Biportal Endoscopic Approach (Biportal Endoscopic Lumbar Discectomy)

Nam Lee, Dong Hwa Heo, and Choon Keun Park

Introduction of Approach

Microdiscectomy is the gold standard surgical treatment for lumbar disc herniation refractory to conservative managements. Recently, various endoscopic approaches have been attempted for lumbar disc herniation. Among them, the technique of biportal endoscopic lumbar discectomy was based on microscopic surgery, and similar to microdiscectomy. Therefore, surgical anatomy and orientation of biportal endoscopic lumbar discectomy may be familiar to spine surgeon.

Biportal endoscopic surgery used two channels. First portal is endoscopic portal and the other is working portal [1–3]. General spine surgical instruments as well as endoscopic specialized instruments can be used through working portal (Fig. 1). Relative shorter learning curve is another advantage of biportal endoscopic lumbar surgery.

Indication and Contraindication

Indication of biportal endoscopic surgery is very similar with conventional lumbar microsurgery. All types of herniated lumbar disc (HLD) including protrusion, extrusion, sequestration type, and central, paracentral, bilateral disc herniation are indication of this procedure. In addition, recurrent lumbar disc herniation, calcified disc herniation, and cauda equina syndrome are also included in indication of this approach [1]. Foraminal and extraforaminal type HLD can be treated by paraspinal approach using biportal endoscopic surgery.

Anesthesia and Position

Surgeon's preference and cooperation with anesthesiologist are very important. The physician can select among epidural anesthesia, spinal anesthesia, and general anesthesia. Epidural anesthesia is a less invasive procedure among them, so the authors recommend epidural anesthesia. In addition, if a mild intravenous sedation is applied, the physician can operate in situation like general anesthesia.

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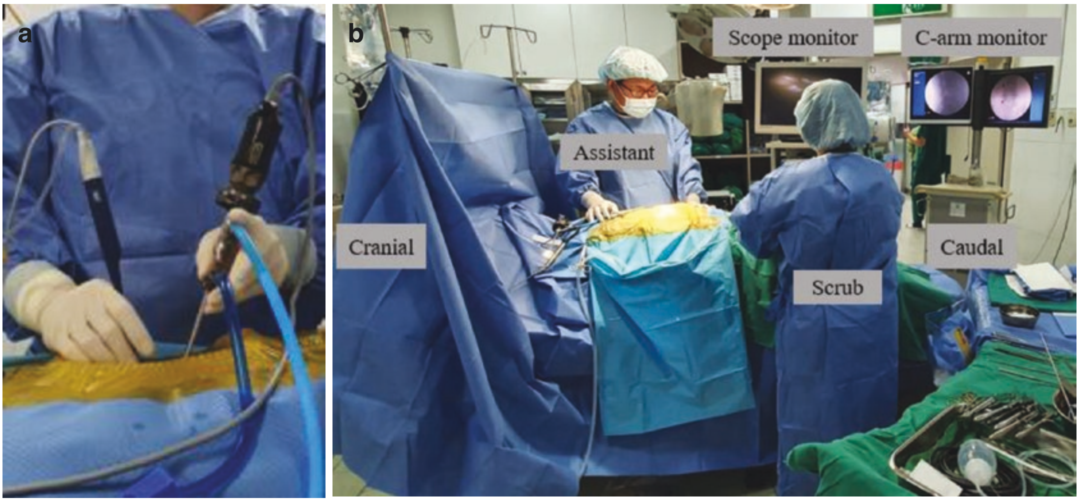

Fig. 1 Overview of biportal endoscopic lumbar discectomy (**a**). Setting of the operating room for biportal endoscopic surgery of left side approach (**b**)

The prone position on a Wilson frame is gold standard position (Fig. 1). A Wilson frame makes better surgical field because it induces distraction of the interlaminar space. C-arm fluoroscopy and a monitor for endoscopy were located at contralateral side to surgeon (Fig. 1).

Special Surgical Instruments (Figs. 2 and 3)

Serial dilators are essential to make portals (Fig. 2). Zero-degree endoscope is most commonly used in biportal endoscopic surgery. Basically, most of biportal endoscopic instruments were shorter than uniportal endoscopic surgical instruments (Fig. 2). Radiofrequency (RF) probe is very useful to control the intraoperative bleeding (Fig. 3). Various kinds of RF probes are available in biportal endoscopic surgery. The power of RF should be reduced when epidural space and dura were exposed. We prefer waterproof diamond drill for prevention and reduction of bone bleeding during operation (Fig. 3). All conventional surgical instruments are available in biportal endoscopic spine surgery.

Surgical Steps

1. **Mark the portal location.** Under fluoroscopic imaging, getting the true A-P image of target level is very important (Fig. 4a). And, we additionally check the locations of two portals using lateral C-arm fluoroscopic view. To make the incisions for portals, the physician must confirm two vertical lines: one is the midline and the other is medial pedicle line. Two portals were made under C-arm fluoroscopic guidance. Endoscopic portal was made at 1 cm cranially and the other working portal was made at 1 cm caudally from mid intervertebral disc space (Fig. 4a, b).
2. **Making "initial" working space (Video 1).** After confirming the locations for portals, make a skin incision using No. 10 blade. Penetrating the fascia clearly by blade is important at this point. One centimeter incision is sufficient for portals. Usually the instrument portal is made firstly. Insert the first serial dilator toward medially and cranially to touch the spinous-laminar junction of inferior laminar border (Fig. 5). After touching this point confirmed by fluoroscopic image, we must detach the muscle insertion

Fig. 2 (*1*) Endoscope retractor. (*2*) Serial dilators and muscle dissector. (*3*) Blunt hook—double-end probe. (*4*) Trocar for endoscope and 0 degree endoscope. (*5*) Various curved curettes. (*6*) Pituitary forceps. (*7*) Various Kerrison punches

Fig. 3 (**a**): (*1*) Radiofrequency probe. (*2*) Small diameter of diamond burr

parts from laminar bone by scraping the surface of laminar bone (Fig. 5). In addition, we must feel the interlaminar space. Loss of the hardness feeling of laminar bone is the interlaminar space. After confirming this feeling, the next serial dilators or muscle dissector can be inserted through the portal. Next, endoscopic portal is made. First serial dilator or trocar for endoscope is a good tool for making endoscopic portal. We usually put in a working sheath or trocar at the working portal. The direction is medial and caudal from skin incision, and the target landing point is the same with the instrument portal. To make the initial working space successfully, two portals' distal endpoints must meet just on the laminar (Fig. 5a, b). After that, connect the 0 degree endoscope and open the water clamp. If the laminar surface is identified clearly by floating the muscle insertion parts dorsally from laminar bone, making the initial working space is finished.

