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HOW I DO IT - SPINE DEGENERATIVE

Percutaneous endoscopic lumbar foraminotomy: how I do it

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Abstract

Background Percutaneous endoscopic lumbar foraminotomy (PELF) is a good alternative for foraminal stenosis. The steep learning curve and lack of a practical manual can make this technique challenging.

Method We describe a step-by-step technique based on the literature review and our experience in actual practice: (1) posterolateral foraminal landing, (2) bony unroofing of the superior articular process, and (3) full-scale soft tissue decompression. Technical tips for preventing complications are also discussed.

Conclusion PELF may be effective and minimally invasive. Standardized surgical techniques are essential for clinical success.

Keywords Endoscopy · Foraminal stenosis · Foraminotomy · Lumbar · Percutaneous · Posterolateral

Relevant surgical anatomy

Endoscopic visualization in percutaneous endoscopic lumbar foraminotomy (PELF) may provide panoramic vision and a broad working space with minimal skin entry [6, 9, 10]. However, the surgical anatomy of endoscopic spine surgery may differ from that of open surgery.

The first structure confirmed during endoscopy is the disc surface that can help the surgeon to have the correct orientation. Then, the surgeon can feel the path of the exiting nerve root (ENR) to be decompressed. The perineural fat around the nerve root is essential to confirm the presence of the ENR. The third structure is the superior articular process (SAP) and ligamentum flavum (LF). Hypertrophic SAP and LF are usually the main pathologies of foraminal stenosis. Therefore, sufficiently removing the bony SAP and soft LF is the main goal of PELF. Finally, the procedure can be completed by decompressing the ENR from the axillary zone to the lateral exit zone.

Description of the technique

The surgical technique is based on the published method of PELF [2, 3, 5, 7]. It can be categorized into three processes: (1) an extraforaminal approach under fluoroscopic control, (2) foraminal bony unroofing using an endoscopic burr, and (3) full-scale foraminal decompression with removal of foraminal ligaments (see Video, Supplemental Digital Content).

Patient preparation

The premedication is administered as follows: midazolam (0.05 mg/kg) intramuscularly on-call and fentanyl (0.8 μg/kg) intravenously before surgery. The patient is laid in a prone position on a radiolucent spine table.

Approach under fluoroscopic view

The primary approach is a posterolateral, extraforaminal approach to foraminal stenosis, avoiding the ENR (out-to-in process). The approach angle and skin entry can be determined based on the pathological point and patient's body size.

The procedure starts with a posterolateral introduction of an 18-gauge spinal needle. The typical skin entry point is about 6–12 cm lateral from the midline, depending on the preoperative imaging studies and intraoperative fluoroscopic view. The needle tip is introduced into the foraminal zone in

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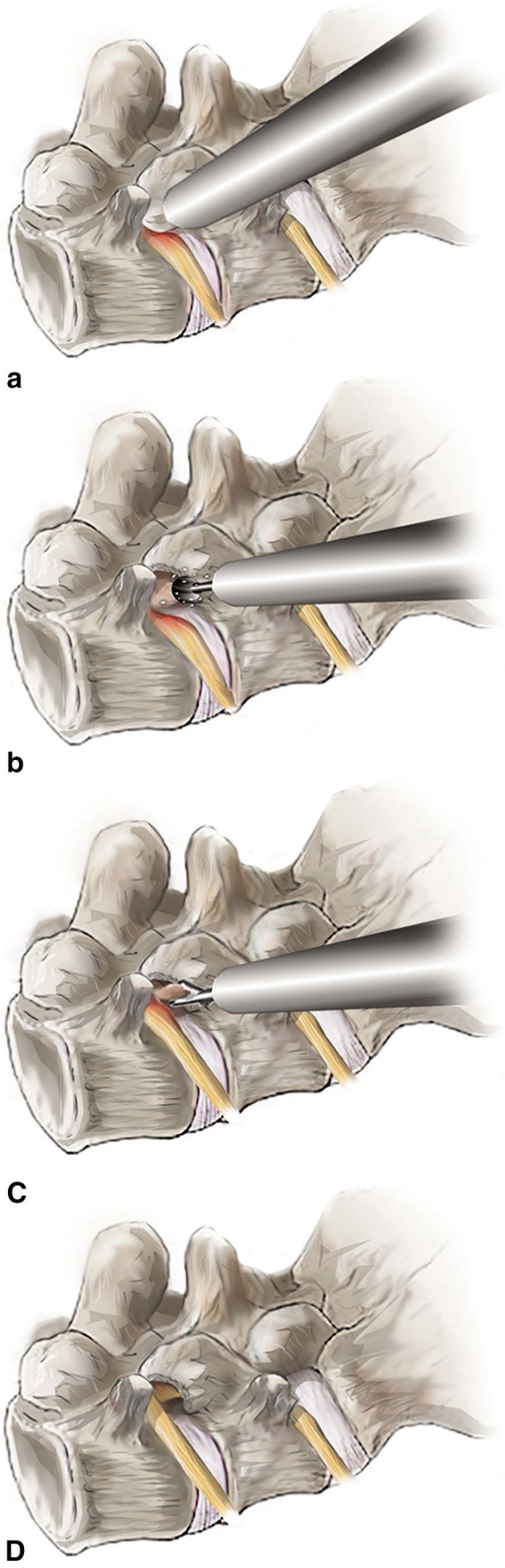

