Chapter 14
Unilateral Biportal Endoscopy for Complex Lumbar Disc Herniations

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Abbreviations

CLA	Contralateral approach
Cs	Central space
E-Fo	Extraforaminal
FLA	Far-lateral approach
Fo	Foraminal
IPA	Ipsilateral posterolateral approach
LBP	Lower back pain
LDH	Lumbar disc herniation
LR	Lateral recess
MRI	Magnetic resonance imaging
MSU	Michigan State University
NR	Nerve root
PC	Paracentral
PELD	Percutaneous endoscopic lumbar discectomy
RF	Radiofrequency
SAP	Superior articular process
UBE	Unilateral biportal endoscopy

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Introduction

Herniation of the nucleus pulposus into or through the annulus fibrosus is a well-recognized cause of lower back pain (LBP) and sciatica. The surgery goal is to identify the lumbar disc fragment and remove it with as minor damage to surrounding structures as possible. The spectrum of endoscopic discectomy is expanding gradually, with some past contraindications now becoming indications [1, 2].

Before starting with the development of the chapter, the reader should know what we consider to be "complex" lumbar disc herniation. It means that there are "simple" herniated discs, which is a big mistake. Lumbar disc herniation can be the most straightforward spinal surgery or the most complex one, even worse than a fusion. Locating the lumbar disc herniation (LDH) position is critical to selecting the appropriate surgical technique. Numerous classifications have been proposed to estimate the difficulty in axial and sagittal planes. For all these reasons, we will define the main factors contributing to LDH surgery's complexity and how to solve it through biportal endoscopic surgery.

Preoperative Planning

When we are planning the surgical procedure in our patients with LDH, we must take into account four critical factors:

Sagittal Migration

The most widely used classification in a sagittal plane is the Lee modified [3]. This one includes seven zones (Fig. 14.1 and Table 14.1):

- "Zero" zone represents "non-migrated" LHD.
- "Low-grade" migrated LDH refers to disc migration limited to the line 3 mm below the inferior margin of the upper pedicle (rostral) or the line of the middle of the lower pedicle (caudal) from the disc margin.
- "High-grade" migrated LDH refers to disc migration beyond the reference line in either the rostral or the caudal direction.
- "Very-high-grade" migrated LDH refers to disc migration that extends beyond the inferior margin of the pedicle in either the rostral or the caudal direction.

UBE could be used to remove all types of migrated intervertebral disc herniation [4, 5].

In 2018, Kim et al. tried to determine the degree of difficulty in treating a lumbar disc herniation from the point of view of full-endoscopic surgery. Unfortunately, this level of complexity was aimed at the full-endoscopic approach. It cannot be

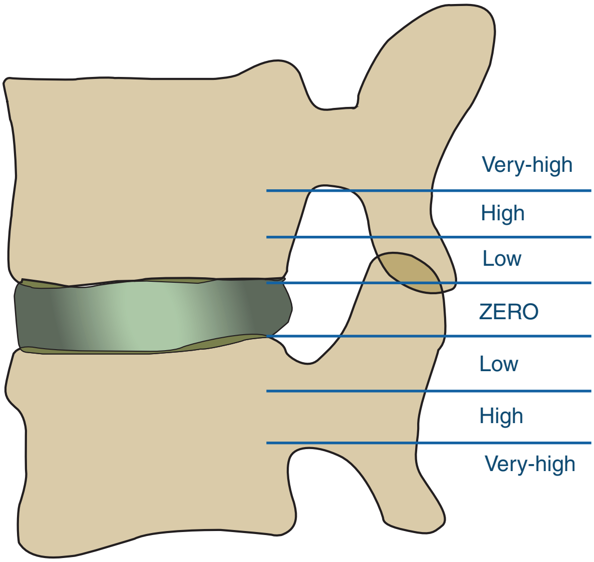

Fig. 14.1 Schematic representation of disc herniation. The direction and degree of migration of herniated discs are divided into seven zones

Table 14.1 Classification of the LDH in the sagittal plane

Degree/direction	Range of migration distance
Very high/upward	From the inferior margin of the upper pedicle
High/upward	From the inferior margin of the upper pedicle to 3 mm below the inferior margin of the upper pedicle
Low/upward	From 3 mm below the inferior margin of the upper pedicle to the superior disc margin
Non-migrated	From the superior disc margin to the inferior disc margin
Low/downward	From the inferior disc margin to the middle of the lower pedicle
High/downward	From the middle of the lower pedicle to the inferior margin of the lower pedicle
Very high/ downward	Beyond the inferior margin of the lower pedicle

extrapolated to biportal surgery since, for example, the "low-grade" downward migration is considered in this study to be of moderate difficulty for PELD, whereas with the biportal technique, the complexity is less [6]. We can assume that any herniated disc presenting as high or very high grade is "complex" LDH for UBE.

Axial Location

Based on the axial MRI, Michigan State University (MSU) classification can be used to precisely position the LDH in the axial plane (Fig. 14.2). To classify the location of the herniated disc, this group places three points along the intrafacet line,

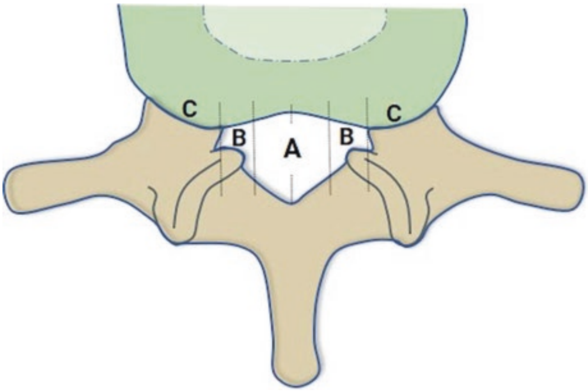

Fig. 14.2 MSU classification in axial MRI

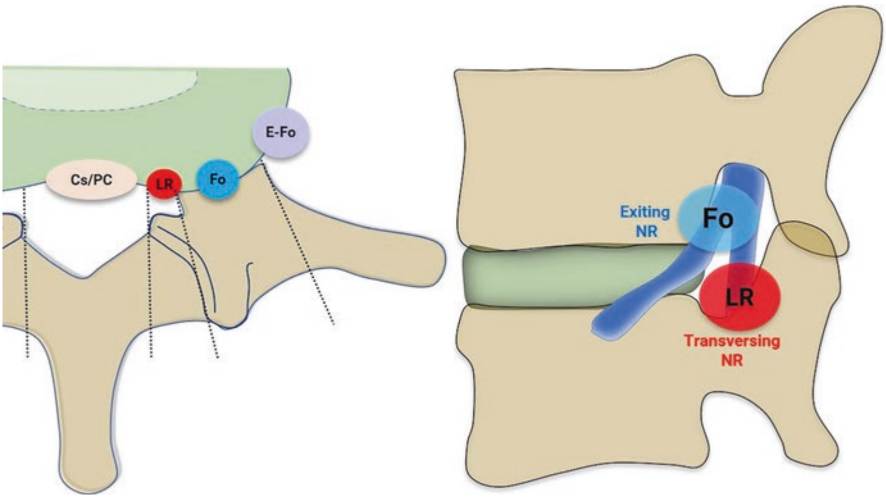

Fig. 14.3 Classical classification of the LHD (left) and the difference between lateral recess and foraminal disc herniation (right). *Cs* central space, *PC* paracentral, *LR* lateral recess, *Fo* foraminal, *E-Fo* extraforaminal, *NR* nerve root

dividing it into four equal quarters [7, 8]. The left and right center quadrants represent zone A (central). The right and left lateral quadrants are zone B (lateral). A third zone C is represented at the level of the foramen by the area that extends beyond the medial margin of any facet joint, beyond the limit of the lateral quadrants. It is there, where the hernia extends into the intraforaminal space and beyond to the right and left sides, that the injury is traditionally known as the far lateral.

