4 Unilateral Biportal Endoscopy for Herniated Lumbar Disc

Seung Kook Kim, Seong Yi, and Jeong Yoon Park

4.1 Introduction

Herniated lumbar disc (HLD) is a common cause of back and leg pain. The initial treatment for HLD is conservative and includes analgesics, physiotherapy, and epidural steroid injections. However, upon failure of conservative treatment, especially when neurological deficits are present with matched radiologic findings, discectomy can be considered [1]. Since 1970, microscopic laminectomy and disc removal have been the gold standard for HLD; however, over the last few years, the progress of endoscopic techniques with the development of new endoscopic instruments and video equipment has led to similar or superior outcomes to microscopic discectomy [2, 3].

Recently, unilateral biportal endoscopic (UBE) spine surgery has been introduced for various spinal diseases [4]. Unlike one-portal endoscopy, biportal endoscopic spinal surgery has a long and wide field of view and the axes and portals for the endoscope and surgical instruments are separated. Therefore, the instruments can be used over a relatively long distance and wide field of view, and this unique feature of the biportal endoscopy facilitates anatomical orientation and handling of instruments. In biportal endoscopic spine surgery, the endoscope and instrument angles are independent and separated, so that the instrument angle does not interfere with vision. In addition, conventional surgical instruments, such as drills and punches, can be used through a working portal. The ability to use conventional instruments has the advantage that the initial setting cost is lower than that in percutaneous one-portal endoscopic spine surgery. One of the main differences between biportal and one-portal endoscopic spine surgery is that various general surgical instruments can be used during the biportal procedure because of the independent working portal. Furthermore, UBE has advantages over the conventional approach in muscle preservation and bone manipulation [5]. To increase the understanding of the procedure, we describe the details below.

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S. K. Kim
Himchan Spine and Joint Centre, University Hospital Sharjah, Sharjah, United Arab Emirates

S. Yi
Department of Neurosurgery, Severance Hospital, Yonsei University College of Medicine, Seoul, South Korea

J. Y. Park (✉)
Department of Neurosurgery, The Spine and Spinal Cord Institute, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, South Korea
e-mail: spinepjy@yuhs.ac

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4.2 Indications and Contraindications

The indications of UBE for HLD are very similar to those of microscopic lumbar discectomy. All types of lumbar disc herniation including protrusion, extrusion, sequestration, and central, paracentral, foraminal, and extraforaminal disc herniations can be removed and decompressed with UBE. Recurrent and calcified disc herniation and cauda equina syndrome are also included in UBE indications [6, 7]. HLD with stenosis was previously considered a contraindication for endoscopic discectomy, but biportal endoscopic surgery can effectively achieve central decompression followed by additional discectomy, thus adding this diagnosis to the indications for biportal endoscopic discectomy [8].

4.3 Special Instruments

The surgical instruments are the same as in standard UBE stenosis decompression surgery. A standard conventional laminectomy set (pituitary forceps, punches, drill, hook, etc.), zero-degree endoscopy, radiofrequency device, and 3000 cc normal saline for continuous irrigation are essential. Additional angle endoscopic views such as 12° and 30° are helpful when a wider field of view is needed. Continuous saline flow is essential, and serial dilators (Fig. 4.1a), various working sheath (Fig. 4.1b), and scope retractor (Fig. 4.1c) are necessary for unimpeded saline flow. Because nerve protection is more important than simple decompression scope retractors (Fig. 4.1c) or assistant retractors (Fig. 4.1d) should be prepared. Various types of radiofrequency (RF) coagulators (Fig. 4.1e) for bleeding control, dissectors (Fig. 4.1f) for adhesiolysis, and variously angled osteotomes/chisels are necessary. A high-speed drill exclusively for endoscopy is helpful, but a conventional drill (such as Midas Rex®) is sufficient.

4.4 Anesthesia and Positioning of the Patient

Epidural, spinal, or general anesthesia can be selected depending on institutional policy and patient condition. The patient can be positioned either on the spine table or Wilson frame, while the C-arm is placed in the anteroposterior (AP) direction for level checking (Fig. 4.2a). A surgical drape is placed in a water-tight fashion and widely, at least 10 cm, apart from the incision site. Recently, a special drape for UBE has been developed and is convenient to use (Fig. 4.2b and c).

4.5 Surgical Steps

4.5.1 Skin Mark and Incision

The surgical level and landmarks are determined during fluoroscopy in the AP direction. The lateral direction can help in the final conformation and in lumbarization or sacralization cases. Generally, the instrumental portal is made on the disc level first, and then the scope portal is made 2.0–3.0 cm apart from the instrumental portal. However, in cases of obese patients, presence of high-level disc, or hyperlordosis this distance may need to be modified. The endoscopic portal is located 2.0–3.0 cm cranially for a left-sided approach and caudally for a right-sided approach (Fig. 4.3a and b), in the case of a right-handed surgeon. For sufficient internal discectomy, unlike simple ruptured particle removal, the instrumental portal should be decided carefully depending on the disc space angle. Preoperative radiologic images should be evaluated to determine this angle (Fig. 4.3a, b). Therefore, the instrumental portal is determined first and the scope portal is determined later. The two portals should be at least 2.0–3.0 cm apart to prevent interruption (Fig. 4.3c, d). Transverse or horizontal incisions are possible, and in the case of longitudinal incision, it is advantageous for

