Full Endoscopic Posterior Approach, In and Out

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Introduction (Key Point and Purpose) of Approach

Many spine surgeons, who were familiar with conventional endoscopic transforaminal discectomy, have bestowed a consideration that a spine surgeon could do endoscopic spine surgery (ESS) in the other spine pathologies, but discectomy for once. Because the endoscope the spine surgeons could make use of was only the one for the transforaminal approach, it was not easy to carry out ESS, with a conventional endoscopic system (too small in diameter and too long in length), particularly in case approaching dorsally. In other words, the conventional endoscopic system should not be appropriate for pathology located in the posterior and epidural space. As a result, the spine surgeons designed a larger diameter and shorter length of endoscopy, compared to the conventional one, along with the development of surgical tools such as rongeurs, forceps, dissectors, and high-speed drills enough to remove ligamentous and bony tissues and bony fragments with the aid of industries. Thereafter, endoscopic surgeons tried to expand the surgical indications, representatively disc herniation regardless of its location, size, and the number of the lesion and degenerative canal stenosis. Nowadays, some spine surgeons succeeded a full endoscopic interbody fusion in the cervical (anterior approach) and lumbar (posterior approach) spines. The endoscopic fusion technology is on clinical trial. According to the title of this chapter, the editors recognized the authors' technique interestingly as an in-and-out procedure.

A representative surgical technology using the in-and-out procedure must be transforaminal endoscopic discectomy. At the early stage of the authors' procedure, a surgeon attempts to move an endoscopy to get close to the main pathology located in the back under the guidance of C-arm, followed by removal of the lesion and soon after endoscopy is taken out.

In this chapter, the authors tried to do their best for readers to understand how to handle this endoscopic system in central stenosis by demonstrating the figures of each surgical step and removal of the main pathology followed as well as presenting the overview of this surgical technique by briefly reviewing surgical indication, outcome, and other relevant issues.

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Indication and Contraindication

Possible indications for the procedure include:

1. Unilateral or bilateral neurogenic claudication or lower limb radiculopathy with or without associated back pain not responding to conservative treatment.
2. Evidence of stenosis on magnetic resonance imaging and/or computed tomography correlating with clinical presentation.

Possible contraindications include:

1. Patients presenting with foraminal stenosis.
2. More than grade 1 degenerative spondylolisthesis.

Anesthesia and Position

Anesthesia

- Epidural anesthesia is performed on patients at a level 1 or 2 above the index level.
- Conscious sedation with sevoflurane (1–2 vol/%) was allowed. This method can be used for patients who cannot perform general anesthesia and reduces the side effects of general anesthesia, such as nausea, dysphagia, and memory loss.

Position

- The patient is positioned prone on a Wilson frame comfortably placed on a standard operating room table or a flat Jackson table to minimize abdominal pressure (Fig. 1).
- A waterproof surgical drape is applied due to continuous saline irrigation (Fig. 2.).
- The surgeon and a scrub nurse with the Mayo trolley stand on the side of the pathology (Fig. 3).
- Across from the surgeon stands the X-ray technician with a mobile or mounted C-arm.
- The anesthesia team stands at the head end of the patient with the anesthetic trolley.

Special Surgical Instruments

- All operative procedures were performed with a complete uniportal endoscopic instrument system: Techcord Endoscopic System (Techcord, Daejeon, Korea) (Fig. 4).
- Uniportal endoscopes are used in the different fashion as an operating microscope employed for open spinal surgery in aspects of 360° operating field rotation.
- The same instruments used for conventional surgery were used during endoscopic surgery by modifying the working length.
- Surgical instruments can be categorized into four groups (Fig. 5):
  - Mechanical instruments: long pituitary forceps (small/large), dissectors (small/large), up-angled curette, ball-tipped probe.
  - Special instruments: obturator, working sleeve, endoscopic customized root retractor.
  - Electrosurgical instruments: bipolar radiofrequency electro-coagulator (OK Medinet Korea, Seoul, Korea), DELPHI radiofre-