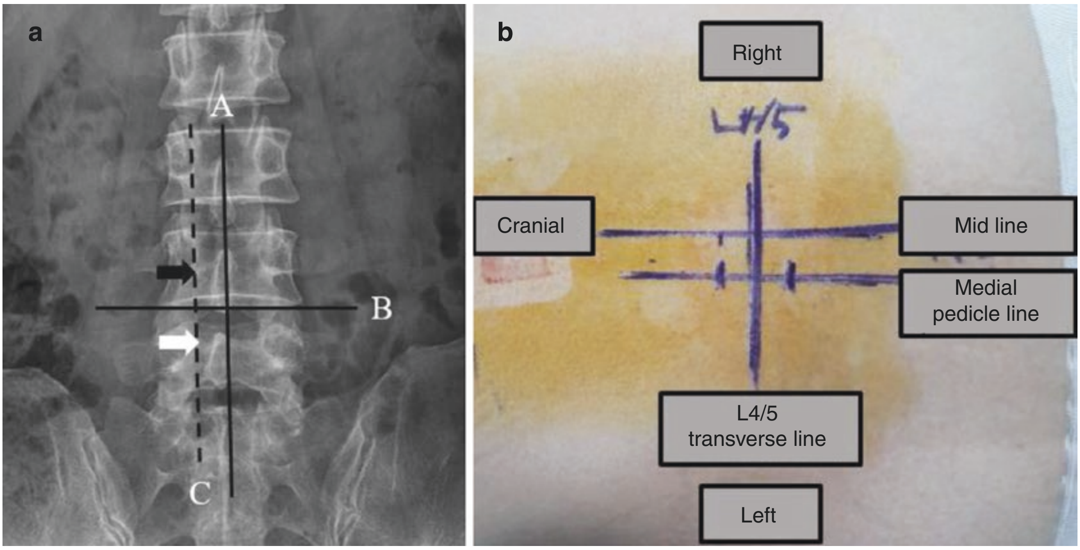

Fig. 4 Radiologic (**a**) and skin (**b**) marking for making two portals. Mid vertical line (**A**) and intervertebral disc transverse line at L45 (**B**). Medial pedicle line (**C**). Black arrow: cranial endoscopic portal (1 cm cranially from line **B**). White arrow: caudal instrument working portal (1 cm caudally from line **B**)

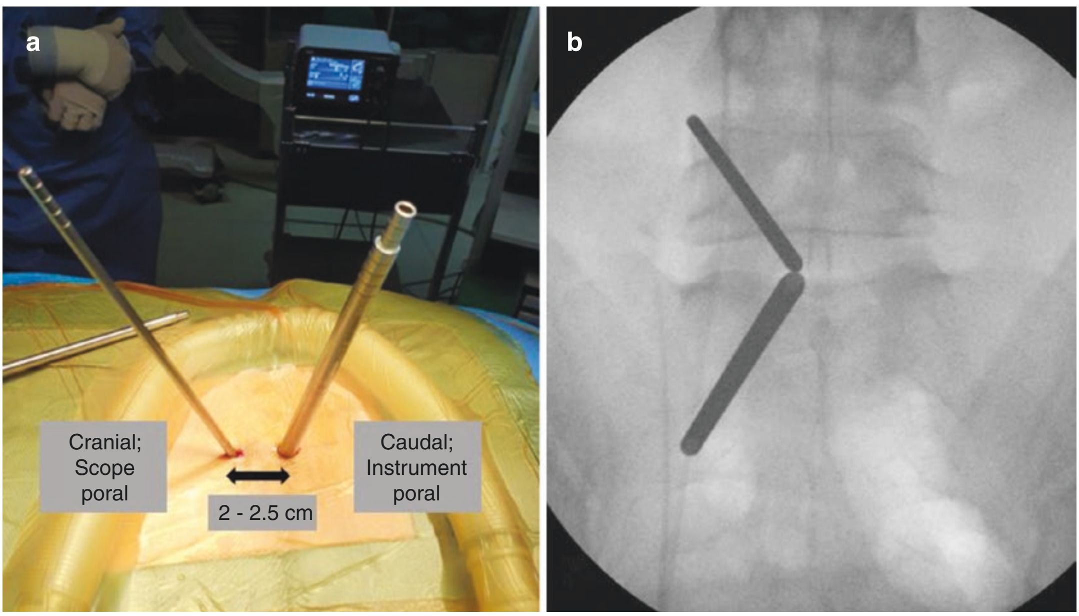

Fig. 5 (**a**) Two dilators are inserted to create the biportal. (**b**) Distal ends of the two dilators meet on the spinous-laminar junction

3. **Making "true" working space.** A partial hemilaminectomy is performed using electrical high-speed burr, Kerrison punch, or osteotome. The authors prefer high-speed burr with thin shaft. Because it is good for emission of bone dust and debris simultaneously. This work is started from spinous-laminar junction and removing the inferior portion of lamina

(Fig. 6a). This laminectomy should end up when the midline recess of the ligamentum flavum is exposed (Fig. 6b). It extends laterally until encountering the meeting point of inferior articular process of cephalad bone and superior articular process of caudal bone. The laminectomy makes the true working space for discectomy (Fig. 6c).

