Uniportal Full Endoscopic Contralateral Approach for Lumbar Foraminal Stenosis

Chang-il Ju, Hyeun Sung Kim, Pang Hung Wu, and Harshvardhan Raor

Introduction

In recent years, the incidence of spinal canal stenosis has increased steeply as the elderly population increases.

Incidence of Foraminal stenosis is proportional to increase in overall incidence of spinal canal stenosis.

Rationale of Endoscopic Contralateral Interlaminar Lumbar Foraminotomy

1. Reduce the lateral wedging instability violation (Fig. 1).
2. Triple crush decompression (Figs. 2 and 3).
3. Reduce the retraction of DRG.

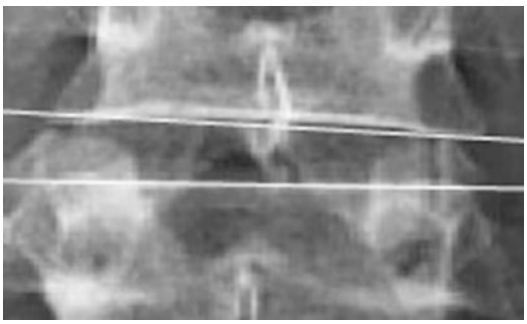


Fig. 1 Lateral wedging instability

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-981-15-8253-0_6) contains supplementary material, which is available to authorized users.

C.-i. Ju
Department of Neurosurgery, Chosun University Hospital, Gwangju, South Korea
e-mail: jchangil@chosun.ac.kr

H. S. Kim (✉) · H. Raor
Department of Neurosurgery, Nanoori Hospital Gangnam, Seoul, South Korea

P. H. Wu
Department of Neurosurgery, Nanoori Hospital Gangnam, Seoul, South Korea

National University Health Systems, JurongHealth Campus, Singapore, Singapore

H. S. Kim et al. (eds.), *Advanced Techniques of Endoscopic Lumbar Spine Surgery*, https://doi.org/10.1007/978-981-15-8253-0_6

Fig. 2 Concept of triple crush compression of foraminal stenosis

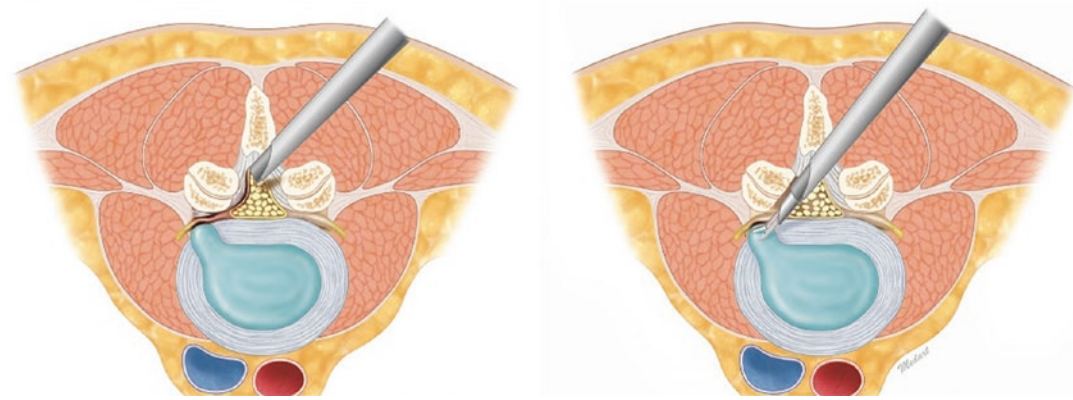


Fig. 3 Illustration of Endoscopic Contralateral Interlaminar Lumbar Foraminotomy

Three important principles to consider in endoscopic foraminal stenosis decompression are (1) successful decompression, (2) reduced neural retraction, and (3) anatomically less violation to preserve stability of facet joints.

