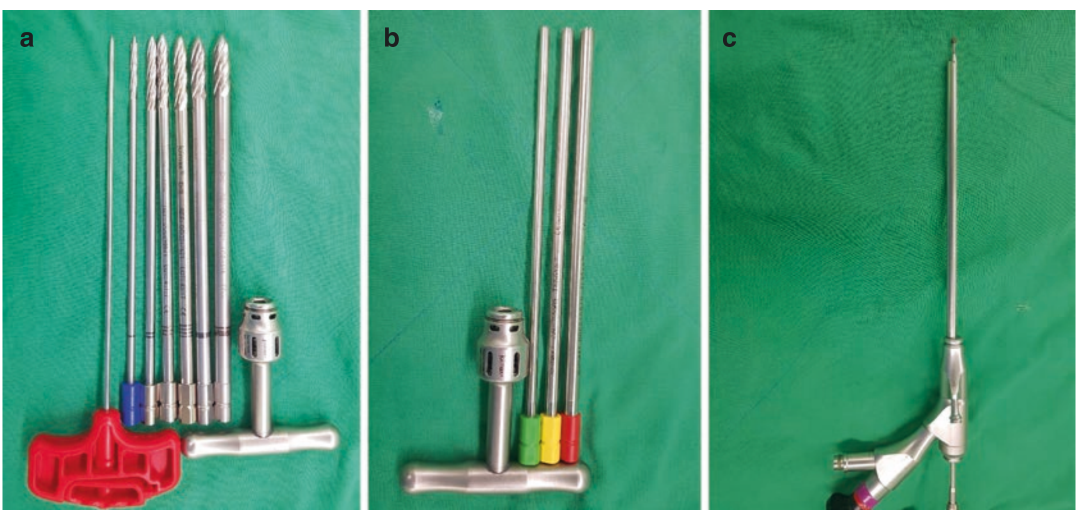

Fig. 1 special surgical instrument used for endoscopic foraminotomy. (**a**) Manual bone drill. (**b**) Manual bone reamer. (**c**) Electrical endoscopic drill

facet joint. The obturator is removed and the ellipsoidal working channel endoscope is inserted. The surgeon can see the superior facet through endoscopic visualization. Hypertrophied part of facet joints can be safely removed using an endoscopic burr or bone reamer with both endoscopic and fluoroscopic guidance. The direction of the bone removal should be from the outside to the inside and form the inferior pedicle to the superior pedicle. If resistance is lost during facet joint undercutting, bone work can be stopped and then foraminal ligament can be observed. When the foraminal ligament is removed, the perineural fat, exiting nerve root, traction spur, and disc surface can be observed. While moving the working cannula, decompression may be selectively carried out to the desired area. Hypertrophied foraminal ligaments can be removed using endoscopic punches, graspers, or scissors, and extruded discs or soft tissues can be coagulated or ablation using bipolar radiofrequency. Holmium:yttrium-aluminum-garnet (HO: YAG) lasers can provide clear vision by removing tissue debris. After decompression, the surgeon can fully observe the course of the exiting nerve root from the pedicle medial margin to the extraforaminal area through endoscopic vision. The endpoint of this procedure is when the exiting nerve root is observed free of the surrounding structure (Fig. 2). After complete decompression, the endoscope is

