9 The Paraspinal Approach with Unilateral Biportal Endoscopy for Lumbar Foraminal Lesions

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9.1 Introduction

Degenerative change of the vertebral disc can induce hypertrophy of the facet joints, thickening of the ligament flavum, and resultant narrowing of the neural foramen. These degenerative changes lead to symptomatic lumbosacral radiculopathy and account for approximately about 10% of lumbar degenerative diseases that required surgical intervention [1, 2].

Before the concept of minimally invasive spine surgery was introduced, lumbar fusion surgery was probably the one and only surgical solution for lumbar foraminal lesions. However, as the endoscopic spine surgical techniques have matured, many lumbar foraminal pathologies can be well treated by just simple decompression [3–5].

In particular, the unilateral biportal endoscopy (UBE) technique allows for minimally invasive surgical access, has no restrictions on the use of surgical instruments, and has a relatively short learning curve by providing a more familiar surgical anatomy based on the classic Wiltse approach.

Furthermore, the endoscopic lens, the so-called "operative eye," can be advanced very close to the lesion, and capture clear and magnified video images of the lesion and its surrounding structures. Visualization of the deep neural structures and pathologies would no longer be limited by the anatomical structures [6].

In this chapter, we provide a step-by-step description of the surgical procedure of the paraspinal approach with the UBE technique using video and pictures. The paraspinal approach for L5–S1 is described separately, because compared to the other levels, it has special anatomical considerations.

9.2 Indications and Contraindications

The surgical indications and contraindications are the same as the microscopic lumbar foraminotomy via Wiltse approach [7].

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9.2.1 Indications

1. Chronic mono-radiculopathy resistant to conservative treatment.
2. Para-sagittal and axial magnetic resonance images (MRI) showing foraminal or extra-foraminal lesions. Stenosis, herniated disc, or hypertrophic osteophyte, etc.

9.2.2 Contraindications

1. Definite segmental instability.
2. Degenerative or isthmic spondylolisthesis over grade 1.

9.3 Anesthesia and Position

The surgery can be performed under general anesthesia or epidural anesthesia, depending on the estimated surgical time, and the patient's conditions. The patient is placed in a prone position on the radiolucent Wilson frame with mild flexion of the lumbar spine and proper padding at the patient's axilla and under his/her knees. To avoid soaking and hypothermia of the patient, the draping must be waterproof (Fig. 9.1).

Fig. 9.1 A waterproof surgical drape is draped around the operative field to ensure that saline is smoothly drained during the surgery, does not soak the patient, and does not flood the floor

9.4 Surgical Steps

9.4.1 [L1–5 Level]

9.4.1.1 Skin Marking and Incision

Under the guidance of C-arm fluoroscopy, two skin incisions are made to form the viewing and working portals. The length of the skin incision is about 0.5 cm, and each skin incision is located above the ipsilateral lateral margin of the transverse processes. The interval between the two portals is about 2 cm to 2.5 cm (Fig. 9.2a).

The docking point of the endoscope and the instrument is the isthmus. The distance of the skin incisions away from the midline can be determined preoperatively on the MRI to make the trajectory of 30 degrees to 40 degrees (Fig. 9.2b–d). This angle is the most ideal approach angle, because foraminotomy can be done through undercutting with the lowest risk of an iatrogenic isthmic fracture. In patients with severe disc space narrowing, it is almost impossible to identify the isthmus. In such cases, the alternative docking point will be the tip of the superior articular process (SAP).

The fascia is opened perpendicularly to the skin incision with a No.15 blade for better saline outflow. Serial dilators are used to separate the back muscle and create the initial operative space. After inserting the cannula, a 0° endoscope is inserted through the scope portal. The authors prefer to use a natural gravity drainage system (about 70 cm high above the operation table) for saline irrigation. But if the use of the saline pumping system is preferred, the recommended hydrostatic pressure is about 30 mmHg. This pressure setting is safe, without risks of increasing the intracranial pressure. After triangulation with the endoscope and instrument on the isthmus or the tip of the SAP, the small bleeding can be effectively controlled using the radiofrequency (RF) wand.

9.4.1.2 Foraminotomy/Discectomy (Video 9.1)

To confirm the surgical anatomy, the RF wand and automated shaver are used to clear the soft