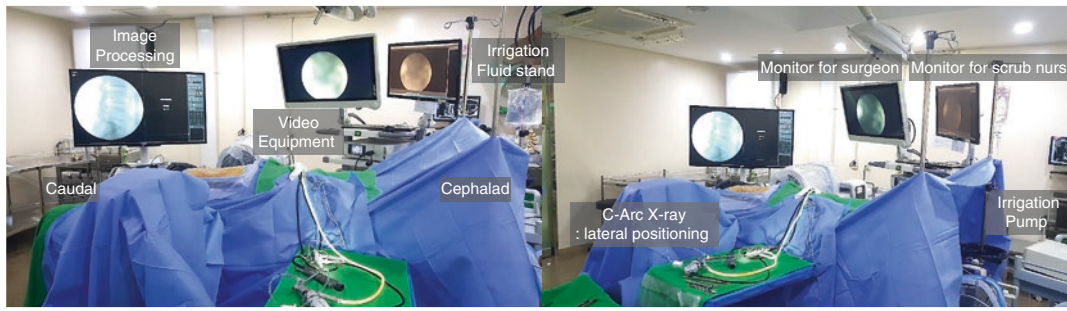

Fig. 1 Patient positioning and operating room setup

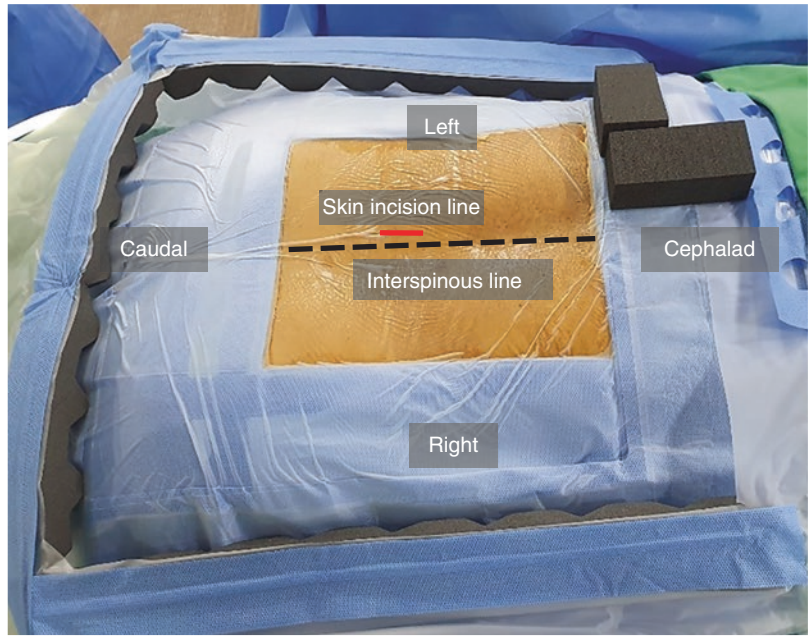

Fig. 2 Waterproof surgical drape for a left-sided L4–5 approach

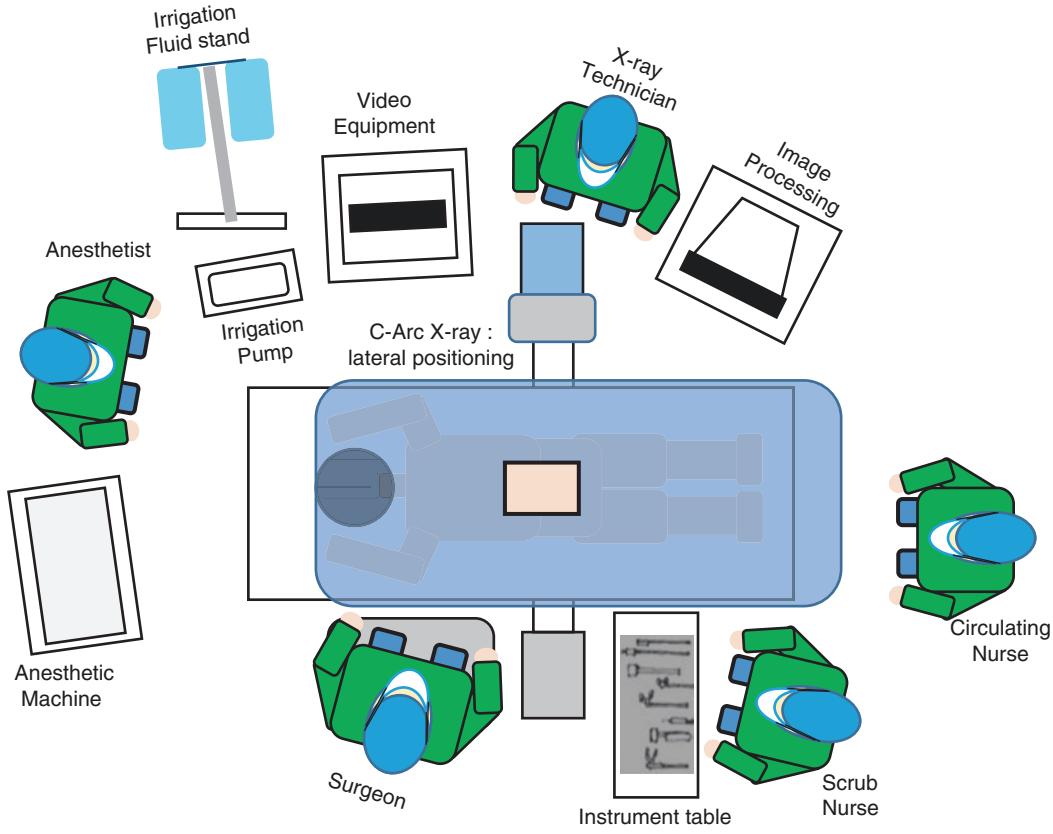

Fig. 3 Standard operating room setup

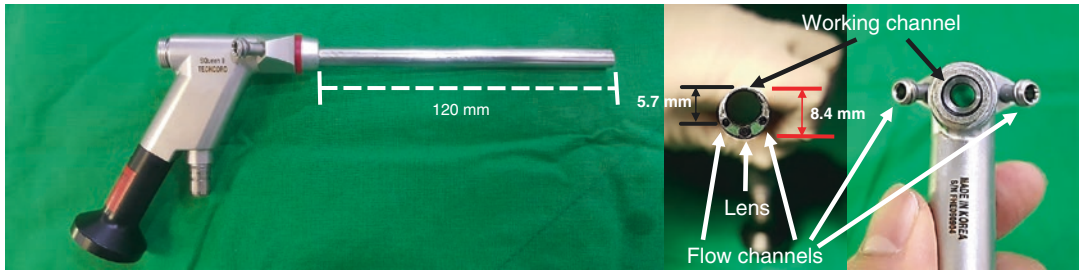

Fig. 4 Techcord Endoscopic System (8.4 mm outer diameter, 5.7 mm working channel and 12° direction of view, 80° field of view)

