REVIEW

Transforaminal full-endoscopic decompression under local anesthesia for foraminal stenosis due to stable L5 isthmic spondylolisthesis, a technical note and review : Pars crisscross decompression

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Abstract : Foraminal stenosis is one of the types of lumbar spinal stenosis. The pathology can be treated minimally invasively by full-endoscopic spine surgery (FESS). The final challenge in transforaminal FESS is foraminal stenosis in patients with stable isthmic spondylolisthesis at L5. This article provides a step-by-step explanation of how to achieve complete decompression. A cannula of 8 mm in diameter is docked at the base of the superior articular process of the sacrum. The pars crisscross that consists of the superior articular process at S1, the floating lamina, the inferior articular process at L4, and the pars ragged edge is then clearly seen endoscopically. Visualization of the pars crisscross is key to successful decompression. Starting with the superior articular process at S1, followed by partial removal of the floating lamina. Next, the tip of the inferior articular process at L4 is removed. The pars ragged edge is then carefully shaved. Finally, decompression of the exiting nerve root at L5 is confirmed. This report provides the first step-by step description of full-endoscopic decompression of foraminal stenosis under local anesthesia in patients with stable L5 isthmic spondylolisthesis, which we have named "full-endoscopic pars crisscross decompression". J. Med. Invest. 71 : 191-196, August, 2024

Keywords **:** *Full-endoscopic spine surgery, foraminal stenosis, crisscross decompression, isthmic spondylolisthesis*

INTRODUCTION

Full-endoscopic spine surgery (FESS) was first performed more than 20 years ago (1-3). Since then, there have been considerable technological improvements in the surgical equipment available, such that a variety of spinal conditions can now be treated endoscopically. The advent of the high-speed drill in particular has enabled bony decompression surgery for spinal stenosis (4-6).

Foraminal stenosis is one type of lumbar spinal stenosis. Nowadays, this pathology is treated by minimally invasive full-endoscopic spine surgery (FESS). This procedure can be performed under local anesthesia using a transforaminal (TF) approach, making it even more minimally invasive in terms of anesthesia. Furthermore, TF-FESS requires only an 8-mm skin incision, so would be the most minimally invasive spine surgery so far. The first description of lumbar foraminotomy by TF-FESS was published by Ahn *et al.* in 2003 (7), who used a bone reamer to enlarge the narrow foramen. These days, foraminal decompression can be performed more safely using a high-speed drill under endoscopic guidance (8-11). Therefore, foraminal stenosis can be successfully treated by TF-FESS.

The final challenge for TF-FESS when treating foraminal stenosis would be stable isthmic spondylolisthesis at L5. First, the stenosis is located at L5/S1, access to which is difficult because of the iliac crest. Second, unlike foraminal stenosis without pars fracture, there are additional pathologies, such as a pars ragged edge, in patients with isthmic spondylolisthesis at L5. There is limited information in the literature on endoscopic decompression of this pathology. In this report, we provide a step-by-step explanation of how to achieve complete decompression by TF-FESS when treating foraminal stenosis with stable isthmic spondylolisthesis at L5.

SURGICAL TECHNIQUE

This surgery is performed endoscopically with the patient in the prone position. First, 10 ml of 1% lidocaine is injected for local anesthesia in skin, subcutaneous, facscia and soft tissues. Then, 8 ml is injected near the pars defect (2 ml in the L4/5 facet joint, 2 ml around the ragged edge, 2 ml in the L5/S1 facet joint, and 2 ml in the superior articular process [SAP] of the sacrum) and the final 2 ml is used on the surface of the disc. Next, a cannula of 8 mm in diameter is docked at the base of the SAP of the sacrum (Figure 1). When the soft tissues are cleaned up and the surface of the SAP is shaved, the pars crisscross is clearly visible endoscopically (Figure 2). The pars crisscross consists of the SAP at S1, the floating lamina, the inferior articular process (IAP) at L4, and the ragged edge of the pars. Figure 2 shows the pars crisscross on a sagittal CT scan (left panel) and under an endoscopic view (middle panel).