Unfortunately, most spine surgeons have not adopted this radiological classification. Instead, they prefer the classical nomenclature where herniated discs can be classified as central/paracentral, lateral recess, foraminal, and extraforaminal (Fig. 14.3) [9], where the main difficulty is in differentiating hernias located in the lateral recess (traversing NR clinic) from those found in the foramen (exiting NR clinic).

As will be discussed in the next section, these four areas in the axial plane allow us to plan the surgery with more precision; that is, if it is central/paracentral hernia or lateral recess (LR), an ipsilateral posterolateral approach (IPA) is indicated. While if the disc fragment is in the foramen, a good option is to perform a contralateral approach (CLA), especially if it is associated with central canal stenosis. Finally, the best suggestion is the far-lateral approach (FLA) if the herniated disc is extraforaminal.

Size and Consistency

The size and location of disc herniation are measured at the level of maximal extrusion in reference to a single intrafacet line drawn transversely across the lumbar canal, to and from the medial edges of the right and left facet joint articulations (Fig. 14.4). To represent the size of the herniated disc, the lesion is described as 1, 2, or 3. The intrafacet line determines whether the herniated disc extends to or less than 50% of the distance from the posterior aspect non-herniated from the disc to the intrafacet line (size 1), or more than 50% of that distance (size 2). If the hernia extends completely beyond the intrafacet line, it is called a size 3 disc [7]. It is important to note that the size of the LDH is not always associated with consistency. It has smooth LDHs that are technically easy to remove even when they are large (size 3), while smaller and generally long-term ones can be difficult to operate. Calcified lumbar disc herniation is a subtype of herniation, probably secondary to a longer course of the disease, changes in the development of the nucleus pulposus, and unknown triggers such as infections and microtrauma. Adhesion between calcification and nerve root or dura increases the surgical difficulty and can cause iatrogenic injuries, such as nerve root injury, dural tear, or both.

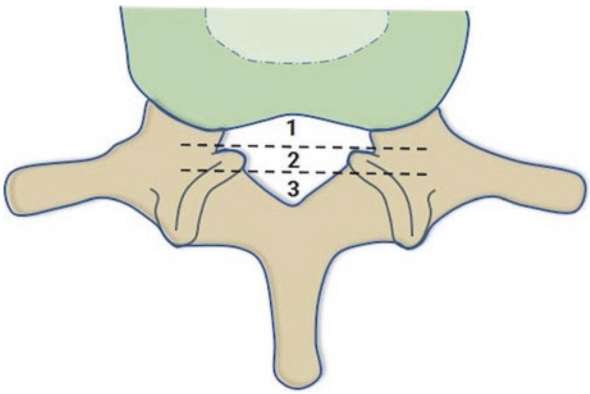

Fig. 14.4 Grading the disc herniation for size

Level

Most LDHs occur in the lower lumbar spine at the L4–L5 and L5–S1 (90–97%). The term upper LDH is not as uniformly defined. Some authors consider the term to include LDH at L1–L2, L2–L3, and L3–L4. However, others consider the term to refer to LDH occurring only at L1–L2 and L2–L3. We know that the postoperative outcomes for LDH at L3–L4 are significantly better than those occurring at L1–L2 and L2–L3 [10]. Furthermore, the anatomic characteristics of LDH at L3–L4 are more similar to those of the lower lumbar spine.

Compared with the lower lumbar spine facets, the upper facets are significantly more parallel to the midsagittal plane. This poses several surgical challenges in performing an ipsilateral endoscopic lumbar discectomy for paracentral and central LDH effectively and safely while preserving the integrity of the pars interarticularis and facet joints. This disparity is likely due to reduced motion and stress at the upper lumbar spine than the lower lumbar spine.

In addition, the upper spine has special anatomical features, including a narrow spinal canal, short nerve roots, and less distance between the dura and nerve roots (Fig. 14.5). Furthermore, the conventional posterior approach for a lumbar

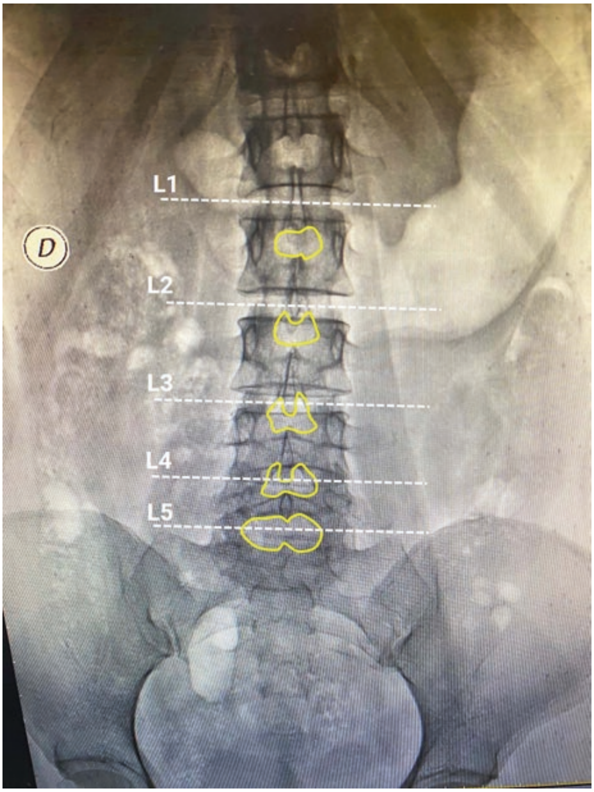

Fig. 14.5 Lumbar AP view. Note the location of the lumbar disc regarding the interlaminar space. In the upper lumbar disc, the window is smaller and the disc is higher regarding the spinolaminar junction

discectomy provides only limited surgical exposure in the upper lumbar spine. Performing a discectomy in such a narrow surgical field can result in over-retraction on the thecal sac and places the neural elements at an increased risk of injury. Alternatively, a near-complete facetectomy and possible pars interarticularis resection are required to obtain adequate bony exposure to safely perform an upper lumbar discectomy with a conventional posterior approach. There are no long-term studies on spinal fusion rates required following conventional ipsilateral open or endoscopic lumbar discectomy. However, as shown in reports performing a complete facetectomy or possible pars resection, or both, an upper lumbar discectomy theoretically accelerates spinal instability and likely requires a lumbar fusion surgery.