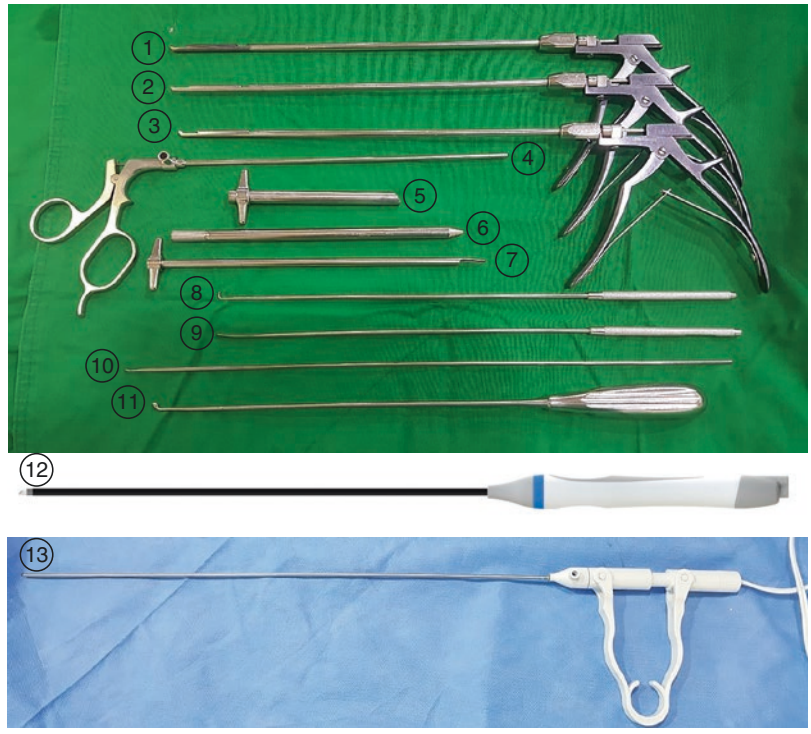

Fig. 5 Essential unit for uniportal endoscopic decompression: [1–3] Kerrison punches, [4] pituitary forceps (large), (5) working sleeve, (6) obturator, (7) endoscopic customized root retractor, (8) ball-tipped probe, (9–10) dissectors (small/large), (11) up-angled curette, (12) DELPHI radiofrequency electrode, (13) bipolar radiofrequency electro-coagulator

quency electrode (C&S Medical, Pocheon, Korea).
- Motorized instruments: endoscopic drill.

Surgical Steps (Illustration, Photos, and Video)

- Step 1: Level marking (Fig. 6).
  - Target level end plates and interlaminar window are roughly marked with obturator under lateral fluoroscopic images.
- Step 2: Skin entry point (Fig. 7).
  - The skin incision is performed two fifth below the index lamina.
  - Target point—just below inferior border of the spinolaminar junction on the ipsilateral side in lateral view C-arm.
- Step 3: Dilation and endoscope insertion.
  - After making a 7–8 mm vertical skin incision, a blunt dilator that served as a guide for the 9.5 mm outer diameter working sleeve was advanced into the lamina on the ipsilateral side in a right-angle direction, just beside the spinous process (Fig. 8).

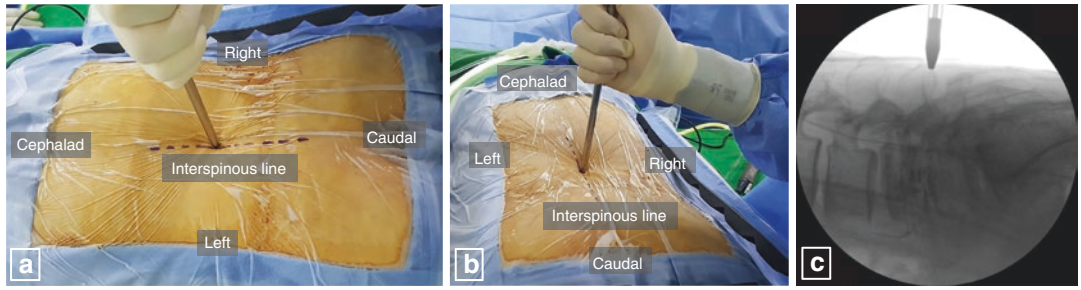

Fig. 6 Right-sided L4–5 uniportal endoscopic decompression. The inferior border of the L4 lamina, close to the base of the corresponding spinous process (**a**, **b**) are roughly marked with obturator under lateral fluoroscopic images (**c**) just beside the spinous process

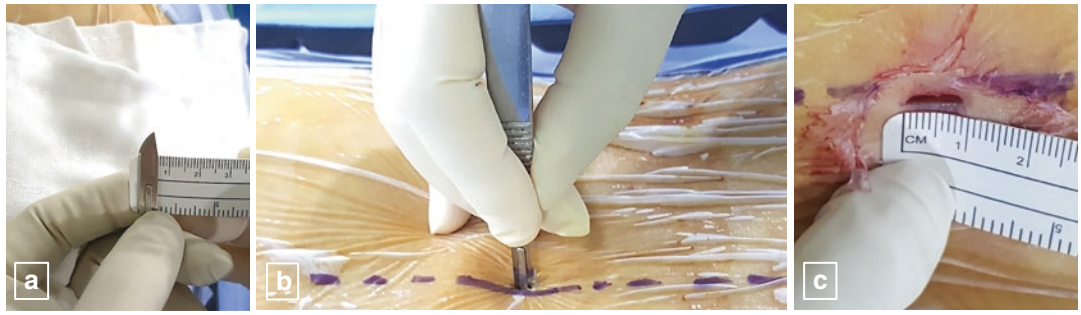

Fig. 7 Skin entry point and skin incision. The skin incision is performed at the previous level marking site with a scalpel blade #10 (**a**, **b**) less then 1cm sized (**c**)