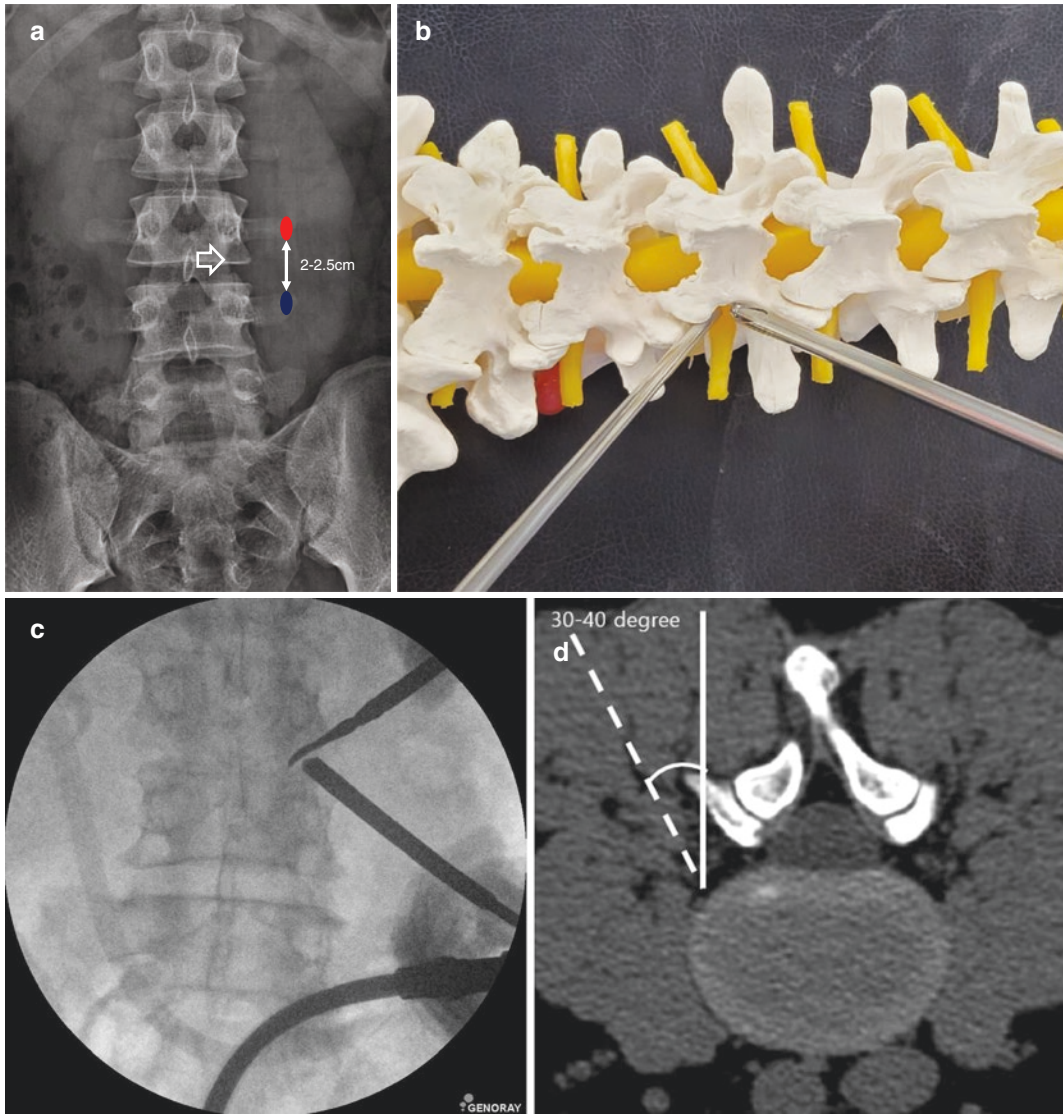

Fig. 9.2 Skin incisions for the scope portal (Blue circle) and the working portal (Red circle) and a docking point (Open white arrow) are illustrated on the X-ray anteroposterior (AP) view (**a**). Endoscope and instruments are triangulated on the isthmus of the artificial lumbar spine model (**b**). Triangulation of endoscope and instruments at the docking point under the C-arm fluoroscopic view (**c**). The appropriate trajectory for the paraspinal approach (white line and white dashed line) is 30 degrees to 40 degrees (**d**)

tissue remnants overlying the lamina and the base of the transverse process. The surgical landmarks, including the lateral aspect of the isthmus, inferior border of the upper transverse process, and lateral aspect of the SAP, should be clearly identified before proceeding to the next step (Fig. 9.3).

A diamond spherical bur is used to drill the lamina. Drilling starts at the lateral border of the isthmus and continues in an under-inside direction. Then the lateral portion of the ligament flavum and the inferior aspect of the pedicle at the base of the transverse process can be exposed (Fig. 9.4a).

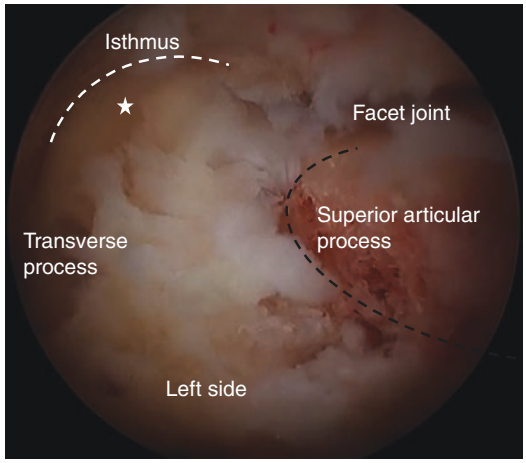

Fig. 9.3 The intraoperative endoscopic image shows the lateral margin of the left isthmus (white dashed line), ligament (asterisk), and facet capsule (black dashed line)

The ligament flavum around the foramen is removed using a curette and Kerrison's punches (Fig. 9.4b). After completion of the flavectomy, the exiting nerve root with its overlying adipose tissue can be exposed (Fig. 9.4c).

If more extent of foraminal decompression is indicated, the cranial tip of the SAP can be resected from the hypertrophic facet joint using a chisel or the diamond bur. If the offending pathology is a lumbar disc herniation, additional discectomy can now be performed, usually from the axilla area of the exiting root (Fig. 9.4d).

After adequate decompression of the exiting root is confirmed, epidural bleeding can be controlled by coagulation with RF wands. A drain is inserted, and after removal of the instruments and the endoscope, the surgical wounds are closed

