Foraminal Disc Herniation

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1 Inside-Out Technique

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Abstract Foraminal disc herniation presents the unique surgical challenge for exiting nerve root retraction and decompression. Several different techniques for transforaminal endoscopic approaches have been developed for the surgical treatment of lumbar disc herniation. In this chapter, we describe inside-out technique for endoscopic decompression of foraminal disc herniations.

Keywords Foraminal disc herniation; Endoscopic discectomy; Transforaminal approach; Inside-out technique; Dorsal root ganglion

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1.1 Introduction

Transforaminal endoscopic lumbar decompression (TELD) is fast becoming the procedure of choice for the surgical management of lumbar disc herniations [1–5]. Endoscopic discectomy techniques have produced surgical results similar to those of other discectomy techniques, while offering various advantages like avoidance of general anesthesia, less postoperative pain, less tissue adherence and scarring, a reduced risk of infection owing to the use of a continuous irrigation system, no risk of spinal destabilization, and faster rehabilitation [1–5]. Cases of foraminal disc herniation (FDH) present a unique surgical challenge for exiting nerve root retraction and decompression. Irrespective of the surgical technique used, the clinical outcome can be significantly affected by both, technique of exiting nerve visualization/retraction and adequacy of decompression. Use of appropriate exiting nerve retraction and visualization technique is paramount to adequate decompression [6, 7]. In this chapter, we will introduce the "inside-out technique" for safe retraction and decompression of the exiting neural structures during TELD in cases of FDH.

S.-H. Lee et al. (eds.), *Transforaminal Endoscopy for Lumbar Spine*,
https://doi.org/10.1007/978-981-19-8971-1_10

1.2 Indications

- Symptomatic foraminal soft disc herniation without calcification that does not respond to conservative treatment.
- Herniated disc fragment is pushing the nerve in the dorsal or cranial direction, revealing the Kambin's triangle.
- "Outside-in technique" is safer if the herniated disc is pushing the nerve in the caudal direction, toward the Kambin's triangle.
- "Outside-in technique" is safer if the foraminal dimension is too narrow and the nerve compression due to the working channel is severe.

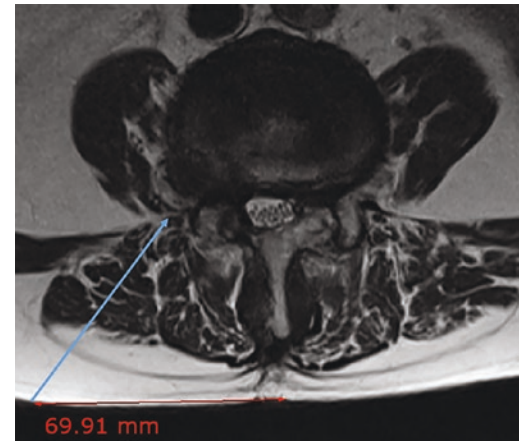

Fig. 1 Entry point is located about 7 cm from the midline for direct targeting the foraminal disc rupture at L34 level in this patient

1.3 Surgical Technique

The procedure was performed under local anesthesia with mild sedation. The patient was positioned prone. A standard lumbar endoscopic instrument set (TESSYS, Joimax GmbH, Germany) was used. The percutaneous endoscopic approach is performed under the guidance of C-arm fluoroscopy, with anteroposterior (AP) and lateral views. The surgical steps were as follows:

1. The skin entry point and trajectory of the endoscope were planned based on the axial images of MRI. In general, the entry point is located about 6–9 cm from the midline because it needed steeper approach angle for direct targeting to the herniation than a paramedian ruptured disc (Fig. 1).
2. An 18G spinal needle was inserted under fluoroscopy guidance along the preplanned trajectory. The needle tip was positioned at one point of the medial pedicle line on the anteroposterior fluoroscopic projection and at the posterior vertebral line on the lateral projection.
3. Epidurography was performed to confirm the location of the neural structures.
4. After confirming the spinal needle tip position at the foraminal targeting point on epidural space, advance the needle into the annulus fibrosis.
5. A guide wire was introduced via the spinal needle, followed by an obturator and a beveled working cannula.
6. The whole procedure was performed under fluoroscopy guidance. After satisfactory positioning of the working channel, a 25° endoscope was introduced.
7. Internal decompression of the degenerated disc in the disc space is first performed to secure the intradiscal space in which the herniated disc can be dropped. Then the working cannula retrieved until its tip was outside the disc.
8. Confirming the epidural space and lateral portion of posterior longitudinal ligament (PLL), proximal exiting nerve root or axilla side of exiting nerve root was also identified.
9. Direct exiting nerve root decompression can be safely performed because the herniated disc is selectively removed by dissection after confirming the exiting nerve root and herniated disc in the endoscopic view.

10. By rotating the opening of the working channel to the cranial or lateral side, endoscopic forceps could be used to grasp the foraminal and extraforaminal disc herniation underneath the exiting root.
11. Rest of the discectomy was performed and concluded in the standard manner. Laser is used to release PLL in medial and extraforaminal area with protection of working channel.