Visualization of the pars crisscross is key to successful decompression. Figure 3 shows how to decompress the pars crisscross step by step. First, removal with the surgical drill is started from the SAP at S1, after which the floating lamina is partially removed near the crisscross. Figure 4 shows an endoscopic view after removal of the SAP at S1. The next step, namely, resection of the tip of the IAP at L4, is the unique part of this procedure.

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After the tip of the IAP at L4 is removed, the entire ragged edge impinging on the exiting L5 nerve root becomes visible. Without resection, the ragged edge is covered with the IAP at L4, and efficient drilling here would be difficult. The entire ragged edge is obvious after resection of the tip of the SAP at S1, the floating lamina, and the IAP at L4 (Figure 5). The ragged edge is carefully shaved with a high-speed drill, after which it is resected completely. Finally, decompression of the L5 exiting nerve root is confirmed from the inlet to the outlet of the foraminal area. Figure 6 shows the final endoscopic view. The decompressed exiting L5 nerve root is seen.

REPRESENTATIVE CASE

The patient was an 81-year-old man who was referred to us with complaints of leg pain and numbness. He had been treated conservatively with medical therapy for more than 5 years. However, his symptoms had been worsening year by year.

Figure 7 shows the plain radiographs obtained for this patient. On a lateral view, there was obvious forward slippage at L5 and bilateral pars fractures. Dynamic flexion and extension radiographs showed slippage of 9.1 mm that did not seem to be unstable. However, foraminal slices on sagittal MRI scans clearly indicated foraminal stenosis at L5/S1 on both sides (Figure 8). The local spine surgeons recommended spinal fusion after reduction with pedicle screw systems. However, he was a local shop owner, so could not take lengthy sick leave. Therefore, he opted for minimally invasive full-endoscopic decompression surgery in the hope of a rapid return to work.

Full-endoscopic pars crisscross decompression was performed under local anesthesia. The operation time was 80 min with unmeasurable estimated blood loss. There were no surgery-related complications, such as exiting nerve root injury, hematoma, or surgical site infection. The symptoms in his right leg disappeared almost immediately after surgery.

CT scans obtained before and after FESS pars crisscross decompression are shown in Figure 9. The sagittal view confirmed complete removal of the ragged edge as planned. A

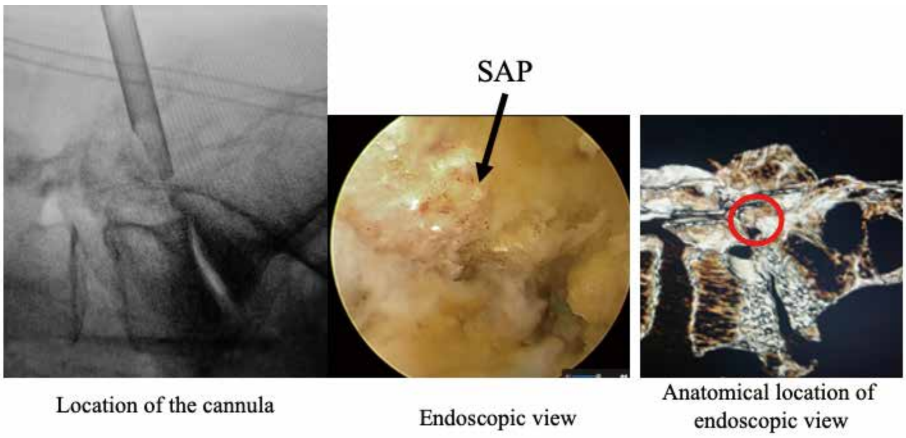

Figure 1. Starting point for pars crisscross decompression. Left panel, location of the cannula. Middle panel, endoscopic view. Right panel, anatomical location in the endoscopic view.
SAP, superior articular process