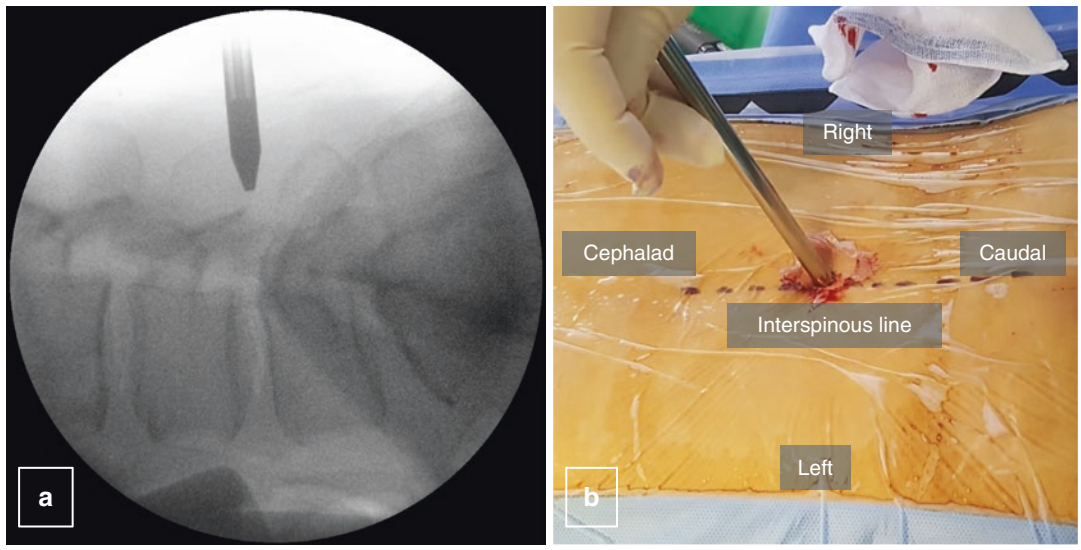

Fig. 8 Dilation for a right-sided L4–5 decompression. The surgeon advanced a blunt dilator with a 9.5 mm outer diameter as a guide for the working sleeve into inferior margin of the L4 lamina, close to the base of the corresponding spinous process under lateral fluoroscopic images (**a**), a photo in the surgical field (**b**)

  - Subsequently, the working sleeve was inserted over the dilator and a rigid angle endoscope (8.4 mm outer diameter, 12° view) was introduced into the lesion from one side through the working sleeve (Fig. 9).
  - The unique surgical approach through fatty atrophy between the spinous process and multifidus muscles helped decrease the postoperative muscle-origin back pain and is considered an advantage of this process.
  - This full procedure is performed under continuous pressure irrigation using cold, antibiotic instilled normal saline. RF is used initially to clear the fat and paraspinal soft tissue and to enhance visibility.
- Step 4: Decompression, in-and-out technique.
  - The epidural space was opened via laminectomy, and the ligamentum flavum and superior articular process were removed to expose the traversing root sequentially

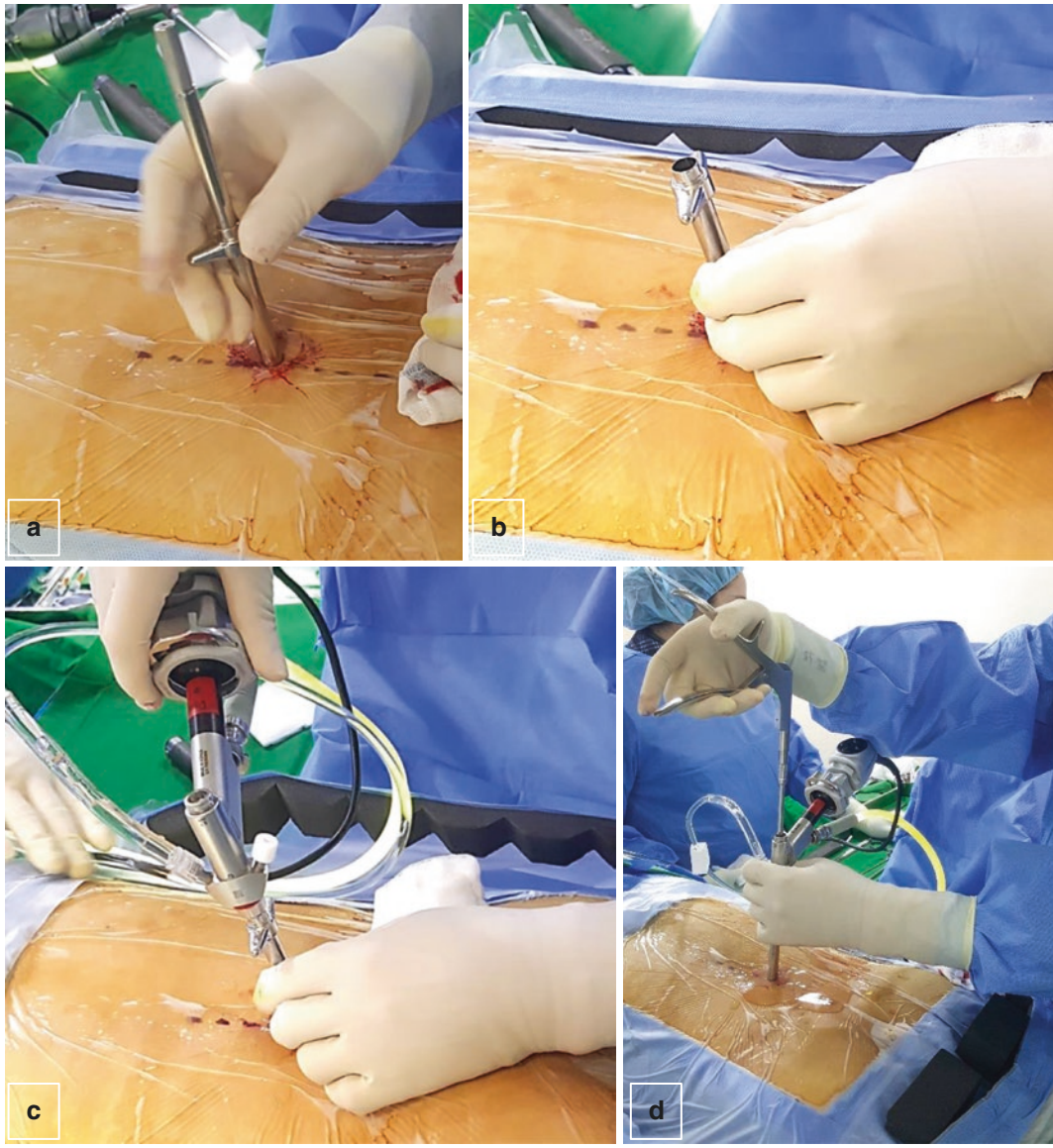

Fig. 9 Endoscope insertion for a right-sided L4–5 decompression. The surgeon inserted the working sleeve over the dilator (**a**, **b**) and introduced a rigid angle endoscope, with an 8.4 mm outer diameter and a 12° view (**c**, **d**)