4. **Ipsilateral flavectomy.** The ligamentum flavum consists of a superficial layer and a deep layer. There is an interlayer slip of the ligamentum flavum that attaches to the superior border of caudal lamina. To accomplish total ipsilateral flavectomy, physician must identify the distal portion of ligamentum flavum (Fig. 6c). Now physician can identify all territories of the ipsilateral ligamentum flavum. The flavectomy is undergone from cranial to caudal, and medial to lateral. The distal portion of deep layer attaches to the anterosuperior surface of caudal lamina; to remove this area safely, authors prefer curette. Upward curved curette is very useful to detach the deep layer of ligament. A sweeping motion of the curette over the edge of the superior border of caudal lamina facilitates deep layer ligament detachment safely. Therefore, full ipsilateral flavectomy can be done just using conventional instruments such as hook, Kerrison punch, and pituitary forceps. After full layer ipsilateral flavectomy, we can clearly identify the epidural space including epidural fat tissue and dura mater (Fig. 6d).
5. **Exploration of epidural space.** The epidural fat tissue can act as a natural barrier for the prevention of postoperative adhesion. If

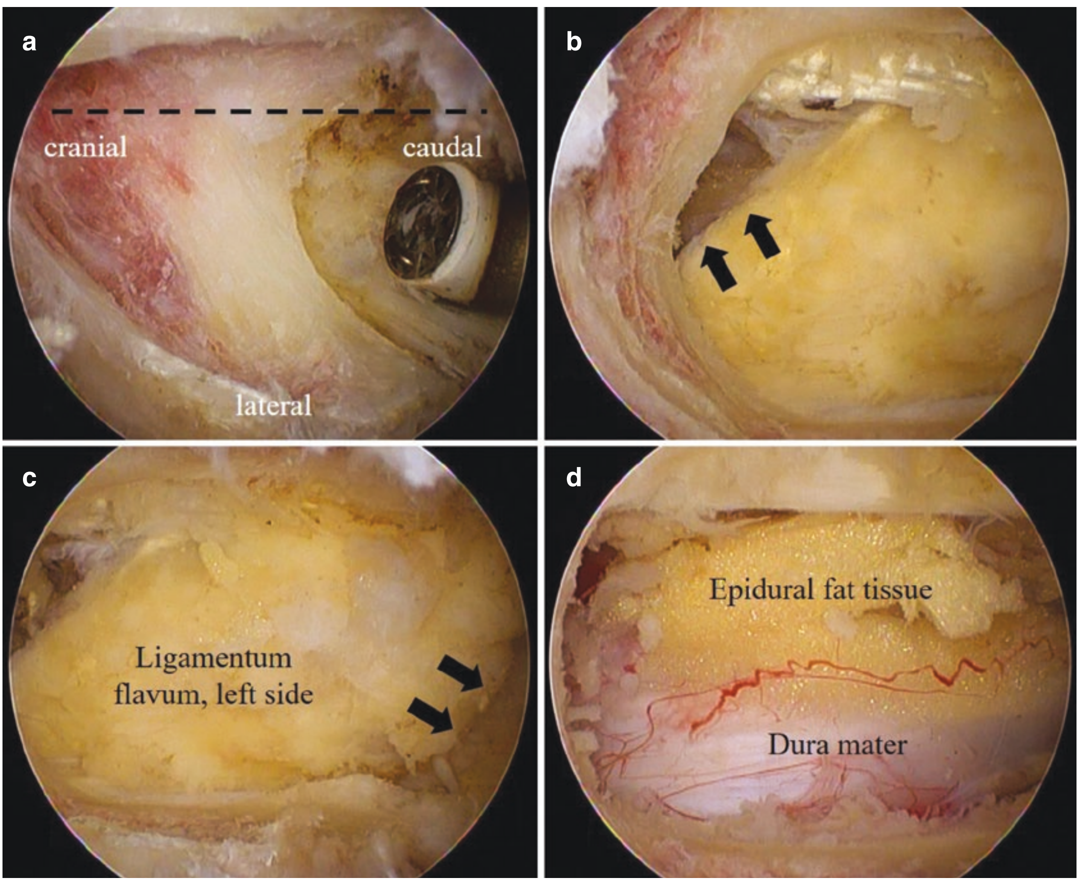

Fig. 6 (**a**) Left side approach view. Ipsilateral left side laminar was removed partially. (**b**) The endpoint of laminectomy cranial portion. Black arrows indicate proximal end of ipsilateral ligamentum flavum (LF). (**c**) The entire area of the ipsilateral LF is identified. Black arrows indicate distal end of ipsilateral LF. (**d**) After flavectomy, both epidural fat tissue and dura mater are confirmed. Also, the physician can see the epidural vessels

possible, epidural fat should be preserved as much as possible. However, the biportal endoscopic surgery is operated in water—the turbulence flow of water—and the fat tissue may disturb the clean operating field. In this situation, the authors recommend to remove the epidural fat tissue. The bleeding from epidural vessels can cause uncleaned operating field. Proper usage of radiofrequency (RF) is essential for controlling the epidural bleeding. Before manipulating the thecal sac, the medial wall of pedicle and lateral border of thecal sac should be identified using blunt hook. Once bloodless operating field is achieved, the compressed nerve root can be identified easily and the nerve root can be retracted medially using a blunt hook or dissector (Fig. 7a, b).

