18 Thoracic Unilateral Laminetomy for Bilateral Decompression by Unilateral Biportal Endoscopy

Man Kyu Park, Sang Kyu Son, and Seung Hyun Choi

18.1 Introduction

Conventional thoracic laminectomy is still the standard surgical approach in the treatment for thoracic spine pathology, including thoracic spinal stenosis or ossified ligamentum flavum (OLF) [1–3]. However, this procedure results in the removal of bony and musculoligamentous structures [3]. Hence, fusion surgery for the prevention of iatrogenic instability is often necessary, and it can also lead to postoperative back pain and complications [2, 4].

Unilateral biportal endoscopy (UBE) is a minimally invasive endoscopic spine surgery that is currently used to treat degenerative spinal diseases involving the cervical, lumbar, and thoracic spine [5–7]. The concept of unilateral laminectomy for bilateral decompression (ULBD) has been employed successfully by spine surgeons for treating lumbar spinal stenosis [8]. The application of ULBD by UBE is also being tried in treating thoracic spinal stenosis or OLF.

Thoracic ULBD by UBE can decrease postoperative instability and back pain by preserving the contralateral facet joint, lamina, and musculoligamentous structures. The main advantage of this technique lies in the availability of a clear and magnified surgical view during operation under endoscopy with continuous saline irrigation. Moreover, the independent movement of the surgical instruments and endoscope provides a wide view for operation with minimal facet violation. This can help achieve complete spinal cord decompression and improve neurological and functional outcomes while avoiding the complications related to conventional thoracic laminectomy.

In this chapter, we discuss the common indications for thoracic ULBD by UBE and the surgical techniques and tips for this procedure. We also focus on specific anatomical landmarks to highlight complication avoidance.

18.2 Indications and Contraindications

It is necessary to understand the indications for thoracic ULBD by UBE to obtain a better outcome.

Supplementary Information The online version contains supplementary material available at [https://doi.org/10.1007/978-981-16-8201-8_18].

M. K. Park · S. K. Son (✉)
Department of Neurosurgery, Parkweonwook Hospital, Busan, South Korea
e-mail: Bread0309@handmail.net

S. H. Choi
Department of Orthopedic Surgery, Parkweonwook Hospital, Busan, South Korea

D. H. Heo et al. (eds.), *Unilateral Biportal Endoscopic Spine Surgery*,
https://doi.org/10.1007/978-981-16-8201-8_18

The indications are as follows:

1. Thoracic spinal stenosis
2. OLF
3. Synovial cysts

Contraindications of thoracic ULBD by UBE are as follows:

1. Central disc herniation
2. Spinal tumor
3. Vascular malformations
4. Instability of the spinal column
5. High-grade deformity
6. Considering safety and technical difficulties, beginner UBE surgeons should exclude patients in cases of fused-type OLF, severe dural ossification, or severe thoracic stenosis.

18.3 Special Instruments

Most of the instruments used in thoracic ULBD by UBE are similar to other surgeries by UBE. Diamond drill and 1-mm Kerrison punch are necessary to perform thoracic ULBD by UBE.

18.4 Anesthesia and Position

After general anesthesia and intraoperative neurophysiological monitoring are performed, a patient is carefully placed in the prone position on a table. Satisfactory positioning is important to avoid abdominal compression. Abdominal compression may cause inadequate venous return and engorgement of the epidural venous plexus. Excessive intraoperative bleeding may lead to overuse of the radiofrequency (RF) probe and subsequent cord injury. Generally, the left-side approach is preferred for a right-handed surgeon. For right-handed surgeons, a left-side portal is used as the scopic portal for the endoscope and a right-side portal is used as a working portal for manipulation of the surgical instruments. An assistant on the opposite side of the operator holds the semi-tubular retractor.

18.5 Surgical Steps

18.5.1 Skin Marking and Making Portal

C-arm fluoroscopy is required to confirm the level of surgery. It is important to compare this count with preoperative images since one of the most common errors in thoracic spine surgery is performing it at a wrong spinal level. The docking point is identified using an anteroposterior (AP) view of C-arm fluoroscopy as the lower part of the cranial lamina. Two incisions are made approximately 2.5 cm apart, with the center being the lower part of the cranial lamina at the midline of the proximal and distal pedicles (Fig. 18.1a). In patients with obesity, the two incisions should be wider and located laterally from the midline. Serial dilators and endoscopic sheath are inserted to the docking point under C-arm guidance. Under C-arm fluoroscopy, serial dilators are inserted through the working portal, and a scopic sheath is introduced at the docking point through the scopic portal. The tip of the dilator and the endoscopic sheath make a triangulation above the docking point, and the locations of the portals are then confirmed on AP and lateral fluoroscopy. The muscle detacher is inserted and used to reach the inferior edge of the cranial lamina and the base of the spinous process. After positioning the endoscope and the semi-tubular retractor through each portal, the initial working space is made available under fluoloscopic guidance (Fig. 18.1b). The semi-tubular retractor is used to maintain the fluid output and to retract the paraspinal muscles. Care should be taken while placing the semi-tubular retractor so that fluid output is more crucial at the thoracic cord level, which is sensitive to pressure.

18.5.2 Bone Working (Video 18.1)

After confirming that both portals are placed correctly, the soft tissues are coagulated by the RF probe to expose the anatomical structure of the cranial lamina, the base of the spinous process, and the interlaminar space (Fig. 18.2a).