using a 4 mm drill and 5 mm Kerrison punch through the 5.7 mm working channel of the endoscope.
- Laminotomy was performed to expose the uppermost portion of the ligamentum flavum, and as much of the ligamentum flavum was removed as possible (Video 1).
- Following ipsilateral decompression, the contralateral ligamentum flavum and superior articular process were removed to decompress the contralateral traversing nerve root. Minimal bone work, as much as required, was performed to preserve the facet joint, which was the first priority (Video 2).
- The contralateral approach with endoscope provides the angulation with which we can approach the facet joint, helping the surgeon to slide the cannula underneath it. This way, we can perform targeted decompression of the most pathological portion of the facet (ventral and medial portion of superior articular process) and preserve the rest of the facet.
- The operative field was irrigated continuously with normal saline using the irrigation pump to provide a clean view with good visualization of epidural anatomy for safety purposes.
- In case of multiple level stenoses, decompression through a single skin entry was achieved via a special technique called the jumping technique (Fig. 10).
- In this technique, after completion of one level, the working sleeve was completely removed and moved cranially or caudally to the other target within the subcutaneous space under image guidance, but still within the same skin incision. Skin has good elasticity and can be used to make another muscle layer tracts by subfascial dissection through a single incision (Fig. 11).
- Then, the same process as for the PSLD procedure was performed in a different direction, upper or lower, for decompression of the remaining lumbar stenosis. After the first muscle tract, the subsequent two muscle tracts have an inconvenient approach angle but do not interfere with decompression. After identification and confirmation of the interlaminar space and laminar space under the C-arm, the dilator was introduced into the created path by a small forceps, and the working sleeve was inserted over the dilator. Upward and downward retraction of the skin allowed the tubular working sleeve to be placed in the upper and lower interlaminar spaces, where the decompression will be performed.
- Every step of the procedure was done under image intensifier control to confirm the exact entry point. The stenoscope was introduced into the lesion and subsequent procedures were performed as described above. After the procedures, a drain was placed in the epidural space to prevent postoperative hematoma for 1 day.

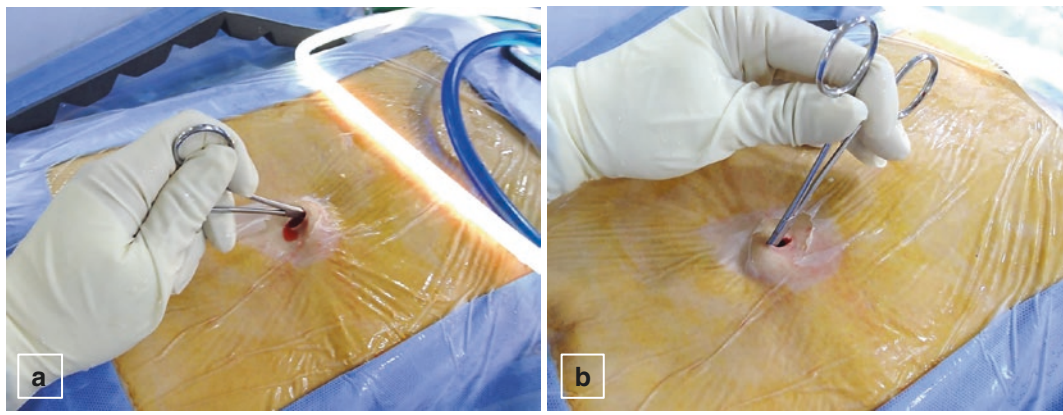

Fig. 10 The jumping technique. After one-level decompression, the upper (**a**) or lower (**b**) interlaminar space and laminar space confirmed with mosquito under the C-arm through the same skin incision site