6. **Discectomy.** To do the discectomy safely, authors recommend the usage of nerve root retractor especially to the beginners. After retraction of nerve root medially, the extruded or sequestrated disc fragments are identified clearly (Fig. 7b). Using blunt hook or pituitary forceps, these fragments can be removed easily. In the case of sub-ligamentous fragments, application of RF on the thinned annulus can lead to an extraction of disc fragments. After initial decompression, subsequent discectomy is easier because the nerve root can be retracted more medially and smoothly, so physician can identify the posterior longitudinal ligament (PLL) which is located in midline (Fig. 7c, d). The surgeon can control the quantity of discectomy (Fig. 8). To achieve

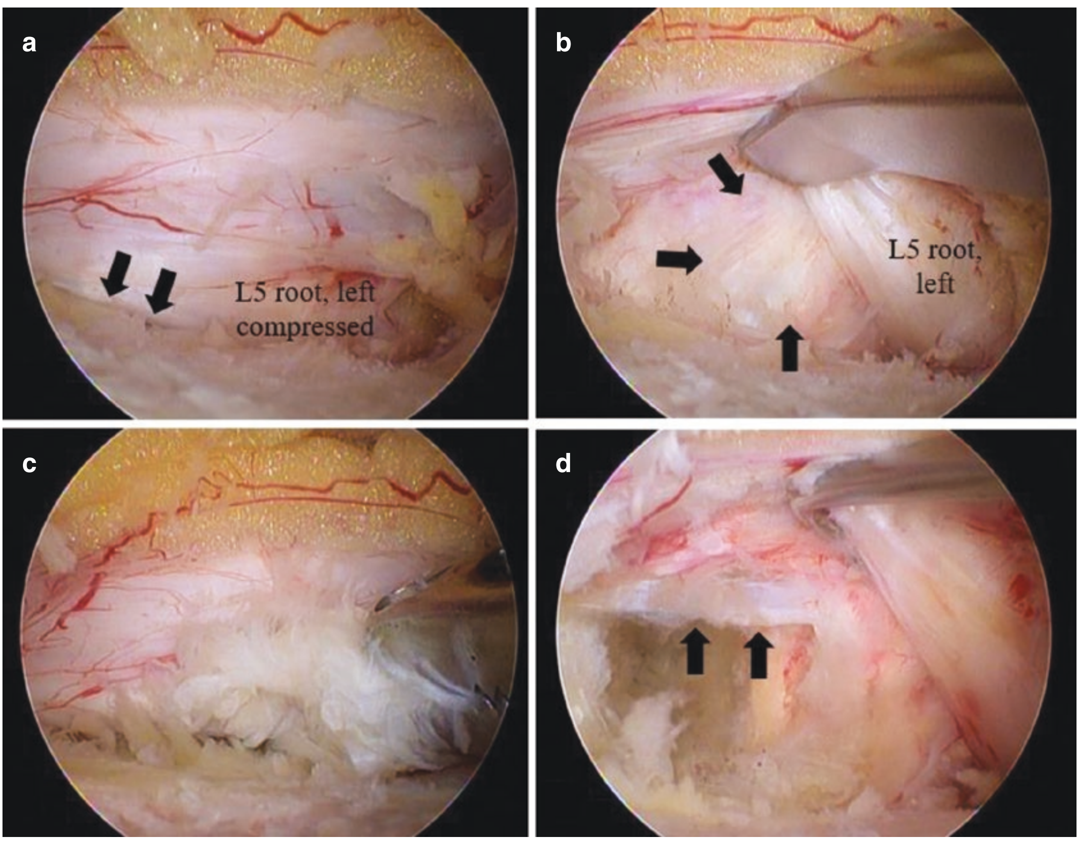

Fig. 7 (**a**) The compressed L5 root is identified. Black arrows indicate the shoulder portion on nerve root. (**b**) After retraction of compressed L5 root medially, extruded disc material is confirmed (black arrows). (**c**) The extruded disc material is removed by pituitary forceps. (**d**) After discectomy, the posterior longitudinal ligament is confirmed (black arrows)

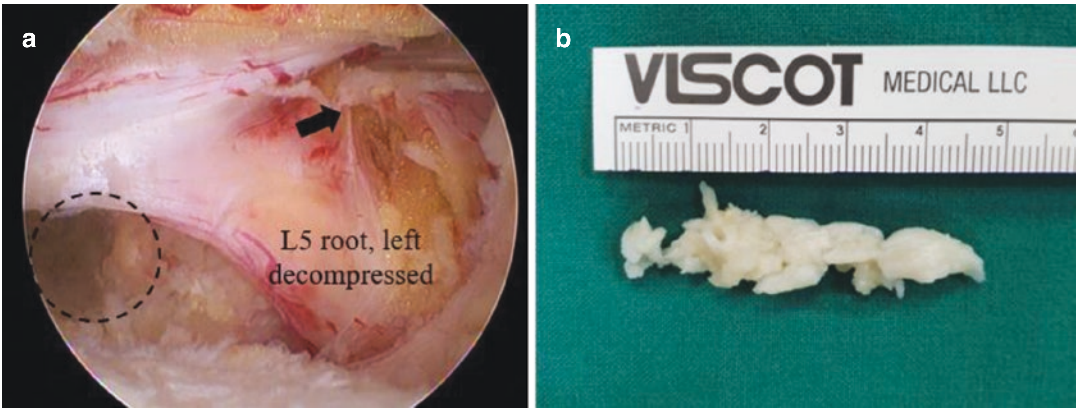

Fig. 8. (**a**) After sufficient discectomy, decompressed nerve is identified, and both shoulder and axillar parts of root are identified (dotted circle: discectomy site, black arrow: axillar part of nerve root). (**b**) The volume of removed intervertebral disc

