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Technical Note

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Biportal Endoscopic Spinal Surgery for Bilateral Lumbar Foraminal Decompression by Switching Surgeon's Position and Primary 2 Portals: A Report of 2 Cases With Technical Note

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Total facetectomy with/without fusion and facet-preserving microforaminotomy have been performed as conventional surgical treatments for lumbar foraminal stenosis (LFS). Recently, endoscopic spinal surgery has been introduced as a minimally invasive therapeutic modality of LFS by several authors. We report two cases of bilateral LFS at lumbosacral junction level successfully treated with a novel biportal endoscopic spine surgery (BES) technique using primary 2 portals. Two patients presented with chronic onset of back pain and neurogenic claudication symptom. They were diagnosed with bilateral LFS at L5–S1 level from magnetic resonance imaging and computed tomography preoperatively. BES for bilateral foraminal decompression was performed via contralateral approach bilaterally without additional skin incision or surgical trajectory by switching surgeon's position and primary 2 portals. After the surgery, preoperative patients' back and leg pain resolved and unilateral leg weakness of the 2 patients gradually improved in a few months. Postoperative radiologic images revealed significantly enlarged bilateral foramens at L5–S1 level.

Keywords: Biportal endoscopic spine surgery, Bilateral lumbar foraminal stenosis, Minimal invasive, Contralateral approach

INTRODUCTION

Lumbar foraminal stenosis (LFS) is a common disease in which degenerative changes of the vertebral column cause foraminal and extra foraminal entrapment of nerve roots and lumbar nerves.[1,2] Burton et al. have reported that 60% of cases of failed–back surgery syndrome are caused by missed nonspecific LFS.[3] Conventional surgery for LFS can be categorized as total facetectomy with/without fusion and facet-preserving micro-foraminotomy using a paraspinal approach.[4-8] With development in minimal invasive surgery, variable usages of spinal endoscope to treat degenerative lumbar diseases have been introduced. Some authors have reported endoscopic foraminal decompression technique, also known as percutaneous endoscopic transforaminal discectomy and/or foraminoplasty, and their favorable clinical outcomes.[8-12] However, all published articles about endoscopic lumbar foraminal decompression dealt with unilateral foraminal pathology treated by uniportal endoscopic lumbar surgery. Recently, biportal endoscopic spine surgery (BES) has been introduced and its clinical efficacy has also been reported by several authors.[13-16] We present 2 cases of bilateral LFS at lumbosacral junction level successfully treated with a novel BES technique using primary 2 portals and describe the surgical technique in detail. To the best of our knowledge, this is the first report to figure out bilateral LFS by spinal endoscope without additional skin incision or surgical trajectory by switching surgeon's position and primary 2 portals.

CASES AND SURGICAL TECHNIQUE

Written informed consent was obtained from all patients for publication and any accompanying images.

1. Case 1

A 63-year-old farmer presented gradual onset of symptoms with complaint of intermittent low back pain (LBP) and numbness over right side of the leg for 2 years prior to presentation. His LBP and radicular leg pain in visual analogue scale (VAS) were 5 and 8, respectively. He could not walk for over 30 minutes due to the pain. Neurologic examination revealed weakness of left great toe dorsiflexion (grade 3) without pain. His right-side motor was normal. However, he complained right leg pain. Straight leg-raising (SLR) test was normal for both sides. X-rays did not show instability in flexion or extension. Computed tomography (CT) and magnetic resonance imaging (MRI) documented bilateral foraminal stenosis with loss of fat signal at L5–S1 level (Wildermuth grade, grade 3 in both foramens) and compressed bilateral L5 exiting roots (Fig. 1A-C). Routine laboratory data and vascular study showed unremarkable findings. The patient underwent BES with switching technique under general anesthesia. Preoperative back and leg pain VAS scores were decreased from 5 and 8 preoperatively to 3 and 2 after the operation, respectively. Weakness of left great toe dorsiflexion was also recovered gradually to grade 4 in four weeks after the operation. Postoperative MRI and CT revealed satisfactory decompression of bilateral foramen in L5–S1 (Fig. 1D-F). Postoperative dynamic X-ray taken 8 months after the operation showed no instability.