The intervertebral foramen is bounded anteriorly by posterior wall of segmental vertebra 1 body and intervertebral disc, superiorly and inferiorly by the pedicles of cranial and caudal corresponding vertebra, and posteriorly by facet joint. Exiting nerve root and blood vessels are held in place by intervertebral foraminal ligaments (Fig. 4). Hypertrophy of any of these structures due to degenerative processes can lead to foraminal narrowing. Narrowing of foraminal dimensions can occur due to disc degeneration and overriding of superior articular facet on inferior articular facet, such loss in foraminal height traditionally are restored by interbody fusion device to jack up the foraminal height. Anterior-posterior foraminal narrowing can occur due to disc bulge, foraminal disc herniation, facet cyst or osteophyte, buckling of the ligamentum flavum, thickening of foraminal ligaments, or any combination of the above. Such narrowing is not easily corrected by restoration of foraminal height by interbody fusion. In both of the scenarios, uniportal full endoscopic contralateral approach for lumbar foraminal stenosis can provide direct decompression of the nerve with maximally preserving the patient's anatomical structures in comparison with the fusion procedure. It can also be done under epidural anesthesia with potentially wider indication to patients with multiple medical comorbidities.

The endoscopic uniportal contralateral endoscopic foraminotomy is a more advanced level of endoscopic decompression which required the

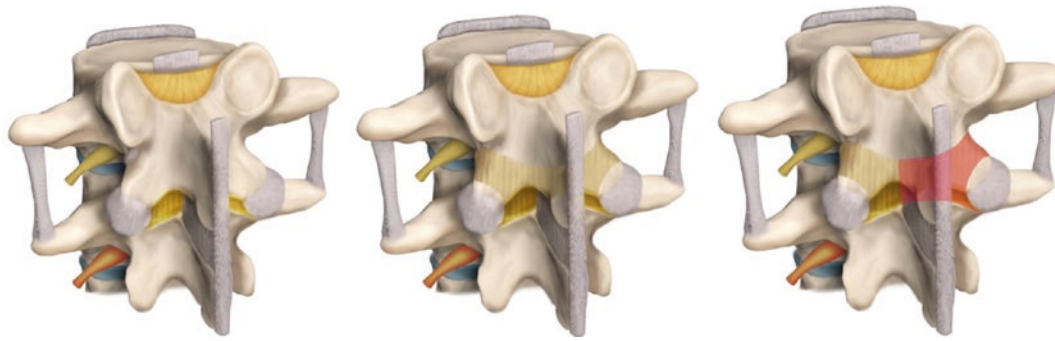


Fig. 4 Outer layer/inner layer/contralateral inner layer to foramen. Layered anatomy showing our target area of ligamentum flavum resection in red

surgeon to have background experience in endoscopic spine surgery.

We present to you the current application of uniportal full endoscopic contralateral approach for lumbar foraminal stenosis secondary to prolapsed foraminal disc (Video Reference).

Indication/Contraindication

Indication

1. Foraminal stenosis.
   (a) Presence of overriding superior articular process and narrowing of foraminal height.
   (b) Hypertrophy of the ligamentum flavum and foraminal ligament.
   (c) Disc protrusion.
   (d) Presence of osteophytes in facet joint and syndesmophytes in disc.
2. Contralateral foraminal HNP.
3. Combined foraminal and extraforaminal HNP.
4. Contralateral facetal cyst.
5. Contralateral pedicle fracture malunion.
6. Segmental instability with lateral wedging.

Contraindication

1. Infection.
2. Tumor.
3. Gross segmental instability.
4. Significant spinal deformity with poor sagittal and coronal balance.
5. Acute traumatic fracture complicated by foraminal stenosis.
6. Presence of central and/or bilateral lateral recess stenosis combined with foraminal stenosis (suitable for bilateral decompression of foraminal stenosis).

Anesthesia/Position

Anesthesia

- Epidural anesthesia with sedation
- In our institution, we use 0.75% ropivacaine mixed with equivalent amount of radiocontrast dye and 1:4,000,000 to make a concoction of epidural anesthetics. We use 10–15 mL of epidural anesthetics depending on spine levels to be done and dermatomes involved. For example, of 10 mL epidural anesthetics, we would add 5 mL 0.75% ropivacaine with 5 mL of radiocontrast dye and 1:400,000 epinephrine.
- General anesthesia
- We do not advocate doing local anesthesia with sedation in uniportal contralateral approach for contralateral foraminal decompression as direct contact of the nerve root with the dura of the neuropathic state causes severe pain in the patient. Therefore, local procedures have a high risk of surgery failure. If the patient moves, there is a high risk of nerve damage.