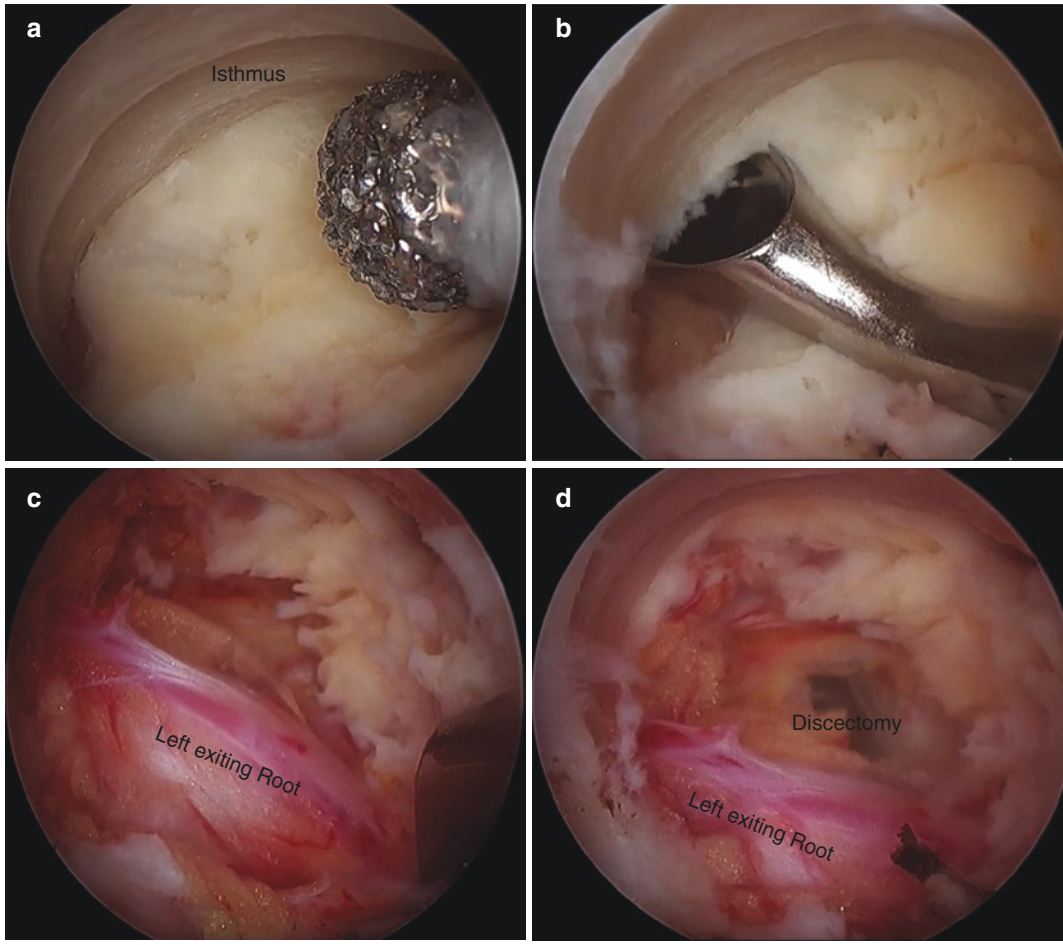

Fig. 9.4 Intraoperative endoscopic view. The starting point of drilling is the lateral margin of the isthmus (**a**). The angled curette is useful in detaching the ligament flavum (**b**). The exiting root is exposed after bleeding control (**c**). Discectomy was done at the axillary portion of the exiting root (**d**)

with a skin stapler. The suction drain is usually kept for 24 h after the surgery, until spontaneous bleeding is controlled.

9.4.2 [L5–S1 Level]

The paraspinal approach at the L5–S1 level has a very limited surgical field. In addition, there are some special and different anatomical features from other lumbar levels. These may include prominent iliac crest, oblique pedicles, and more coronally oriented facet joints. Therefore, it is difficult to create a surgical trajectory to the medial direction of the L5 isthmus.

9.4.2.1 Skin Marking and Incision

Under the guidance of C-arm fluoroscopy, two skin incisions are made to form the viewing and working portals. The length of the skin incision is about 0.5 cm, and each skin incision is located above the ipsilateral lateral margin of the L5 transverse process and sacral alar. The interval between the two portals is about 2 cm (Fig. 9.5a).

Different from other lumbar levels, the isthmus of L5 is very narrow, and the docking point of the endoscope and the instrument is determined by the osseous triangle consisting of the lateral border of the SAP, the sacral alar, and the base of the L5 transverse process (Fig. 9.5b, c). Exposing the boundary of this osseous triangle

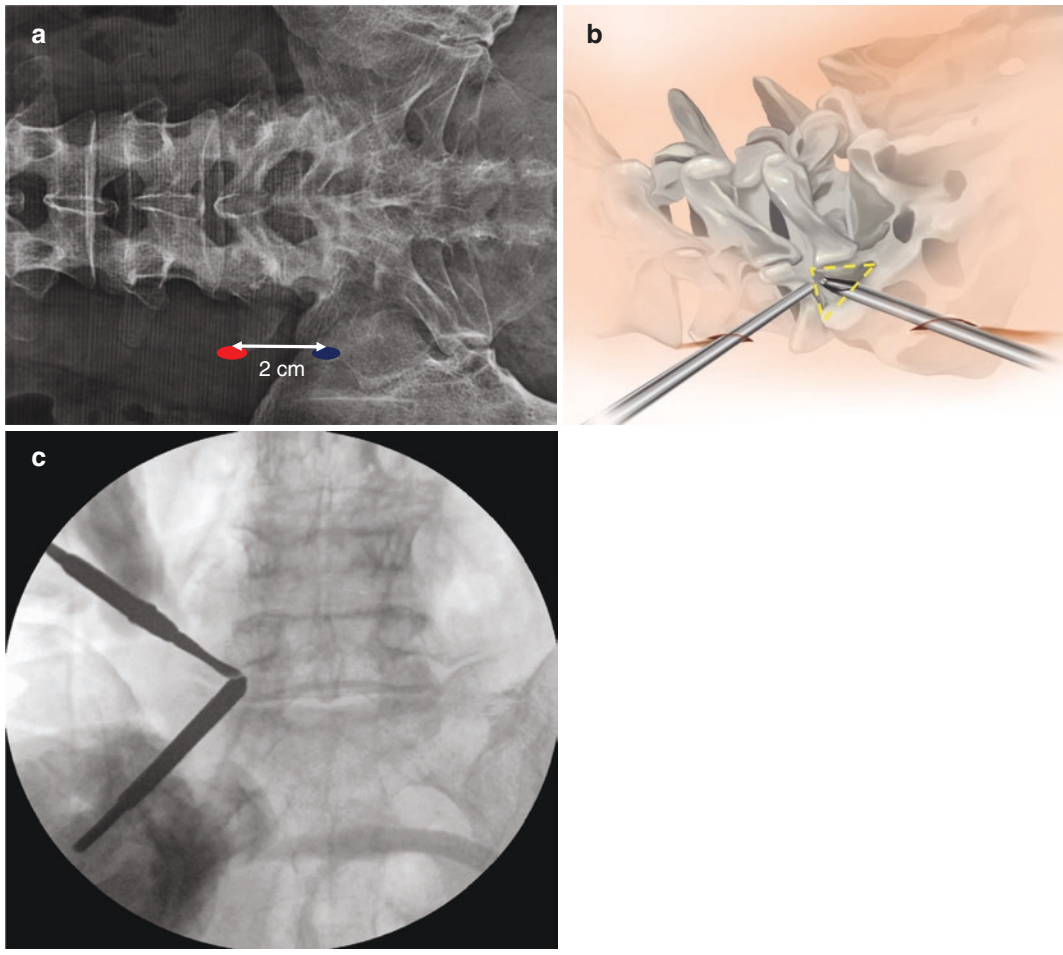

Fig. 9.5 Skin incisions for the scope portal (Red circle) and the working portal (Blue circles) for the paraspinal approach for L5–S1 are illustrated on the X-ray AP view (**a**). The osseous triangle is drawn by the yellow dashed lines on the schematic, and the endoscope and instruments are triangulated on the right osseous triangle (**b**). Triangulation of endoscope and instruments at the osseous triangle under the C-arm fluoroscopic view (**c**)

makes it easier to understand the complex anatomic structures around the L5–S foramen. The recommended trajectory angle is the same as for the other lumbar levels.