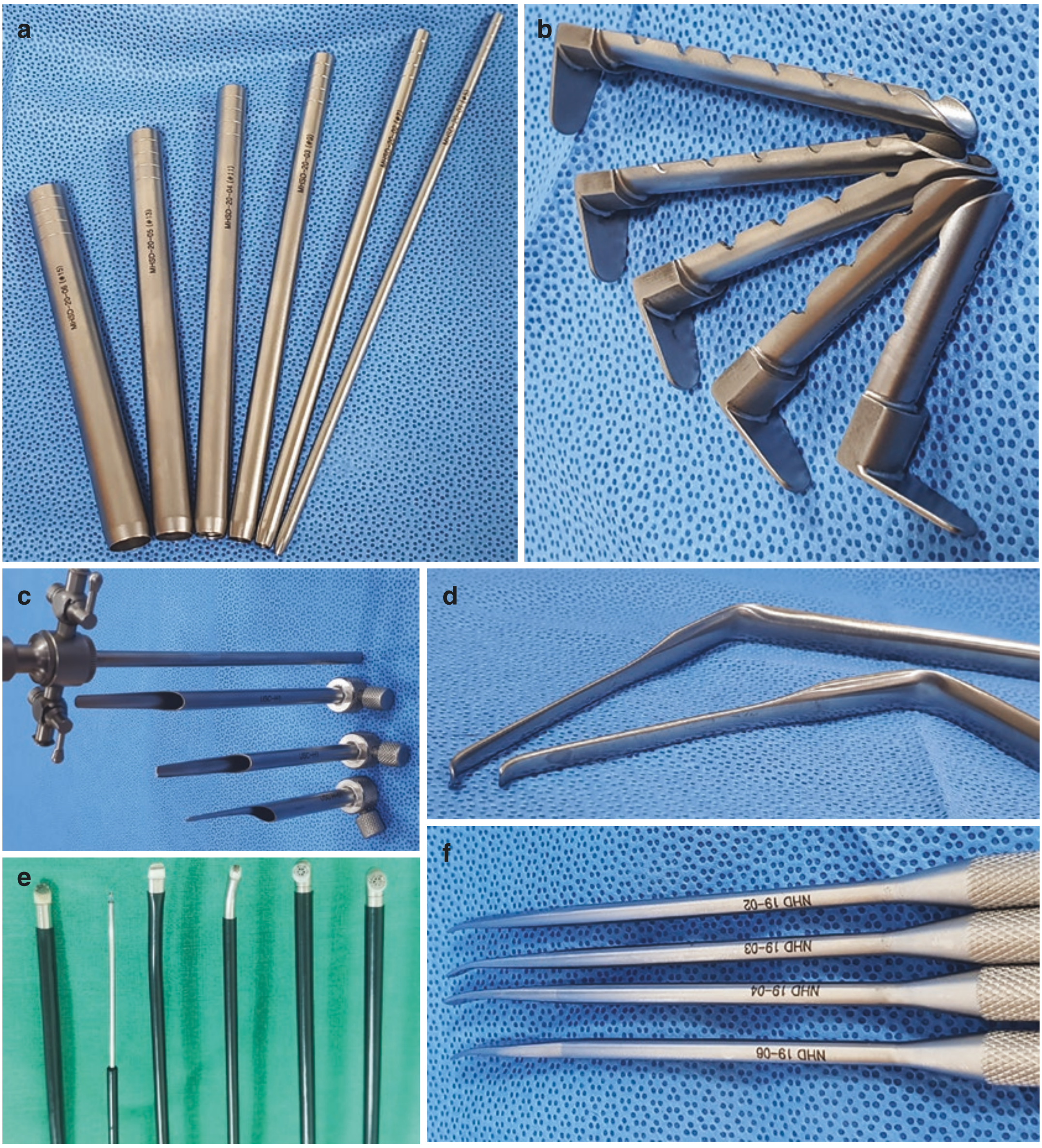

Fig. 4.1 Special instruments for unilateral biportal endoscopic discectomy. Serial dilators (**a**), working cannula for continuous irrigation (**b**), and scope retractors (**c**), assistant retractors (**d**), radiofrequency coagulators (**e**), and dissectors (**f**)

contralateral decompression to be made on the medial pedicle line.

4.5.2 Creation of Two Portals

Portal size should be at least 0.7 cm in diameter for unimpeded saline flow. Transverse incision facilitates saline flow more than horizontal incision due to fascia and muscle fiber dissection. Adequate muscle dissection with a serial dilator or dissector is necessary for this purpose. A 3000 cc saline bag placed 100 cm above the operation area (100 cm H_20 injection pressure) or an automatic injector could be used. Water pressure should be maintained below 23 mmHg dur-

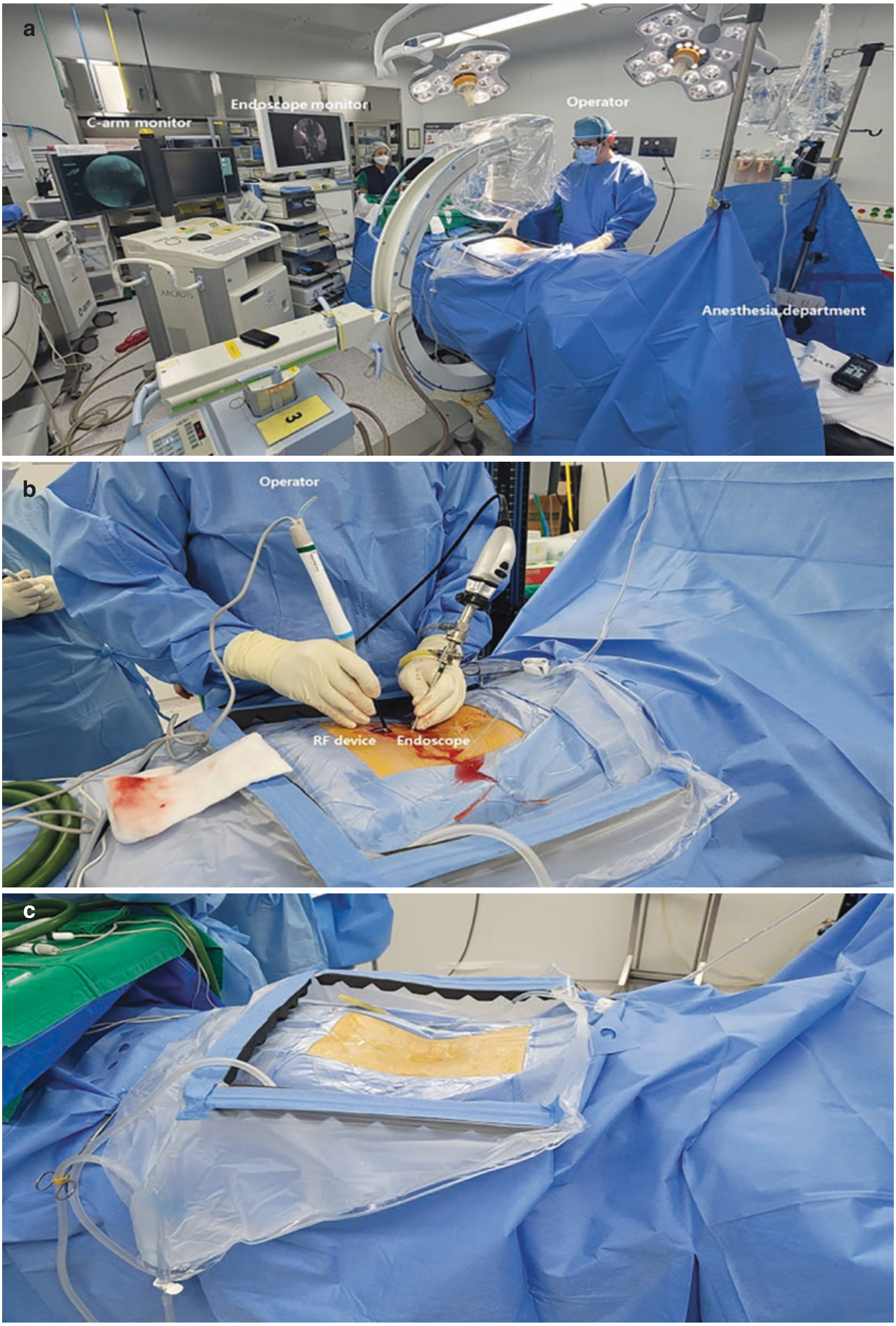

Fig. 4.2 Operation room arrangement and surgical drape (**a**). Detailed view of operation site (**b**). Water-tight surgical drape (**c**)