Position

- Prone position with Wilson frame.

Special Surgical Instrument

Basic Instrument

1. Irrigation pump.
2. C-arm image intensifier.
3. Guidewire.
4. Working channel and serial dilators with a gradual dilation of up to 10–16 mm.
5. Endoscope of a 30° viewing angle, 7.3 mm outer diameter or equivalent, and a working length of 171 mm.
6. The radiofrequency probe.
7. Endoscopic high-speed drill system typically 3.5 mm coarse diamond tip drill.
8. Endoscopic pituitary forceps.
9. Endoscopic Kerrison rongeurs.
10. Endoscopic probe.

Special Instrument

1. Flexible bend drill.
2. Side firing laser.

Both of these special equipment are seldom used by the authors of this chapter.

Surgical Steps

Anatomical Consideration

We are exploring the sublaminar space between contralateral ligamentum flavum and bony structures, namely, spinous process, lamina, inferior articular facet, and superior articular facet en route to the contralateral foramen. The 2 ligamentum flavum are separated at the midline which is filled with a slit of epidural fat which helps mark the margin of the ligamentum flavum. The other tell-tale sign of crossing into contralateral flavum is the presence of interspinous ligaments in the space at the midpoint. Our aim is to remove contralateral ligamentum flavum attachment on the ventral surface of the lower half of the cephalad vertebral lamina and attach to the dorsal surface and upper lip of caudal vertebral lamina, extending laterally to a variable distance on the ventral surface of the tip of superior articular process (Fig. 4).

Skin Marking/Skin Incision

Skin Marking

Skin Incision

(a) All aseptic precautions were maintained throughout the procedure. The image intensifier was brought into the surgical field and disc level and interlaminar space identified on posteroanterior view.

(b) Some variation of skin incision is calculated based on the midline to the extrapolated point of intersection which subtends the angle of contralateral lamina with the horizontal line on MRI. The skin incision was marked typically 1.5 cm lateral to the midline contralateral to the side of foramen to be decompressed and directed towards the side of stenosis. We check with intraoperative image intensifier with an oblique wire aiming towards the contralateral foramen. The skin incision should lie within this trajectory (Fig. 5).

Fig. 5 Patient is in prone position for a right side approach to the left (contralateral side) foramen. Patient underwent epidural anesthesia and sedation placed on Wilson frame. C-arm, scope and video output screen are placed in position, head of the patient is on the right in this case

Approach and Docking

Docking can be done at either point A (the base of spinolaminar junction on the ipsilateral side cranial laminae) or point B (the deepest point of caudal laminae which would then move up to point A) (Figs. 6b and 7a). We start our docking with introduction of 18G spinal needle of 90 mm in length followed by blunt tip guidewire and serial dilation obturator. Once we are satisfied with docking on our AP and lateral intraoperative XR. We use endoscope for foraminal work with a 30° viewing angle, a 7.3 mm outer diameter, and a 4.7 mm working channel endoscope system of 171 mm length (Joimax GmbH) for better visualization of the foramen and lateral recess. The entire process is done under saline irrigation.

Sublaminar Approach Drilling

We typically use the sublaminar approach to contralateral foramen. Begin drilling on the ventral surface of distal spinous process and some part of interspinous ligament to get access of the working channel and drill to the contralateral sublaminar space (Figs. 6 and 9). We removed the superficial layer of the ligamentum flavum to create more working space to proficiently remove the inner layer of contralateral ligamentum flavum. Once we reached the contralateral sublaminar space, we proceed to drill inner lamina towards to contralateral ventral surface of the tip of superior articular process to detach the lateral margin of ligamentum flavum attachment (Fig. 10). Next, we drill cephalad towards the inner ventral lower half of the cephalad vertebra lamina to detach the cephalad ligamentum flavum attachment.

In patients with contralateral lateral recess stenosis, we can perform translaminar approach which would involve contralateral laminectomy (Fig. 7b).

Detachment of the Ligamentum Flavum

Follow the cranial margin of the inner layer of the ligamentum flavum and systematically detach the ligamentum flavum starting from middle to lateral attachments with endoscopic probe as shown in Fig. 10. Once the ligamentum flavum is detached.