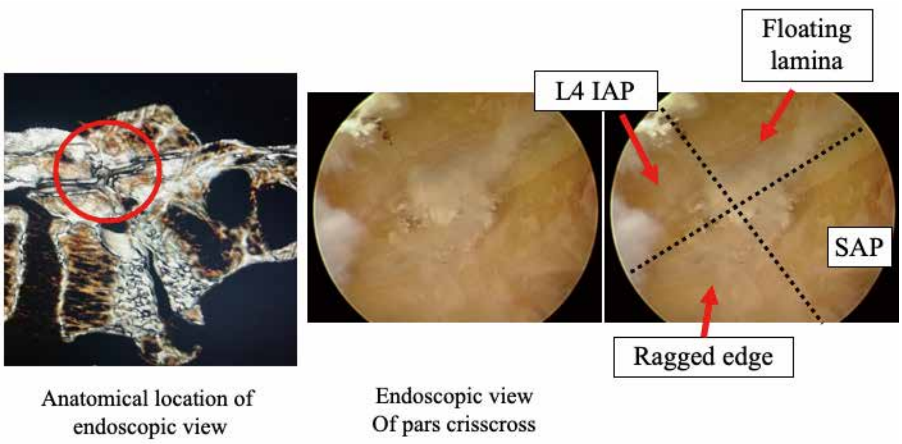

Figure 2. Endoscopic confirmation of the pars crisscross. When the soft tissues are cleaned up and the surface of SAP is shaved, the pars crisscross can be clearly visualized. The pars crisscross consists of the SAP of S1, the floating lamina, the inferior articular process of L4, and the pars ragged edge. The pars crisscross is shown on a sagittal computed tomography scan in the left panel and under an endoscopic view in the middle panel. The detail is explained in the right panel.
IAP, inferior articular process ; SAP, superior articular process

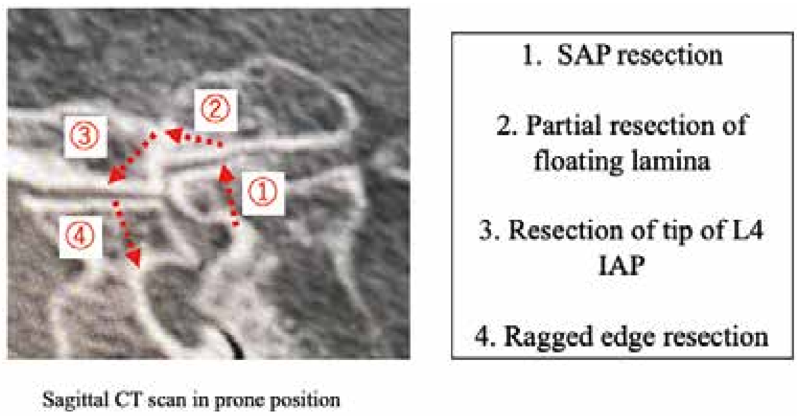

Figure 3. Step-by-step strategy for endoscopic decompression of the pars crisscross. Removal with the surgical drill is started from the SAP at S1. Next, the floating lamina is partially removed near the crisscross. Resection of the tip of the IAP at L4 is the key part of this procedure. Finally, the entire ragged edge can be removed.
CT, computed tomography ; FL, floating lamina ; IAP, inferior articular process ; SAP, superior articular process

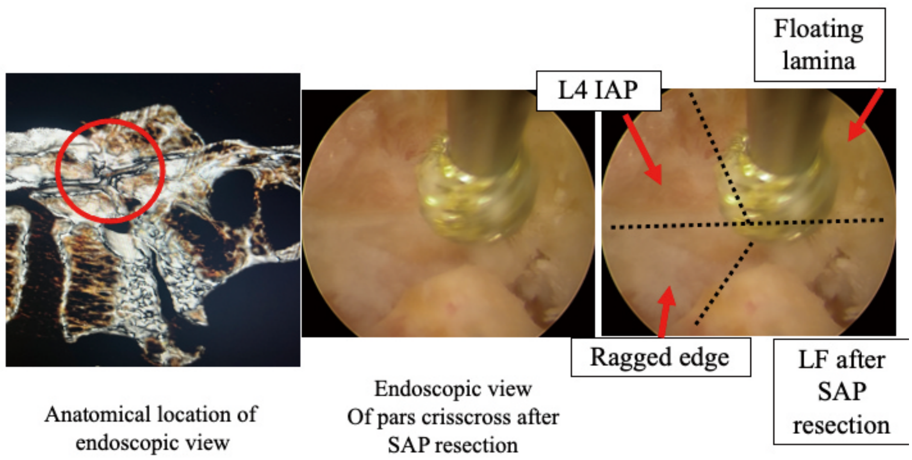

Figure 4. Endoscopic view after resection of the SAP. Left panel, anatomical location in the endoscopic view. Middle panel, endoscopic view of the pars crisscross after resection of the SAP. The detail is explained in the right panel.
FL, floating lamina ; IAP, inferior articular process ; SAP, superior articular process