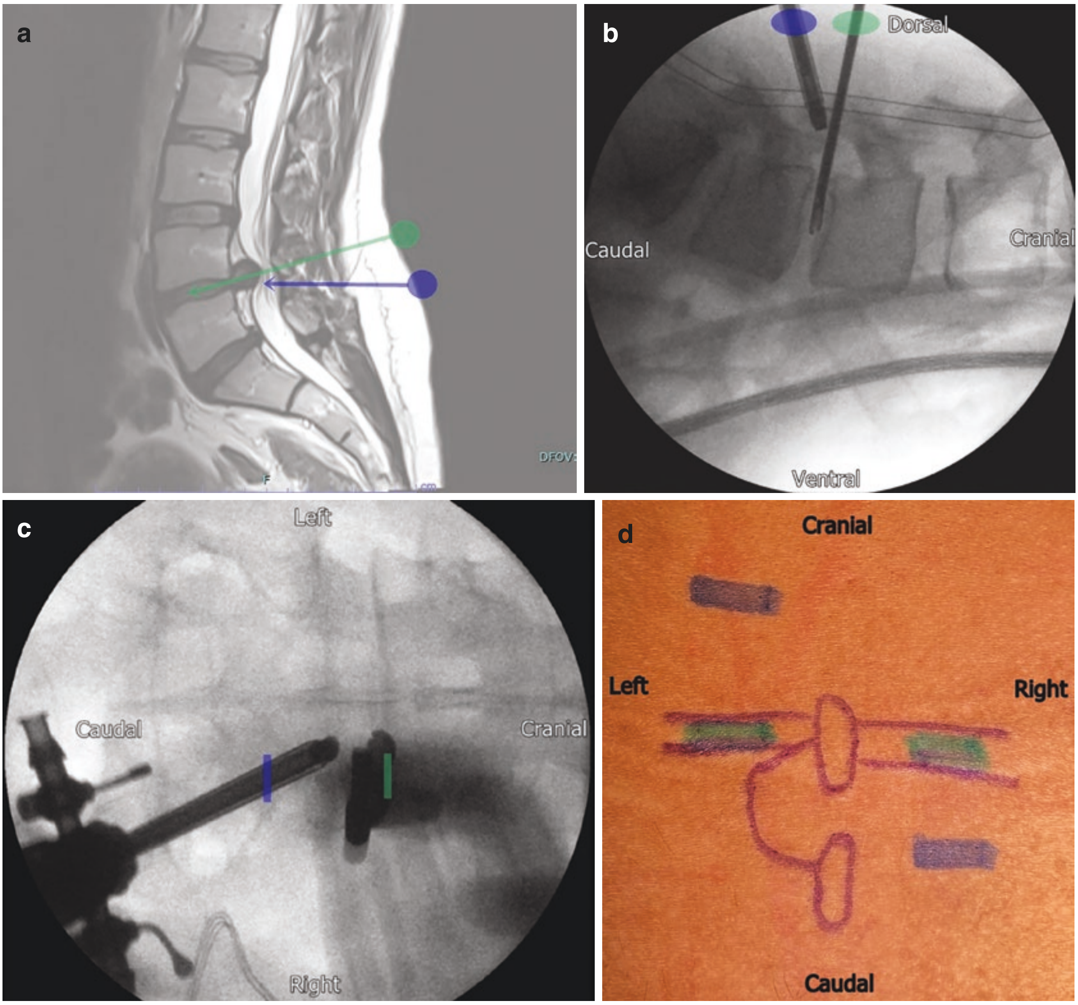

Fig. 4.3 Decision of incision site. Preoperative T2 weighted magnetic resonance (MR) sagittal imaging is important. For a right-sided approach, instrumental portal (green) and scope portal (blue) are decided from preoperative MR sagittal image (**a**). The same portals are confirmed by intraoperative fluoroscopic lateral (**b**) and anteroposterior image (**c**). Skin marks for left and right-sided approach. Instrumental portal (green) and scope portal (blue) should be different according to the approach side (**d**)

ing the procedure [9]. If blurred vision in the absence of bleeding or water retention are noted due to water retention, portal dilatation and fascia dissection should be repeated. Obese and young male patients with large muscle mass need more careful portal preparations or maintenance of working sheaths or cannulas (Fig. 4.1b) for unimpeded saline flow during the procedure (Video 4.1).

4.5.3 Working Space Preparation

Using a muscle detacher, muscle detachment should be performed on the lower border of the upper lamina and upper border of the lower lamina (Fig. 4.4a). For working space preparation, coagulation of muscle with a radiofrequency (RF) coagulator and soft tissue removal with a muscle shaver is helpful. The first step after the