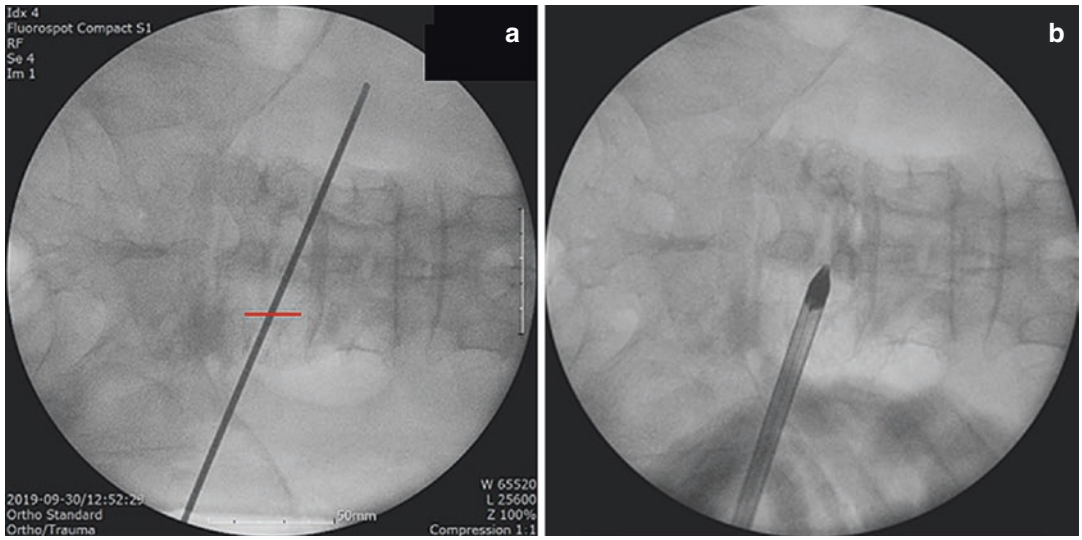


Fig. 6 (**a**) (in red) incision over the middle (for L1–4)/medial pedicle line (for L5 and S1) and lateral edge of interlaminar window and perpendicular to end plate of caudal vertebra body. Intraoperative image of guidewire pointing towards contralateral foramen showing direction of approach to contralateral foramen. (**b**) Docking on the spinolaminar junction.

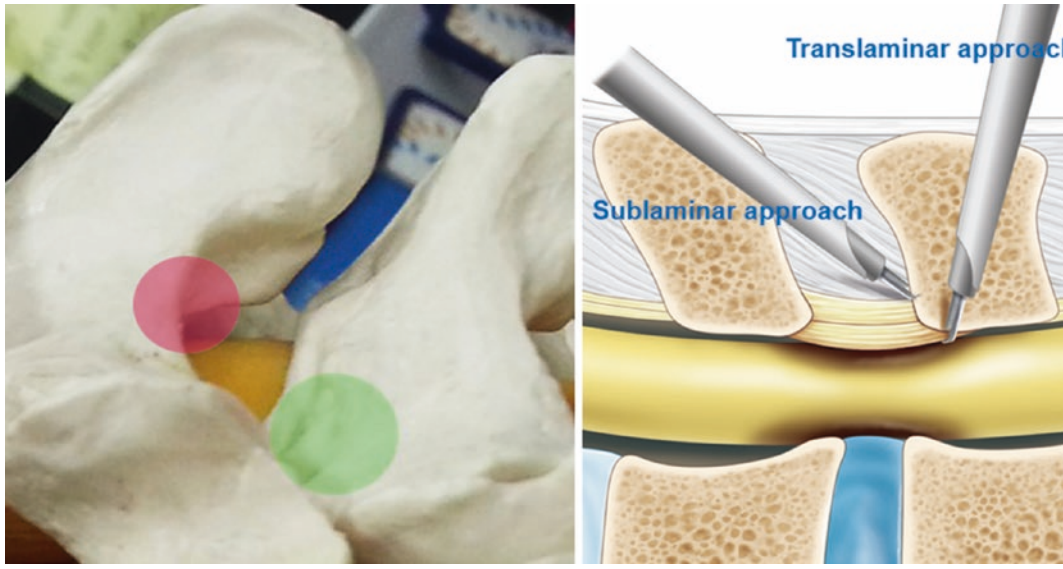


Fig. 7 (**a**) Docking sites. Point A in red: spinolaminar junction. Point B in green: deepest point of caudal lamina. (**b**) Sublaminar and translaminar approach