9.4.2.2 Foraminotomy/Discectomy (Video 9.2)

To confirm the surgical anatomy, the RF wand and automated shaver are used to clear the soft tissue remnants overlying the osseous triangle (Fig. 9.6a).

After the small bleeders are controlled and the remnant soft tissue around the osseous triangle is cleared, the base of the L5 transverse process and the cranial and lateral aspect of SAP are first drilled out (Fig. 9.6b).

Then, the remaining SAP that is located deep in the foramen is removed. At this point, the remaining SAP is too deep and too steep to be reached by the bur. Angled instruments, such as a hockey stick chisel and angled pituitary clamp, are useful in these situations (Fig. 9.6c). While all of these tasks can be accomplished with a 0° scope, sometimes a 30° scope is more useful to provide a wider vision, especially in obese patients.

After drilling out the bone, the ligament flavum is removed using a curette and Kerrison's punches (Fig. 9.6d). After flavectomy, the L5 exiting root, the perineural fat, and the disc space can be checked (Fig. 9.6e).

If there are offending pathologies at the extra-foraminal area, such as a far lateral disc or marginal osteophytes arising from the vertebral body, it is a good option to drill out the sacral alar before removing the ligament flavum. Removing a part of the sacral alar provides sufficient space to manipulate the endoscope and the surgical instruments. This also allows more space between the L5 exiting root and the disc. This space makes it easier and safer to manipulate the root and remove the herniated disc or the osteophytes (Fig. 9.6f).

After adequate decompression of the L5 exiting root is confirmed, epidural bleeding is controlled by coagulation with RF wands.

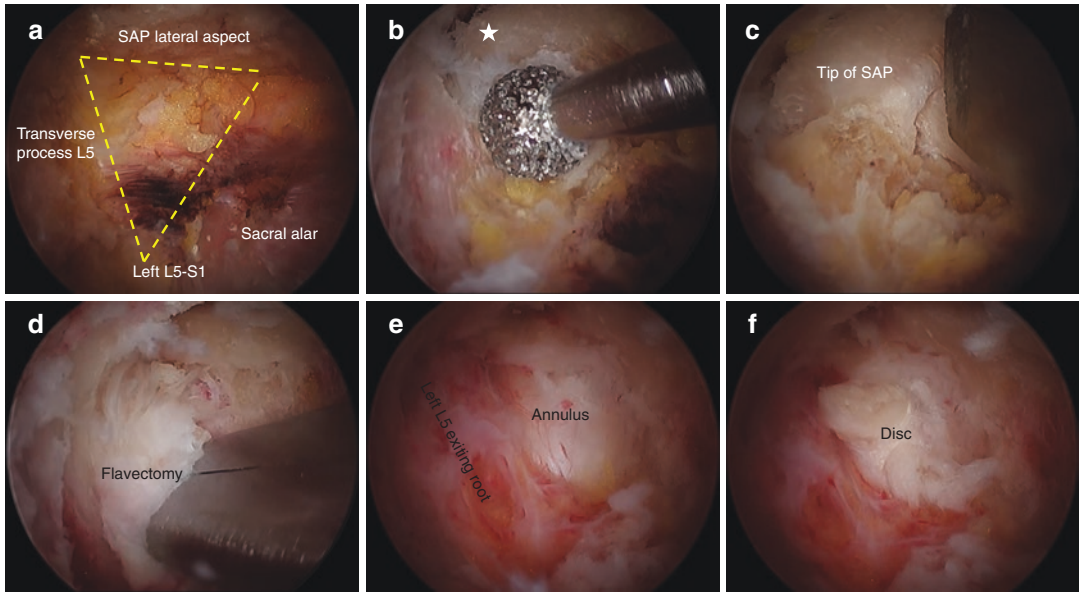

Fig. 9.6 Intraoperative endoscopic view. The osseous triangle (yellow dashed line) consists of the lateral aspect of SAP, the L5 transverse process, and the sacral alar (**a**). The base of the L5 transverse process and the tip of the SAP (asterisk) are drilled out (**b**). The hockey stick chisel is useful for resecting the deep portion of the SAP tip (**c**). Flavectomy is done by Kerrison's punches (**d**). L5 exiting root, perineural fat, and disc space are shown after flavectomy (**e**). A discectomy is done at the axillary portion of the exiting root. If the space is too narrow for discectomy, additional bone-work must be done at the sacral alar (**f**)

9.5 Illustrated Cases

9.5.1 Case 1: Paraspinal Foraminotomy at L3–4 Right Side Approach

A 68-year-old male patient complained about L3 pattern radiation pain in his right leg. The symptoms had been noted for 12 months, and he had difficulty walking because of the pain. The straight leg raising (SLR) test was normal. The neurological intermittent claudication was less than 300 meters to 400 meters. He had motor weakness on the right ankle dorsiflexion (grade 4). The Visual Analogue Scale (VAS) for his right leg pain was 7. Preoperative MRI and computed tomography (CT) scan showed right-side foraminal stenosis at the L3–4 level with a bony spur on the right L4 SAP (Fig. 9.7a, b, f).

A paraspinal foraminotomy using the UBE technique under general anesthesia was performed. Under the endoscope, the right L3 exiting root was decompressed, and the bony spur of the SAP was removed (Fig. 9.7e). Postoperative MRI and CT scan confirmed that the right L3–4 foramen was sufficiently decompressed (Fig. 9.7c, d, g). After the surgery, his symptom disappeared immediately.