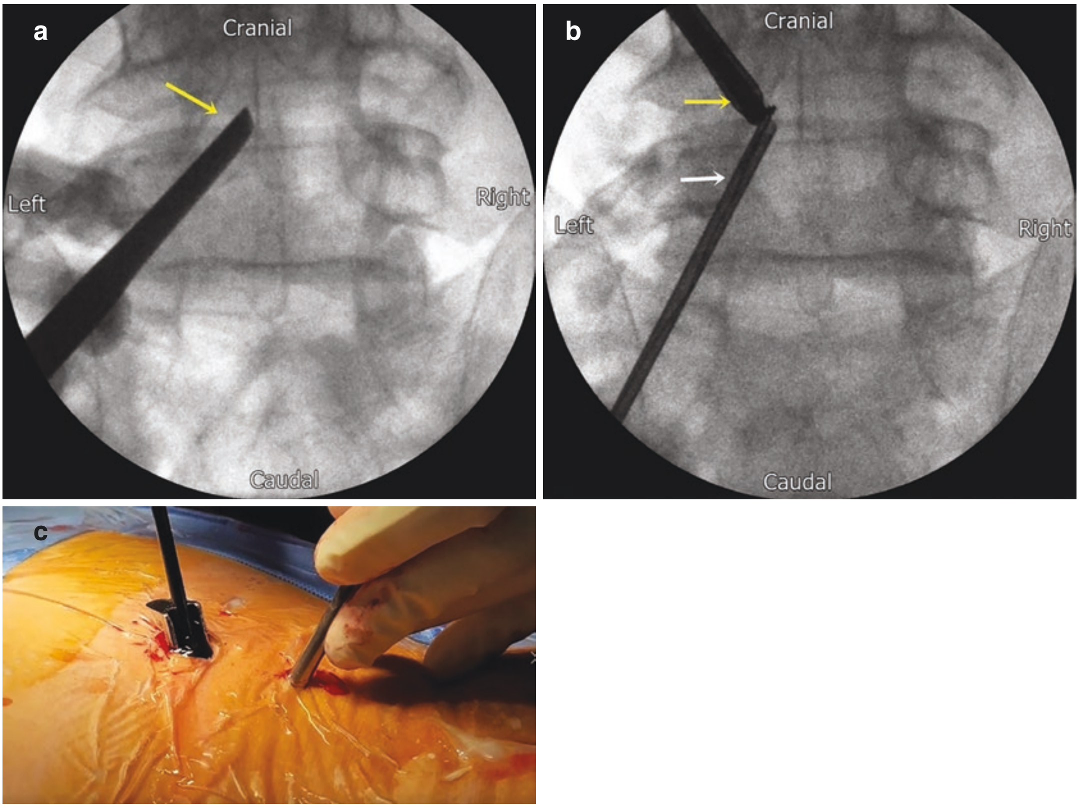

Fig. 4.4 Working space preparation. Muscle detachment on lower end of upper lamina (yellow arrow, left-sided approach) (**a**). Instrumental portal (white arrow) and scope portal (yellow arrow) are identified over lamina (**b**). Intraoperative field image of adequate saline flow (**c**). Single-wing type working cannula was used

creation of the portal involves coagulating the soft tissues around both the scope and instrument portals as needed and locating the tip of the RF coagulator on endoscopic vision or under fluoroscopy (Fig. 4.4b). Using a Kerrison punch or pituitary forceps, the outer layer of the ligamentum flavum and bulky soft tissues are removed for identification of landmarks for laminectomy. Adequate saline flow should be ensured before starting the laminectomy (Fig. 4.4c). Th3e importance of continuous and adequate saline flow during UBE cannot be overemphasized.

4.5.4 Laminectomy and Flavectomy (Video 4.2)

An illustrative case with a left-sided approach at L4/5 is demonstrated in its entirety in Video 4.2. Partial hemi-laminectomy starts with an automated drill or osteotome until a point slightly medially to the midline and by the upper free margin of the ligamentum flavum cranially. After the L4 lower laminar border is confirmed, laminectomy starts from the lower margin with the drill (Fig. 4.5a). L4 partial laminectomy continues until the upper free margin of the ligamentum flavum is exposed (Fig. 4.5b). The ligamentum flavum lower free margin is then detached from the L5 upper laminar border (Fig. 4.5c) and is removed using pituitary forceps, and the lateral margin of the dural sac and nerve root are confirmed (Fig. 4.5d). To avoid excessive traction of the nerve, sufficient ligamentum flavum removal and partial removal of the superior articular process are necessary. Dissection begins from the origin of the traversing root and proceeds between the nerve and discussing dissectors (Fig. 4.5e).