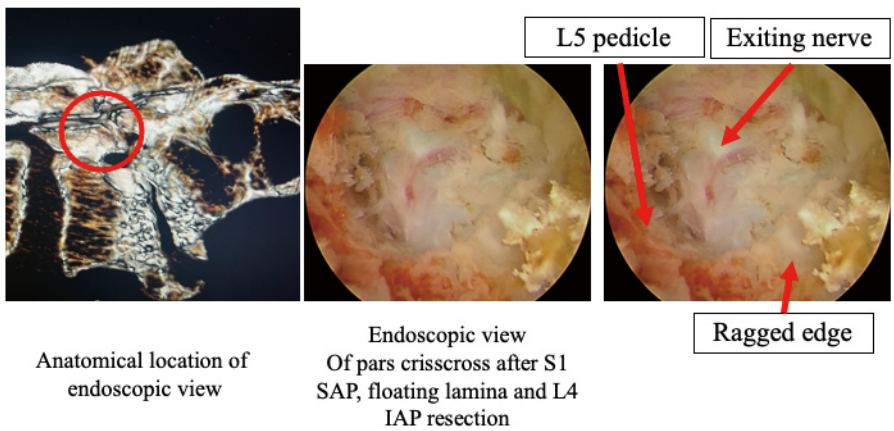

Figure 5. Endoscopic view after resection of the SAP at S1, floating lamina, and IAP at L4. At this stage, the impinged exiting nerve root is exposed at the inlet of the foramen. Left panel, anatomical location in an endoscopic view. Middle panel, endoscopic view of the pars crisscross after resection of the SAP at S1, floating lamina, and the IAP at L4. The detail is explained in the right panel.
IAP, inferior articular process ; SAP, superior articular process

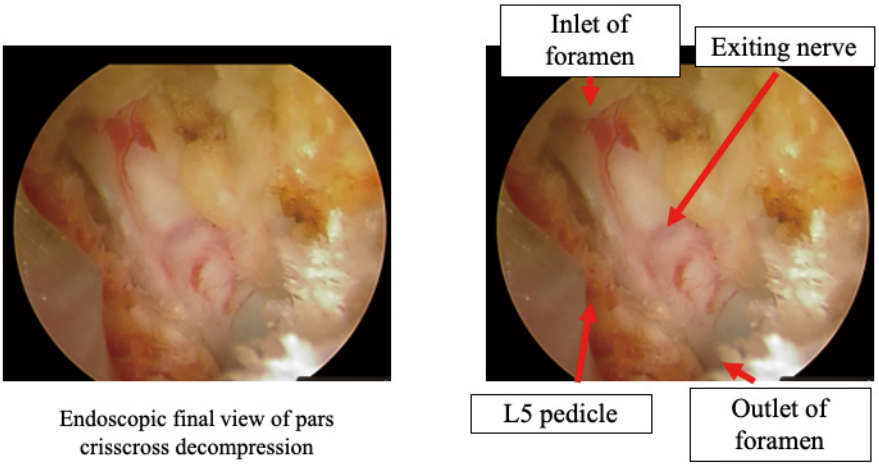

Figure 6. Final view of the pars crisscross decompression. Left panel, final endoscopic view of pars crisscross decompression. The detail is explained in the right panel. Decompression of the L5 exiting nerve is confirmed from the inlet to outlet of the foraminal area after complete removal of the ragged edge. The decompressed exiting L5 nerve root is clearly seen.