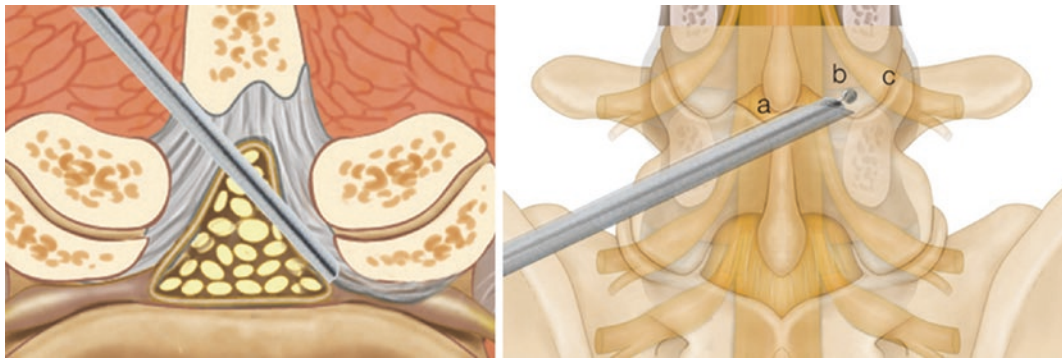


Fig. 8 Left diagram showing direction of scope to avoid inadvertent compression of neural element and detachment of the ligamentum flavum on superior articular process. Right diagram showing systematic drilling of point A, spinolaminar junction to reach the contralateral side and perform some central and lateral recess decompression; point B, ventral lower half of cephalad lamina attachment of the ligamentum flavum; and point C, ligamentum attachment on superior ventral edge of superior articular process

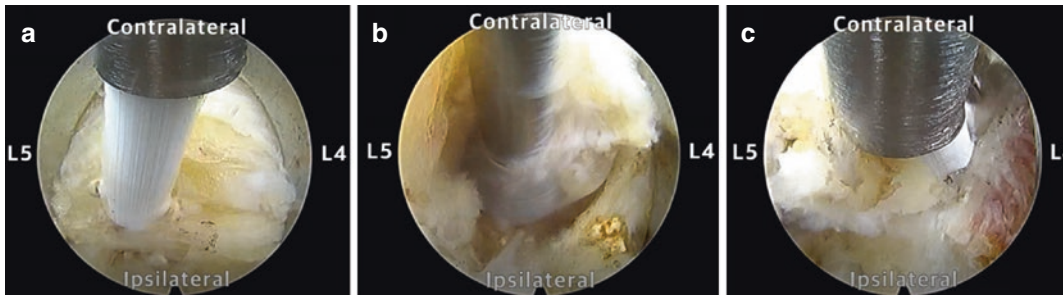


Fig. 9 Showing ipsilateral sublaminar approach with dissection of interspinous ligament (**a**), drilling of interspinous ligament and midline base of spinolaminar junction (**b**), and dissection of flavum off the midline spinolaminar junction (**c**) and Video 1