Fig. 1 Schematic illustrations depicting the surgical procedure of percutaneous endoscopic lumbar foraminotomy. **a** Extraforaminal placement of working sheath viewing the foraminal zone. **b** Bony unroofing and removal of the superior articular process using an endoscopic burr. **c** Soft tissue decompression with removal of foraminal ligaments and ligamentum flavum. **d** Endpoint of the full-scale foraminal decompression

contact with the SAP surface and lands on the disc surface or caudal vertebral body in the foraminal area. The main objective of this access route is a safe foraminal docking of the working sheath, avoiding ENR injury. The surgeon should not cross the posterior vertebral line until the needle tip is safely landed to prevent unexpected damage to the extraforaminal vascular or visceral structures. The needle is then replaced by a guidewire, followed by the insertion of serial dilators and an obturator. The obturator should be firmly fixed in the foramen and in contact with the disc surface. A bevel-ended final working sheath is slid over the obturator and docked in the foramen with its sharp end, avoiding the ENR (Fig. 1a). It should be gently fixed or placed in the foramen.

Endoscopic view

An eccentric working channel endoscope that contains working, viewing, and irrigation channels can then be inserted. The initial view includes the disc surface and ENR at the same time. Starting from the disc space enables the surgeon to maintain the correct orientation during the procedure. If the initial surgical field misses the disc space, the surgeon may lose the anatomical orientation. After securing early exposure, the primary decompression process can be initiated.

Bone work

First, the surface of the SAP is exposed by moving the endoscope. The tip of the SAP is then gradually drilled out using an endoscopic burr until the LF and axillar epidural space are identified (Fig. 1b). During this process, bone bleeding should be controlled using a radiofrequency (RF) coagulator and hemostatic materials.

Soft tissue work

After sufficient SAP resection, sophisticated soft tissue decompression is performed. The hypertrophic LF and foraminal ligaments are removed using forceps, micropunches, and supplementary RF or laser (Fig. 1c). As the soft tissue decompression goes, the compressed ENR becomes exposed and relieved from the neural entrapment. Discrimination between the ENR and other pathologic tissues, including redundant disc and hypertrophic LF, is mandatory in this process.