1.4 Case Illustration

A 79-year-old woman was presented with chief complaints of right buttock and leg pain. She also had paresthesia on the right thigh area. Symptom has developed 2 weeks ago. The imaging studies showed L34 right foraminal disc rupture (Fig. 2). We have performed L34 TELD (Fig. 3). After surgery, her symptoms have improved without any complications. The postoperative images show well-removed ruptured disc (Fig. 4).

1.5 Summary

Compared with central disc herniations, foraminal disc herniation discectomies (microscopic/endoscopic) have a reportedly higher postoperative incidence of remnant radicular pain and paresthesia. The authors postulate that the inferior outcomes of FDH discectomies can be attributed to DRG (dorsal root ganglion) manipulation. Furthermore, removal of FDH can result in disc height decrement, segmental instability and foraminal stenosis [5].

The inside-out technique is a simple-easy-to-learn maneuver to safely insert the working channel to the target area for FDH. After checking the exiting nerve root by rotating the working cannula, the pathological disc material can be completely removed by safely retracting the nerve.

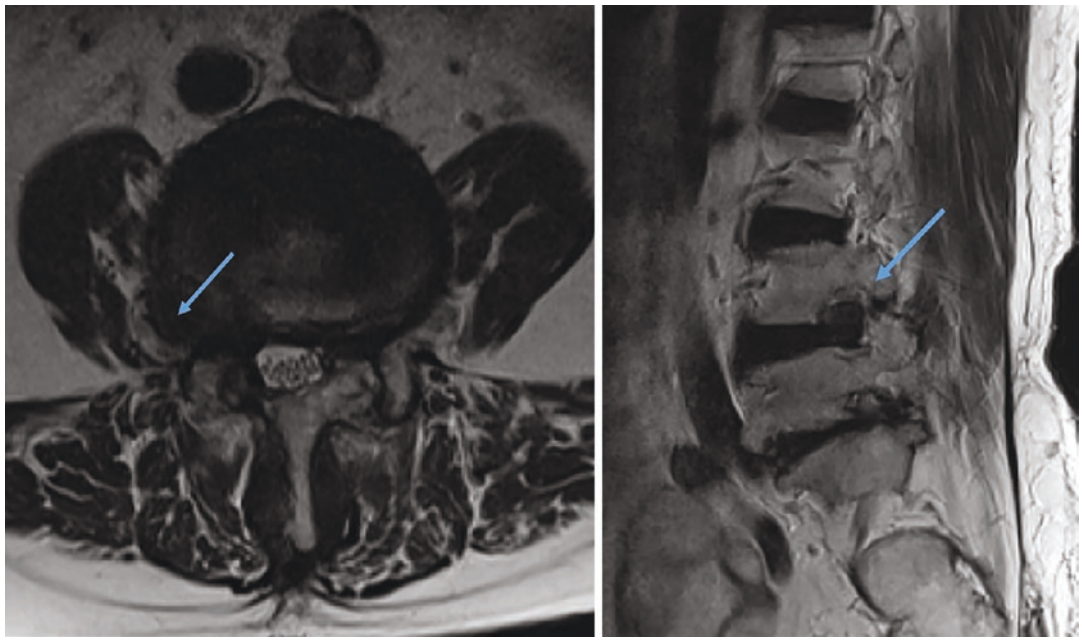

Fig. 2 Pre-op MRI showing right-side foraminal disc herniation L34 level

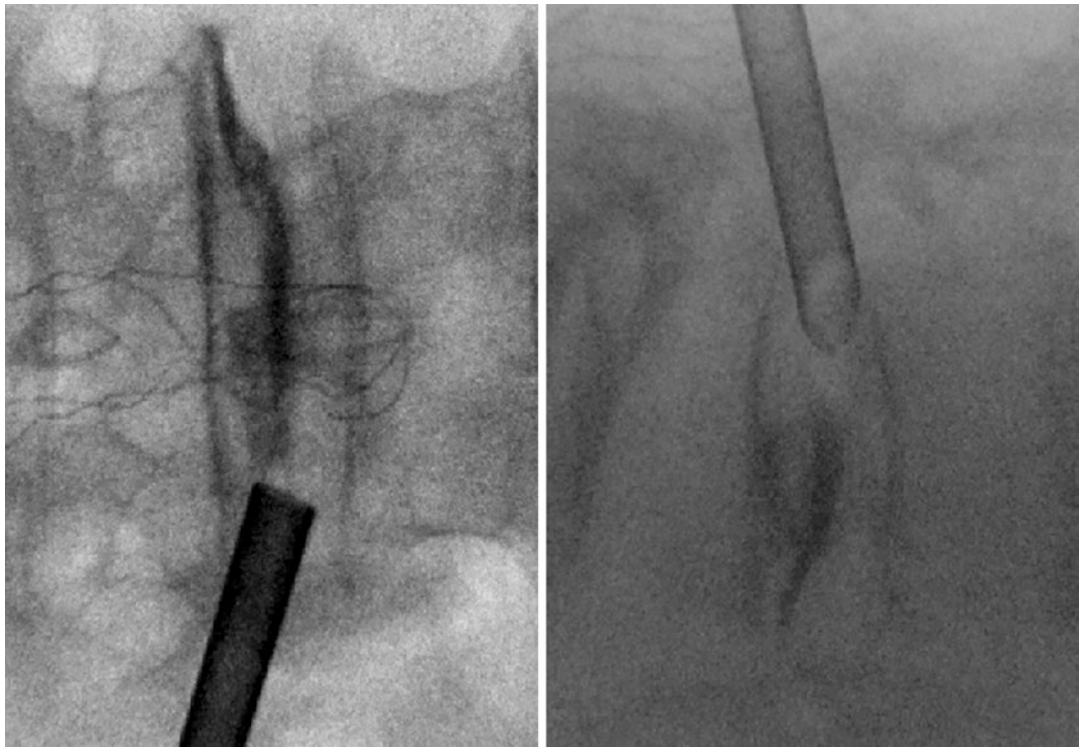

Fig. 3 The working channel was inserted at the foraminal targeting point

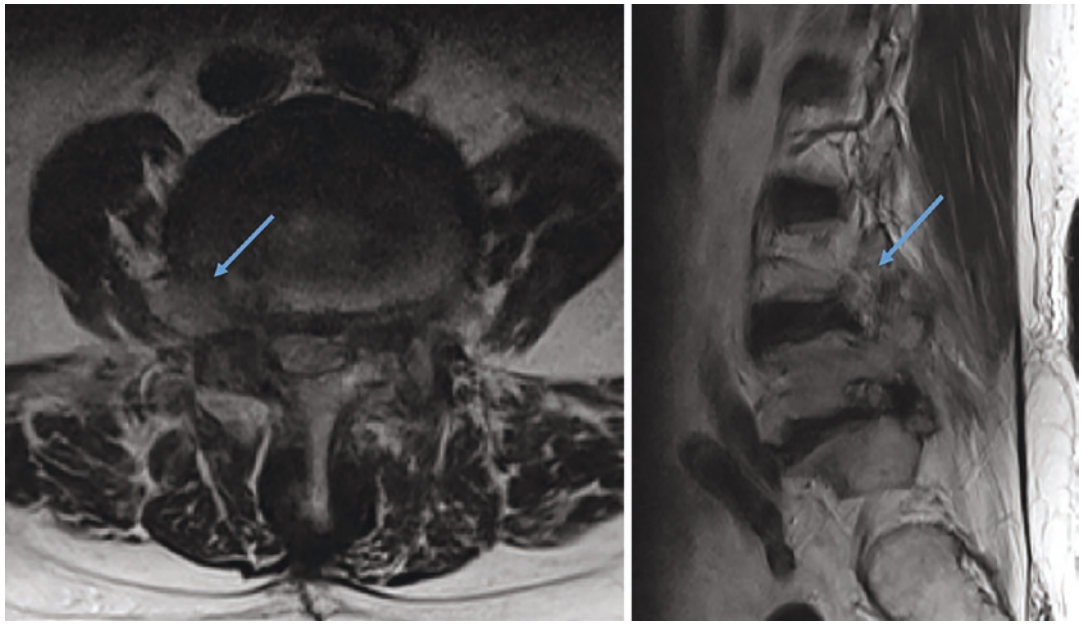

Fig. 4 Post-op MRI showing removal of foraminal disc herniation

2 Outside-In Technique

Jisang Kim and Won-Chul Choi

Abstract Foraminal lumbar disc herniation is a relatively rare disease entity. In today's era when minimally invasive spinal surgery has been performed commonly, percutaneous endoscopic lumbar discectomy has become a procedure of choice for foraminal lumbar disc herniations. In the outside-in technique for foraminal disc herniation, the working cannula is placed on the disc surface and within the intervertebral foramen. With this outside-in technique, surgeons can address the ruptured disc fragment which generates pain.