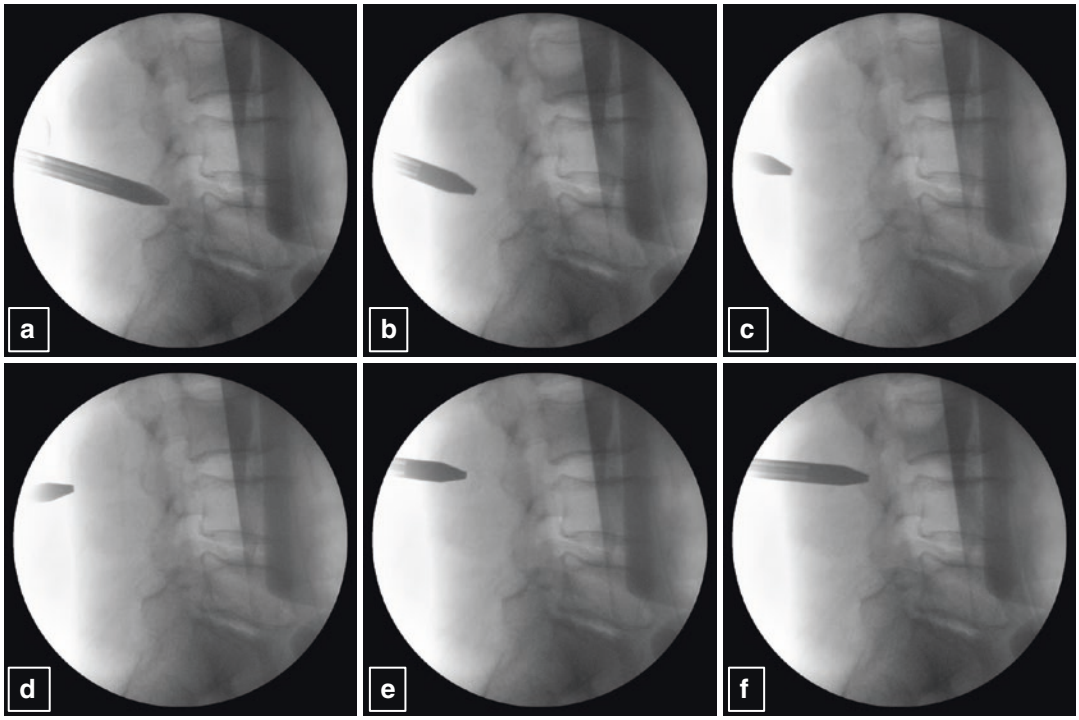

Fig. 11 Lateral fluoroscopic images of the jumping technique (A case of L3–4, L4–5 level decompression). After L4–5 level decompression (**a**), the obturator was moved cranially to the L3–4 interlaminar space within the subcutaneous space under image guidance (**b**–**f**), but still within the same skin incision

Illustrated Case or Cases

- Case 1: 1-level decompression (Fig. 12, Video 3).
  - A 76-year-old female complained of both buttock and radiating pain (L5 dermatome) refractory to conservative management. Preoperative MRI (magnetic resonance imaging) showed severe stenosis of L4–5 segment with protruded calcified disc. We performed uniportal endoscopic decompression (left-side unilateral laminotomy and bilateral decompression). Postoperative MRI shows complete bilateral decompression.
- Case 2: 2-level decompression (Fig. 13).
  - A 72-year-old female presented with both leg and buttock pain. Preoperative MRI showed severe multiple stenosis. We performed uniportal endoscopic multiple decompression with one skin incision. Postoperative MR images show enough decompression without paraspinal muscle damage.
- Case 3: 3-level decompression (Fig. 14).
  - A 76-year-old female presented with severe back pain, leg pain, and buttock pain. Preoperative MRI showed severe multiple stenosis at L2–3, L3–4, and L4–5. We performed uniportal endoscopic multiple decompression with one skin incision by the jumping technique. Postoperative MR images show enough bilateral decompression.

Complication and its Management

Surgery-related complications are incidental dural tears that include root herniation, epidural hematoma and infection, and facet damage. The incidence of dural tears appeared to be increased