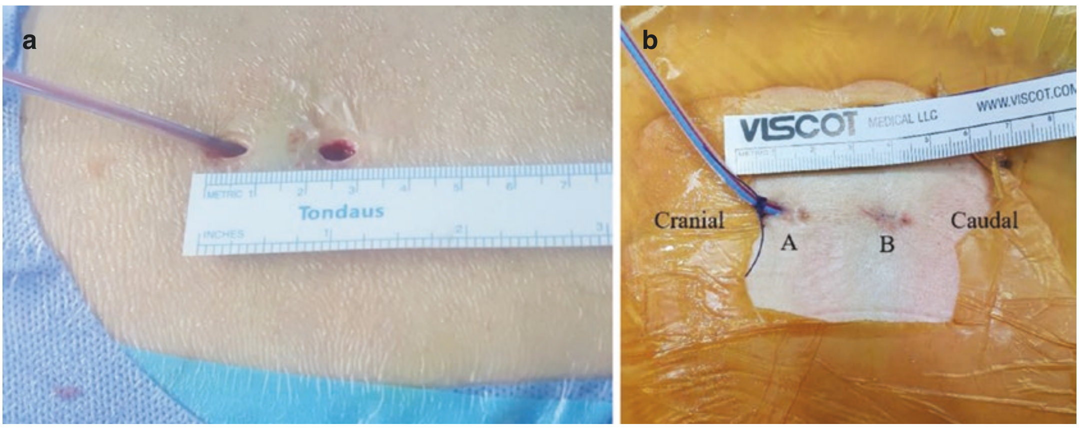

Fig. 9 Skin wound size of two portals. (**a**) Scope portal. (**b**) Working portal. A drainage is inserted

the sufficient discectomy, physician can add the annulotomy using No. 15 blade or Kerrison punch. Authors prefer the Kerrison punch to prevent unintended dura injury.

7. **Finish the procedure.** After adequate discectomy, the physician should inspect the operating field entirely. The remnant disc fragment or residual debris should be removed absolutely from the working space. Longer blunt hooks are used to explore the perineural space including shoulder and axillar portion of nerve root (Fig. 8). After biportal endoscopic discectomy, authors always put the drainage catheter over the dura mater (Fig. 9a). Although there is no prominent bleeding in the working space during operation, hidden epidural bleeding and muscular bleeding can be emerged after surgery. The fascial layer is closed with one-point absorbable suture and subcutaneous layer is also closed with absorbable suture too (Fig. 9). Finally, several pieces of sterilized tape are applied to skin closure.

Illustrated Cases

Case 1 (Video 2)

Forty-two-year-old male patient complained of severe lower back pain and left side radiating pain. The preoperative MRI images showed her-

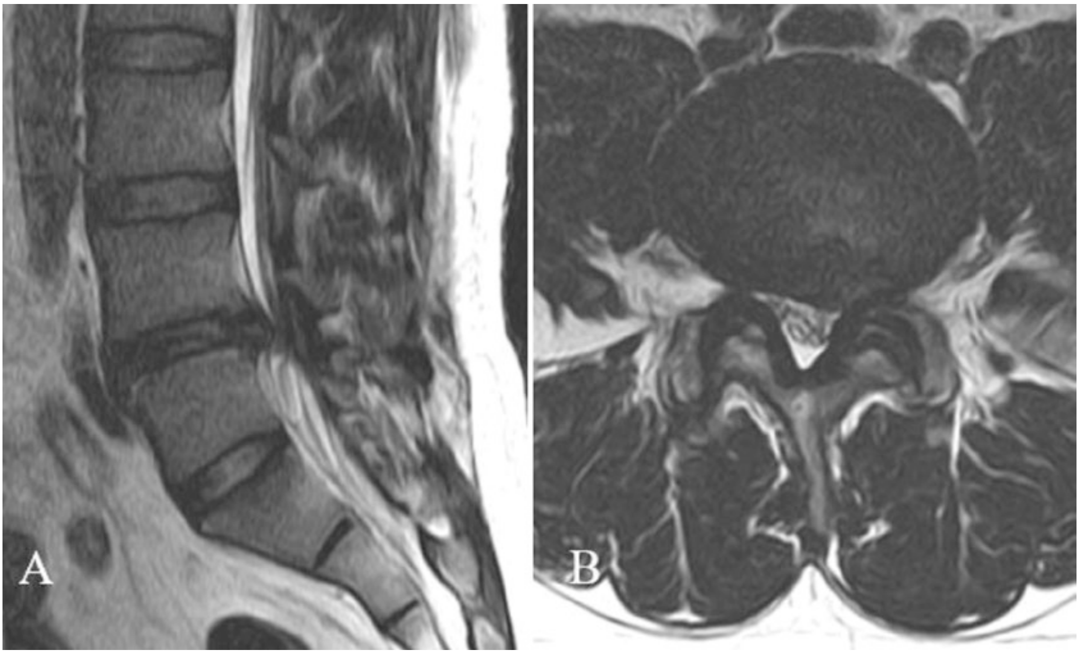

Fig. 10 (**a**) Preoperative MRI shows HLD L4/5 (sagittal view). (**b**) Axial view shows left side paracentral HLD at L4/5 intervertebral disc level

niated lumbar disc (HLD) L4/5 left side that compressed the L5 nerve root significantly (Fig. 10a, b). The author underwent biportal endoscopic discectomy surgery with left side approach (Fig. 7 and Video 1).

After decompression, the postoperative MRI (POD 1day) showed well-decompressed state at L4/5 level. There was no postoperative hematoma or prominent paraspinal muscle damage (Fig. 11a, b).

Case 2 (Foraminal HLD L5/S1, Right) (Figs. 12 and 13)

Fifty-four-year-old female patient complained of severe right side buttock pain and radiating pain. She showed L5 dermatome radiculopathy. Preoperative MRI images showed foraminal HLD L5/S1 right side that compressed the L5 dorsal root ganglion (DRG) (Fig. 12 a, b). The author performed biportal endoscopic decompression using right side paraspinal approach. Intraoperative endoscopic images during operation show sequential steps (Fig. 13). Postoperative MRI images (POD 1day) showed complete removal of HLD at L5/S1 level (Fig. 12c, d).

Case 3 (Highly Downward Migrated HLD L2/3, Left) (Figs. 14 and 15)

Sixty-two-year-old male patient complained of severe left side anterior thigh pain. His MRI showed highly downward migrated HLD L2/3 left side and ruptured disc material was located at L3 pedicle level (Fig. 14a, b). The author performed biportal endoscopic decompression using left side paramedian approach. Intraoperative endoscopic images show sequential steps (Fig. 15). The ruptured disc material disappeared completely in postoperative MRI images (POD 1day) (Fig. 14c, d).