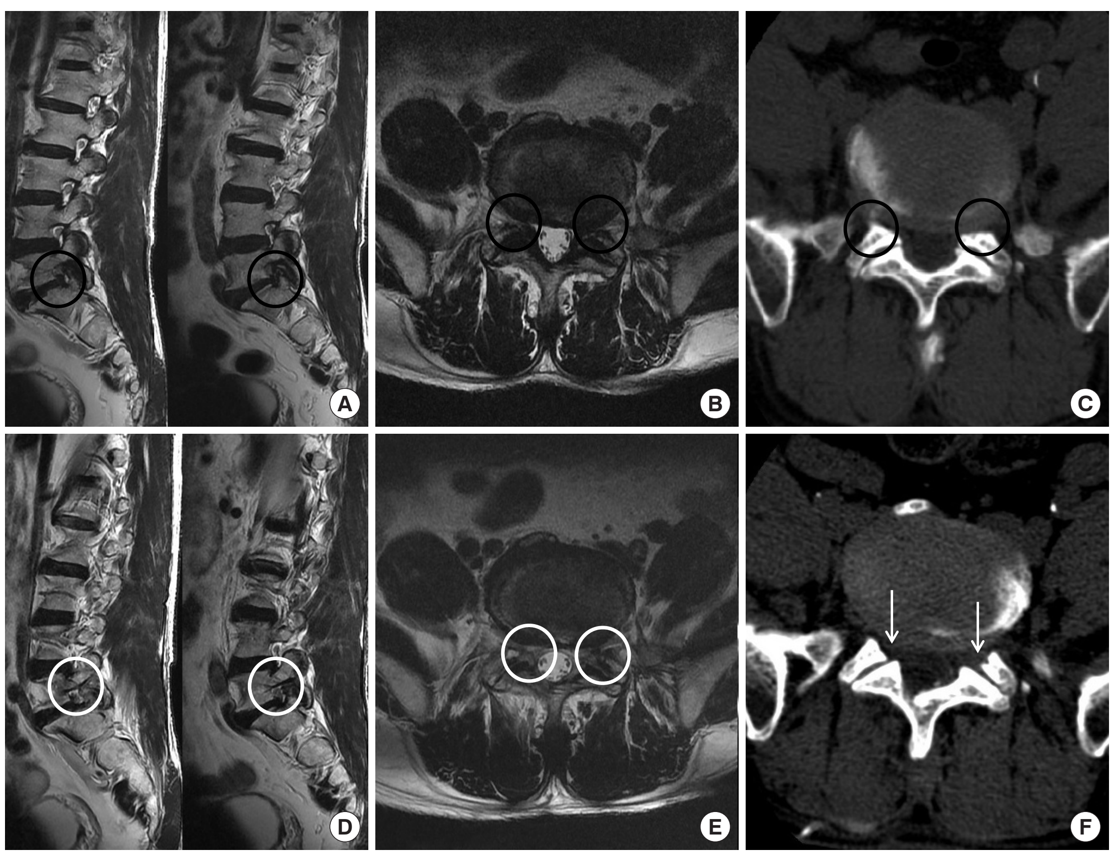

Fig. 1. Pre- and postoperative radiologic images of the first case. (A) Preoperative parasagittal T2-weighted magnetic resonance imaging (MRI) image. (B) Preoperative axial T2-weighted MRI image. (C) Preoperative axial computed tomography (CT) image. (D) Postoperative parasagittal T2-weighted MRI image. (E) Postoperative axial. (F) Postoperative axial CT image of resected superior articular process. Black circles: compressed areas of bilateral L5 nerve root by L5–S1 foraminal stenosis. White circles: decompressed foraminal areas for bilateral L5 exiting roots. White arrows: resected areas of bilateral superior articular process of S1.

2. Case 2

An 84-year-old woman presented with a 3-year history of LBP and bilateral leg pain radiating down the calf and dorsum of foot consistent with L5 nerve root territory. No benefit was obtained from the use of analgesic or nonsteroidal anti-inflammatory medications. Her LBP and leg pain in VAS were 7 and 8, respectively. She could not walk for over 20 minutes due to pain. She had lumbar inter-body fusion at L1–2 level 2 years ago at other hospital. Neurologic examination revealed weakness of bilateral toe dorsiflexion (right, grade 4; left, grade 3). SLR test was normal for both sides. X-rays did not show instability in flexion or extension. CT and MRI demonstrated bilateral foraminal stenosis at L5–S1 level (Wildermuth grade: right, grade 2; left, grade 3) (Fig. 2A-C). Results of routine laboratory and vascular study were within normal limits. She also underwent BES in the same manner as the first case under epidural anesthesia. After the operation, her VAS scores of back and leg pain were decreased from 7 and 8 preoperatively to 3 and 2 after the operation, respectively. The weakness of bilateral great toes dorsiflexion also gradually recovered to grade 4 in 8weeks. Postoperative MRI and CT demonstrated satisfactory decompression of bilateral foramen (Fig. 2D-F). Postoperative X-ray showed no instability.

3. Surgical technique

1) Equipment used in BES with switching technique

During surgical procedures, we used 4-mm spherical burrs (Striker, Kalamazoo, MI, USA), 5-mm shavers (Striker), 3.5-mm bendable diamond burs (All care, Seoul, Korea), and 0° 3.0-mm-diameter arthroscopes (Striker). To control intraoperative bleeding, 90° 3.75-mm radiofrequency probe (VAPR, DePuy Mitec, Raynham, MA, USA) and 30° 1.4-mm microablator radiofrequency probe (DePuy Mitec) were used. We also used standard laminectomy instrument such as serial dilator, Kerrison punch-