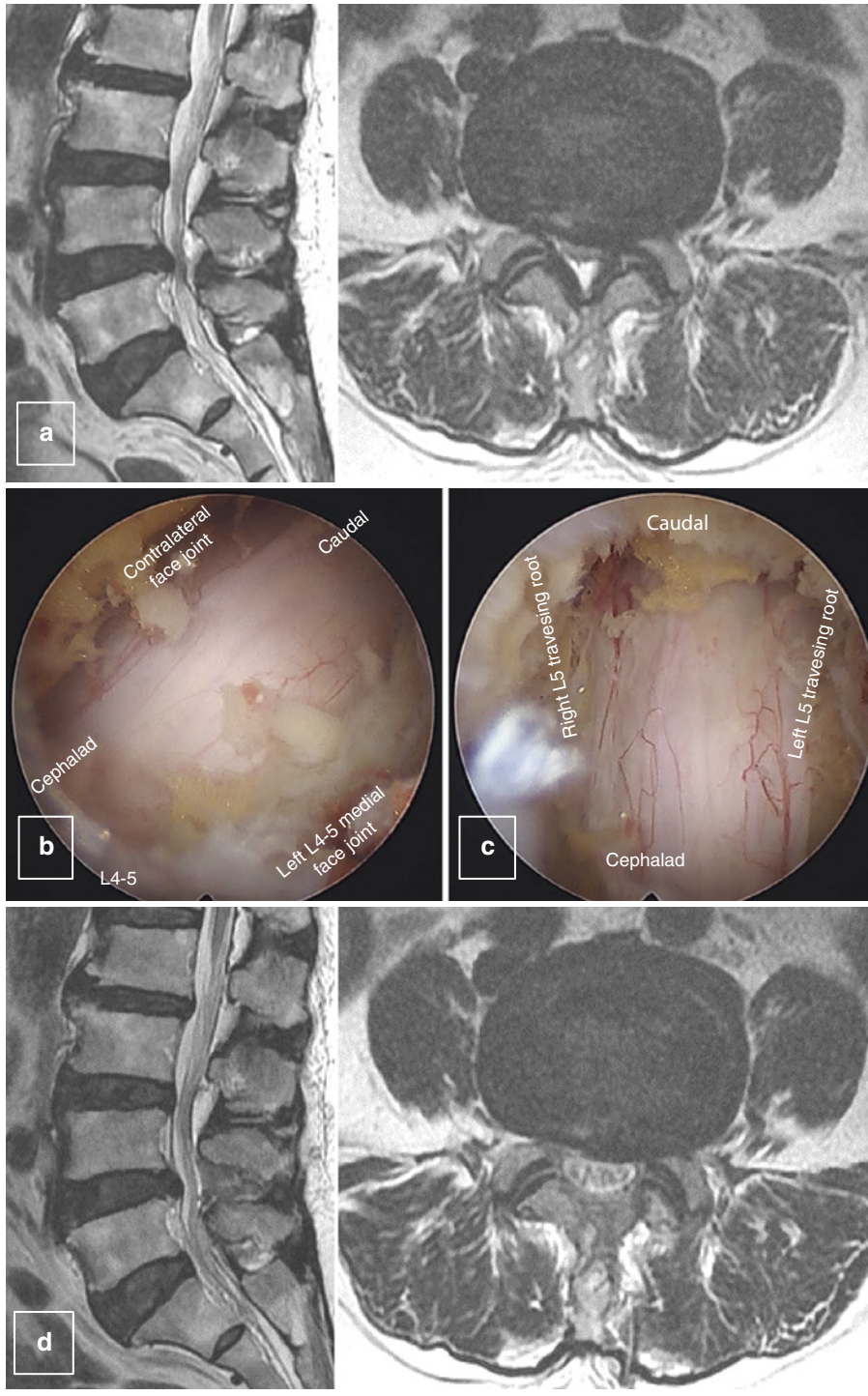

Fig. 12 Images of a 76-year-old woman with both buttock and radiating pain (L5 dermatome). Preoperative MR images show lumbar stenosis at L4–5 (**a**). Intraoperative endoscopic images show hypertrophic ligamentum flavum compressed left L5 nerve root (**b**) and the spinal canal was well decompressed (**c**). Postoperative MR images show enough decompression without paraspinal muscle damage (**d**)

when performing the resection of superior articular process of ipsilateral and contralateral side by Kerrison punch. Intraoperatively, a thin layer of TachoSil®, a hemostatic dural sealant, is provided locally at the site of the dural tear and defects [1]. The incidence of infection is very low in endoscopic surgery due to the use of a large amount of irrigation fluids resulting in an increased washout. C-reactive protein and ESR were the most sensitive clinical laboratory maker to assess the presence of infection and effectiveness of antibiotic treatment response. MRI is the imaging modality of choice in the diagnosis of postoperative infection. Infected patients were managed adequately with broad-spectrum antibiotics and immobilization. The incidence of facet damage is rare during decompression due to its steerability of endoscopy. It is easy to see ipsilateral anatomical structures in more detail compared to open microscopic decompression.

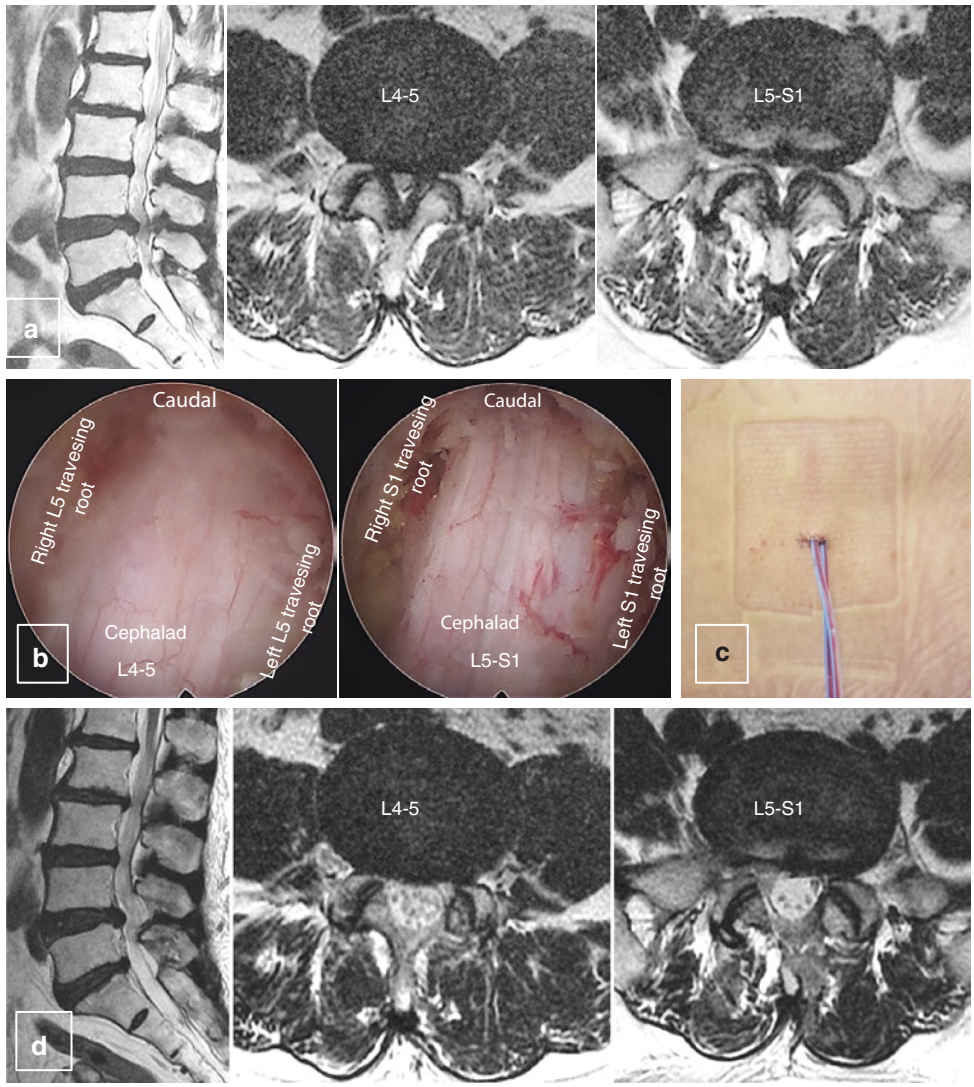

Fig. 13 Images of a 72-year-old woman with both buttock and leg pain. Preoperative MR images show severe lumbar stenosis at L4–5 and L5–S1 (**a**). Intraoperative endoscopic images show the spinal canal was well decompressed (**b**). Postoperative 1 day, two drainage were inserted on the skin incision site (**c**). Postoperative MR images show complete bilateral decompression (**d**)