9.5.2 Case 2: Paraspinal Discectomy with Resection of the SAP Tip at L3–4 Left

A 56-year-old male patient suffered from left side anterior thigh pain. The pain was distributed along the left L3 dermatome. The pain started 5 days ago, and because of the severe pain, he could not walk. The SLR test was negative on the right leg, and 30 degrees on the left leg. The neurological intermittent claudication was less than 200 meters to 300 meters. The manual muscle test for hip flexion was grade 3 on the left side. The VAS of the left leg pain was 9. Preoperative MRI and CT scan showed a left-side foraminal herniated disc with foraminal stenosis at the L3–4 level (Fig. 9.8a–d).

A paraspinal foraminotomy and discectomy using the UBE technique were performed under general anesthesia. Under the endoscope, the ruptured disc mass was found in the axillar portion of the left L3 exiting root (Fig. 9.8e). After discectomy, the tip of the SAP was removed by a chisel for foraminal decompression. Postoperative MRI and CT scan confirmed that the left L3–4 foramen was sufficiently decompressed (Fig. 9.8f–h). After surgery, his leg pain was immediately improved, and after 1 month, the motor weakness was recovered.

9.5.3 Case 3: Paraspinal Discectomy at L3–4 Left Side Approach

An 84-year-old female patient visited the hospital with severe left lateral thigh pain. The pain was distributed along the left L3 dermatome. The symptoms started 2 months ago, and because of the pain, she could not sit. The SLR test was negative on the right leg, and 10 degrees on the left leg. The manual muscle test of hip flexion and ankle dorsiflexion were both grade 3 on the left side. The VAS of the left leg pain was 9. Preoperative MRI showed an upward migrated disc herniation at the left L3–4 foramen (Fig. 9.9a, b).

A paraspinal discectomy using the UBE technique was performed under epidural anesthesia. Under the endoscope, the ruptured disc was found beneath the left L3 exiting root. After discectomy, the left L3 exiting root was released, and the engorgement of the root also disappeared (Video 9.3). The postoperative MRI and CT scan showed that the left L3–4 foramen was sufficiently decompressed (Fig. 9.9c, d). After surgery, the VAS of the leg pain was improved from 9 to 1. Motor weakness was not recovered till 3 months after the surgery.

9.5.4 Case 4: Paraspinal Foraminotomy at L5–S1 Right Side Approach (Video 9.4)

A 62-year-old male patient suffered from right buttock pain. Symptoms had been noted for one

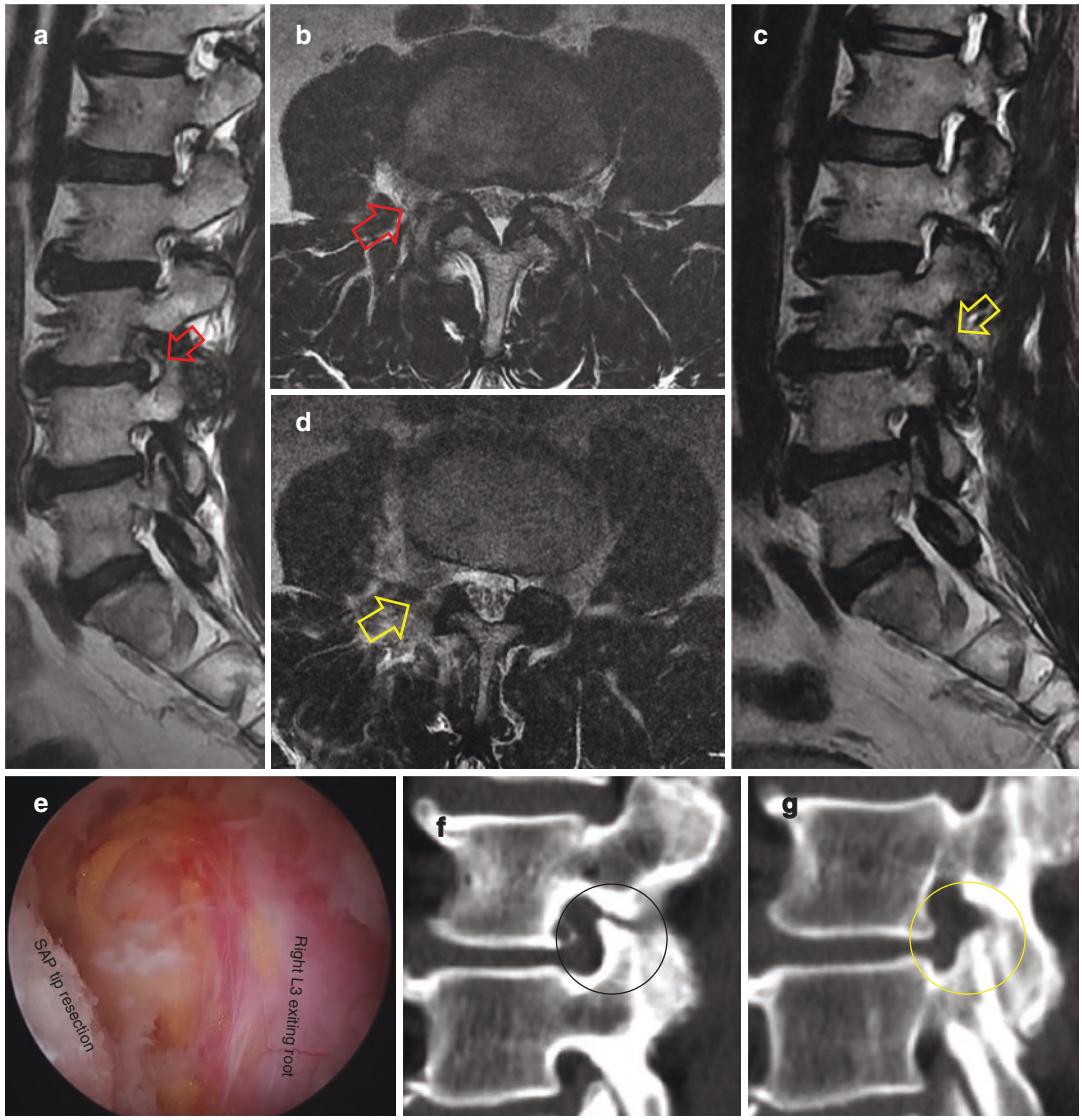

Fig. 9.7 Case 1. The preoperative right para-sagittal (**a**) and T2-weighted MR axial image (**b**) show that the right L3 exiting root is compressed by the bony spur of the SAP (red open arrows). The postoperative right para-sagittal (**c**) and T2 weighted MR axial image (**d**) show that the right L3 exiting root is decompressed, and the right L3–4 foramen is widened (yellow open arrows). The intraoperative endoscopic view shows that after resection of the SAP tip, the right L3 exiting root is released (**e**). The preoperative (**f**) and postoperative CT scan (**g**) show the partial resection (yellow circle) of the cranial tip of the right L4 SAP and bony spur (black circle) without instability

year, and in recent months had gradually worsened. Gradually, the limping phenomenon began to appear when walking. He had tried the conservative treatment for eight months with no significant improvement. The VAS for his left leg pain was 6. The SLR test was negative. The neurological intermittent claudication was less than 400 meters to 500 meters. The motor function was normal.