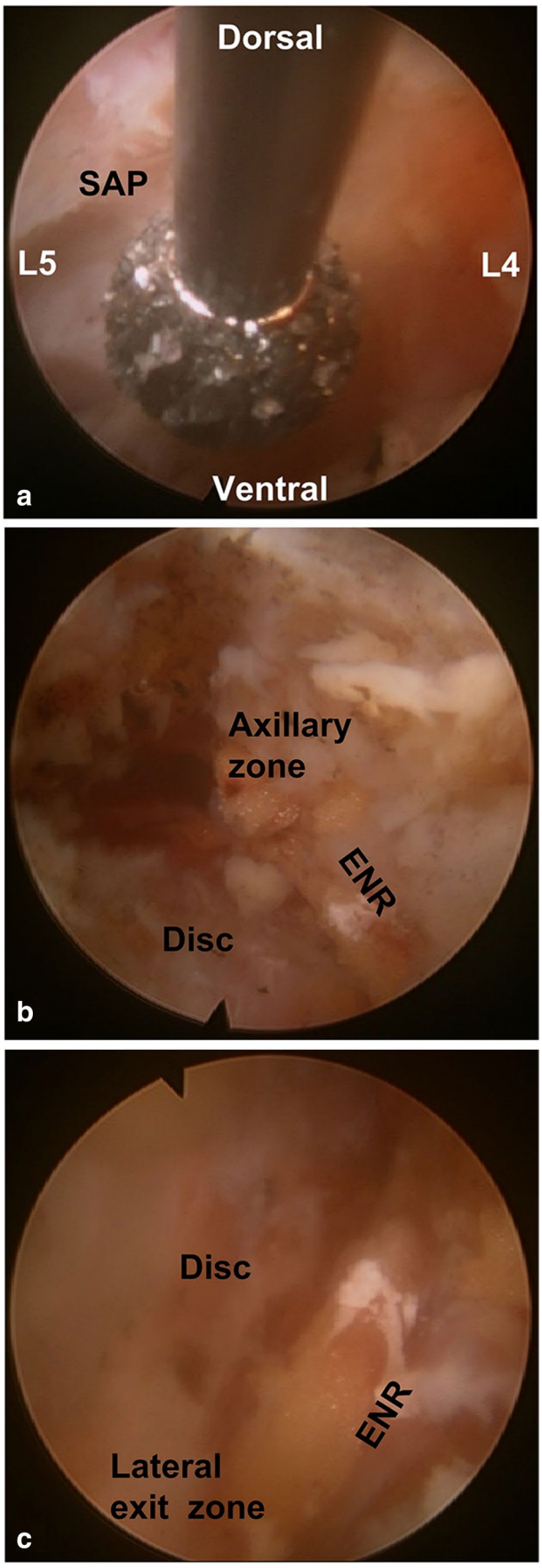

Fig. 2 Intraoperative endoscopic views of the surgical procedure. **a** ▶ Removal of the superior articular process (SAP) and ligamentum flavum by using endoscopic burrs and punches. Note the proximal (**b**) and distal (**c**) part of the exiting nerve root (ENR) after the full-scale foraminal decompression

The surgeon should prevent major adverse events during decompression procedures, such as dural tears and bleeding from epidural veins and bone. To achieve this, the ENR should always be kept in the surgeon's visual field, and the fluoroscopic view should be checked intermittently. Any intervening bleeding can be controlled by an RF coagulator or transient packing of hemostatic agents for a few minutes.

Finish

The endpoint of this full-scale foraminal decompression can be determined by free mobilization and strong pulsation of the dural sac (Fig. 1d). The surgeon should identify the axillary point where the ENR protrudes from the dural sac. If there is no harmful event, the patient can be discharged within 24 h postoperatively.

Indications

(1) Foraminal or far-lateral lumbar stenosis demonstrated by both magnetic resonance imaging (MRI) and computed tomography (CT) scans, regardless of a herniated disc; (2) intractable radiculopathy despite more than 6 weeks of nonoperative therapy, including a selective nerve root block.

Limitations

1. Severe foraminal stenosis with collapsed disc space is not adequate for the endoscopic procedure because introducing a working channel endoscope is limited.
2. Extreme lateral stenosis of the L5-S1 level caused by hypertrophied sacral ala may be challenging with the full-endoscopic technique.
3. Foraminal stenosis with concurrent central stenosis, spondylolisthesis, or segmental instability requires additional decompression and stabilization procedures.

How to avoid complications

1. Prevention of ENR injury is the first and primary subjective assessment during the transforaminal approach [4]. In most cases, the working space for foraminal decompression is very narrow. To avoid significant ENR injury,

careful extraforaminal docking of the working sheath, with the direction of the sharp end away from the ENR, is essential.
2. Excessive ventral and extraforaminal landings may cause serious arterial bleeding during the approach or decompression steps [1]. Therefore, the approaching needle should not cross the posterior vertebral line during the initial course.
3. Dural tear during decompression may be the most critical adverse event leading to significant neurological deficits [8]. The surgeon should always maintain the endoscopic orientation and precise neural tissue recognition from the surrounding tissues.
4. Only exposure to ENR in the surgical field is insufficient because the intervertebral foramen is a narrow tube or tunnel. Thorough decompression from the axillary portion to the lateral exit zone is mandatory for clinical success.

Specific information for the patient

Preoperatively, a thorough pathology evaluation should be conducted through sophisticated physical examination and imaging studies, such as MRI and CT scans. The patient is also recommended to undergo a selective nerve root block to confirm the exact offending point.

Postoperatively, the patient should be assessed for postoperative status, including general conditions, neurological symptoms, and signs. Postoperative MRI or CT scans may be checked for precise evaluation of the primary pathology as required (Fig. 2).

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Declarations

Research involving human participants and/or animals Not applicable.

Informed consent Not applicable.

Competing interests The authors declare no competing interests.

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Key points • Thorough preoperative evaluation and appropriate patient selection are essential for minimally invasive endoscopic spine surgery.

• Safe and precise docking (landing) of the working sheath in the safety zone of the stenotic foramen is the first critical step in PELF.

• Starting orientation under endoscopic view should consist of confirmation of disc surface and ENR.

• The first and primary decompression process is resectioning SAP using endoscopic burr (foraminal unroofing).

• After bone resection, the thickened LF and foraminal ligaments should be removed using endoscopic punches and supplementary devices (soft tissue decompression).

• The proximal decompression should be conducted until the ENR and dural sac are exposed simultaneously in the axillary area.

• Distally, the ENR should be released at the lateral exit zone.

• The endpoint of this procedure is full-scale foraminal decompression in which the ENR becomes freely mobilized, and a robust dural sac pulsation is secured.

• Preventing intraoperative complications, such as a dural tear, bleeding, and neural injury, is essential for clinical success.

• The technique will be more practical by developing various surgical instruments, such as flexible instruments and visual designs.