Keywords Foraminal lumbar disc herniation; Percutaneous endoscopic lumbar discectomy; Outside-in technique; Selective fragmentectomy

2.1 Introduction

Foraminal lumbar disc herniations (LDH) have been reported to account for 1–12% of all LDHs [8–10]. Since there have been recent improvements in minimally invasive spinal surgery and equipment, percutaneous endoscopic lumbar discectomy (PELD) is becoming a preferred procedure of treatment for foraminal LDH. PELD has presented favorable clinical results similar to those of open microdiscectomy while presenting various advantages such as preservation of normal tissue, shorter operation time, and hospital stay [5, 11, 12].

Two main techniques for PELD have been described: the inside-out and the outside-in technique. The distinction between these two methods is the initial placement of the endoscopic working cannula either inside the intervertebral disc (inside-out) or within the intervertebral foramen (outside-in).

The choice between the two techniques is determined intraoperatively. In cases where the extruded disc is the source of pain and the pressure made by the obturator being introduced evokes intolerable pain, the outside-in technique is considered.

The advantages of the outside-in technique are less pain for the patients with discogenic pain, less disc injury, easy epidural exposure, and easy manipulation of the working cannula.

In this chapter, we describe the outside-in technique of PELD for foraminal LDH.

2.2 Indications

The indications of PELD for foraminal LDH are the same as those of microdiscectomy.

1. Radiologic confirmation of foraminal soft disc herniation.
2. Concordant clinical symptoms of nerve root compression not responding to more than 6 weeks of conservative treatment such as medication, physical therapy, or selective nerve root blocks.

In cases where the extruded disc is the pain generator and the patient complains of severe pain with the pressure made by the obturator being introduced, the placement of the obturator inside the intervertebral disc should be avoided and the outside-in technique is to be considered.