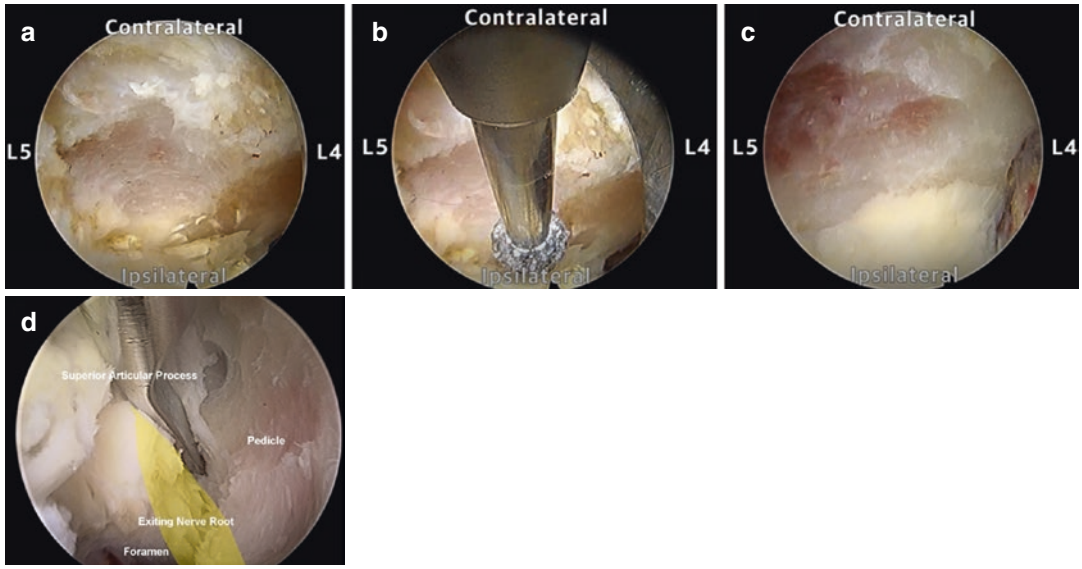


Fig. 10 Detachment of the ligamentum flavum with endoscopic probe off the superior articular process (SAP). Exposure of contralateral lamina, SAP (**a**, **b**). Using working channel to push in and stretch the ligamentum flavum attachment on SAP (**c**). Rotate and tilt the working channel and endoscope to expose the edge of superior articular process and lateral recess for decompression (**d**) (Video 2)

It is removed with endoscopic forceps. Bony and soft tissue lesions leading to foraminal stenosis is identified and decompressed systematically.

Foraminotomy

(a) Resection of foraminal ligament done with endoscopic Kerrison rongeur.
(b) Resection of inferior articular process and superior articular process done with drill (Fig. 10).
(c) Resection of foraminal disc first by coagulation with RF followed by drill and probe (Fig. 11a, b).
(d) Resection of osteophytic upper vertebrae and ventral vertebrae (Fig. 11c).

Final Confirmation Decompression of Foramen

(a) Free exiting nerve root (Fig. 11d).
(b) Checking the free lateral margin of the exiting nerve root: angle area in the lateral margin (Fig. 11e).