Surgical Technique

Anesthesia and Position

The physician can select local, spinal, and general anesthesia. For many years, the benefits of using local/epidural anesthesia to maintain patient collaboration have been published; however, in our experience, the complications associated with general anesthesia every day are less even in elderly patients. Remember that lumbar disc herniation will be one of your first procedures to perform UBE, and since the learning curve is not short, we strongly recommend using general anesthesia; if your patient is calm, you will be relaxed.

The prone position on a radiolucent table and Wilson frame is the gold standard position. C-arm fluoroscopy and a monitor for endoscopy were located at the contralateral side of the surgeon (remember that you will need an AP projection more frequently than in open surgery). A Wilson frame is recommendable because it induces distraction of the interlaminar space and makes a better view. To reduce brain complications associated with continuous saline irrigation, we recommend keeping the patient's head slightly above the lumbar spine (Fig. 14.6).

Surgical Steps

Unilateral biportal spine surgery can be performed using three different approaches:

1. The ipsilateral posterior approach (IPA) or paramedian is a good and formal way to perform an ipsilateral discectomy with or without bilateral decompression of the lateral recess stenosis (Fig. 14.7).

Fig. 14.6 OR setting. The C-arm and endoscopic tower are in front of the surgeon

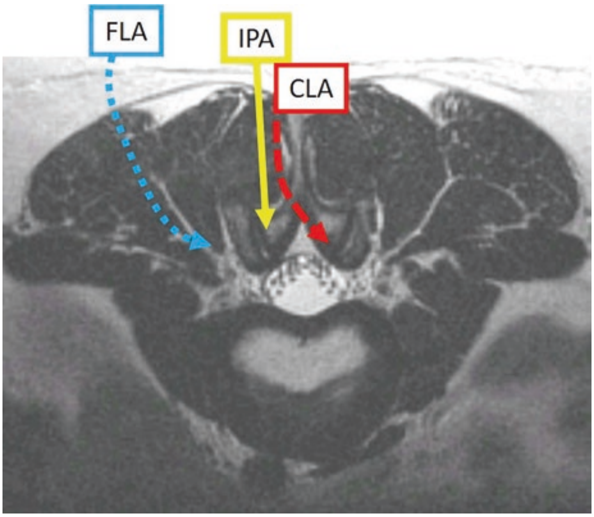

Fig. 14.7 Different biportal approaches to LDH. *CLA* contralateral approach, *FLA* far-lateral approach, *IPA* ipsilateral posterolateral approach

2. The contralateral approach (CLA) is an excellent option to decompress a foraminal disc herniation, especially in the upper lumbar space, to reduce the risk of postoperative instability.
3. The far-lateral approach (FLA) or paraspinal is the treatment of choice for foraminal LDH, especially those located in the extraforaminal area.

Skin Marking

Under fluoroscopic imaging, getting the "true" AP image of the target level (your C-arm not tilted) is very important (Fig. 14.8). Check the locations of two portals using the lateral C-arm fluoroscopic view. In the AP view, draw two lines, one in the midline coinciding with the spinous processes and the second as the

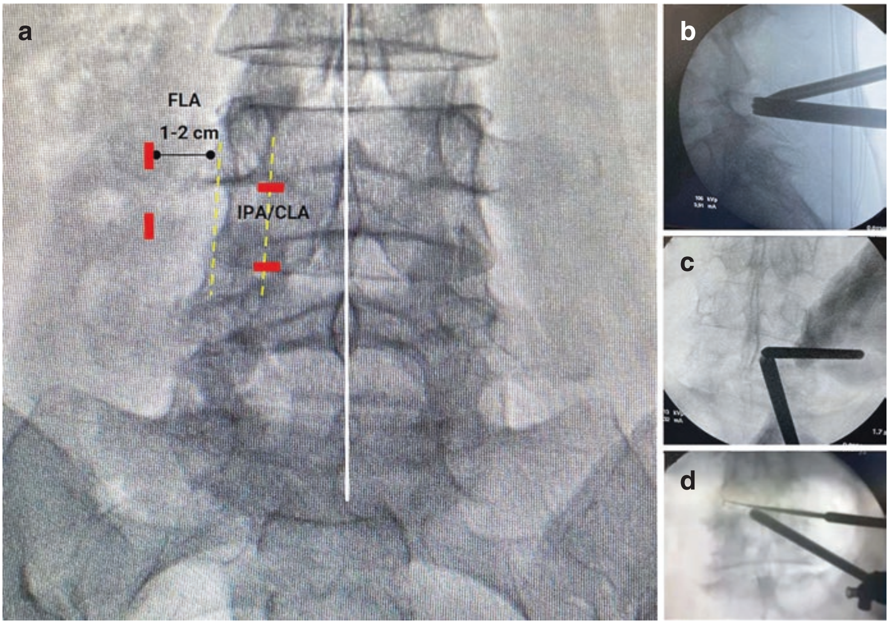

Fig. 14.8 The skin incision should be planned with the AP view of your C-arm (**a**), verify its correct trajectory in the lateral view (**b**, **c**), and carry out controls throughout the surgery, especially when performing a contralateral approach (**d**)

mid-interpedicular line. The third line is perpendicular to the previous ones at the disk level.

A viewing portal is made at 1 cm cranially, and the working portal can be set at 1 cm caudally from mid-intervertebral disc space. You can make vertical or horizontal incisions. In your first cases, the vertical incisions allow you to join both incisions if you need to transform the surgery into an open procedure. When planning an IPA or CLA technique, the two portals are located close to the midline to reach the ipsilateral or the contralateral spinal canal without or with a bit of bone resection as possible. For an FLA, the incision should be made 2 cm lateral to the outer margin of the pedicle to reduce the risk of damage to the lateral wall of the facet (Fig. 14.8). Incision of the portals is performed through penetration of skin and fascia. The fascia incision should be in the form of a cross for easy flow out of irrigation fluid and convenient use of instruments.

Making Working Space and Triangulation

First, we recommend introducing the dilators through the working portal for a craniocaudal disinsertion movement of the multifidus muscle until the spinolaminar angle is located. Next, make the viewing channel and begin irrigation; remember that to have a good vision, the inlet pressure of the irrigation is not so important (we usually use gravity) but a correct outflow through the work port; this allows a constant flow of saline solution and maintains the surgical view clear. To do the initial successful workspace, two distal portals at the endpoints must be found only in the laminar. This concept of "triangulation" has been conditioned by the distance between the incisions (Fig. 14.9). If you make incisions too far apart, it is very likely that you will not see your instruments, while if you make incisions too close together, your instruments get blocked (fighting for space), having to remove the scope to be able to insert the dissector.