2.3 Surgical Technique

PELD for foraminal LDH is usually performed under local anesthesia. To avoid any injury to the neural structure, the procedure proceeds with continuous feedback from the patient. Midazolam or fentanyl may be administered intravenously to relieve pain and sedation during the procedure. Patients are placed in the prone position with his/her spine, knees, and hips flexed to reduce lumbar lordosis. This position increases the diameter of the intervertebral foramen without causing tension of the lumbar nerve roots.

The skin entry point is typically approximately 8–13 cm from the midline. The entry point is dictated by the size of the patient, the dimensions of the facet joints, and the desired location for the tip of the triangular working zone. After infiltration of local anesthesia, a 6-in.

18-G spinal needle is inserted until it reaches the border between the cranial part of the caudal pedicle and the superior articular process (SAP). Additional epidural blockade with 0.5% lidocaine is done to prevent approach-related pain. 1 ml of indigo carmine mixed with contrast medium is injected into the disc. This discography is helpful for selective fragmentectomy under an endoscopic view. The spinal needle is then replaced by a guidewire and an obturator with a small stab incision of 8 mm. Either a bevel-ended or a lateral window working cannula is then introduced along the obturator.

Foraminoplasty using a high-speed drill is necessary to avoid exiting nerve root (ENR) injury in case of the narrow intervertebral foramen. Since the patient may feel heat sense on his/her leg when drilling is being performed, intermittent cessation of drilling and irrigation with normal saline are helpful to reduce the patients' discomfort. The heat sense disappears within a few seconds of irrigation. With the fluoroscopic anteroposterior view, the drilling can be performed safely beyond the medial pedicular line (Fig. 5).

After foraminoplasty, the working cannula is placed on the disc surface and just within the intervertebral foramen (Fig. 6). The location of the cannula can be confirmed under the C-arm fluoroscopic guidance. An endoscope is then introduced. If the cannula is placed properly, the disc surface and SAP are visible on the endoscopic view at 6 and 12 o'clock, respectively (Fig. 7). Bone debris and soft tissue in the epidural space are removed using radiofrequency coagulator and endoscopic forceps.

The cannula is rotated so that the opening of the bevel is on the cranial side (Fig. 8). The

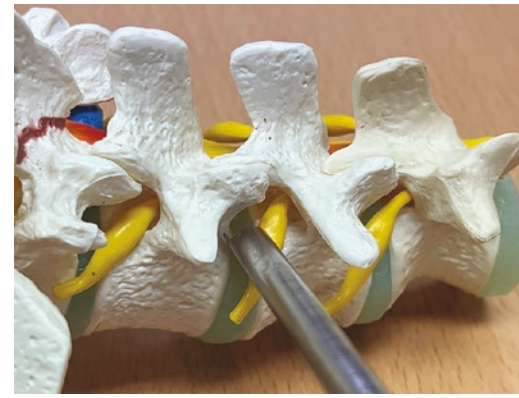

Fig. 6 Initial placement of the working cannula is within the intervertebral foramen

Fig. 5 A 5-mm drill is used for foraminoplasty, and the drilling can be performed safely beyond the medial pedicular line on the fluoroscopic anteroposterior view

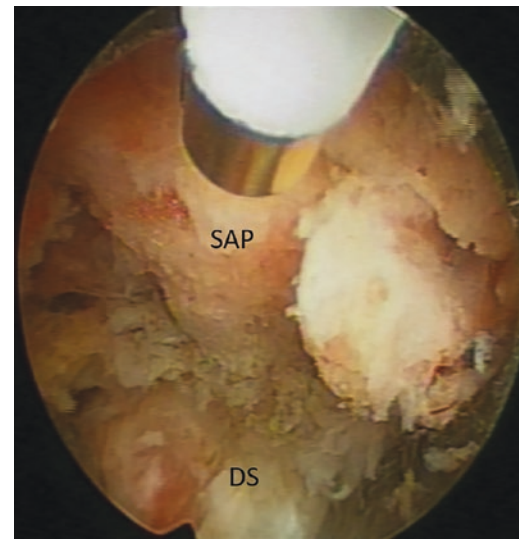

Fig. 7 Endoscopic view showing the disc surface (DS) and SAP at 6 and 12 o'clock after foraminoplasty

foraminal ligament over the ENR is seen on the endoscopic view and can be resected using an endoscopic bite punch or side-firing laser. The ENR covered with perineural fat tissue is then visible. After confirming the ENR, the ENR is retracted along the direction of it by levering the cannula, which minimizes the pain for the patient whereas retracting to the craniolateral side may evoke pain (Figs. 9 and 10). This procedure of retraction should proceed in cooperation with the patient. The targeted herniated disc compressing the ENR is seen with an appropriate retraction of ENR and direct fragmentectomy is performed with endoscopic forceps (Fig. 11). The whole procedure ends when decompression of the intervertebral foramen and the free ENR is confirmed.