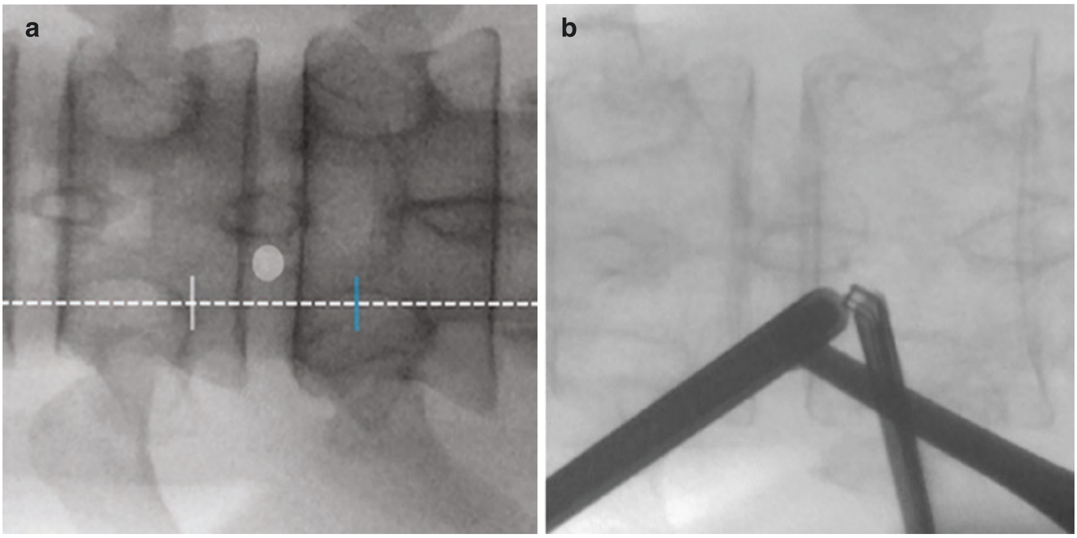

Fig. 18.1 Skin incision and docking point on the fluoroscopic anteroposterior view. The docking point (white circle) is the lower part of the cranial lamina. Two skin incisions (working portal: blue line, scopic portal: white line) are made about 2.5 cm apart, with the center being the lower part of the cranial lamina at the midline of the proximal and distal pedicles (dotted line) (**a**). The positioning the endoscope and surgical instruments with a semi-tubular retractor through each portal (**b**)

Subsequently, the outer cortex of cranial lamina is removed to expose the cancellous bone, and the round cutting burr is used to remove the cranial lamina down to the ligamentum flavum (LF) (Fig. 18.2b). Care should be taken not to compress the LF by burr or Kerrison punch. The base of the spinous processes is removed to make space for safe bone working, especially in contralateral decompression (Fig. 18.2c). The purpose of removing the base of the spinous process is to reduce compression of the spinal cord by the endoscope or surgical instruments when performing contralateral decompression (Fig. 18.3). After that, the midline gap of LF, which is the anatomical landmark of midline orientation, is identified (Fig. 18.2d). Based on this landmark, the extent of the bone working can be assessed by removing the base of the spinous process from the ipsilateral to the contralateral side as well as cranially and caudally underneath the spinous process. The cranial lamina is removed until the cranial attachment of the LF is exposed (Fig. 18.2e). Contact with the burr could bring serious complications to the spinal cord. Therefore, to avoid neural injury during thoracic ULBD by UBE, the LF is left as a protector until bone working is completed. After completing laminectomy wide enough to decompress both sides of the surgical segment while maintaining the LF, the medial aspect of the facet joint is partially removed (Fig. 18.2f). The lateral end of the laminectomy overlaps with the medial aspect of the facet joint, which should be preserved as far as possible for stability.

18.5.3 Removal of LF (Video 18.2)

After the finishing of bone working, the superficial layer of the LF is detached from the posterior surface of the caudal lamina using a freer elevator and pituitary forceps (Fig. 18.4a). Afterward, the junction between the medial margin of the superior articular process (SAP) and the caudal lamina is identified as a landmark for lateral decompression (Fig. 18.4b). Before the removal of these structures, a diamond burr is used to thin out the medial aspect of SAP and the upper portion of the caudal lamina, without which the Kerrison punch could compress the spinal cord underneath the bony structures (Fig. 18.4c, d). Once thinned out, the caudal lamina is partially