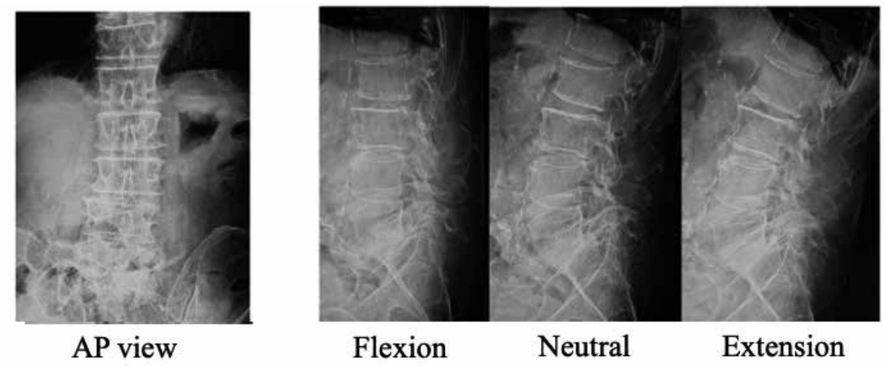

Figure 7. Plain radiographs obtained before surgery. In the lateral view, there is obvious L5 forward slippage with bilateral pars fractures. On dynamic flexion and extension films, the slippage seems not to be unstable, although the slippage is 9.1 mm.
AP, anterior-posterior

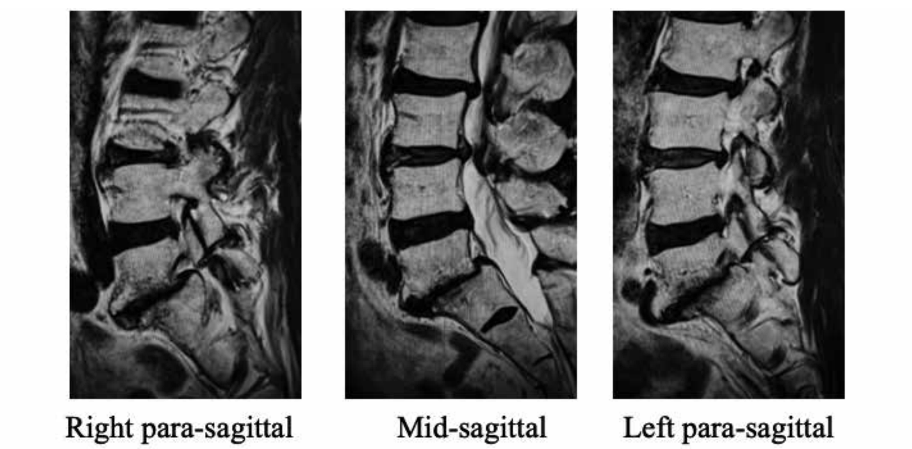

Figure 8. Sagittal magnetic resonance images obtained before surgery. The sagittal foraminal slices clearly indicate foraminal stenosis at L5/S1 on both sides.

Figure 9. Computed tomography scans obtained before and after surgery. On the sagittal scans, complete removal of the ragged edge is obvious as planned. The three-dimensional scans also show efficient enlargement of the foramen after surgery.

three-dimensional CT scan showed efficient enlargement of the foramen after surgery. Four months later, visual analog scale was 1.0, which was 7 out of 10 before surgery. Figure 10 demonstrates the incisional scar, which is unclear in the skin wrinkles.

Figure 10. Incisional scar of the FESS crisscross decompression.

DISCUSSION

This technical note explains in detail how to decompress L5 isthmic spondylolisthesis, demonstrating the endoscopic view step-by-step. We believe that endoscopic confirmation of the pars crisscross is key to successful decompression. This procedure also has the advantage of being able to be performed under local anesthesia.

FESS decompression for isthmic spondylolisthesis at L5

There are few reports in the literature on endoscopic foraminal decompression for isthmic spondylolisthesis performed via the TF route. The first report was published in 2003 by Knight and Goswami (12), who used laser-assisted endoscopic foraminal decompression. Essentially, they used a laser to ablate, resect, and divide the bone and soft tissues. Although they described their clinical results, they did not provide any information on radiological outcomes. Another report described the difficulty encountered when attempting to decompress an osseous narrowing with a pars ragged edge (13), which is believed to be the main cause of nerve root impingement in isthmic spondylolisthesis. After that report, no other reports were published for 15 years. In 2018, Yeung and Kotheeranurak (14) published an article on endoscopic decompression via a TF approach for stable isthmic spondylolisthesis. Although they did not describe the endoscopic procedure in detail, they reported a good clinical outcome.