Illustrative Case Figures

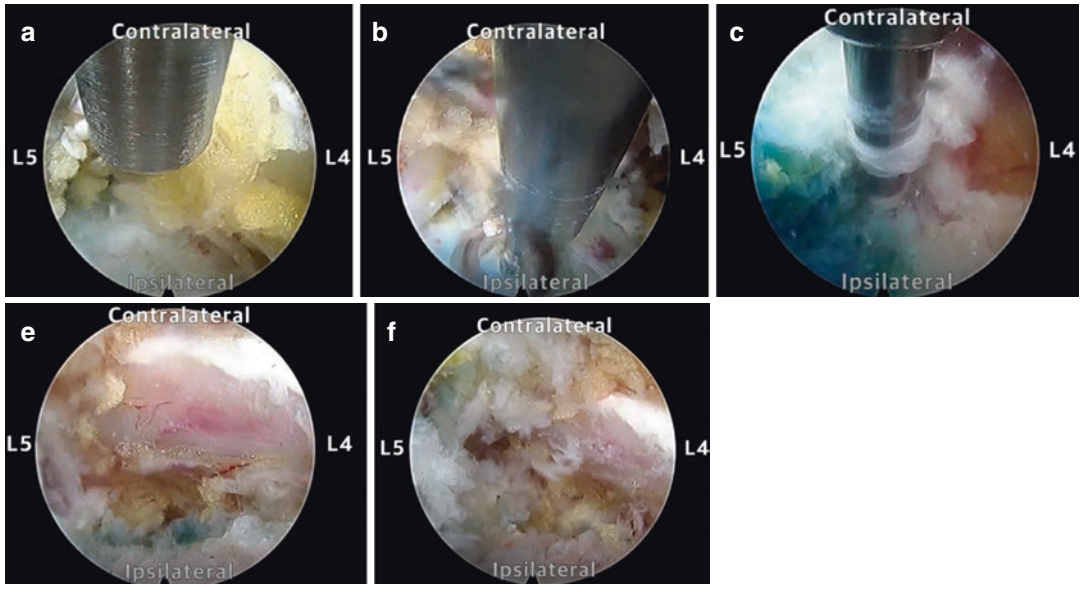
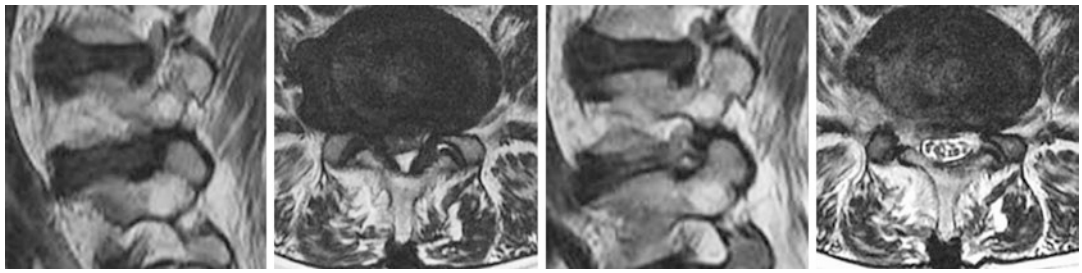
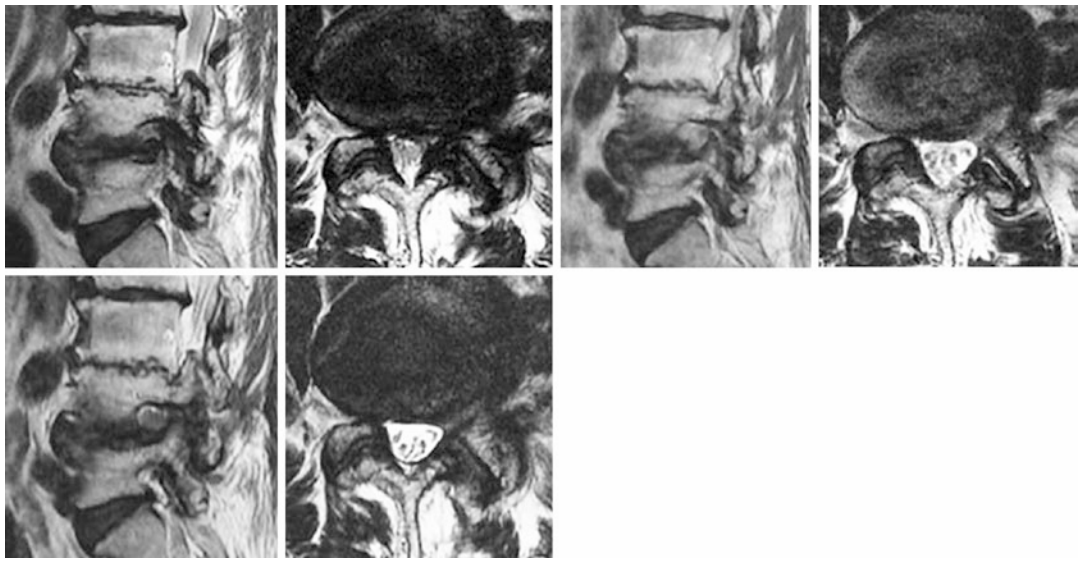


Fig. 11 Foraminal decompression. Exposure of lateral recess and disc (**a**). Discectomy (**b**). Foraminal syndesmophyte decompression (**c**). Tracing exiting nerve root out of foramen without need of retraction in ventral decompression (**d**, **e**) (Video 3)

- Preop/Postop/6 months FU.



- Preop/Postop.



- Preop/Postop/6 months FU.

Complication/Management

1. Incomplete decompression.
   - Revision decompression.
   - Revision fusion with interbody cage.
2. Dural tear.
   - Patch blocking dural repair technique.
   - Open suture.
3. Infection.
   - Antibiotics.
   - Open decompression and drainage.
4. Recurrence.
   - Revision endoscopic decompression.
   - Fusion.
5. Instability.
   - Fusion.
6. Worsening of coronal imbalance.
   - Deformity correction.