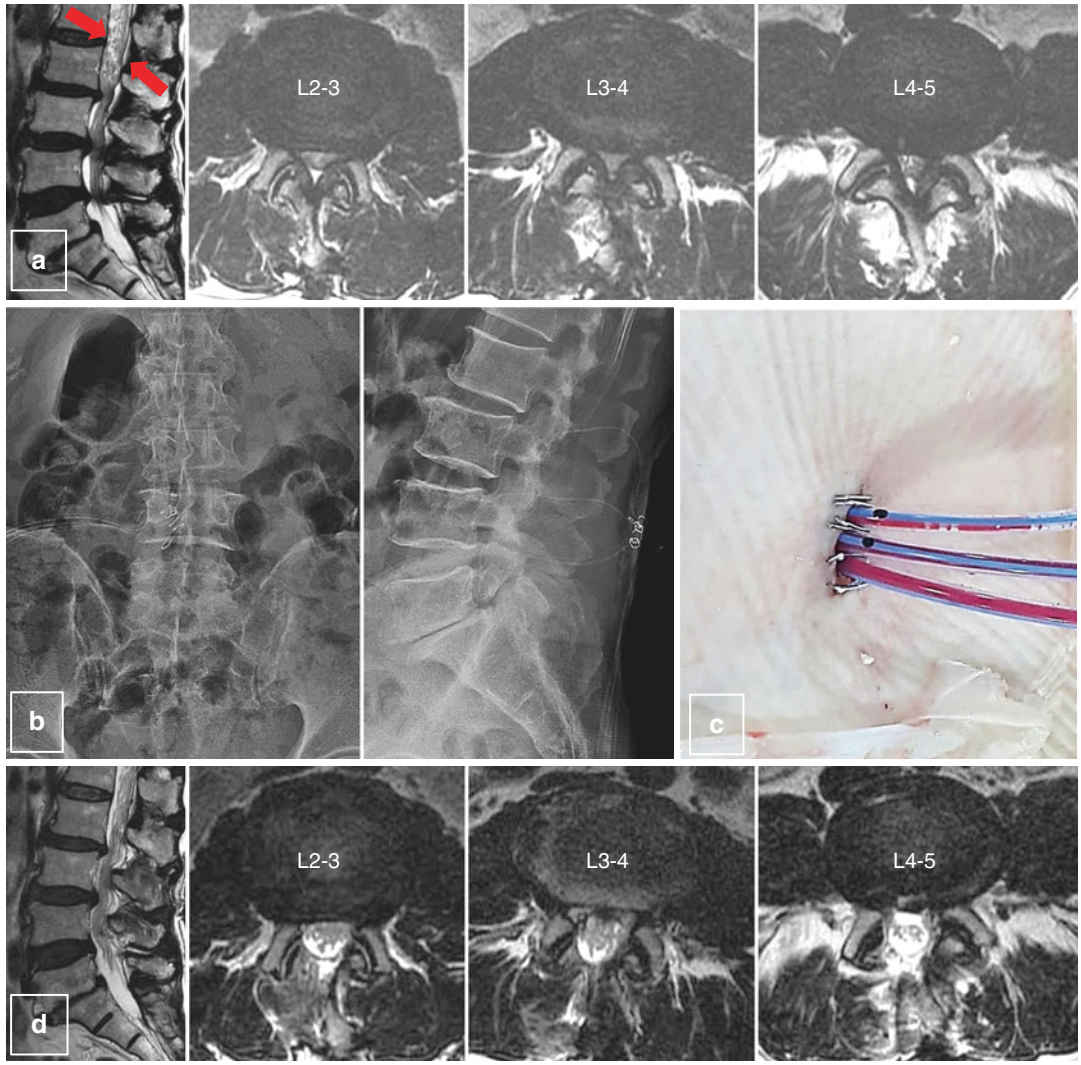

Fig. 14 Images of a 76-year-old woman with severe back pain, leg pain, and buttock pain. Preoperative MR images show severe lumbar stenosis at L2–3, L3–4, and L4–5 with hourglass appearance of lumbar spine. The tortuous nerve roots above the level of compression are depicted with red arrows (**a**). Postoperative X-ray after L3–4, L4–5, L5–S1, and 3-level decompression with one skin incision by the jumping technique (**b**). The jumping technique for multiple layer decompression with one skin incision. Three drainage were inserted on the skin incision site (**c**). Postoperative MRI shows enough bilateral decompression without paraspinal muscle damage (**d**)

Brief Discussion: Surgical Tip and Pitfall

Inside-out technique procedures for decompression of spinal canal include exposure of lateral margin of neural structures first, after removal of ipsilateral ligamentum flavum and superior articular process [2]. The main purpose of endoscopic surgery can be to save the bony structures that will act as a scaffold of body architecture. Bone work for decomperession should be calculated before removal of bone. Endoscopic approaches are feasible for central canal and lateral recess stenosis and are also found to be successful in huge herniated discs, or migrated disc, upward and downward, and for foraminal stenosis, extraforaminal

disc herniation with paraspinal approach and cervical posterior decompression in foraminal cervical stenosis was a good option to relive cervical stenosis symptoms also. A 12° angle optic lens of endoscopy is helpful in watching ipsilateral facet during procedures after removal of ligamentum flavum (inside-out technique) so that surgeon can do minimum bone work to remove the hypertrophied superior articular process and can be beneficial in preventing root injury [1]. The patients who underwent inside-out technique had significant improvements in canal size without facet damages, radiating pain, and functional status postoperatively and were still statistically significant after 12 months of follow-up without iatrogenic spinal instability. Endoscopic surgery with inside-out technique would help decrease the use of narcotics and antibiotics, incidence of symptomatic CSF leaks, and incidence of wound infections [3, 4].

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