In 2020, Liu and Kadimcherla (15) reported their full-endoscopic decompression technique for isthmic spondylolisthesis. Their report included preoperative and postoperative CT scans, which clearly demonstrated enlargement of the foramen after surgery. As with our procedure, they started at the base of the SAP of the sacrum. Next, they removed the soft tissue in the pars defect, after which the bony defects and facet joint were clearly exposed. Finally, the bony fragments impinging on the exiting nerve root were removed using a Kerrison rongeur, burr, and shaver. However, they did not mention their removal procedure in detail. The preoperative and postoperative CT scans that accompany their article indicate that the narrow foramen was markedly enlarged after surgery. However, unlike with our technique, the ragged edge could not be completely removed because the surgery did not involve the IAP at L4. Complete removal of the ragged edge is possible after partial removal of the tip of the IAP at L4, as shown in Figures 6 and 9.

In 2023, Van Isseldyk *et al*. described their full-endoscopic foraminotomy procedure for low-grade spondylolisthesis that included degenerative and isthmic pathology (16). They treated 19 patients with isthmic spondylolisthesis using either of two surgical techniques, namely, TF or contralateral interlaminar decompression. However, their report described SAP-based foraminotomy, so it was difficult to understand in detail how the ragged edge was decompressed.

Unique features of FESS pars crisscross decompression

Our procedure has the following unique features : the pars crisscross serves as an anatomical landmark for efficient decompression ; the ragged edge can be confirmed following partial resection of the IAP at L4 ; and the procedure can be performed under local anesthesia.

The base of the SAP is usually used as the anatomical starting point (15, 16), given that it can be seen using a C-arm intensifier. As shown in Figure 1, the SAP base is very easy to identify. The next step is identification of the pars crisscross (Figure 2). When the pars crisscross has been confirmed, step-by step decompression is straightforward (Figure 3). Therefore, we strongly recommend searching for the pars crisscross to allow for successful endoscopic decompression.

We have been performing advanced foraminotomy for typical foraminal stenosis (17). This includes total resection of the SAP and undercutting laminectomy. However, this surgery cannot completely remove the ragged edge in cases of isthmic spondylolisthesis. Therefore, we now remove the tip of IAP of L4 so that we can observe the entire ragged edge (Figure 5). It is then possible to completely decompress the L5 exiting nerve root from the inlet to the outlet of the foramen (Figure 6). Partial resection of the IAP at L4 allows successful decompression of isthmic spondylolisthesis.

Another advantage of FESS pars crisscross decompression is that, similar to other TF full-endoscopic surgeries (1-6, 9, 10, 14, 17), it can be performed under local anesthesia. Another FESS procedure utilizes an interlaminar approach. Van Isseldyk *et al.* (16) reported that when the iliac crest is very high with L5 isthmic spondylolysis, the contralateral side can be decompressed using interlaminar FESS. However, this approach essentially requires general anesthesia. Most cases of foraminal stenosis with isthmic spondylolisthesis are encountered in the elderly, in whom general anesthesia is often contraindicated because of comorbidities. In super-aging societies, spine surgery that can be performed under local anesthesia will become increasingly important.

CONCLUSION

This paper describes a full-endoscopic technique that can effectively decompress foraminal stenosis due to L5 isthmic spondylolisthesis under local anesthesia. We believe that endoscopic confirmation of the location of the anatomical crisscross is the key to successful decompression. Total resection of the ragged edge and significant enlargement of the foraminal area is possible using this maneuver. Endoscopically, the decompressed exiting nerve root can be observed from the inlet to the outlet. The FESS pars crisscross decompression technique is likely to become increasingly important in super-aging societies because it can be performed under local anesthesia.

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