Hemilaminectomy is performed using high-speed burr, Kerrison punch, or osteotome. The bone removal begins from the spinolaminar junction and the lower portion of the lamina of the superior vertebra until detaching the superior margin of the flavum ligament. The flavum ligament consists of a superficial layer and a deep layer. The lower portion of the deep layer attaches to the anterosuperior surface of

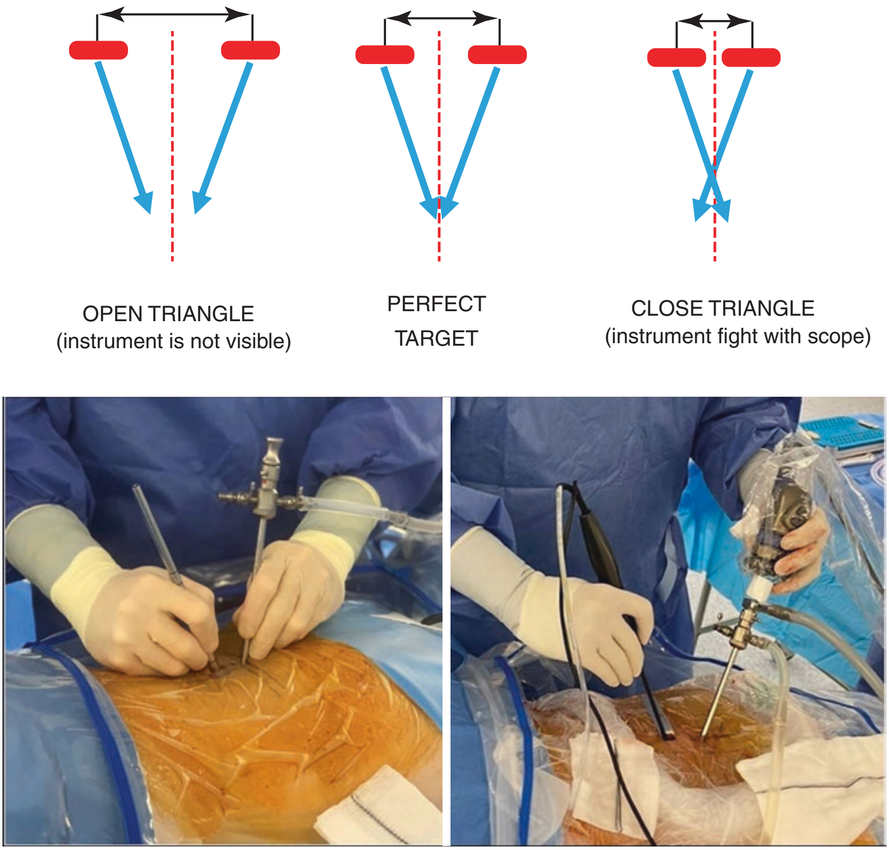

Fig. 14.9 Schematic illustration of the most common failures during instrument triangulation. Before introducing the endoscopy, you should check that the tips of your instruments are at the level of the desired surgical field

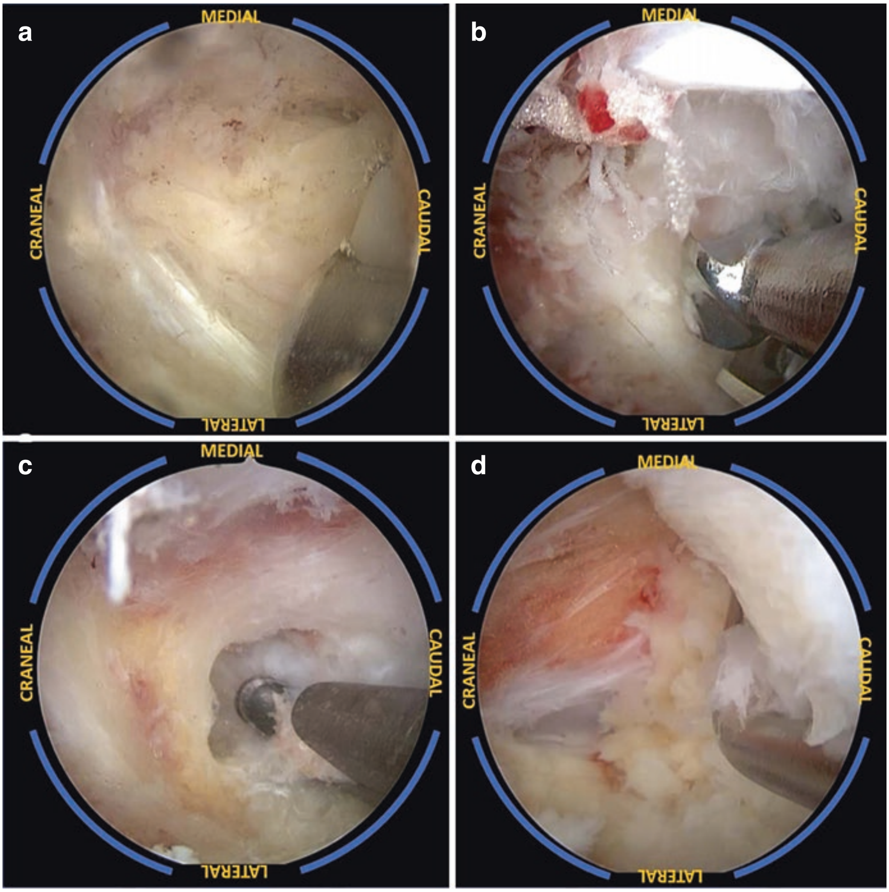

Fig. 14.10 Intraoperative endoscopic images. The initial target must be in a spinolaminar junction (**a**), and then you can drill (**b**) or bite with K-punch the upper lamina (**c**) until the flavum ligament is detached (**d**)

the caudal lamina (Fig. 14.10). The flavectomy is undergone from cranial to caudal and medial to lateral. The flavum ligament was carefully dissected and completely resected.

Discectomy

Once a bloodless field of operation is achieved (sometimes part of the epidural fatty tissue has to be removed), consider the LDH location if it is in the axilla or the shoulder of the nerve root. After gently retracting the nerve root medially, the extruded or sequestrated disc fragments are identified, and 2 mm pituitary forceps help you remove easily (Fig. 14.11). The physician should inspect the operating field entirely. Any remnant disc fragment or residual debris should be removed absolutely from the intracanal space.

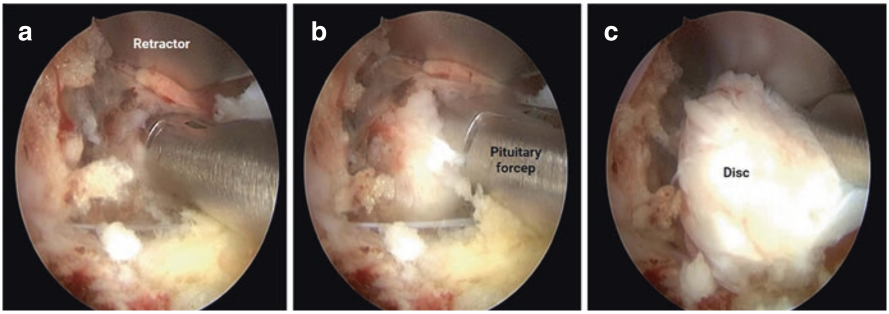

Fig. 14.11 Sequential endoscopic imaging during disc fragment removal (**a**–**c**)

Close and End the Procedure

Usually, before the surgery ends, we close the irrigation to detect bleeding that has gone unnoticed previously. Bleeding control is achieved using the RF and bone wax. If the surgical field is clear, we usually do not leave lumbar drainage unless a major laminectomy has been performed. Finally, we suture with stitches in a single plane. Patients are monitored 24 h after surgery for any complications.