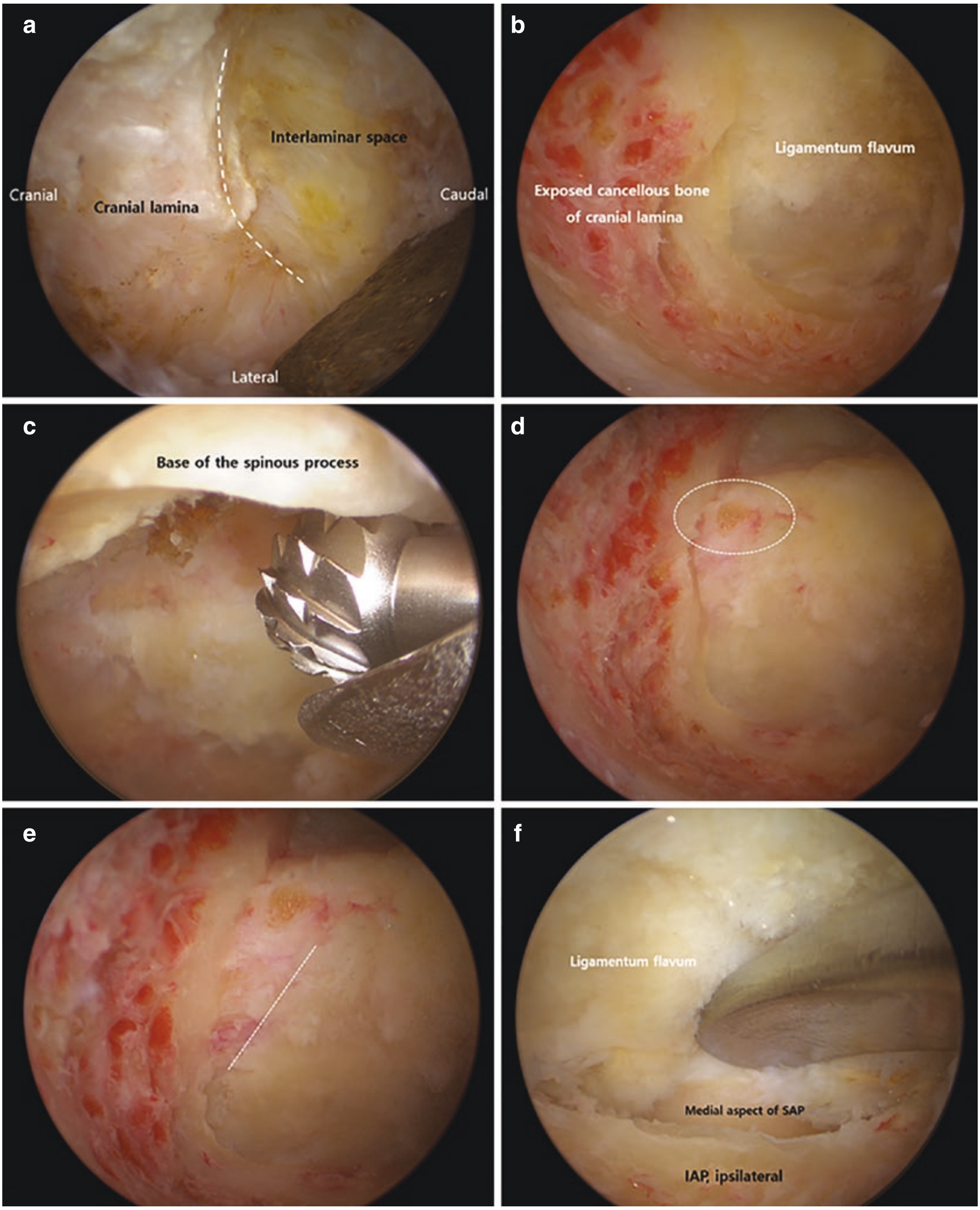

Fig. 18.2 Serial sequence endoscopic images of the bone working. The surgical anatomy is first noticed in the inferior edge of the cranial lamina (dotted line) and the interlaminar space (**a**). The outer cortex of cranial lamina is removed to expose the cancellous bone, and the round cutting burr is used to remove the cranial lamina down to the ligamentum flavum (**b**). The base of the spinous processes is removed to make space for safe bone working, especially in contralateral decompression (**c**). Anatomical landmark for midline orientation. Endoscopic view of midline gap of ligamentum flavum (white circle) (**d**). Anatomical landmark for cranial bone working. Dotted line indicates cranial end of the ligamentum flavum of ipsilateral side (**e**). Anatomical landmark for lateral bone working. The lateral end of the laminectomy overlaps with the medial aspect of the facet joint (**f**)

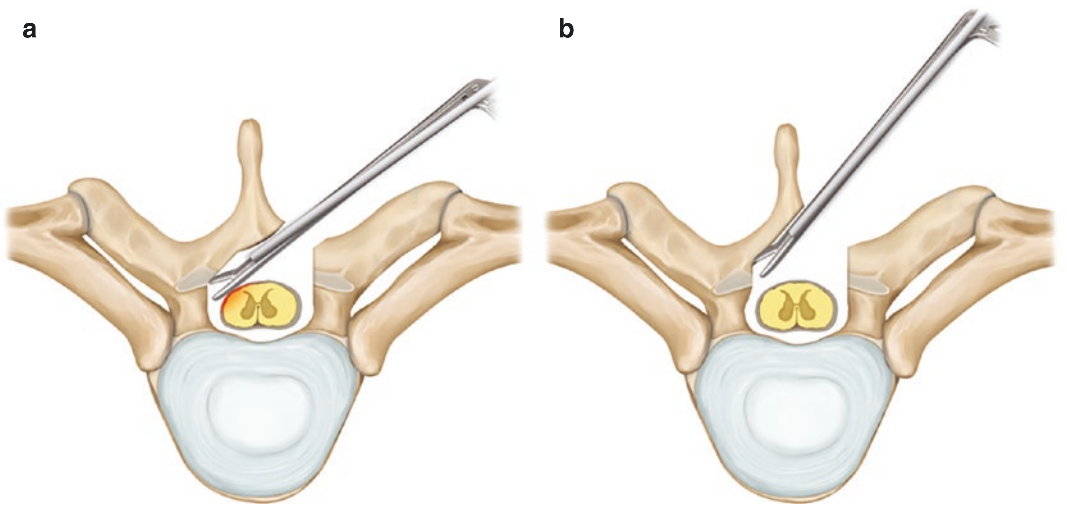

Fig. 18.3 Securing space for safe surgery in thoracic ULBD by UBE. If the base of the spinous process is not sufficiently removed, there is a possibility of cord injury caused by the instruments during contralateral decompression (**a**). The base of the spinous processes is removed to make space for safe bone working, especially in contralateral decompression (**b**)