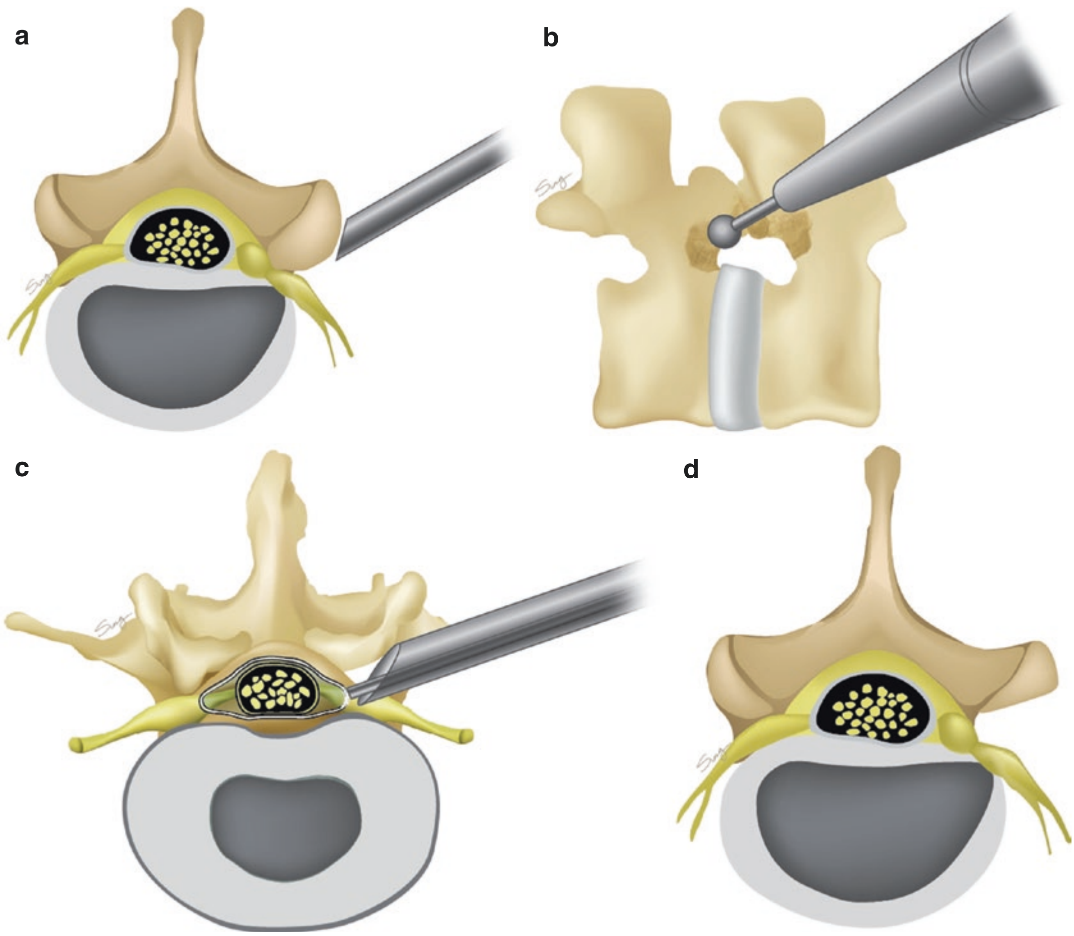

Fig. 2 Schematic illustrations of endoscopic foraminal decompression. (**a**) Extraforaminal landing of working cannula. (**b**) Undercutting of facet joint using endoscopic drill. (**c**) Selective foraminal decompression. (**d**) Confirmation of full decompression along the course of exiting nerve root

removed and wound closure is performed. After several hours of observation, the patient can be discharged.

Illustrated Cases

Case 1

A 54-year-old female patient presented with left leg pain. Preoperative magnetic resonance (MR) image demonstrated foraminal stenosis caused by hypertrophied ligamentum flavum and facet joint (Fig. 3a). After endoscopic foraminotomy, the patient's symptom improved and postoperative MR image showed complete decompression of foramen (Fig. 3b) (Video 1).

Case 2

A 58-year-old male patient presented with right leg pain. Preoperative magnetic resonance (MR) image demonstrated foraminal stenosis caused by osteophytic spur (Fig. 4a). After endoscopic foraminotomy, the patient's symptom improved and postoperative MR and CT images showed complete decompression of foramen (Fig. 4b) (Video 2).

Complication and its Management

Excessive manipulation or irritation of the dorsal root ganglion during foraminal decompression can lead to postoperative dysesthesia.

Fig. 3 (**a**) Preoperative magnetic resonance (MR) image showing foraminal stenosis caused by hypertrophied ligamentum flavum and facet joint. (**b**) Postoperative MR image showed complete decompression of foramen