Illustrated Cases

Case 1: L3–L4 High-Grade Migrated Hernia with Multilevel Canal Stenosis
A 67-year-old man has complained of severe back pain and bilateral sciatic pain 10 years prior. The last month presents a progressive worsening. MRI revealed multilevel canal stenosis (L2–L3, L3–L4, L4–L5) and a left high-grade upward migrated herniation on the L3–L4 level. We performed biportal endoscopic "over-the-top" decompression on L3–L4, and the disc fragment was removed ipsilaterally. Finally, we completed the decompression with a UBE on L2–L3 and L4–L5 levels. MRI showed multilevel well decompression and hernia resection (Fig. 14.12 and Video 14.1).

Case 2: L4–L5 Very-High-Grade Migrated Hernia with L4–L5 Disc Collapse
A 61-year-old man presented with progressively worsening back and right leg pain from 5 months before visiting. MRI revealed the very-high-grade downward migrated herniation at the L4–L5 level. The L4–L5 disc showed severe degenerative change with collapse of the disc space. We performed biportal endoscopic discectomy by IPA approach and completed the procedure with OLIF fusion (oblique lateral lumbar interbody fusion) (Fig. 14.13 and Video 14.2).

Case 3: Extraforaminal L2–L3 Disc Herniation
A 55-year-old man presented lower back pain (LBP) and 2 months of right radicular leg pain in the L2 dermatome. Preoperative MRI demonstrated an intra- and extraforaminal herniation at the right L2–L3 level. Therefore, we performed discectomy using the FLA approach associated with foraminoplasty, which means resecting the

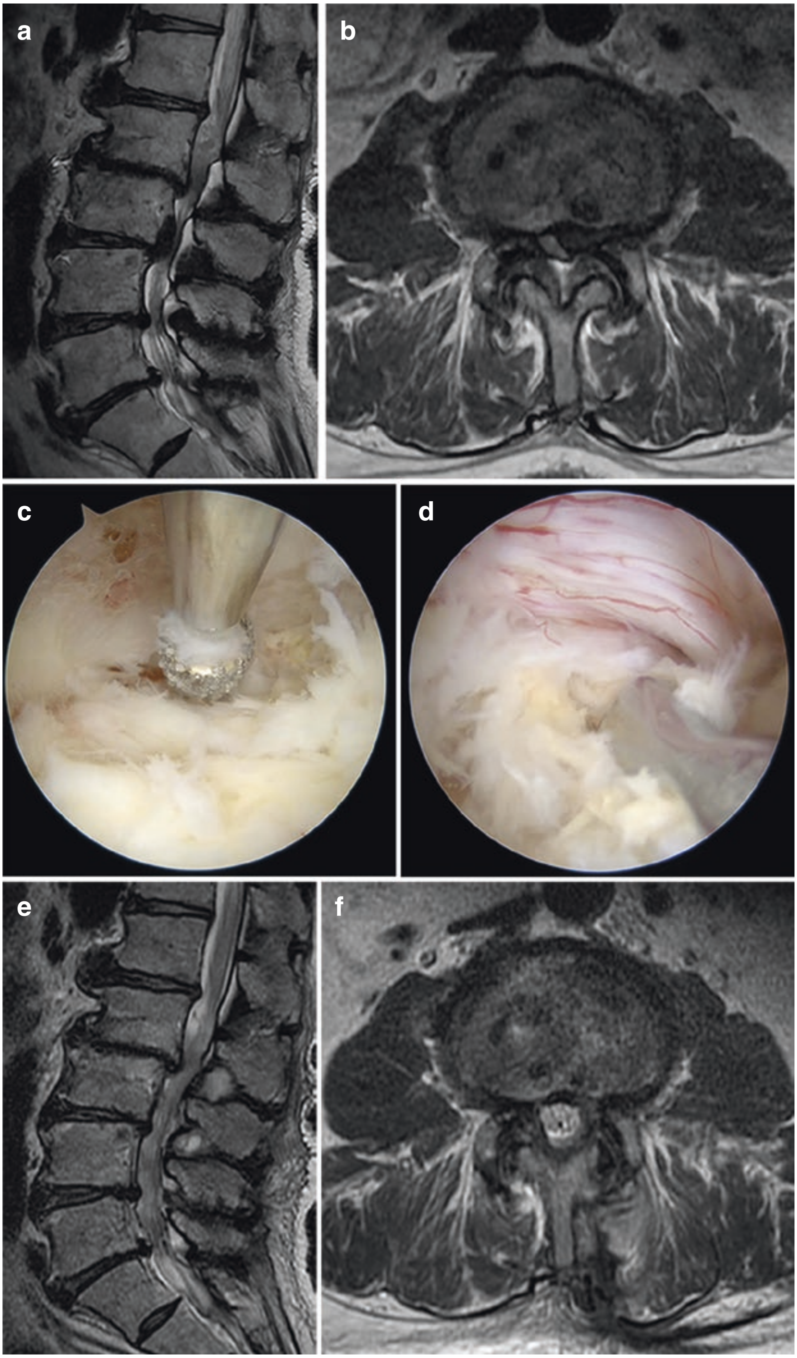

Fig. 14.12 Case 1. Preoperative T2-weighted images show multilevel lumbar spinal stenosis (**a**) and left high-grade upward-migrated L3–L4 herniation (**b**). Intraoperative endoscopic images show the contralateral decompression (**c**) and ipsilateral discectomy (**d**). Postoperative MRI demonstrated complete decompression and hernia fragment resection at L3–L4 on sagittal (**e**) and axial (**f**) views