Complication and Its Management

Most common complication is dura tear during flavectomy. This complication often happens in learning curve period [2]. Most common site of dura tear is lateral aspect of thecal sac or shoulder portion of traversing nerve root. This happens in the situation that there is not sufficient space or gap between deep layer of ligamentum flavum and dura mater. The flavectomy is per-

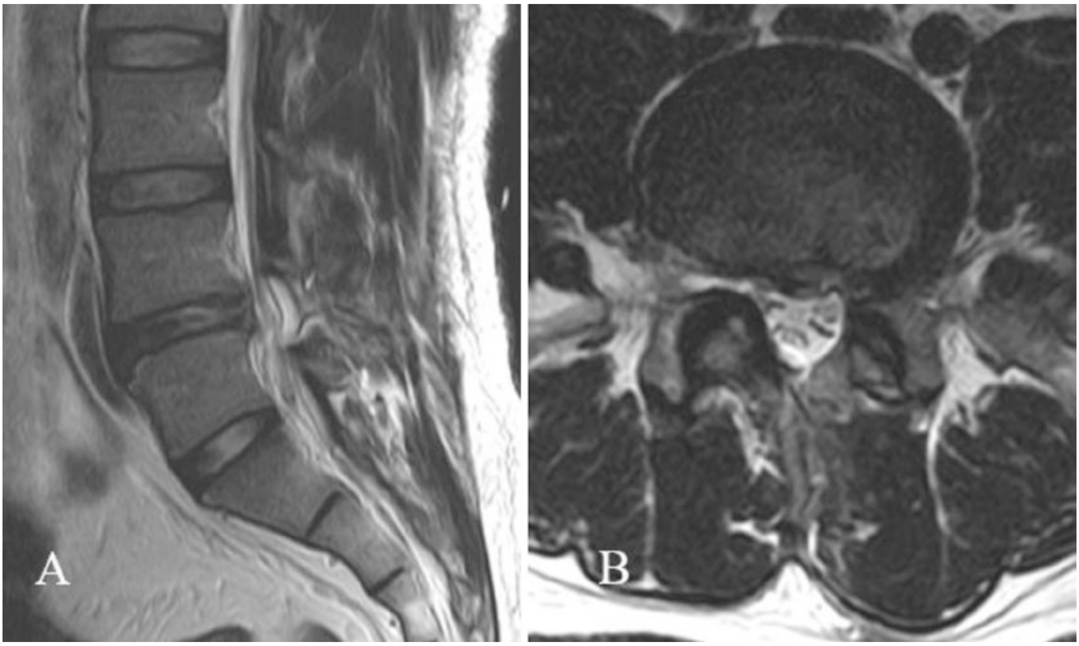

Fig. 11 (**a**) Postoperative MRI shows decompressed state at L4/5 (sagittal view). (**b**) Axial view shows well-decompressed lesion site at L4/5 intervertebral disc level. In addition, postoperative paraspinal muscle change is slight

formed mainly by Kerrison punch. The surgeon sometimes does not notice that the Kerrison punch trapped both ligament and dura mater. The dura mater locates just beneath the ligamentum flavum anatomically; if there is an adhesion between ligament and dura mater, the risk of dura defect may be increased. To reduce this complication, the surgeon should confirm the detachment of ligament from thecal sac using blunt hook or dissector especially in lateral aspect of ligament. If the size of dura defect is relatively small, simple dura packing is enough. If the size of dura defect is large and seems difficult to treat the defect, the surgeon should decide to convert to the open surgery promptly.

Postoperative epidural hematoma is another complication of posterior endoscopic approach. Meticulous bleeding control is necessary during operation. A drainage catheter was routinely inserted postoperatively for the prevention of epidural hematoma.

Discussion: Surgical Tip and Pitfall

Before starting of biportal endoscopic surgeries, the surgeon should have many experiences of microscopic spine surgery. The most significant advantage of this biportal endoscopic technique is that it can be applied to all types of lumbar disc herniation [4]. In order to successfully complete this approach, it is of most importance that the initial working space be created quickly. For beginners, this task is often insufficient, and this results in the poor vision of endoscopic operating field. The successful approach is that the cortical surface of the laminar bone is exposed immediately when water perfusion begins. Many beginners do not overcome this initial step, so they convert to the conventional open laminectomy. If you overcome this initial step, the rest of the biportal endoscopic surgery is similar conventional microdiscectomy, so the physician can performe this procedure well [5]. Furthermore, after acquiring discectomy using this technique, bilat-