Preoperative MRI and CT scan showed right side foraminal stenosis at the L5–S1 level without segmental instability (Fig. 9.10a–c).

A paraspinal foraminotomy using the UBE technique was performed under epidural anesthe-

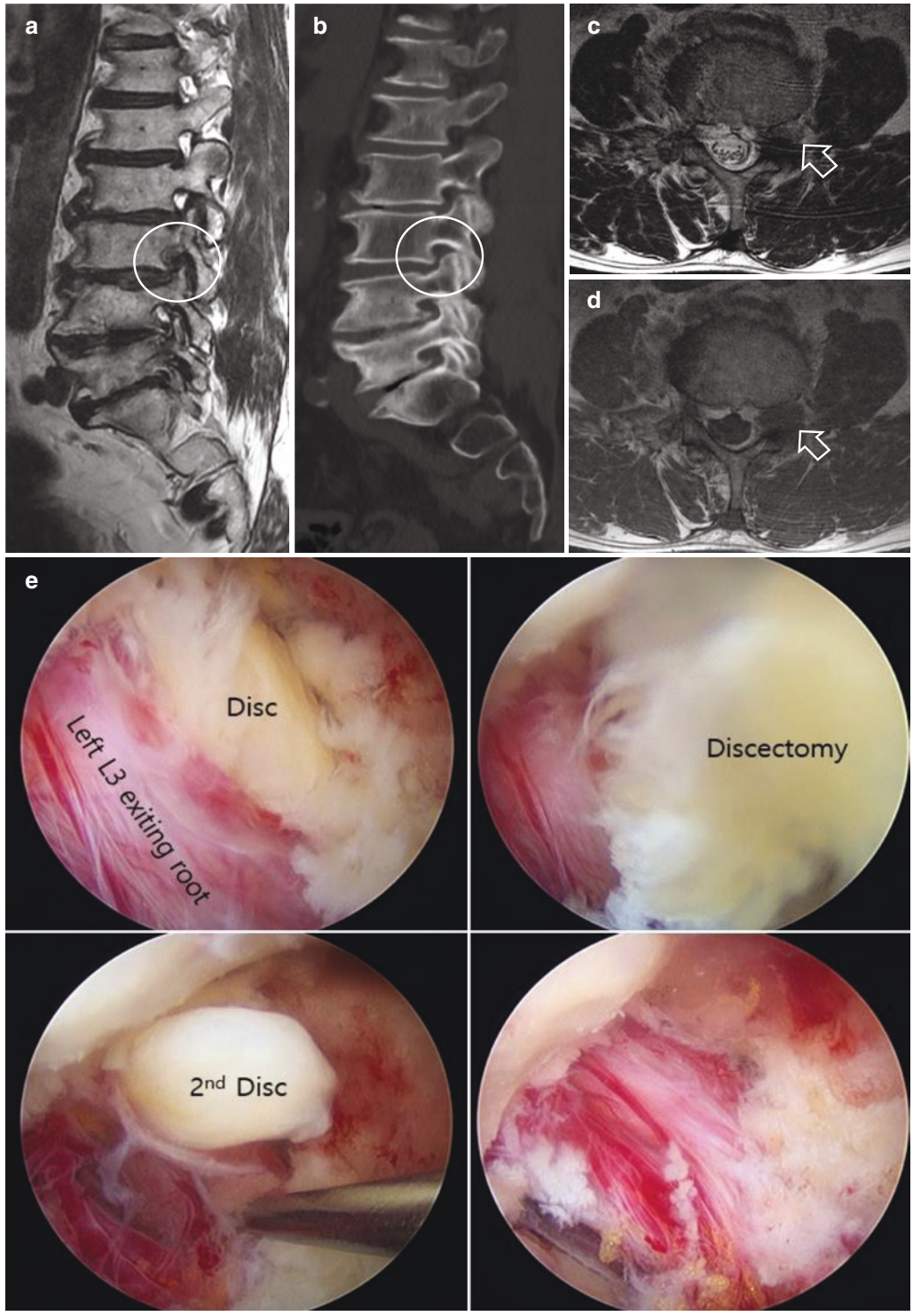

Fig. 9.8 Case 2. The preoperative left para-sagittal T2 weighted MRI (**a**) and CT scan (**b**) reveal severe foraminal stenosis (white circles) with hypertrophic facet joint at the L3–4 left side. The T2 (**c**) and T1 (**d**) weighted MR axial images show that the left L3 root is swollen (white open arrows). The intraoperative endoscopic view shows that the ruptured disc particles are located beneath the left L3 exiting root (**e**). The postoperative left para-sagittal (**f**) and axial T2 weighted MRI (**g**) show that the swelling of the left L3 exiting root is improved (yellow open arrows). The left para-sagittal CT scan (**h**) reveals the resection of the tip of the left L4 SAP (white circle) (**h**)