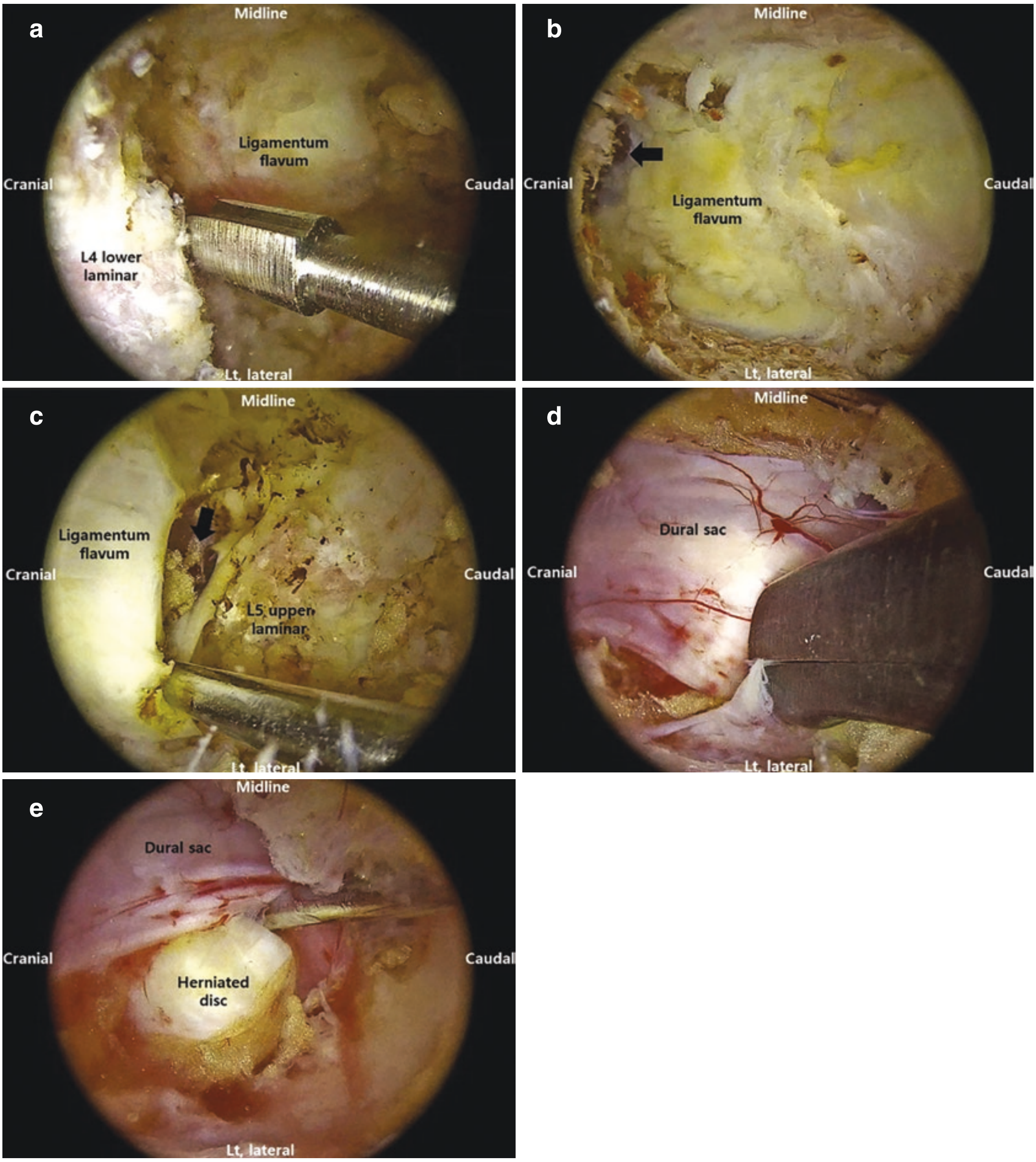

Fig. 4.5 Laminectomy and flavectomy at L4/5 from a left-sided approach. After the L4 lower laminar border is confirmed, laminectomy is started from the L4 laminar lower margin with drill (**a**). L4 partial laminectomy is performed until the ligamentum flavum upper free margin (black arrow) is exposed (**b**). The ligamentum flavum lower free margin (black arrow) is detached from the L5 upper laminar border (**c**). The ligamentum flavum is removed and the dural sac and root lateral margin are confirmed (**d**). Starting from the origin of the traversing root, dissection proceeds between the nerve and disc with the use of dissectors (**e**). The full procedure can be viewed in Video 4.2

4.5.5 Discectomy (Video 4.2)

The disc space is located medially to the superior articular process. After locating the herniated disc (Fig. 4.5e), the ruptured disc particle is removed (Fig. 4.6a). Additional discectomy is performed using pituitary forceps ensuring root protection with a root retractor (Fig. 4.6b). Bleeding control and annuloplasty can be achieved with RF coagulators, whereas annulotomy can be performed with an Indian knife. Removal of the ruptured disc with forceps with concomitant nerve protection is important. Scope retractors and assistant retractors are also helpful for nerve protection. With a scope retractor more efficient nerve protection can be expected compared to assistant retractors. Intermittent root traction and release are important to prevent nerve traction injuries. There are four corridors for discectomy: ipsilateral shoulder (Fig. 4.6c),

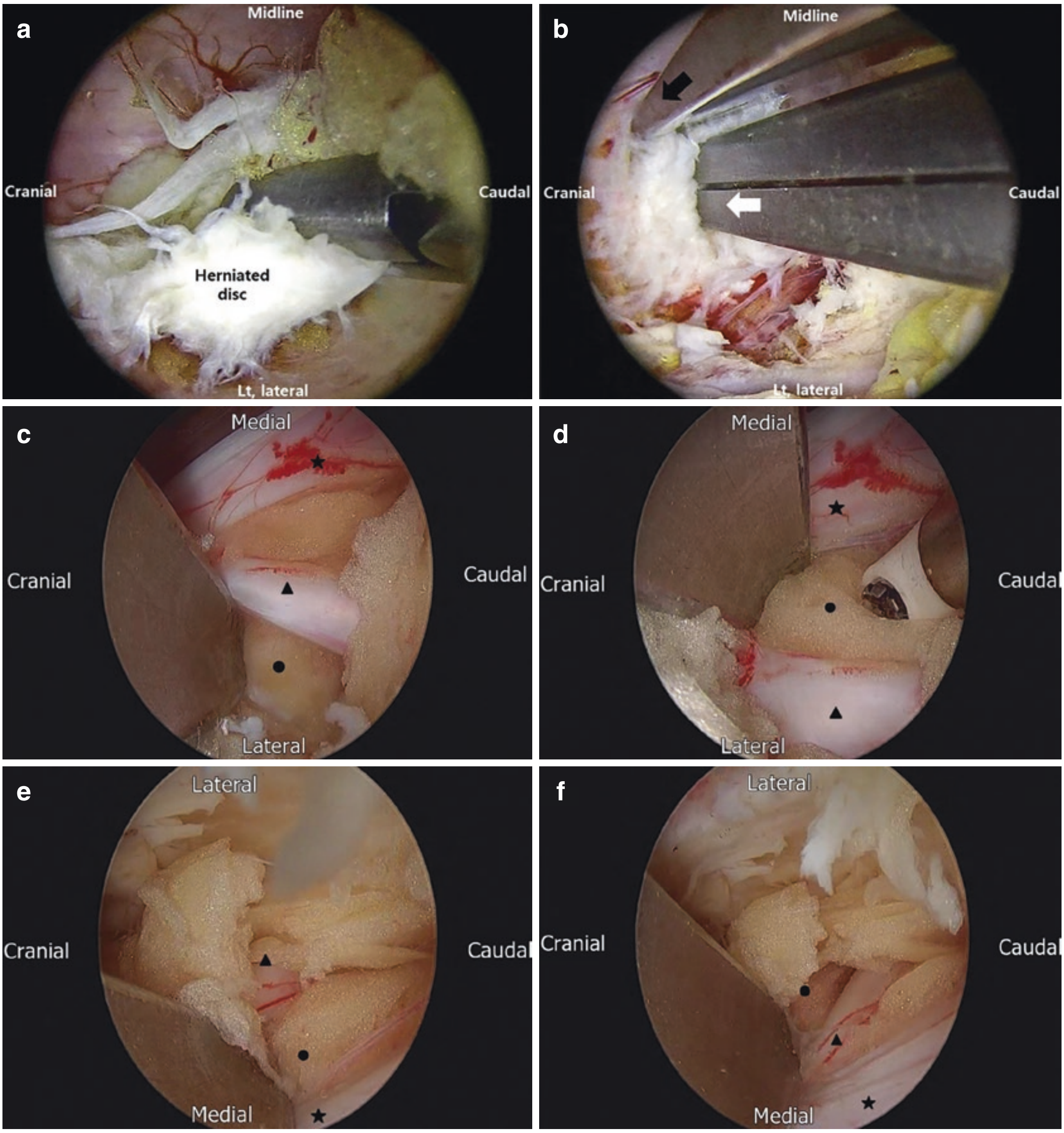

Fig. 4.6 Discectomy at L4/5 from a left-sided approach. The herniated and ruptured disc is located and removed (**a**). Additional discectomy is done with pituitary forceps (white arrow), after ensuring root protection with root retractor (black arrow) (**b**). There are four corridors for discectomy, ipsilateral shoulder (**c**), ipsilateral axillary (**d**), contralateral axillary (**e**) and contralateral shoulder (**f**) (triangle: nerve root, dot: disc, star: thecal sac). Depending on location and characteristics of disc, the appropriate approach should be chosen to reduce chances of nerve traction injury. After complete discectomy, the surgeon must confirm complete neural structure decompression (**g**). In this case, an incidental dural tear (black arrow) was discovered (**g**) and addressed with direct dural repair (**h**). The full procedure can be viewed in Video 4.2