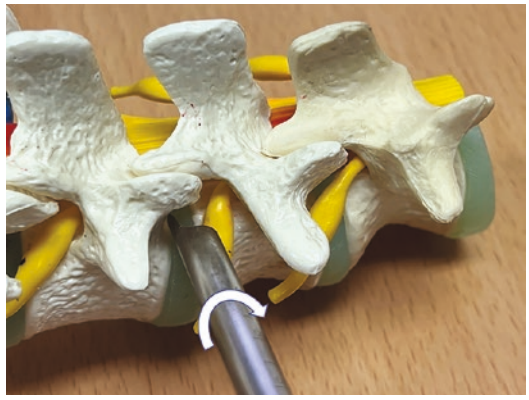

Fig. 8 The cannula is rotated so that the lateral window is on the cranial side

Fig. 9 The ENR is retracted along the direction of it by levering the cannula to minimize the pain

2.4 Postoperative Consideration

A neurological examination should be done immediately after the procedure. This can confirm whether the symptom is improved and the motor deficit has occurred. Postoperative magnetic resonance imaging (MRI) can be used to check for complete decompression. The patient may be discharged after several hours of observation. At discharge, oral antibiotics are prescribed to prevent postprocedural infection.

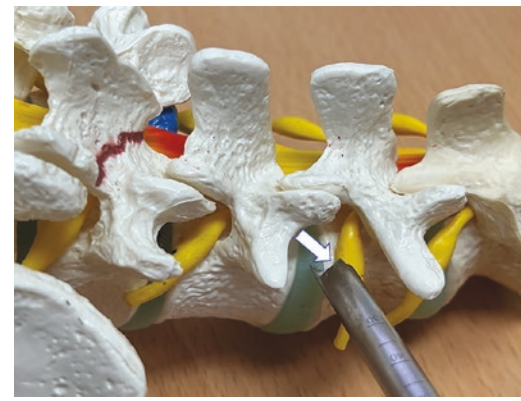

Fig. 10 Retracting to the craniolateral side may evoke pain by compressing the dorsal root ganglion

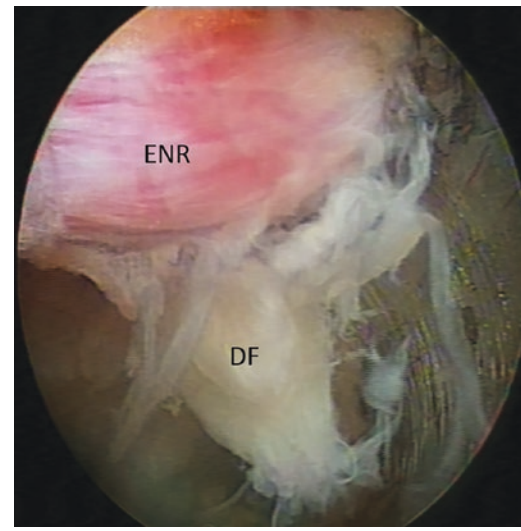

Fig. 11 Endoscopic view showing the targeted disc fragment (DF) underneath the ENR with an appropriate retraction

Fig. 12 (**a**, **b**) Preoperative MRI showing right-side foraminal disc herniation (white arrow) at L4/5 level. (**c**, **d**) Postoperative MRI showing removal of foraminal disc herniation

2.5 Case Illustration

A 61-year-old female patient presented with right leg pain which persisted for 2 months. On MRI, foraminal stenosis was seen on the right L4/5 level caused by disc extrusion. The patient underwent PELD. Postoperative MRI showed complete decompression of the right L4/5 foraminal stenosis. The patient had complete resolution of her symptoms (Fig. 12).

3 Extraforaminal Disc Herniation: Outside-In Technique

Shin-Jae Kim and Sang-Ha Shin

Abstract Inside-out technique is an ordinary approach of TELD which first decompresses the inner annulus to sink down the protruded disc. However this technique causes an iatrogenic

annulus tear during the approach. Recurred rate through this tear site reported as 8% [13]. Outside-in technique is an approach that can compensate for these shortcomings. Extraforaminal disc protrusion is a typical indication for this approach. Key point of this technique is "Rotate-to-retract technique," which safely retracts and decompresses the exiting neural structures.

Keywords Endoscopy; Transforaminal endoscopy; TELD; Extraforaminal disc; Outside-in technique

3.1 Introduction

There are two main approaches to TELD. Inside-out technique inserts the working cannula inside the annulus first and decompresses the inner annulus to sink down the protrusion disc. This procedure secures a working space between the endplate and the PLL safely. However, this technique contains the disadvantage of the iatrogenic tear of the foramen part of the annulus. Recurred disc rate through this incidental tear site after TELD is reported as 8% [13]. Postoperative dysesthesia due to the exiting root injury has been also reported [14].

Outside-in technique aims to reduce the incidental damage of the annulus and remove the targeted disc fragment. It is more useful for certain types of disc such as extraforaminal disc herniation [15, 16]. The extraforaminal approach of TELD is very different from general TELD in that the needle insertion angle is steeper and it directly targets the prolapsed disc rather than the intervertebral foramen. While reducing the iatrogenic tear of the annulus, the possibility of damaging the exiting root is higher, so technical skill to overcome this is important for safety. "Rotate-to-retract technique" is a safe technique that can reduce injury of the exiting root.

3.2 Indications

Extraforaminal disc herniation.

3.3 Surgical Technique

The standard paramedian TELD approach (inside-out technique) is as follows [17, 18].