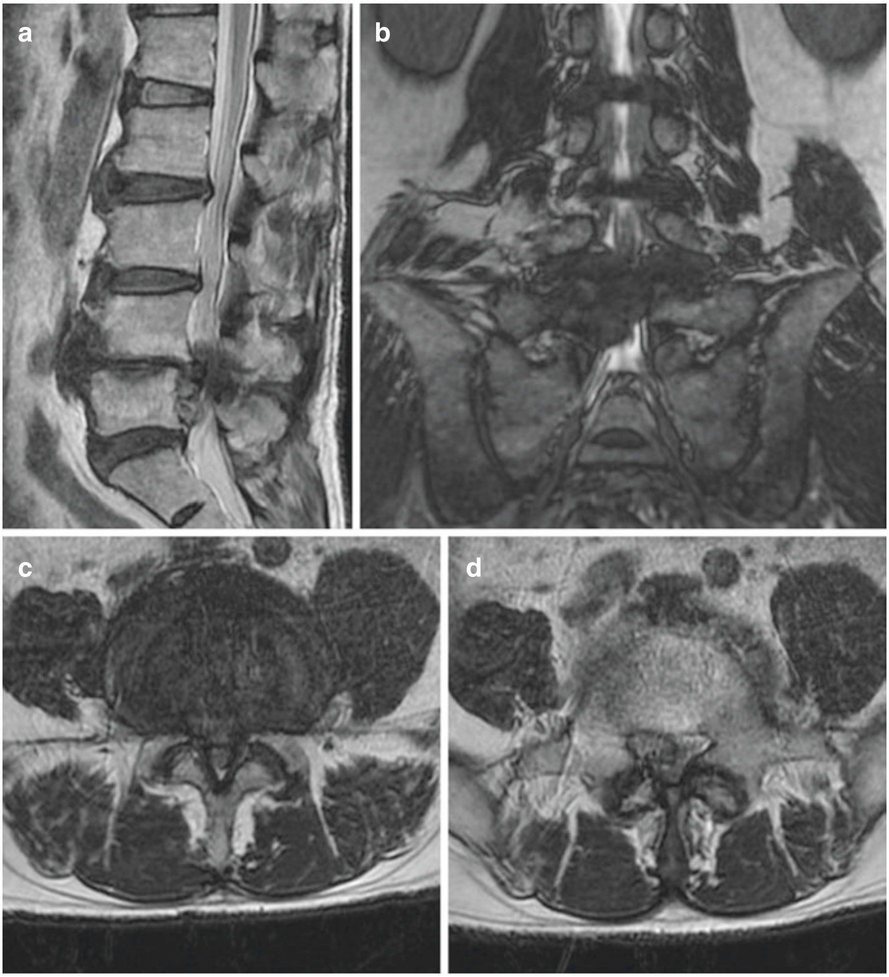

Fig. 14.13 Case 2. Preoperative T2-weighted images show a very-high-grade downward-migrated large herniation at the L4–L5 level on the sagittal (**a**) and coronal (**b**) views. The axial views of MRI show a disc herniation migrated from the L4–L5 (**c**) disc level to the parapedicular space at L5 (**d**). An intraoperative endoscopic image shows disc fragments in the shoulder (**e**) and axilla (**f**) of the L5 nerve root. Decompression was completed with an oblique lateral lumbar interbody fusion for stabilizing the segment (**g**, **h**)

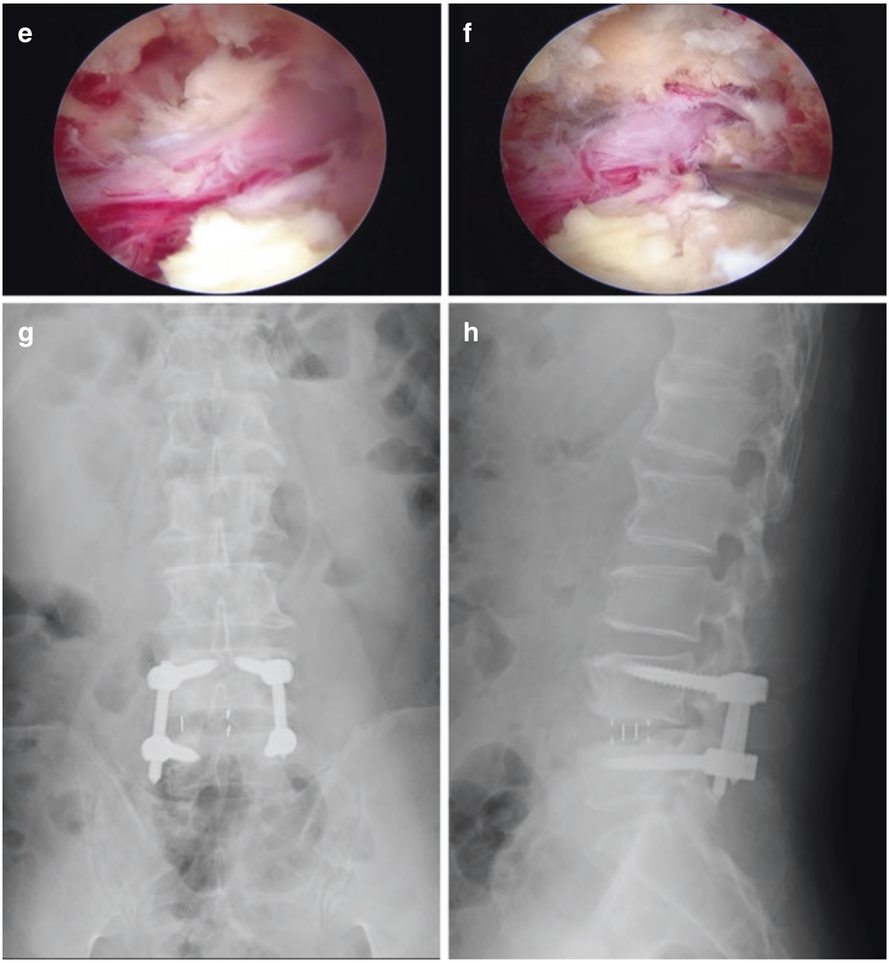

Fig. 14.13 (continued)

ventral part of SAP (superior articular process). Postoperative MRI revealed total removal of herniation (Fig. 14.14 and Video 14.3).

Case 4: Multiple Lumbar Discs: Right L2–L3 and Left L3–L4
A 70-year-old man presented LBP with left anterior thigh pain. The patient's symptom was mild, and he hoped for conservative treatment. However, a month after starting symptomatic therapy, he complained of another pain on the opposite thigh. MRI demonstrated a right low-grade upward migrated herniation at the L2–L3 level, and a left-side very-high-grade upward migrated herniation at the L3–L4 level. Therefore, we performed the endoscopic herniotomy by IPA for both levels. After surgery, the patient recovered from both legs' pain. Postoperative MRI revealed complete removal of HLD at L2–L3 and L3–L4 (Fig. 14.15 and Video 14.4).