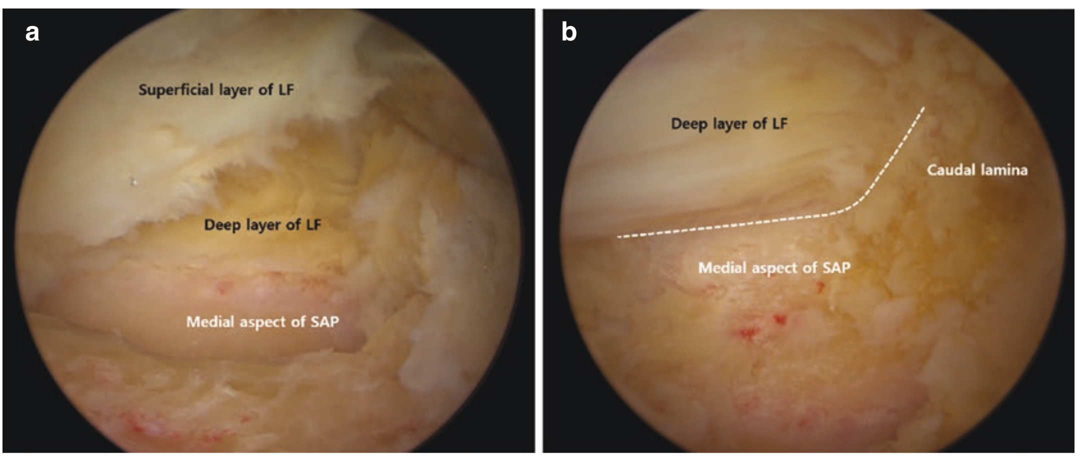

Fig. 18.4 Endoscopic images showing the sequential steps of removal of ligamentum flavum (LF). Detachment of the superficial layer of LF (**a**). Exposure of the upper portion of the caudal lamina and medial margin of the superior articular process at ipsilateral side (white dotted curved line) (**b**). A diamond burr is used to thin out the medial aspect of SAP and the upper portion of the caudal lamina (**c** and **d**). Once thinned out, the caudal lamina is partially removed with a freer elevator or 1-mm Kerrison punch that continues along the medial margin of the SAP and exposes the caudal end of the deep layer of LF (**e** and **f**). Because cord compression is usually not severe around the cranial part of the LF, the cranial side of the LF (white arrow) should be released after the detachment of the caudal part of LF (**g**). Exposure of the upper portion of the caudal lamina and medial margin of the SAP at contralateral side (white dotted curved line) (**h**). A diamond burr is used to thin out the medial aspect of SAP and the upper portion of the caudal lamina (**i**). Removal of the medial aspect of SAP and the upper portion of the caudal lamina (**j**). Coagulation of the cranial side of the LF (white arrow). Dotted line indicates midline (**k**). Detachment of the cranial side of the LF (white arrow) (**l**). The remaining medial aspects of SAP can be removed until the lateral margin of the thecal sac is confirmed, which is easily identified by epidural fat tissue (asterisk) (**m**). Confirmation of complete decompression (**n**)

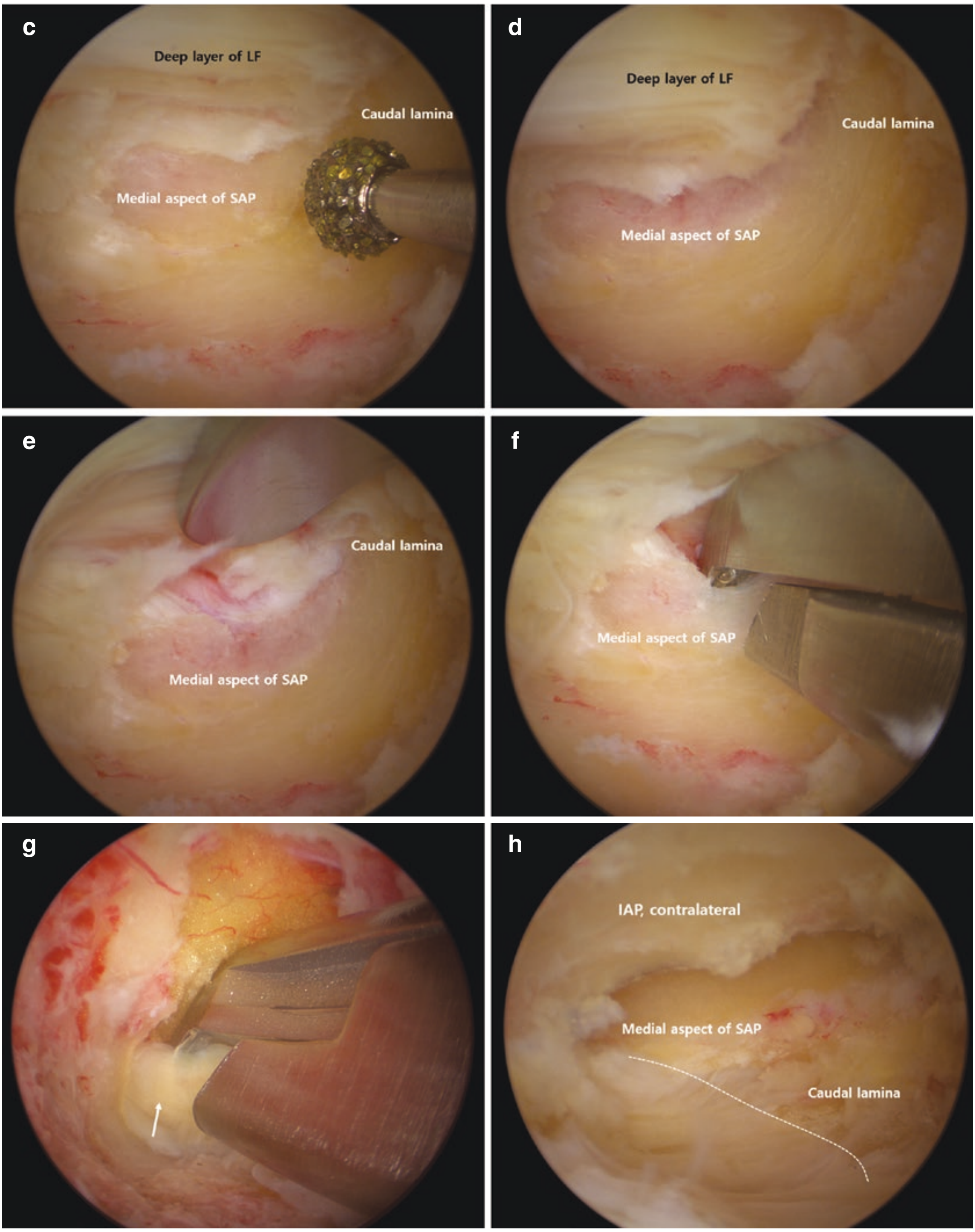

Fig. 18.4 (continued)