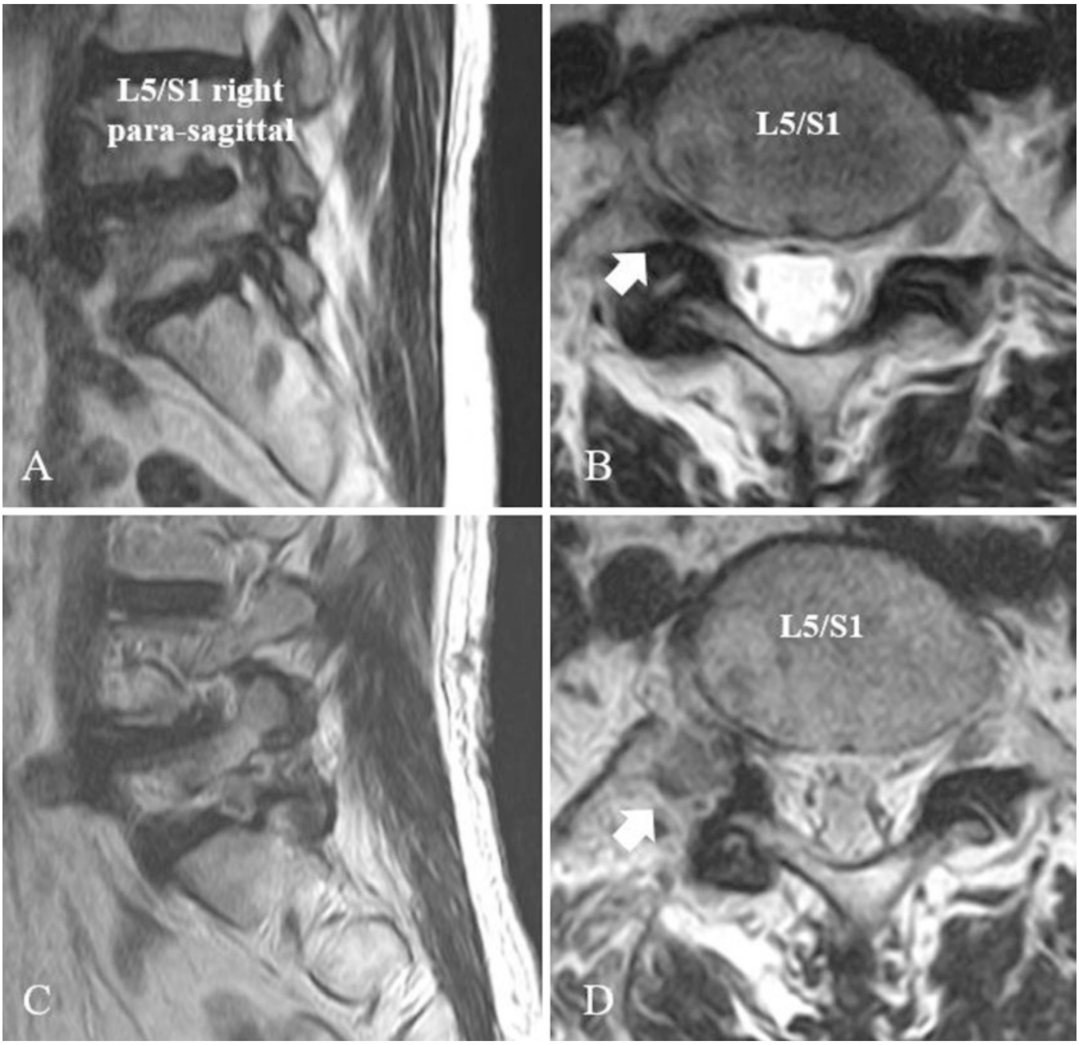

Fig. 12 Preoperative MRI images show foraminal HLD L5/S1 right side (**a** and **b**). Postoperative MRI images show complete removal of HLD at right foramen (**c** and **d**)

eral discectomy using unilateral laminotomy will be possible [6].

Most important factor to maintain the clean visual field during procedure is to keep the continuous water flow. The authors usually use a water irrigation pump set to 30 mmHg and keep this rate unless there is an unexpected event such as arterial bleeding or significant venous bleeding. In these situations, temporarily increasing water flow pressure can help to identify the bleeding site. In addition, bleeding site can be more difficult to identify when you pull back the endoscope, so it is easier to control the situation by placing the endoscope closer to the bleeding suspected site. It is very useful to use proper hemostatic materials such as Gelfoam® sponge, Floseal®, or bone wax. If bleeding is well controlled, the increased water flow pressure should be lowered back to the previous level. This is because if the in-flow pressure of the water is continuously increased in a situation where the outflow of the water is not smooth, the water may