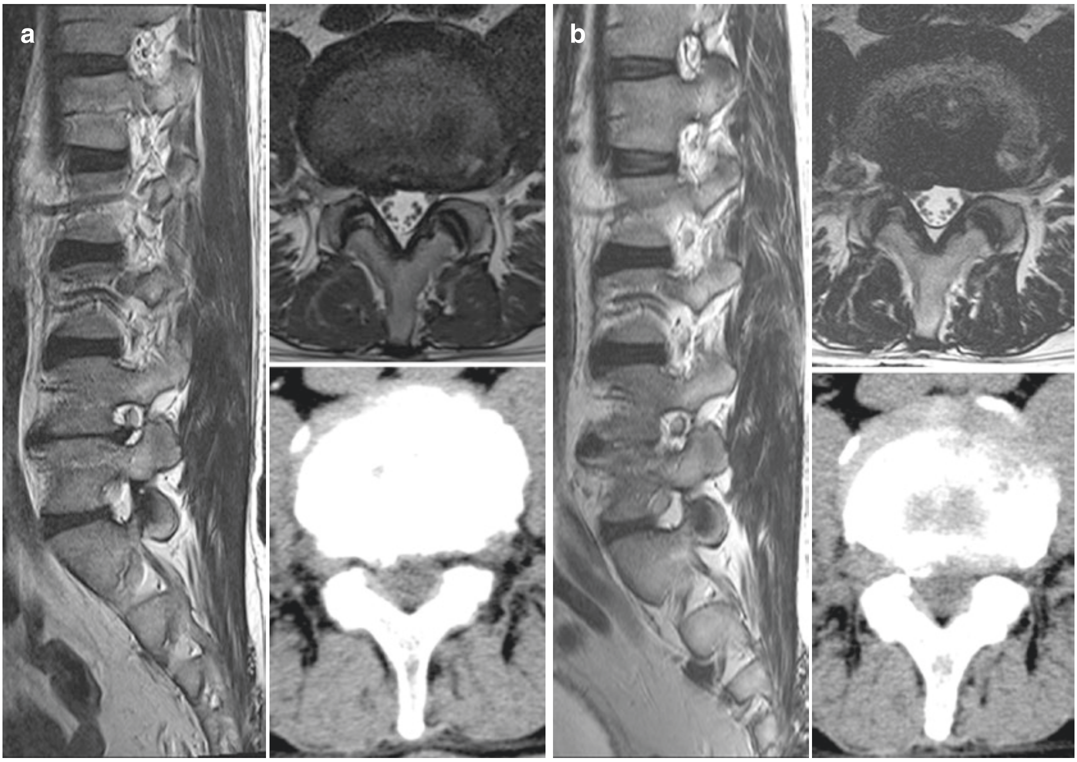

Fig. 4 (**a**) Preoperative MR image showing foraminal stenosis caused by osteophytic spur. (**b**) Postoperative MR and computed tomography images showing complete decompression of foramen

Postoperative dysesthesia can occur from 6.5% to 24% [1, 2]. Most patients improve gradually with conservative treatments such as nerve root blocks or medication therapy.

The posterior lateral transforaminal approach has limited working mobility and narrower vision than the open paraspinal approach. Thus, incomplete decompression may occur. In patients with pain that persists after endoscopic decompression, fusion surgery is usually needed.

Postoperative hematoma can also occur after endoscopic decompression. This can be reduced by the use of meticulous bleeding control and hemostatic agents during the procedure. Bone bleeding may occur after bone resection, which is difficult to control using endoscopic instruments. If there is uncontrolled bone bleeding, a drainage tube can be inserted and removed when the volume of blood decreases during the postoperative period [7].

Brief Discussion: Surgical Tip and Pitfall

The main target of decompression of endoscopic foraminotomy is the structures that compress the exiting nerve root. Therefore, the surgeon needs to identify the exiting nerve root and proceed with decompression along its course. For safe foraminal decompression, it is important to approach the foramen after a partial resection of the superior articular process after landing into the superior articular process of the extraforaminal area. In patients with foraminal stenosis, the working zone is very narrow, and there is a risk of nerve damage when the working cannula is inserted directly into the foramen without partial decompression of the facet. When working on the bone, use a drill or reamer to fully expose the lower margin of the upper pedicle and the upper margin of the lower pedicle under the guidance of fluoroscope and endoscope. Partial resection of the superior articular process only at the disc level may be insufficient to expose the proximal part of the exiting nerve root.

After access to the foramen, full-scale foraminal decompression along the exiting nerve root can be performed using a variety of surgical instruments. Instruments such as endoscopic burrs, bone reamers, punches, forceps, and lasers can be used for selective decompression under high-resolution endoscopic vision.

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