1. The patient is placed in a prone position with some lumbar flexion.
2. IVG anesthesia is applied after aseptic preparation.
3. An 18G needle is inserted into the disc space 12 cm away from the midline.
4. Discography is done to confirm concordant pain.
5. Serial dilation and insertion of the obturator and working channel is done under C-arm fluoroscopy.
6. Confirmation of appropriate position of the working channel is done using AP and lateral fluoroscopy.
7. Disc herniation is confirmed and removed using side-firing laser and pituitary forceps until satisfactory decompression is done.
8. After confirming adequate decompression, injection of mixed solution of dexamethasone and lidocaine is done through the working channel before removal.
9. Finally, subcuticular sutures are done. All procedures are done under full communication with the patient.

Standard trajectory (laterally 8–12 cm) should be approached more from the medial side (8–12 cm) and convergence (20–25 degrees) should be approached at a more shallow angle (50 degrees). Inside-out technique targets foramen and after confirming the epidural space of the Kambin's triangle, cannula is inserted further inside the annulus (Figs. 13 and 14). Extraforaminal disc might be reached right below the superior articular

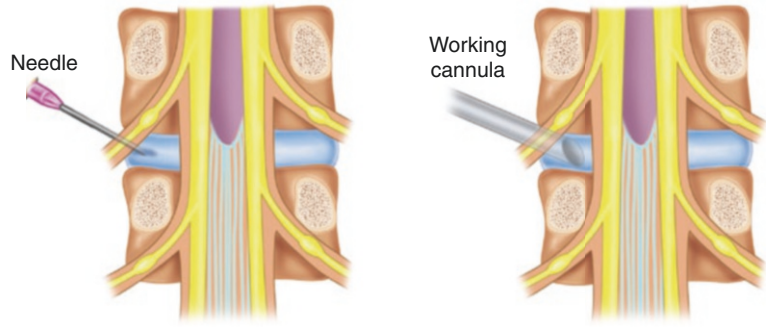

Fig. 13 (1) Locating the needle to the extraforaminal annuls surface. (2) following the working cannula

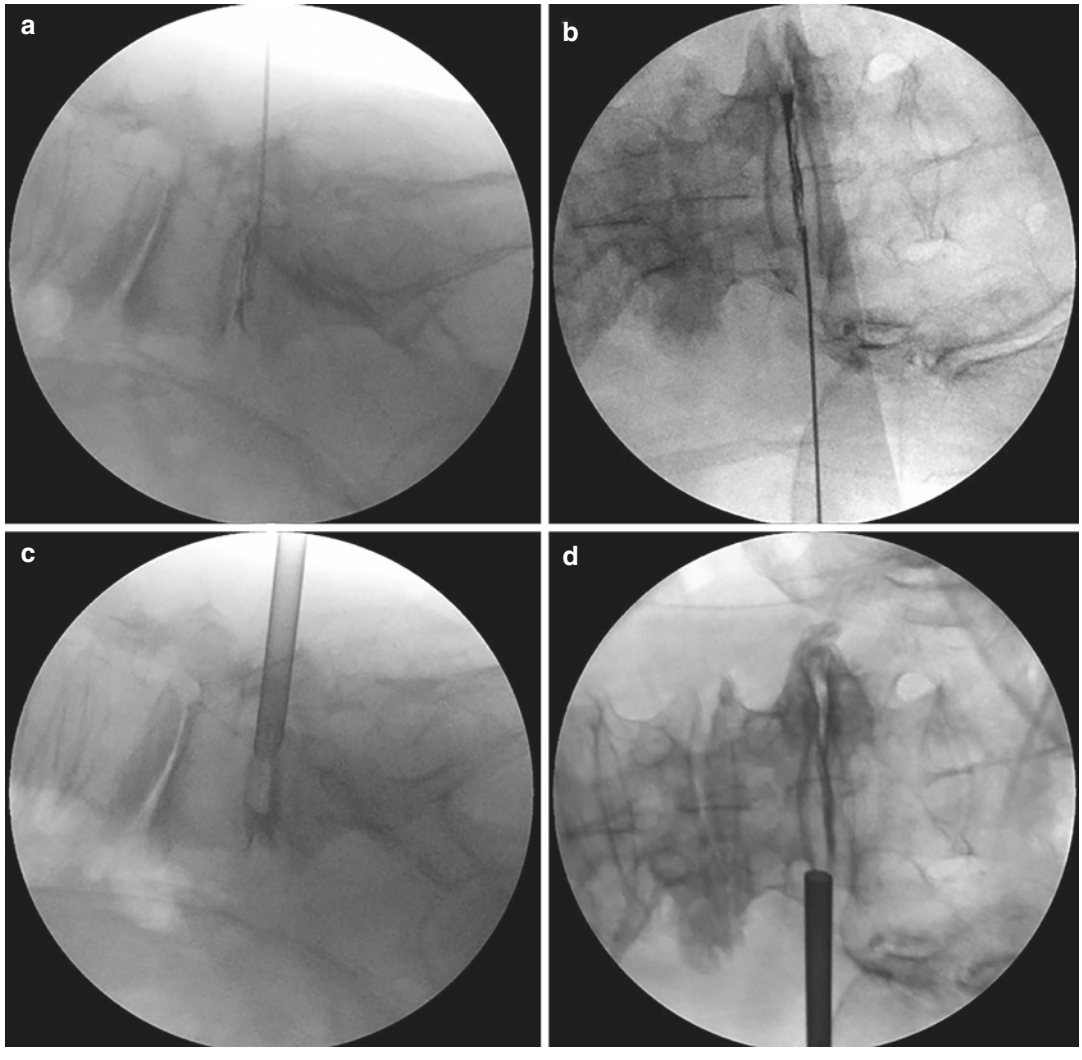

Fig. 14 C-arm images shows the approach of the endoscope. (**a**, **b**) Inserting the guidewire to the Kambin's triangle. Indo carmine dye confirmed the insertion of the wire. (**c**, **d**) Instead of inserting the working cannula to the inner annulus, it is inserted at a more steep angle to reach the annulus of the extraforaminal area