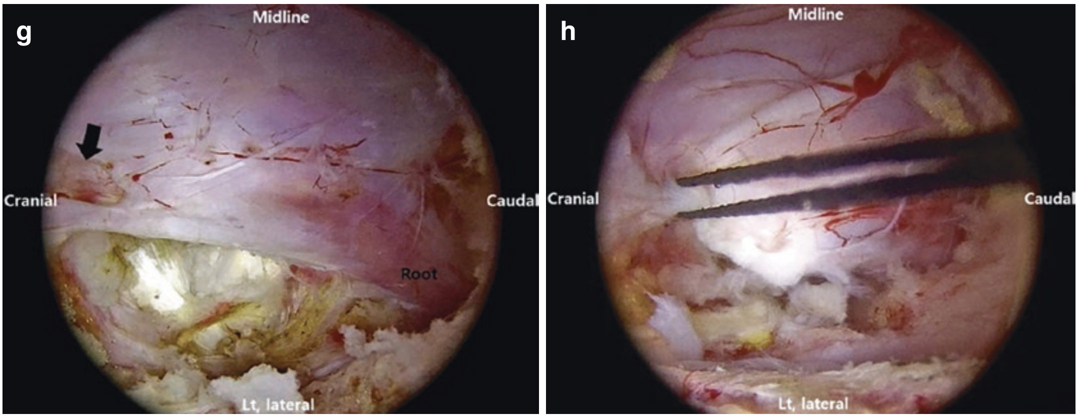

Fig. 4.6 (continued)

ipsilateral axillary (Fig. 4.6d), contralateral axillary (Fig. 4.6e), and contralateral shoulder (Fig. 4.6f). Depending on the location and characteristics of the disc, an appropriate approach for reducing root traction injury should be chosen. Soft disc material can be removed with pituitary forceps, whereas calcified disc particles can be detached with Kerrison punches or osteotomes. Regarding internal disc decompression, which, if performed, is associated with less risk of recurrence, it can be accomplished by the use of pituitary forceps or RF ablation to remove the internal nucleus. After sufficient decompression, annuloplasty with an RF coagulator can be performed. After complete discectomy, the surgeon must confirm complete neural structure decompression (Fig. 4.6g). In the presented case, an incidental dural tear (Fig. 4.6g, black arrow) was discovered which was addressed with direct dural repair (Fig. 4.6h).

4.5.6 Drainage and Closure

Surgical drain insertion is optional in unilateral laminectomy and discectomy procedures. To skip drain insertion, meticulous bleeding control is mandatory. Repetitive skin compression around the portal can decrease soft tissue water retention before suturing. A 50 cc or 100 cc drain can be inserted under endoscopic guidance or blindly through the instrumental or endoscopic portal over the laminar or dural sac (Fig. 4.7a). The skin is sutured with nylon 3:0 at both portals and a tagging drainage tube is left in the portal site (Fig. 4.7b). We recommend the insertion of a drain line through the instrumental rather than the endoscopic portal because it is the instrumental portal patency that maintains unimpeded saline flow during the entire procedure.

4.6 Illustrated Cases

4.6.1 Case 1 (Left Side Axillar Approach, Video 4.3)

A 37-year-old woman was seen for a 1-year history of back and right leg radiating pain. The straight leg raise test (SLRT) was 30 °. Magnetic resonance imaging (MRI) showed severe disc herniation and left inferior migration at the L5/S1 level (Fig. 4.8). For a left-sided approach, the instrumental portal was placed on the disc space level, and the scope portal was placed 3 cm above. Laminectomy and flavectomy were performed in the same manner as described above. The entire discectomy procedure is presented in Video 4.3. After ligamentum flavum removal, the migrated disc material was located in the axillary space. The large migrated disc was removed, followed by a thorough exploration of the shoulder space and additional internal discectomy. The discectomy was performed with pituitary forceps, whereas an RF coagulator was used for concurrent annuloplasty. A drain was inserted, and the skin was sutured with 3-0 nylon. Immediately postoperatively the leg radiating pain improved while the back pain at the operation site resolved on postoperative day 3.

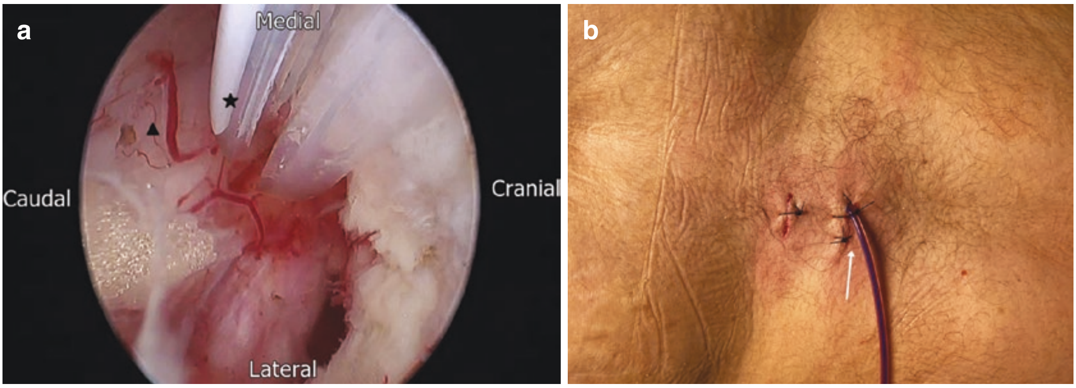

Fig. 4.7 Drain insertion under endoscopic guidance (star: hemovac, triangle: thecal sac) (**a**). Skin suture and drain tagging (white arrow) (**b**)