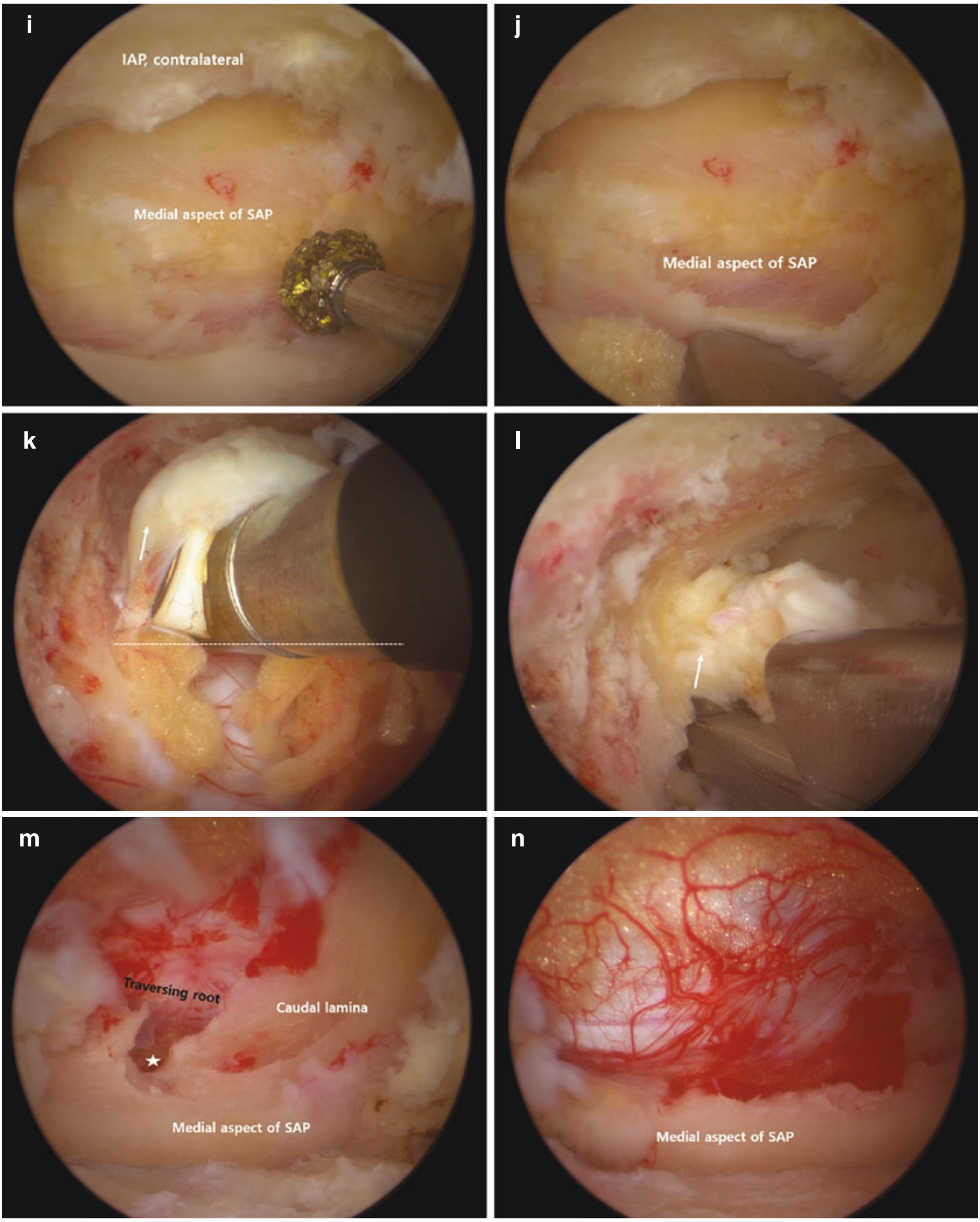

Fig. 18.4 (continued)

removed with a 1 mm Kerrison punch or freer elevator that continues along the medial margin of the SAP and exposes the caudal end of the deep layer of LF (Fig. 18.4e, f). Because cord compression is usually not severe around the cranial part of the LF, the cranial side of the LF should be released after the detachment of the caudal part of LF (Fig. 18.4g). This technique makes the *en block* removal of the deep layer of LF possible. Additionally, it should be noted that during the removal of the LF, there is often an adhesion between LF and dural matter that can access a plane below the LF.

The method for removing LF at the contralateral side is the same as mentioned above (Fig. 18.4h–l). Prior to the removal of LF at contralateral side, because of the abundance of epidural blood vessels around the cranial attachment of LF, the coagulation by RF probe is helpful for bleeding control (Fig. 18.4k). When removing the contralateral side of LF, the surgeon should pay attention not to compress the spinal cord with surgical instruments such as the Kerrison punch. In order to do this, the base of the spinous process should be sufficiently removed and the caudal lamina and medial aspect of SAP should be thinned out using a diamond drill (Fig. 18.3). The remaining medial aspects of SAP can be removed until the lateral margin of the thecal sac is confirmed, which is easily identified by epidural fat tissue (Fig. 18.4m). The lateral end of decompression is the medial aspect of the pedicle and the lateral margin of the thecal sac. The endpoint of decompression is spinal cord decompression, which can be confirmed with endoscopic guidance (Fig. 18.4n).

18.5.4 Removal of OLF (If Present) (Videos 18.3 and 18.4)

The removal of OLF can be organized as thinning-detaching-removing. After the removal of the nonossified LF, the underlying OLF can be identified (Fig. 18.5a). Basically, OLFs are thick and hard, and removing them with Kerrison punch is