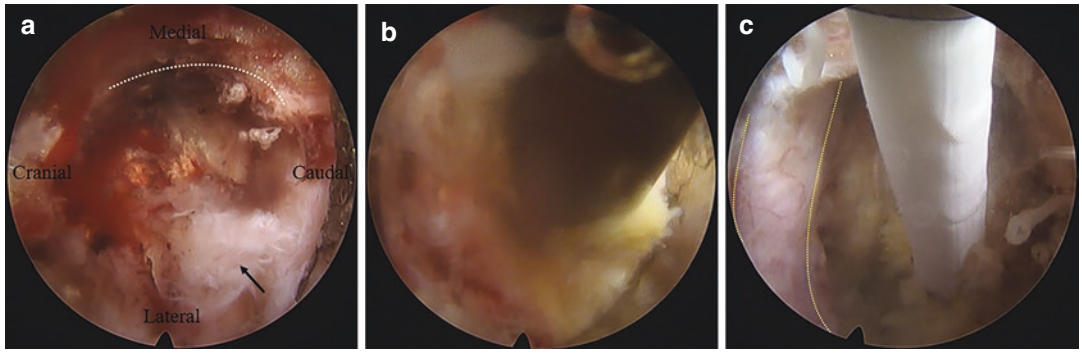

Fig. 15 Endoscopic images. (**a**) After inserting the working cannula at the extraforaminal annulus of the disc, ruptured disc fragment is directly observed (black arrow). Superior articular process is observed at the medial part (white dot line). (**b**) Disc fragment is being removed by forceps. (**c**) After rotating the tip of the working cannula in counterclockwise direction, exiting root is observed (yellow dot line). Additional annulus is being removed

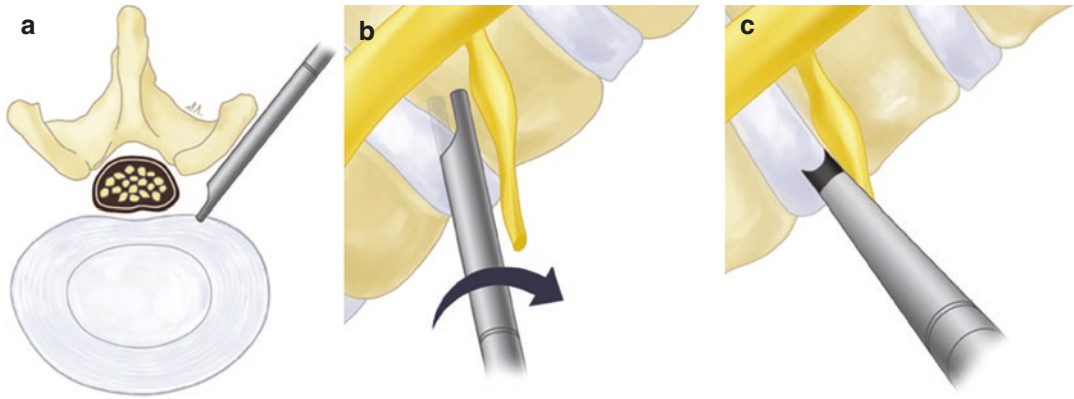

Fig. 16 (**a**) The working cannula is slightly pulled out until it is located outside the annulus. (**b**) The tip of the working cannula is rotated clockwise, which resulted in spontaneous retraction of the exiting nerve root. (**c**) The tip of the working cannula is placed laterally, which may retract the exiting root. Devices inserted through the opening side may remove the disc fragment safely

process. In this case, there is no need to make the incidental tear of the annulus. After confirming the Kambin's triangle, feel the outer surface of the annulus after passing the superior articular process. Then place the cannula in that position (Fig. 15). Since the convergence of the cannula should be steeper than the inside-out technique, this might contain a higher risk of exiting root injury. "Rotate-to-retract technique" (Fig. 16) [19]" is useful for safe retraction and decompression of the exiting neural structures.

3.4 Case Illustration

An 82-year-old female patient with lower back pain and left leg numbness which started from 2 years ago and aggravated from 1 month ago visited hospital. The left ankle dorsiflexion motor was decreased to grade 3. Left extraforaminal disc protrusion on L5-S1 level was diagnosed (Fig. 17). Considering patient's age and radiographic finding, TELD with outside-in technique was planned (Fig. 18).