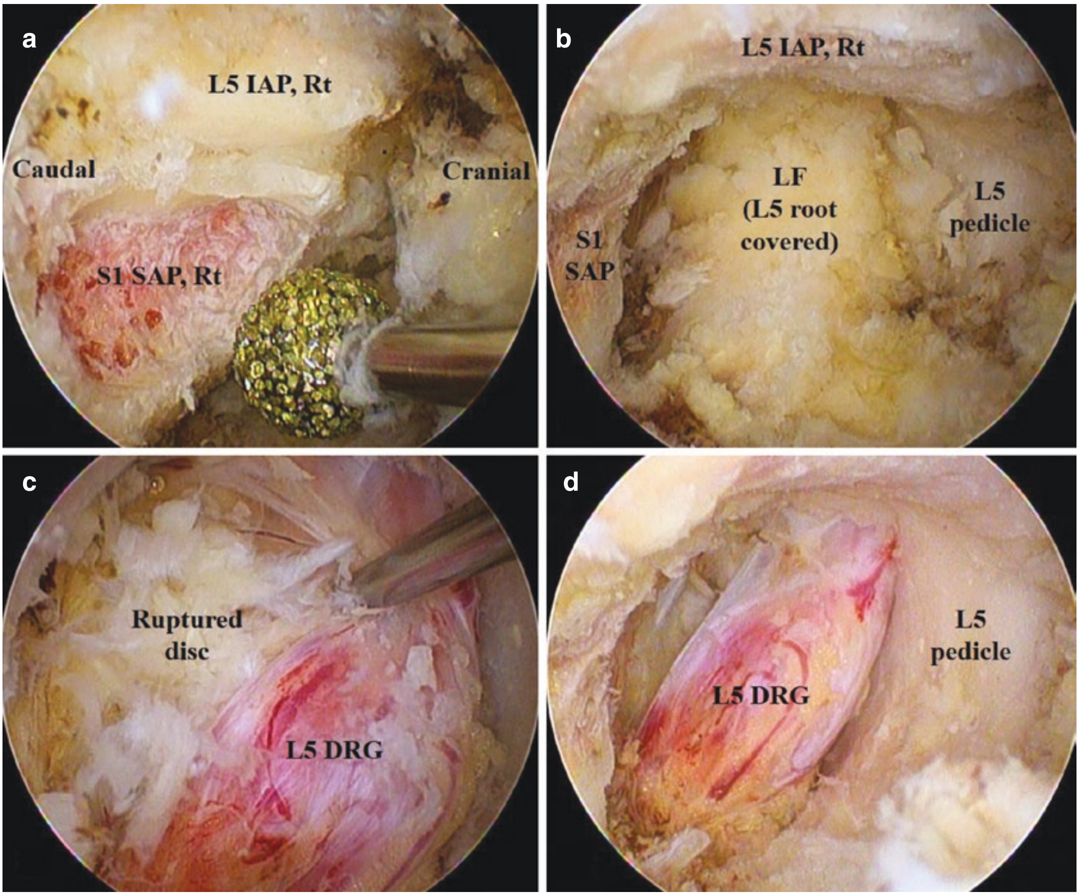

Fig. 13 Serial sequence images of foraminal decompression. (**a**) S1 superior articular process (SAP) removal is the first step of foraminal approach. L5 inferior articular process (IAP) was also identified clearly. (**b**) The image shows foraminal ligamentum flavum which covers the L5 root. (**c**) After flavectomy, compressed L5 DRG and ruptured disc material were confirmed. (**d**) The endpoint view of decompression, well-decompressed DRG was confirmed

penetrate into the paraspinal muscle or enter the spinal canal and press the dura mater. Therefore, the physician should make sure that the water is discharged well during procedure. Water penetrating into the paraspinal muscles can be seen by swelling of the skin on the surgical site.

Keeping the endoscopic orientation constantly is also a very important factor to complete this procedure successfully. One of the challenges for beginners is that endoscopic view is very different from conventional view. Endoscopic view is much closer to the target, making it difficult to maintain spinal anatomy orientation. In order to minimize this difficulty, it is recommended not to rotate the endoscope during surgery, but to maintain the patient's cranial-to-caudal and medial-to-lateral orientation. If the physician misses this orientation, he may perform surgery on normal areas other than the target lesion. If the orientation is uncertain or you encounter an unexpected anatomical structure, do not hesitate to check it with fluoroscopic imaging.

Finally, the height of the physician should be proper. If the height of the endoscopic surgery

Fig. 14 Preoperative MRI images show highly downward migrated HLD L2/3 left side (**a** and **b**). Postoperative MRI images show complete removal of ruptured disc material (**c** and **d**)

field is too high, excessive force will be applied to both shoulder joints, causing both shoulder joints to fatigue easily. Therefore, if necessary, the height should be adjusted so that both shoulder joints of the physician can be comfortable using the appropriate steps.

Many good results have been published in areas that were difficult to treat with conventional endoscopic surgery, such as lumbar spinal stenosis or segmental instability [7–9].

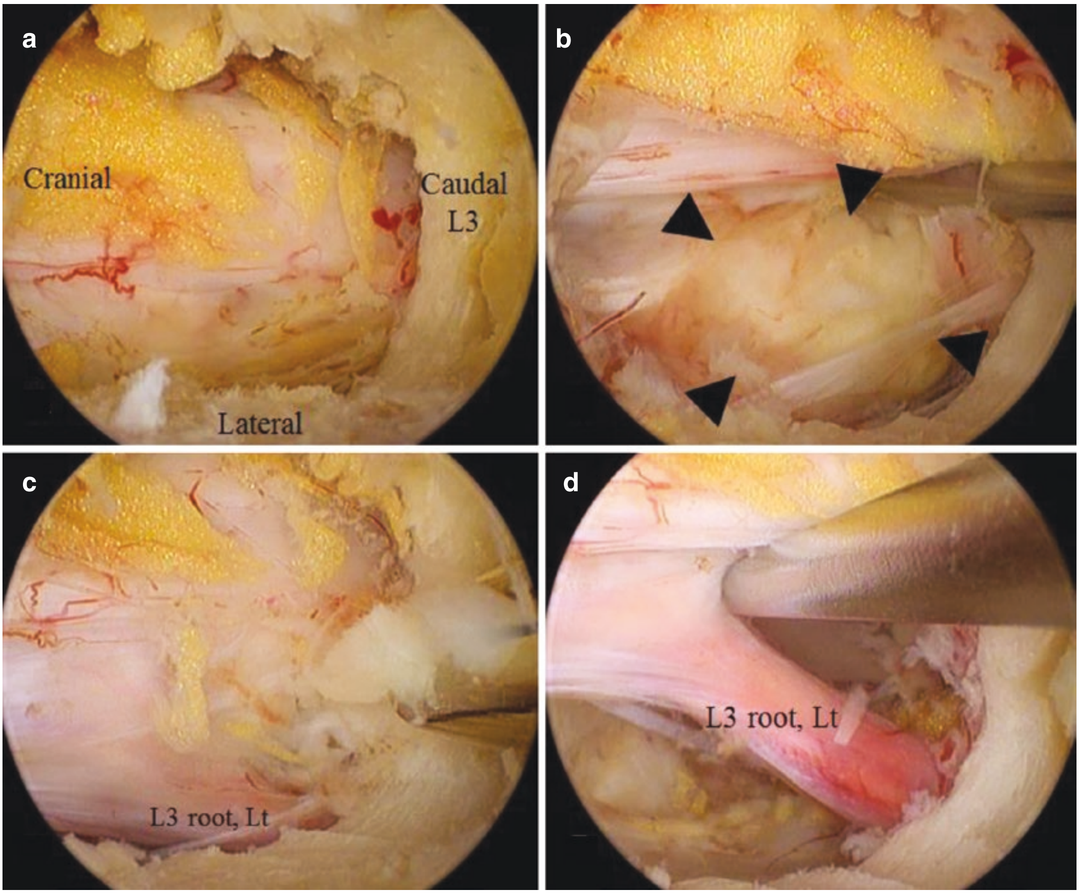

Fig. 15 Serial sequence images of L2/3 decompression. (**a**) After flavectomy, the epidural fat tissue and thecal sac were identified. (**b**) After retraction of L3 root medially, the downward migrated disc material was confirmed (black arrow heads). (**c**) The disc material was removed using pituitary forceps. (**d**) The endpoint view of decompression, well-decompressed L3 root was confirmed

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