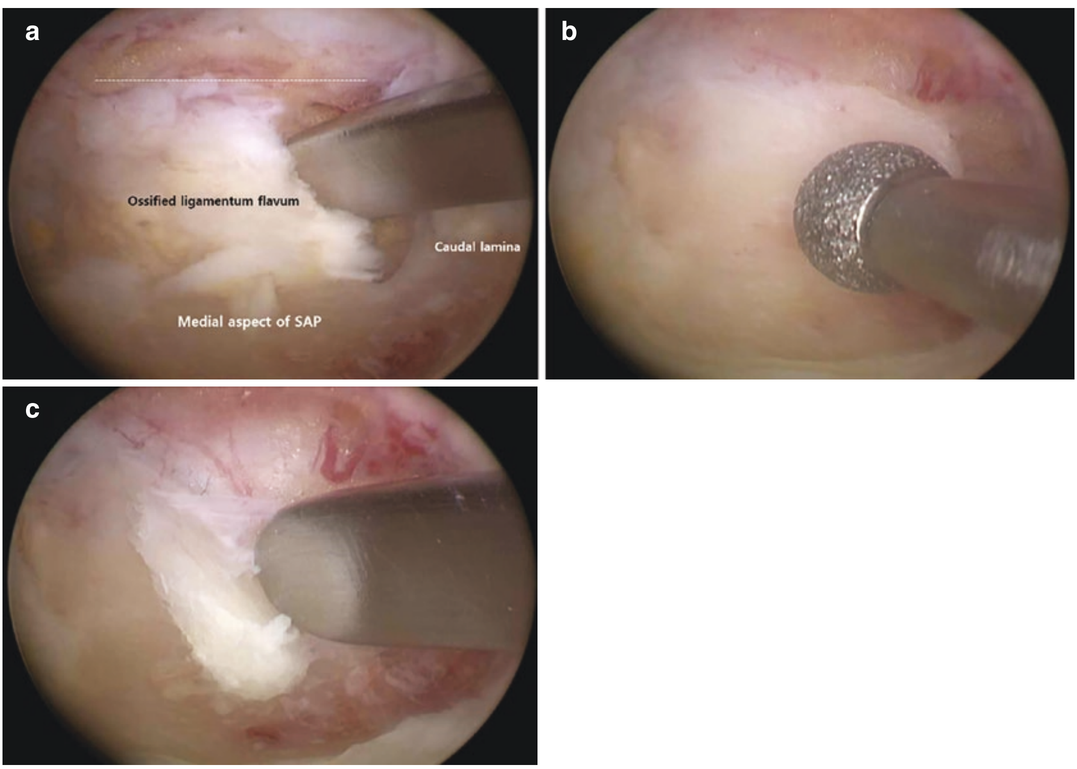

Fig. 18.5 Serial sequence endoscopic images of removal of ossified ligamentum flavum (OLF). Identification of the OLF. Dotted line indicates midline (**a**). The OLF is ground into a thin and translucent form using a diamond drill (**b**). The thinned-out OLF can be detached from the thecal sac using the freer elevator (**c**)

difficult and dangerous. Since the thoracic cord is particularly sensitive to compression, the OLF should be removed cautiously without unintended compression on the spinal cord. After the exposure of OLF, the OLF is ground into a thin and translucent form using a diamond drill (Fig. 18.5b). The thinned OLF should remain stable until the drilling is over as it protects the spinal cord from the diamond burr. The thinned-out OLF can be detached from the thecal sac using the freer elevator and removed gently piece by piece using small-sized pituitary forceps or a 1 mm Kerrison punch (Fig. 18.5c). If the removal of OLF fails due to severe adhesion or dural ossification, the OLF should be left as it is also known as the floating method. The complications that arise if dura tear occurs are described in detail later. Finally, free-floating dura mater is a sign of sufficient decompression under endoscopic guidance.

18.5.5 Postoperative Drain

After complete decompression, a Jackson–Pratt surgical drain (100 cc) is usually placed through the working portal to prevent postoperative hematoma. If the Jackson–Pratt surgical drain is inserted deeply, the tip of the drain could cause cord injury.

18.5.6 Postoperative Care

The patient may ambulate and be discharged the first day after the operation. Bedrest is needed if a dura tear occurs and is recommended for 5–7 days if lumbar drain is utilized. A postoperative MRI should be performed in 2 days to check for possible postoperative epidural hematoma and the degree of decompression.

18.6 Illustrated Cases

18.6.1 Case (1): Thoracic Spinal Stenosis

A 73-year-old woman exhibited neurologic symptoms in the bilateral lower extremities caused by compressive myelopathy because of thoracic spinal stenosis at T11-T12 for 12 months. She was treated conservatively for 2 months; however, her symptoms aggravated instead of improving. MRI scans revealed thoracic spinal stenosis at the T11-T12 level (Fig. 18.6a, b). The spinal cord was compressed by the bilateral hypertrophied LF at T11-T12. Postoperative MRI scans revealed adequate decompression of spinal cord at the T11-T12 level (Fig. 18.6c, d). The symptoms improved significantly. The patient had no symptoms of spastic paraparesis at the time of follow-up.

18.6.2 Case (2): OLF

A 61-year-old man presented with a 9-month history of spastic paraparesis. On preoperative MRI (Fig. 18.7a, b) and CT (Fig. 18.7c), we identified bilateral OLF, compressing the cord at the T9-T10 level. ULBD by UBE at T9–10 level was performed from the left side. The OLF was removed and the thecal sac was thoroughly decompressed. After surgery, the result was confirmed on postoperative MRI (Fig. 18.7d, e) and CT scan (Fig. 18.7f). At follow-up after 6 months, his physical strength in the lower extremities returned to 5 bilaterally, and he was able to walk long distances.

18.7 Complications and Their Management

18.7.1 Dural Tear (Video 18.5)

Small-sized dura tear can be treated with careful packing with fibrin collagen patch (TachoComb) and bed rest for 5–7 days. When dural tear occurs, the Jackson–Pratt surgical drain may be contraindicated or should be removed early as it may keep the dural tear patent. However, if the size of dural tear is larger than 10 mm, the dural defect should be repaired directly by a dural suture or by repair conversion under microscopic surgery.