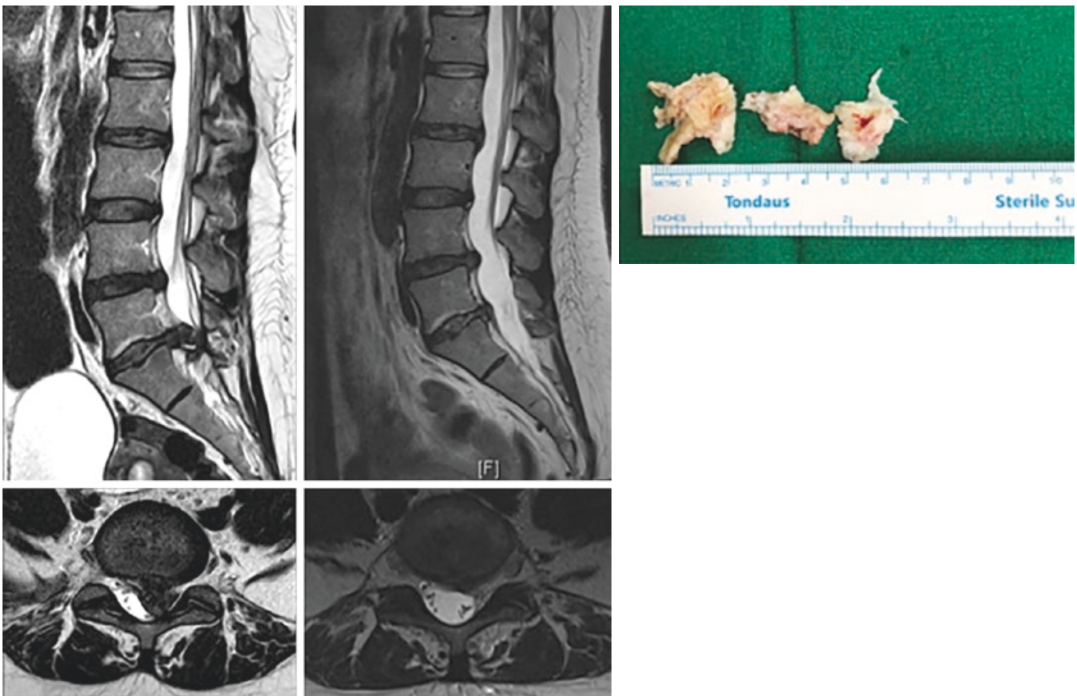

Fig. 4.8 Case 1. MRI showed severe disc herniation and inferior migration at the L5/S1 level on the left. From the left: preoperative, postoperative MRI and removed disc particles

4.6.2 Case 2 (Left-sided Shoulder Approach, Video 4.4)

A 43-year-old female presented to the outpatient clinic with left buttock pain for 6 months. Visual analogue scale (VAS) score was 3 for the back and 9 for buttock to leg. Mild weakness of the left ankle was noted. The SLRT was positive at 30 °. MRI showed a superiorly migrated large disc at L5/S1 level on the left (Fig. 4.9). For a left-sided approach, the instrumental portal was placed on the disc space level, and the scope portal was placed 3 cm above. Laminectomy and flavectomy were performed in the same manner as described above. The entire discectomy procedure is described in Video 4.4. First, the lower margin of

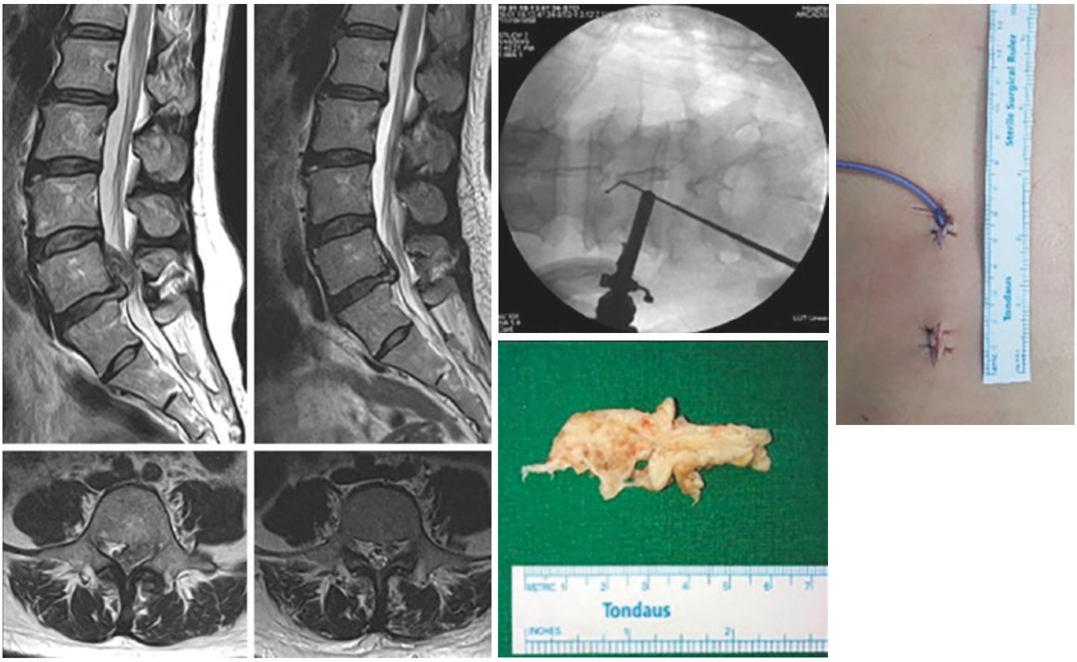

Fig. 4.9 Case 2. MRI showed large superior migrated disc at the L5/S1 level on the left. From left: preoperative, postoperative MRI, X-ray image during operation, removed disc particles, and final wound

the L5 lamina was identified using an RF coagulator. After sufficient L5 laminar drilling, the upper free margin of the ligamentum flavum was exposed and the S1 laminar upper margin was identified. Using Kerrison punches, the S1 upper lamina was partially removed to confirm the lower free margin of the ligmentum flavum. After careful dissection with a blunt hook, the ligamentum flavum was removed and the large superior migrated disc was located and removed (Fig. 4.9). A blunt hook was used to explore disc remnants superiorly (Fig. 4.9). After confirming complete removal of the migrated disc, a 100 cc drainage bag was inserted and the skin was sutured. On a postoperative day 1 VAS scores were 4 for the back and 3 for the leg, and after POD 7 VAS decreased to 1 for both the back and leg.

4.6.3 Case 3 (Left-sided Contralateral Approach to Right Foramen, Video 4.5)

A 71-year-old female with right buttock and leg pain for 6 months presented to the outpatient clinic. The VAS score was 7 for buttock to leg. Mild weakness was observed in the right knee, and the SLRT was positive at 30°. Conservative treatment, including physiotherapy and medication, was not helpful. MRI showed foraminal disc herniation at the L 2/3 level on the right (Fig. 4.10). Laminectomy was performed in the same manner as described above. For the contralateral approach, additional midline laminectomy was performed over the ligamentum flavum midline slit with an osteotome and punch. The entire discectomy procedure is described in Video 4.5. After sufficient L2 laminar removal to the contralateral foramen, the ligamentum flavum was removed to the level of L2/3 right foramen, and the contralateral foramen was explored to find the ruptured disc. After careful dissection with a hook, the superiorly migrated disc was found and removed. With a blunt hook, the superior foraminal space was explored to find any disc remnants. After confirming complete removal of the migrated disc, a 100-cc drain was inserted and the skin was sutured. The patient was discharged 3 days later, and on postoperative day 3, the VAS score was 2 for the leg.