Discussion

With the evolution of endoscopic spine surgery, foraminal stenosis treatment is very diverse at the moment. Endoscopic surgical options of foraminal stenosis are uniportal full endoscopic contralateral approach for lumbar foraminal stenosis, percutaneous full endoscopic bilateral lumbar decompression of spinal stenosis through uniportal-contralateral approach [1, 2], uniportal endoscopic transforaminal approach [3], biportal paraspinal approach, biportal contralateral approach [4], and endofusion with uniportal or biportal techniques [5]. Traditional techniques such as tubular microscopic contralateral decompression [6], open laminectomy and foraminotomy, Wiltse tubular approach and/or open posterolateral approach for decompression and/or fusion, and indirect decompression by anterior/lateral approach fusion techniques are other options for spine surgeons who are not practicing endoscopic technique [7]. A wide diversity of options suggest that there is no gold standard as many factors affect the outcome of surgery. For uniportal full endoscopic contralateral approach for lumbar foraminal stenosis, a certain level of endoscopic experience will be paramount to produce consistent good outcomes. In our opinion among these options, uniportal full endoscopic contralateral approach for lumbar foraminal stenosis is superior in conservation of the native anatomy with main focus on direct decompression of the elements which caused foraminal stenosis.

Some tips and pitfalls applied in this technique are:

1. Create sufficient sublaminar working space for the drill and working channel to allow contralateral ligamentum flavum resection without pressure of retraction and compression of the ligamentum flavum and underlying dura.
2. Contralateral lateral recess decompression with Kerrison punch on superior articular process can be challenging; we need to tilt and rotate the scope with full view of traversing nerve root and pointing punch away from the nerve root (Fig. 8).
3. When there is significant foraminal stenosis, drilling of the ventral syndesmophyte of the adjacent vertebra bodies and discectomy should be done to create space ventral to the exiting nerve root rather than excessive retraction of the nerve root.
4. Check intraoperative image when crossing the midline and when completion of foraminal stenosis. It can be confusing especially for beginners on the adequacy of contralateral decompression.
5. If lateral wedging and overriding superior articular facet is secondary to lateral listhesis and instability, fusion surgery should be considered instead of decompression.

Summary

The management of foraminal stenosis of the nerve root by uniportal full endoscopic contralateral approach for lumbar foraminal stenosis provides effective and safe decompression with facet joint preservation and other benefits of the minimally invasive spine procedure [2, 8].

References

1. Zygourakis CC, DiGiorgio AM, Crutcher CL, Safaee M, Nicholls FH, Dalle Ore C, et al. The safety and efficacy of CT-guided, fluoroscopy-free Vertebroplasty in adult spinal deformity surgery. World Neurosurg. 2018;116:e944–e50.
2. Kim H-SMDP, Paudel BMDMS, JSMDP J, SHMDP O, Lee SBE, Park JEBS, et al. Percutaneous full endoscopic bilateral lumbar decompression of spinal stenosis through Uniportal-contralateral approach: techniques and preliminary results. World Neurosurg. 2017;103:201–9.
3. Kim HS, Sharma SB, Raorane HD. How I do it? Transforaminal endoscopic decompression of intraspinal facet cyst. Acta Neurochir. 2019;161(9):1895–900.
4. Heo DH, Kim JS, Park CW, Park CK, Quillo-Olvera J. Contralateral sublaminar endoscopic approach for removal of lumbar Juxtafacet cysts using percutaneous Biportal endoscopic surgery: technical report and preliminary results. World Neurosurg. 2019;122:474–9.
5. Son SK, Park WW, Choi SH, Ahn Y, Youn MS, Heo DH. Endoscopic transforaminal lumbar interbody fusion: a comprehensive review. Neurosurg Rev. 2019;16(5):373–80.
6. Yamada K, Matsuda H, Cho H, Habunaga H, Kono H, Nakamura H. Clinical and radiological outcomes of microscopic partial pediculectomy for degenerative lumbar foraminal stenosis. Spine. 2013;38(12):E723–E31.
7. Orita S, Inage K, Eguchi Y, Kubota G, Aoki Y, Nakamura J, et al. Lumbar foraminal stenosis, the hidden stenosis including at L5/S1. Eur J Orthop Surg Traumatol. 2016;26(7):685–93.
8. Hwang JHMD, Park CWMDP. Contralateral interlaminar keyhole percutaneous endoscopic surgery in patients with unilateral radiculopathy: technical notes. World Neurosurg. 2017;