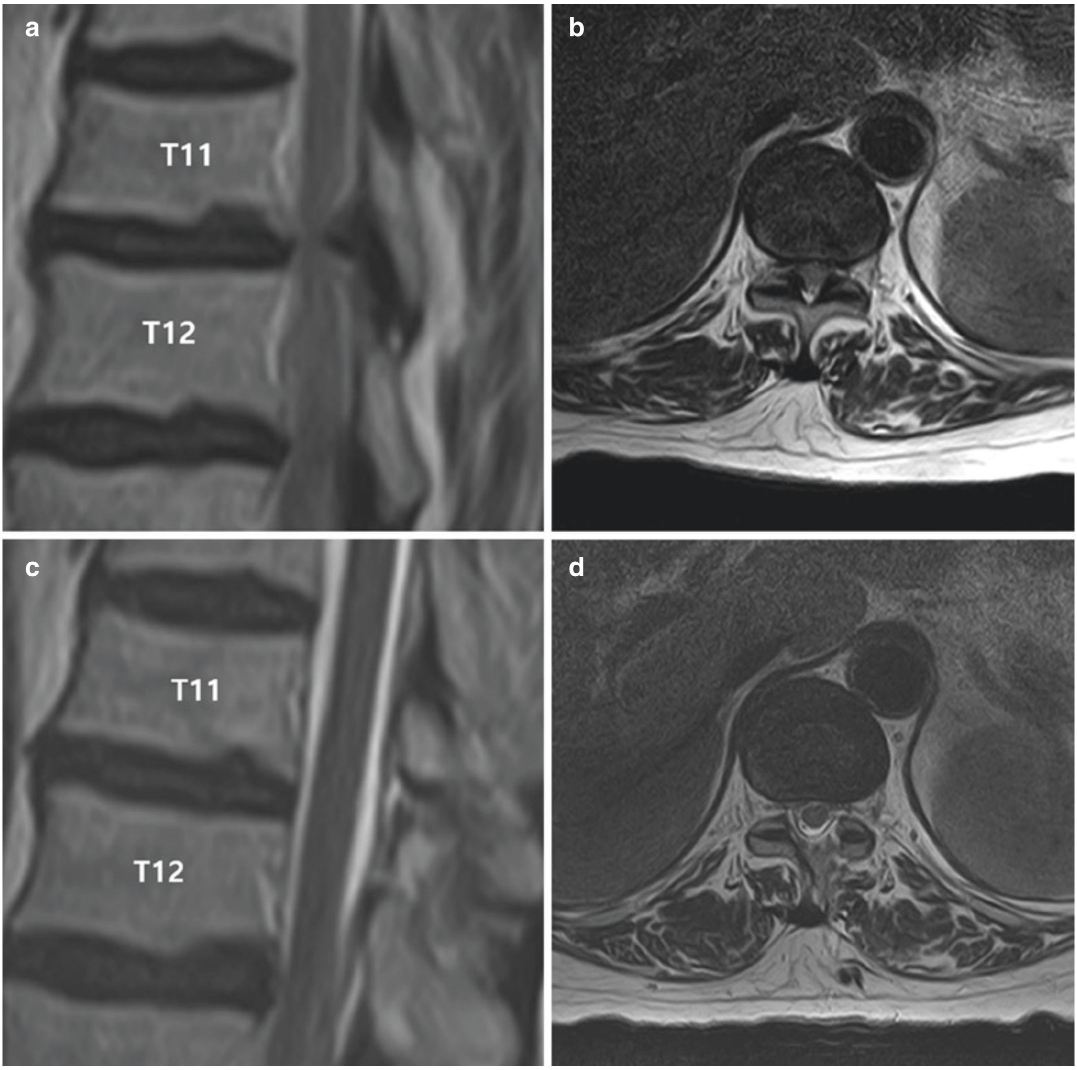

Fig. 18.6 Images of a 73-year-old woman with thoracic spinal stenosis at T11-T12 level. Preoperative MR images show thoracic spinal stenosis with bilateral hypertrophied LF at T11–12 level (sagittal: **a**, axial: **b**). Postoperative axial T2-weighted MRI show enough decompression with minimal facet violation (sagittal: **c**, axial: **d**)

18.7.2 Cord Injury

Care should be taken to avoid cord manipulation at all costs. Since the thoracic cord is particularly sensitive to compression, the thoracic decompression should be removed without inadvertent compression of the spinal cord. Therefore, to avoid cord injury during the bone working, the LF is left as a protector until bone working is completed. Additionally, it is important to sufficiently remove the base of the spinous process and to thin out bony structures or OLF using a diamond drill. If the removal of OLF is difficult due to severe adhesion or dural ossification, it is safe to leave OLF using the floating method. The RF probe should be used with much caution near neural structures. When manipulating an RF probe around the neural structures, surgeons should pay special attention to use it against neural structures with low power.

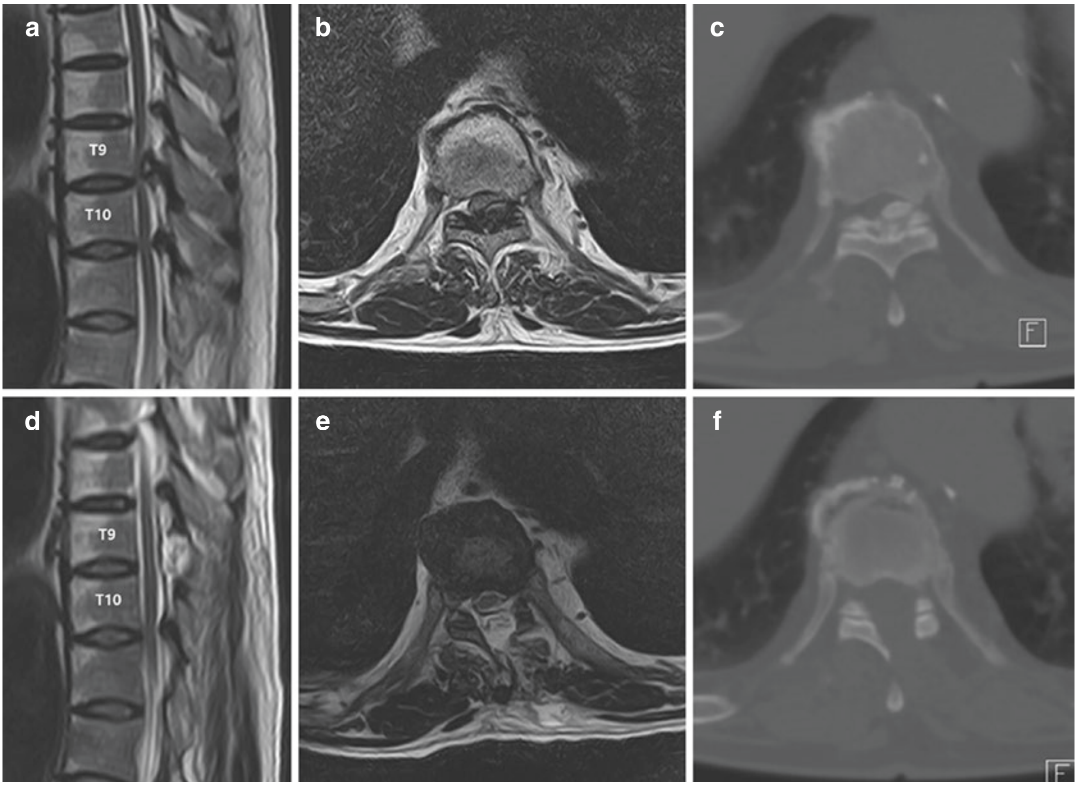

Fig. 18.7 Images of a 61-year-old man with OLF. Preoperative MRI and CT show bilateral OLF, compressing the cord at the T9-T10 level. (MRI sagittal: **a** and axial: **b**, CT axial: **c**). Postoperative axial T2-weighted MRI show well decompression of bilateral OLF (MRI sagittal: **d** and axial: **e**, CT axial: **f**)