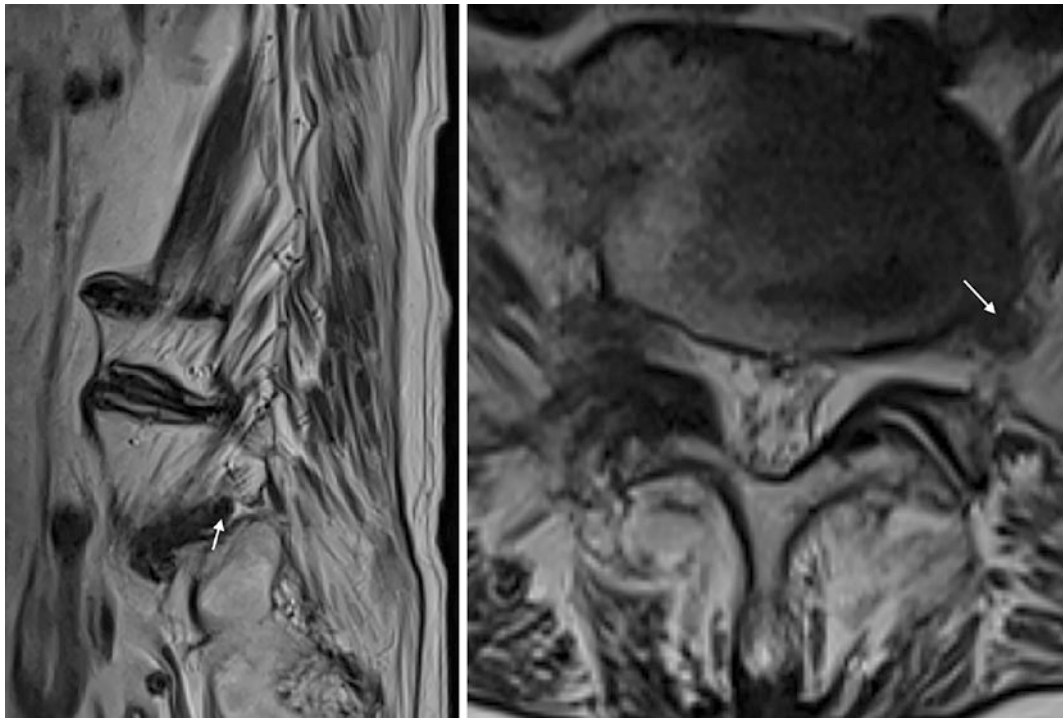

Fig. 17 Preoperative MRI images show extraforaminal disc on L5-S1 level

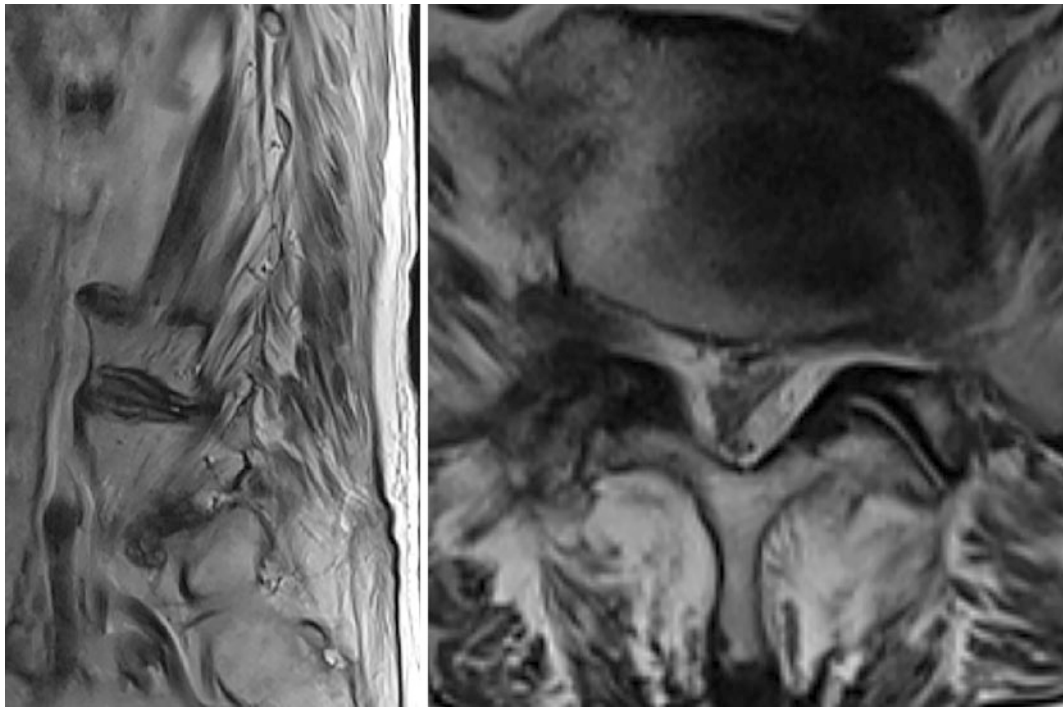

Fig. 18 Postoperative MRI images show well-removed extraforaminal disc fragment on L5-S1 level

3.5 Summary

The outside-in technique minimizes iatrogenic annular tear and provides precise decompression through direct access to the ruptured disc. Extraforaminal disc is a good indication of this technical approach. The risk of exiting root can be reduced by technical skill as rotate-to-retract technique.

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