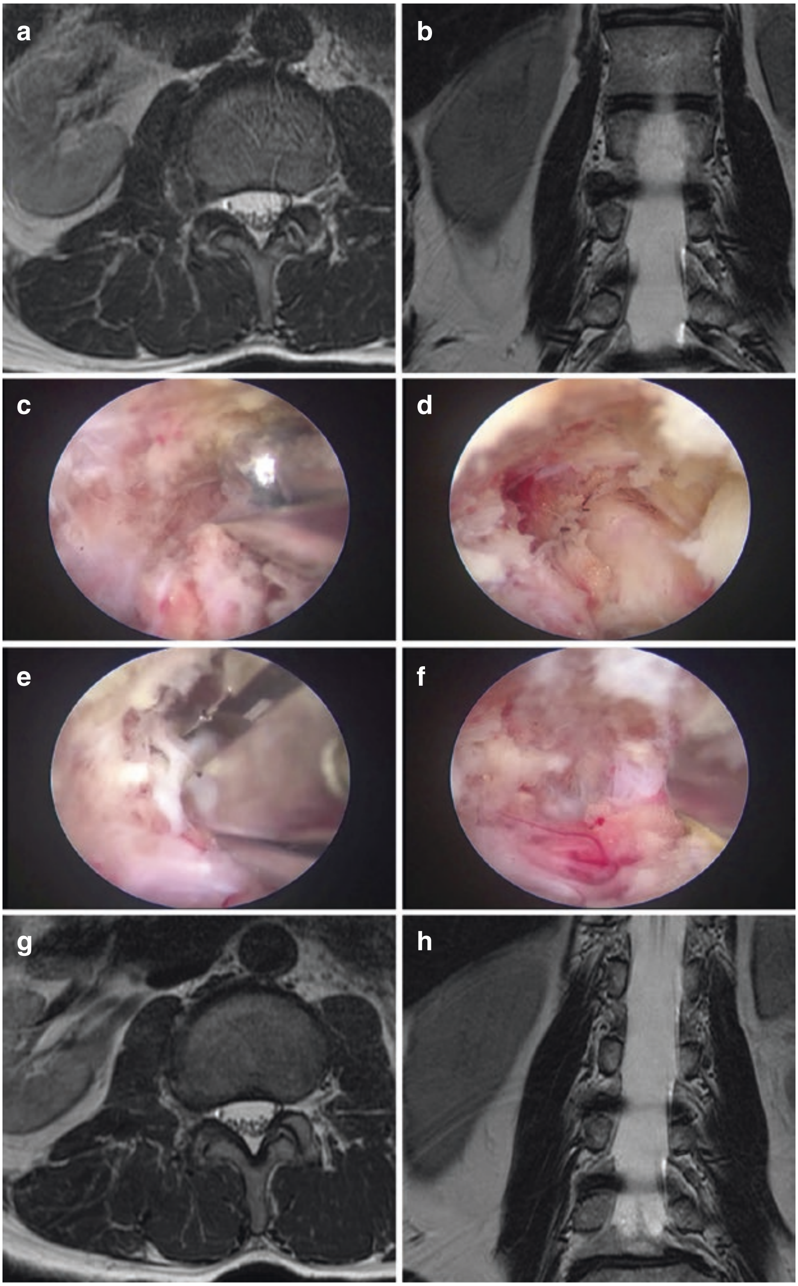

Fig. 14.14 Case 3. Preoperative axial (**a**) and coronal (**b**) T2-weighted images showing an extra- and intraforaminal herniation at L2–L3. Intraoperative endoscopic images show the foraminoplasty to reach the disc (**c**). A bulging disc can be observed (**d**). Disc removal (**e**). Foraminal decompression achieved (**f**). Postoperative MRI in axial (**g**) and coronal (**h**) T2-weighted views showing complete removal of the disc herniation

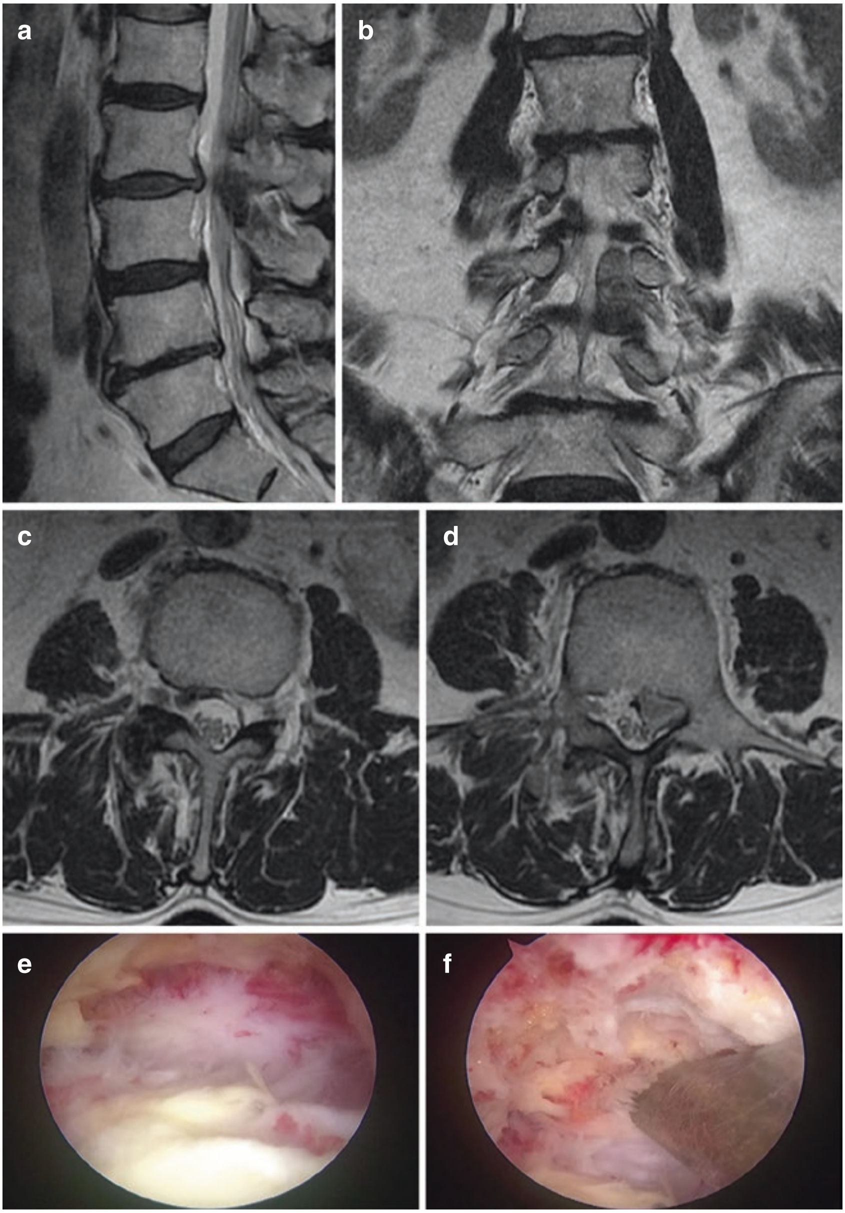

Fig. 14.15 Case 4. Preoperative T2-weighted images show low-grade upward-migrated L2–L3 herniation at the right side and high-grade upward-migrated herniation at the opposite side of one level below (**a**–**d**). Intraoperative photographs demonstrate L2–L3 herniotomy. The first intraoperative view uses 0° endoscopy, and the herniation is hidden behind the lamina and yellow ligament (**e**). In the second view, the hernia is revealed by using a 30° angled endoscope (**f**). The postoperative axial T2-weighted image shows complete removal of the herniations (**g**, **h**). Postoperative computed tomography image shows adequate laminectomy to get enough space for herniotomy while preserving the facet (**i**)