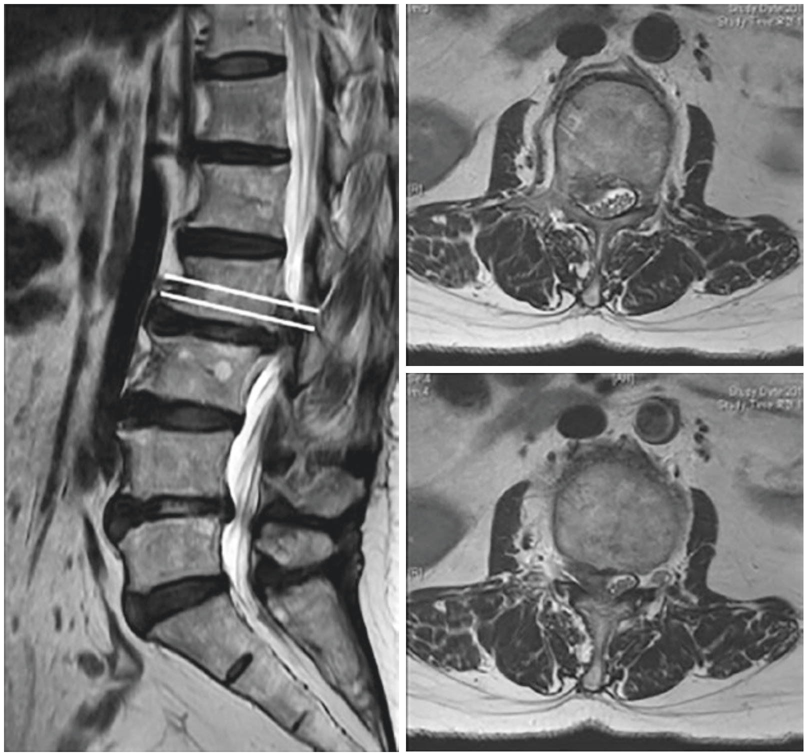

Fig. 4.10 Case #3. MRI showed foraminal disc herniation at the L2/3 level on the right. From left: preoperative sagittal, lower pedicle level, and lower endplate level axial MRI image (white line)

4.7 Complications and Their Management

4.7.1 Bleeding

Bone bleeding can be controlled using bone wax or an RF coagulator. A small tip RF coagulator (Fig. 4.1e) is helpful for controlling small vessel bleeding. In the case of diffuse spontaneous bleeding without major visible bleeding vessels a hemostatic matrix (Floseal®) is useful. Influent saline can be falsely perceived as operation site bleeding. Before attempting to control bleeding, the saline flow should also be checked. It has been reported that the use of an infusion pump may increase the risk of epidural hematoma because high water pressure may hide bleeding during surgery.

4.7.2 Traction Injury and Dural Tear

Excessive traction and aggressive adhesiolysis can cause dysesthesia and paresthesia after surgery. Regarding the choice of retractor, we recommend a scope retractor (Fig. 4.1c). Between the scope retractor and assistant retractor, the scope retractor can avoid excessive retraction because the operator can feel the resistance of the nerve. However, even with the use of a scope retractor, intermittent release of retractor tension should be applied to prevent nerve traction injury. During laminectomy, the ligamentum flavum should not be removed too early. The ligamentum flavum is an important protector against the sharp side of the instrument during laminectomy. If the epidural space is already exposed, the ligamentum flavum should be removed from above the epidural fat, as hidden neural structures may be located under the fat. After ligamentum flavum removal, the use of the RF coagulator on coagulation mode only, or on ablation mode with low power (20 w) is recommended as high power energy can induce nerve injury or dural tears. If a dural tear has already occurred, the water pressure should be decreased and the size of the dural tear determined. Depending on the size of the injury, we chose observation, fibrin sealant patch, non-penetrating clip, or endoscopic suture (Fig. 4.6h, Video 4.1).

4.7.3 Learning Curve and Important Points

UBE discectomy requires nerve protection and skillful disc removal, which are important steps in the preparation of interbody fusion surgery. Simple lumbar stenosis decompression without discectomy with working space preparation, laminectomy, safe ligamentum flavum removal, and exposure of the nerve root should be repeated before starting discectomy. In the early stages of the learning curve, identifying important anatomical landmarks (origin of traversing nerve root and medial wall of pedicle) before discectomy and using discrimination dye (Indigo carmine) could be helpful.

4.7.4 Surgical Tips and Pitfalls

Currently, one prospective [8] and three retrospective studies [3, 5, 10] have reported on UBE discectomy. These studies showed that UBE had similar, but not superior, results to other discectomy techniques. Advantages were less postoperative back pain and shorter hospital stay, and possible disadvantages were persistent back pain, dural tear, and incomplete disc decompression [11]. To overcome these possible disadvantages we offer the following surgical tips.

Blurred vision due to excessive saline flow and lack of experience with the endoscopic procedure can result in incomplete surgery and increased perioperative risks. Sufficient muscle detachment, portal widening with serial dilation, soft tissue reduction with muscle shaver, and careful bleeding control with an RF device are the first and most important steps for all kinds of UBE procedures. The importance of continuous and unimpeded saline flow during UBE cannot be overemphasized, and the above steps can help to ensure this. Compared to microscopic procedures and percutaneous one-portal endoscopic discectomy, UBE allows various working distances and viewing angles; therefore, surgeons should be familiar with the control of the endoscope. For example, most of the scope has two controllers: focus control and magnification control. Both should be properly adjusted during the entire procedure.

Incomplete discectomy and dural tear can occur due to insufficient laminectomy and incorrect use of instruments. In cases of soft disc herniation without degeneration, target-oriented small laminectomy and ligamentum flavum splitting techniques are helpful. However, with calcified and degenerated migrated discs enough bone should be removed, the ligamentum flavum should be resected in its entirety, and all anatomical landmarks should be identified carefully. Kerrison punches, osteotomes, and various scope retractors can decrease the risk of incomplete discectomy. If a dural tear occurs unexpectedly a sufficient effort should be made to achieve enough decompression and ligamentum flavum removal followed by disc removal as planned, before the dural injury is managed. Unlike open surgery, endoscopic spine surgery usually does not result in cerebrospinal fluid leakage because of strong muscle barriers. UBE discectomy is a safe and effective surgery with many benefits. As more UBE-specific instruments are developed, and UBE surgical skills improve we expect to see better outcomes for the proper indications.

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