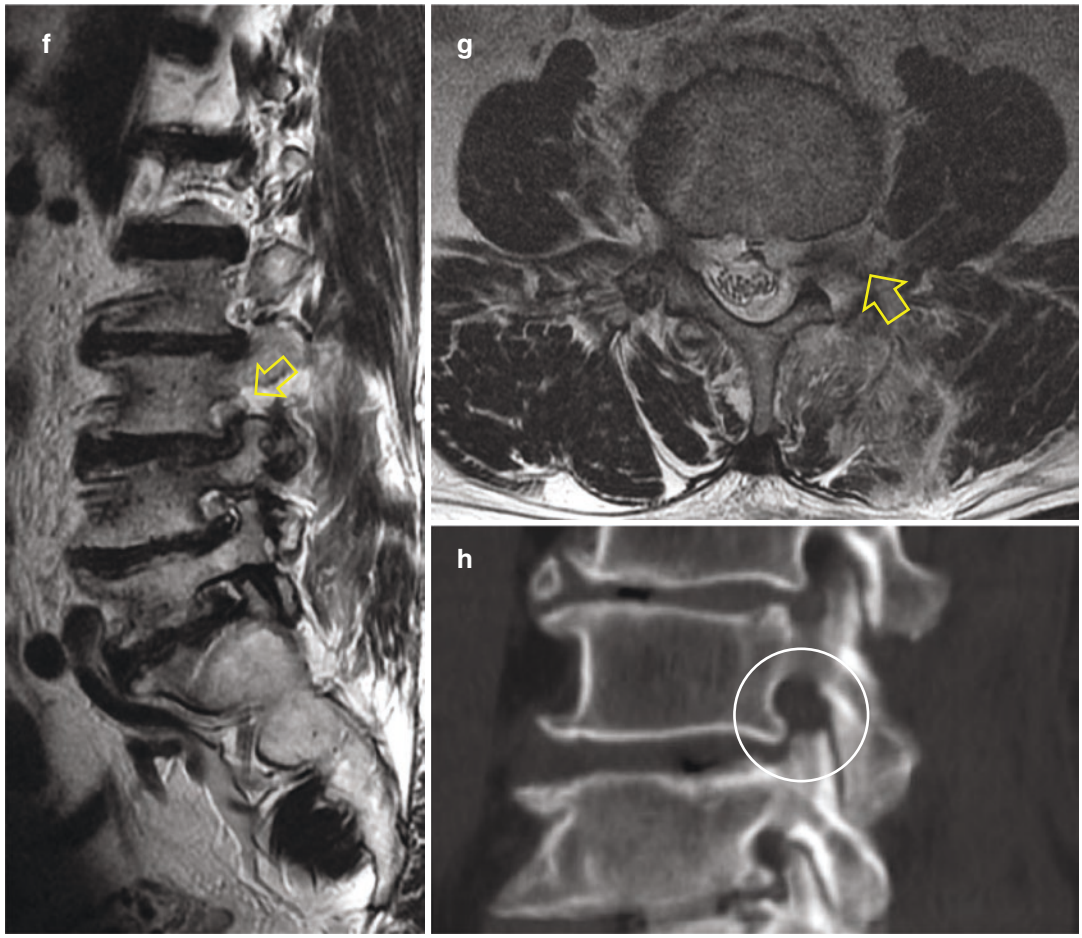

Fig. 9.8 (continued)

sia. Under the endoscope, the neural foramen was compromised, due to a bulging disc and hypertrophy of the foraminal ligament (Fig. 9.10d).

The postoperative MRI and CT scan confirmed that the right L5-S1 foramen was sufficiently decompressed (Fig. 9.10e–g). After surgery, his symptom was improved, and the abnormal gait was recovered immediately.

9.6 Complications and Their Management

9.6.1 Bleeding

Occasionally, radicular arterial bleeding can create many difficulties in performing surgery by obscuring the endoscopic visual field due to massive bleeding. The best way is to coagulate the small vessels using the RF wand before bleeding occurs. The alternative hemostatic technique is to ligate the small vessels using a vessel clip.

If bleeding is so severe as to interfere with the surgery, the scope can be advanced as close as possible toward the possible bleeding focus, and the water pressure temporarily increased to wash out the bleeding, find the bleeding focus, and coagulate the bleeding using a small size RF wand (Video 9.5).

Bleeding from the laminotomy surface can be effectively controlled using bone wax. After the surgery, a suction drain tube is mandatory to drain out the oozing from the perineural plexus and muscles, to prevent epidural hematoma.

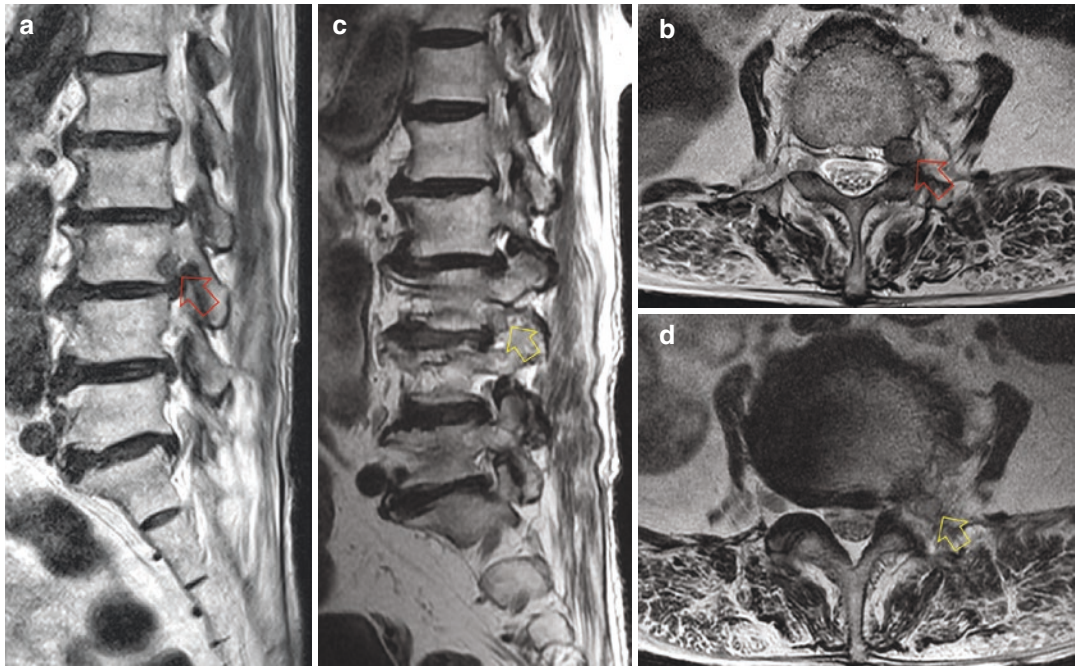

Fig. 9.9 Case 3. The preoperative left para-sagittal T2 weighted MRI (**a**) and T2 weighted MR axial image (**b**) reveal the up-migrated disc herniation at the left foraminal L3–4 level (red open arrows). The postoperative left para-sagittal (**c**) and axial T2 weighted MRI (**d**) show that even though the disc has been removed, the left L3 exiting root is still swollen (yellow open arrows)

9.6.2 Dural Tear/Root Irritation

Dura tear is not a common complication, because the surgery is performed around the exiting root. Rather, postoperative numbness and paresthesia may occur due to excessive manipulation of the root, especially when the operation is done around the dorsal root ganglion. Therefore, this problem can be prevented by gentle manipulation of the root.