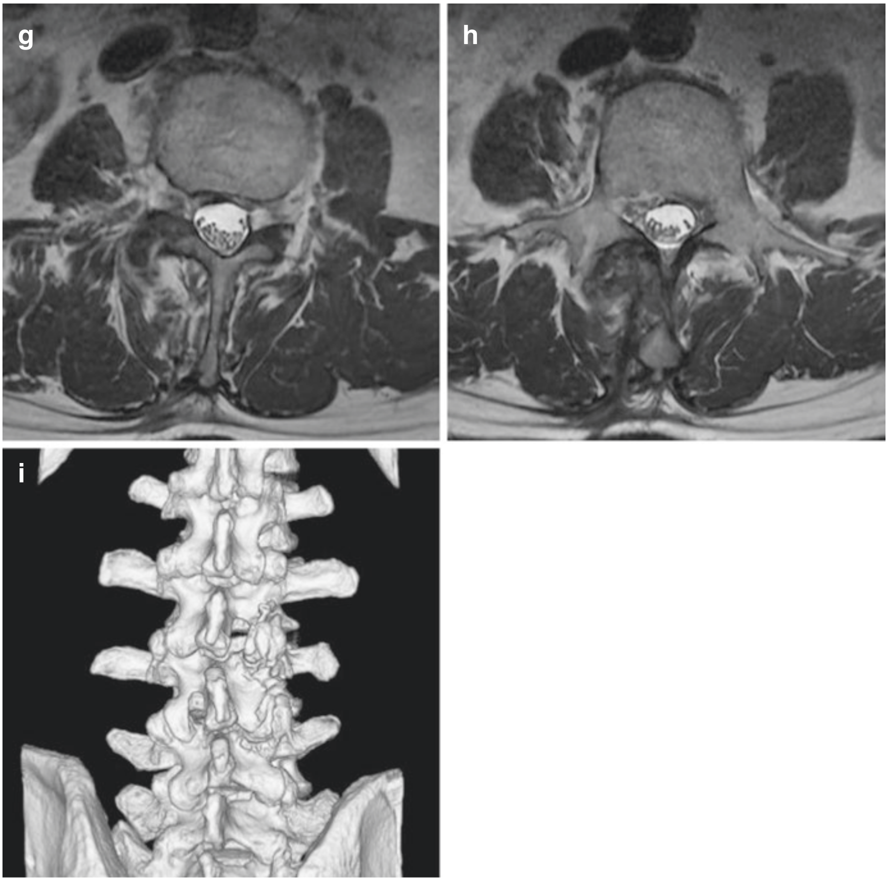

Fig. 14.15 (continued)

Discussion

Biportal endoscopic discectomy showed satisfactory clinical outcomes in all types of LDH and specialty in high-grade migrated disc herniations without increasing operation time [1, 2]. By using two portals, free movement, handling, and angulation of the surgical instruments and the arthroscope are allowed independently without crowding of instruments. In addition, this technique provides technical flexibility with sufficient bony and soft-tissue work, comparable to conventional surgery. Continuous saline perfusion can control bleeding and reduce the risk of infection and dural tear by a slight compression of the dura mater by continuous saline perfusion.

How to Avoid Complications

The complications of biportal endoscopic discectomy are similar to those of microdiscectomy. Especially, dura injury, intraoperative bleeding, epidural hematoma, and residual disc fragment are serious perioperative complications.

Dural Tear

Like conventional spinal operation, incidental durotomy or dural injury may occur during endoscopic procedures. The dural tear usually occurs during the flavectomy. Meticulous dissection of the dura and ligament flavum is encouraged before a complete flavectomy. Direct dural repair may be challenging through an endoscopic procedure. Dura-sealing materials like TachoSil (Takeda Pharma) can treat small dural tears. In a water environment, the adherent property of TachoSil is maintained. Therefore, some pieces of TachoSil (Takeda Pharma) can be applied to the dural defect. Even with the fibrin sealant patch, 5–7 days of absolute bed rest is recommended. Significant dural defects should be treated by direct repair, including suture and sealing materials. The authors suggest that endoscopic surgery should convert to microsurgery.

Bleeding and Epidural Hematoma

Bleeding obstructs the intraoperative view and should be staunched as quickly as possible. In most cases, this can be adequately achieved by a radiofrequency (RF) probe. The bleeding sources during the procedure included articular arteries, cancellous bone, and epidural veins.

Arterial bleeding that comes from branches of the segmental artery can be observed during much of the approach. They are known as articular arteries. In most patients, three arteries can be seen:

1. The superior articular artery at 9 o'clock
2. The interarticular artery at 7 o'clock
3. The inferior articular artery at 5 o'clock (UBE from the left side)

Bleeding coming from cancellous bone can be blocked with bone wax. But saline with a lower temperature could be difficult if spreading into tiny bleeding foci. Sometimes with the RF device, it is enough to stop bone bleeding. In addition, the diamond tip of the endoscopic burr can be beneficial to stop bone bleeding due to the thermal effect while drilling.

Bleeding from small epidural vessels is more complicated. Sometimes, the vessels are too close to the dural surface to be separated, and we have to perform procedures with the blurred visual field. If possible, you would better control even small bleeding in every possible way. If the bleeding foci are discriminated against, they can be controlled by an RF-tiny probe set at the lowest generation level (level 1 coagulation). But it comes from the underside of the proximal lamina just after proximal flavectomy, the foci are covered, and it cannot be coagulated easily. Besides increasing the pressure of continuous saline irrigation and hemostatic agents such as Gelfoam® sponge or Floseal®, hemostatic matrix might also help protect visualization and hemostasis.

After removing the herniated disc, epidural bleeding should also be meticulously coagulated with a bipolar RF probe to avoid epidural hematoma. Although a postoperative epidural hematoma can occur like conventional spine surgery, the incidence of "symptomatic" epidural hematoma may be very low. Keeping of drainage catheter may be effective for the prevention of epidural hematoma.

Residual Fragment

Residual disc fragments were observed in 2.8–15% of patients in several studies in which immediate postoperative MRI was performed after discectomy [11]. Although many factors were proposed for these complications, migration grade and surgical experience were the most frequent risk factors. Although the presence of a residual disc fragment with persistent compression is one cause of redo surgery, not all residual disc fragments observed on immediate postoperative MRI are symptomatic. Residual disc fragments are not always associated with poor longitudinal clinical outcomes. When the sequestrated disc is a large and fragile fragment, the total removal of the disc may be difficult through the small surgical corridor. The main take-away message is that "wait and see" is a good strategy for asymptomatic patients, even with persistent compression by a mixed tissue with a residual disc, retained fluid, and edematous tissue. The authors strongly recommend immediate postoperative MRI in patients with partial or complete radicular pain after surgery.

Conclusions

Biportal endoscopic discectomy has satisfactory results in complex herniated discs. Therefore, biportal endoscopic spine surgery can effectively treat all types of lumbar disc herniation. However, carefully evaluating preoperative radiographic images is essential for patient selection, planning the correct approach, and preventing complications.

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