18.7.3 Postoperative Hematoma

After decompression, bleeding from bone edges is thoroughly applied with bone wax, epidural veins are coagulated by a hook RF probe, and soluble hemostatic gauze (WoundClot) or Gelfoam is placed on the bleeding site in the epidural space. To prevent postoperative epidural hematoma, it is recommended to keep the Jackson–Pratt surgical drain (100 cc) in the working portal for 1 or 2 days.

18.8 Surgical Tips and Pitfall

The anatomy of the thoracic spine is different from that of the cervical and lumbar spine. The spinal canal is smaller in the thoracic spine, and the lamina is short, thick, broad, and overlapping. Also, the thoracic spinal cord has poor tolerance to compression as well as a limited amount of space to perform surgery [9]. Therefore, excessive compression of the spinal cord by surgical instruments may lead to spinal cord injury [4]. Thus, securing space for safe surgery is of utmost importance. In thoracic ULBD by UBE, surgeons are able to make enough space by undercutting the base of the spinous process and preserving the posterior bony and musculoligamentous structures.

Although UBE has gained widespread popularity in recent years, the adoption of UBE techniques on thoracic spine surgery can be challenging. Therefore, it is recommended to perform thoracic ULBD by UBE only when the surgeon has enough experience in performing lumbar decompression by UBE. This ensures that surgeons are familiar with the movement of the endoscope and the manipulation of surgical instruments and that the fluid output can be maintained well. Further, surgeons must keep in mind the anatomical landmark and the following surgical tips for thoracic ULBD by UBE to minimize potential complications.

1. A more lateral incision is recommended for patients with obesity.
2. The placement of semi-tubular retractor for fluid output requires more attention than lumbar surgery because the poor output of water at cord level is more likely to increase intracranial pressure and cord injury.
3. The diamond drill, fine Kerrison punch, and hook RF probe are invaluable tools.
4. Based on the midline gap of LF, the extent of the bone working can be accomplished by removing the base of the spinous process from the ipsilateral to the contralateral side as well as cranially and caudally by working entirely beneath the spinous process.
5. The cranial lamina is removed until the cranial attachment of the LF is exposed, and the junction between the medial edge of the SAP and caudal lamina is identified as a landmark for lateral decompression.
6. When performing contralateral decompression, special attention should be paid not to compress the spinal cord with surgical instruments such as the Kerrison punch. It is important to sufficiently remove the base of the spinous process and to thin out bony structures using a diamond drill.
7. Since it is dangerous to remove the OLF with a Kerrison punch, the OLF is drilled into a thin and translucent shape using a diamond drill.
8. The pathophysiology of OLF can lead to dural ossification, which is a technical challenge in UBE. If predictive signs of dural ossification are checked in preoperative images, we recommend the thinning and floating techniques. After floating of OLF, the dural opening should be completely sealed with a fibrin collagen patch.
9. Considering safety and technical difficulties, beginner UBE surgeons should exclude patients with fused-type OLF or severe thoracic stenosis as they may exhibit more severe clinical manifestations and poor prognosis.

References

1. Liao CC, Chen TY, Jung SM, Chen LR. Surgical experience with symptomatic thoracic ossification of the ligamentum flavum. J Neurosurg Spine. 2005;2(1):34–9.
2. Okada K, Oka S, Tohge K, Ono K, Yonenobu K, Hosoya T. Thoracic myelopathy caused by ossification of the ligamentum flavum. Clinicopathologic study and surgical treatment. Spine (Phila Pa 1976). 1991;16(3):280–7.
3. Palumbo MA, Hilibrand AS, Hart RA, Bohlman HH. Surgical treatment of thoracic spinal stenosis: a 2- to 9-year follow-up. Spine (Phila Pa 1976). 2001;26(5):558–66.
4. Yang Z, Xue Y, Zhang C, Dai Q, Zhou H. Surgical treatment of ossification of the ligamentum flavum associated with dural ossification in the thoracic spine. J Clin Neurosci. 2013;20(2):212–6.
5. Heo DH, Lee N, Park CW, Kim HS, Chung HJ. Endoscopic unilateral laminotomy with bilateral discectomy using biportal endoscopic approach: technical report and preliminary clinical results. World Neurosurg. 2020;137:31–7.
6. Park MK, Park SA, Son SK, Park WW, Choi SH. Clinical and radiological outcomes of unilateral biportal endoscopic lumbar interbody fusion (ULIF) compared with conventional posterior lumbar interbody fusion (PLIF): 1-year follow-up. Neurosurg Rev. 2019;42(3):753–61.
7. Kim J, Heo DH, Lee DC, Chung HT. Biportal endoscopic unilateral laminotomy with bilateral decompression for the treatment of cervical spondylotic myelopathy. Acta Neurochir. 2021;163(9):2537–43.
8. Ikuta K, Arima J, Tanaka T, Oga M, Nakano S, Sasaki K, et al. Short-term results of microendoscopic posterior decompression for lumbar spinal stenosis. Technical note. J Neurosurg Spine. 2005;2(5):624–33.
9. Dommisse GF. The blood supply of the spinal cord. A critical vascular zone in spinal surgery. J Bone Joint Surg Br. 1974;56(2):225–35.