9.7 Surgical Tips and Pitfalls

There are several surgical technical tips and tricks.

First, if the anatomy is confusing, discography can be helpful.

Second, make the approaching angle of the endoscope and instrument 30 degrees to 40 degrees. So, portal incision must be made on the lateral tip of the lower and upper transverse process.

Third, the cranial tip of the SAP can be removed to provide space for additional bone working.

Fourth, when performing partial resection of the SAP tip, the scope retractor is useful for protecting the exiting root.

Fifth, some surgeons do not perform enough SAP resection, because they worry that excessive removal of SAP may predispose them to instability. However, this may result in insufficient neural decompression with persistent symptoms. According to biomechanical studies, less than 75% resection does not induce segmental instability [8, 9]. Because of subsequent articular regeneration, the importance of sufficient neural decompression should over-weigh preserving the integrity of the facet joint.

Finally, radicular artery ligation is needed to maintain a clear operative view.

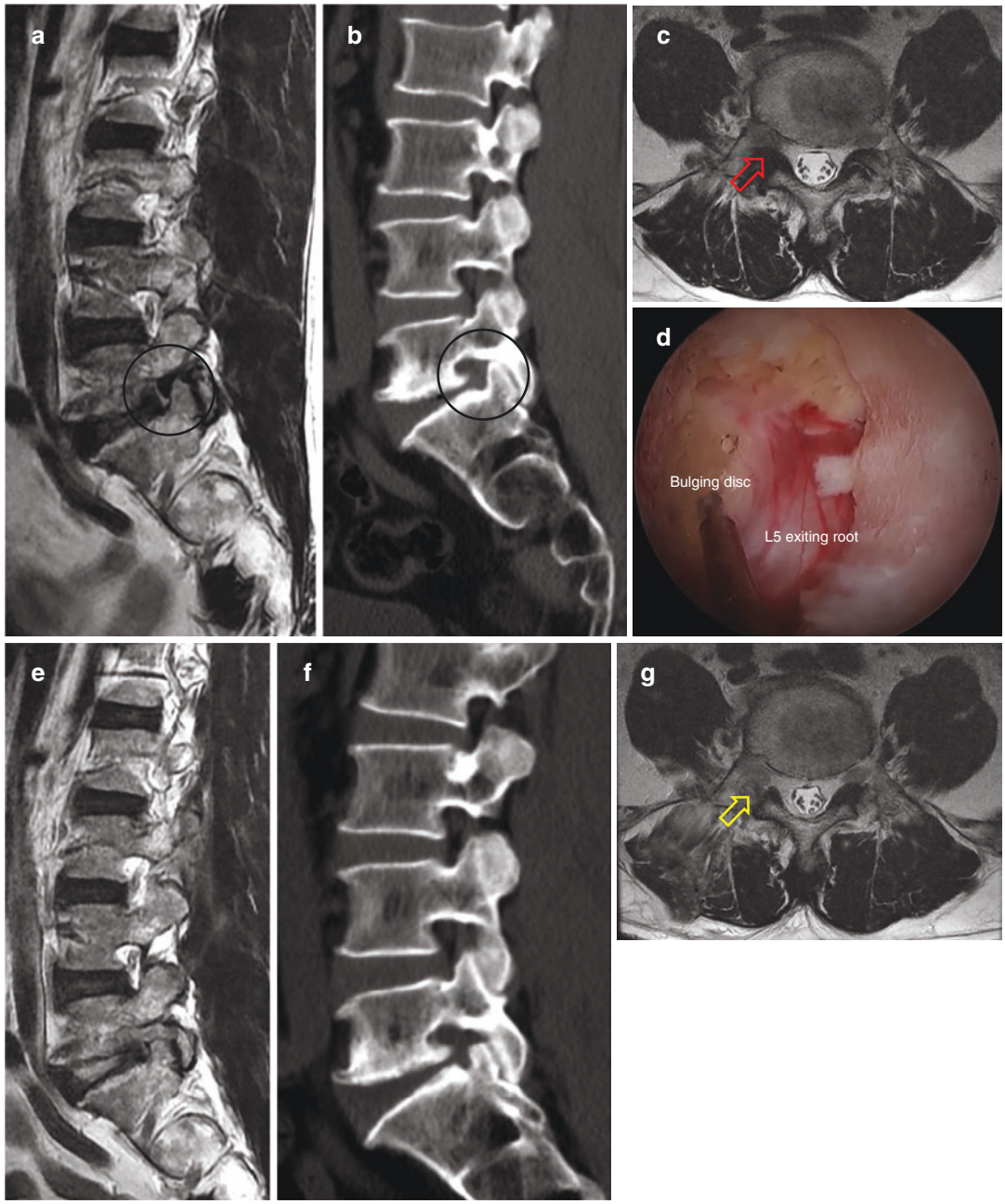

Fig. 9.10 Case 4. The preoperative right para-sagittal T2 weighted MRI (**a**) and CT scan (**b**) reveal the right side foraminal stenosis at the L5–S1 level (black circles). The preoperative T2 weighted MR axial image (**c**) shows the hypertrophic foraminal ligament around the right L5 exiting root (red open arrow). The intraoperative endoscopic view shows the decompressed L5 exiting nerve root and annuloplasty in the bulging disc (**d**). The postoperative right para-sagittal (**e**) and CT scan (**f**) show that the foraminal ligament is removed (white circle) and the tip of SAP is partially resected (yellow dashed circle). The postoperative T2 weighted MR axial image (**g**) reveals the decompression around the right L5 exiting nerve root after the foraminal ligament is removed (yellow open arrow)

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