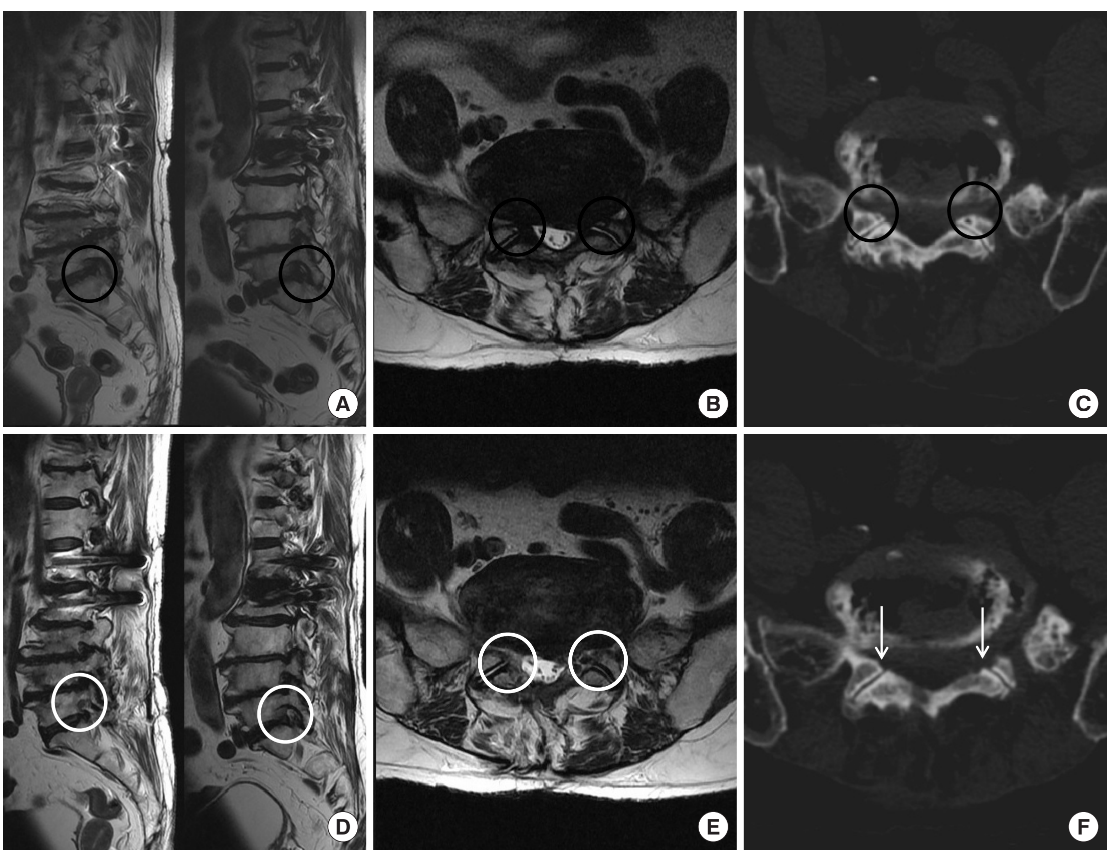

Fig. 2. Pre- and postoperative radiologic images of the second case. (A) Preoperative parasagittal T2-weighted magnetic resonance imaging (MRI) image. (B) Preoperative axial T2-weighted MRI image. (C) Preoperative axial computed tomography (CT) image. (D) Postoperative parasagittal T2-weighted MRI image. (E) Postoperative axial T2-weighted MRI image. (F) Postoperative axial CT image. Black circles: compressed areas of bilateral L5 nerve root by L5-S1 foraminal stenosis. White circles: decompressed foraminal areas for bilateral L5 exiting roots. White arrows: resected areas of bilateral superior articular process of S1.

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es (3,2 mm), pituitary forceps (standard and upbite), and variable angled chisels and curettes (Fig. 3).

2) Surgical procedure

Patients underwent surgery under general or epidural anesthesia in a prone position on radiolucent Wilson frame with proper padding. A waterproof surgical drape was performed. For making 2 portals, under the guidance of C-arm fluoroscopy, 2 skin incisions of 0.5 cm long were made vertically. Both skin incisions were located about 0.5 cm lateral to the ipsilateral spinous process. The first skin incision for cranial portal was made at lower 1/3 of upper lamina while the other skin incision for caudal portal was made at supero-lateral border of lower lamina. Distance between these 2 portals was about 2 cm (Fig. 4A, B). Serial dilators were used to dissect the back muscle and acquire operative space. A 0° endoscope (Striker) was inserted through the caudal portal after inserting the cannula. A saline irrigation system was applied with natural drainage (70 cm high from operation table). Surgical instruments were inserted through the cranial working portal. After triangulation with the endoscope and instrument, minor bleeding was controlled with radiofrequency probe. Debridement of remnant soft-tissues over-

Fig. 3. Equipment used in percutaneous biportal endoscopic surgery with switching technique. 0° 3-mm diameter arthroscope (1), 3-mm unhooded barrel bur (2), 3-mm unhooded round bur (3), 5-mm shaver (4), 3.5-mm bendable diamond burs (5), chisels: 5-mm width chisel, straight (6), straight (7) and 40° angled (8), curettes: 90° (9), right angled (10, 11), up (12) and downward (13) directed, 90°, 3.75-mm radiofrequency probe (14), 30° 1.4-mm microblator radiofrequency probe (15).

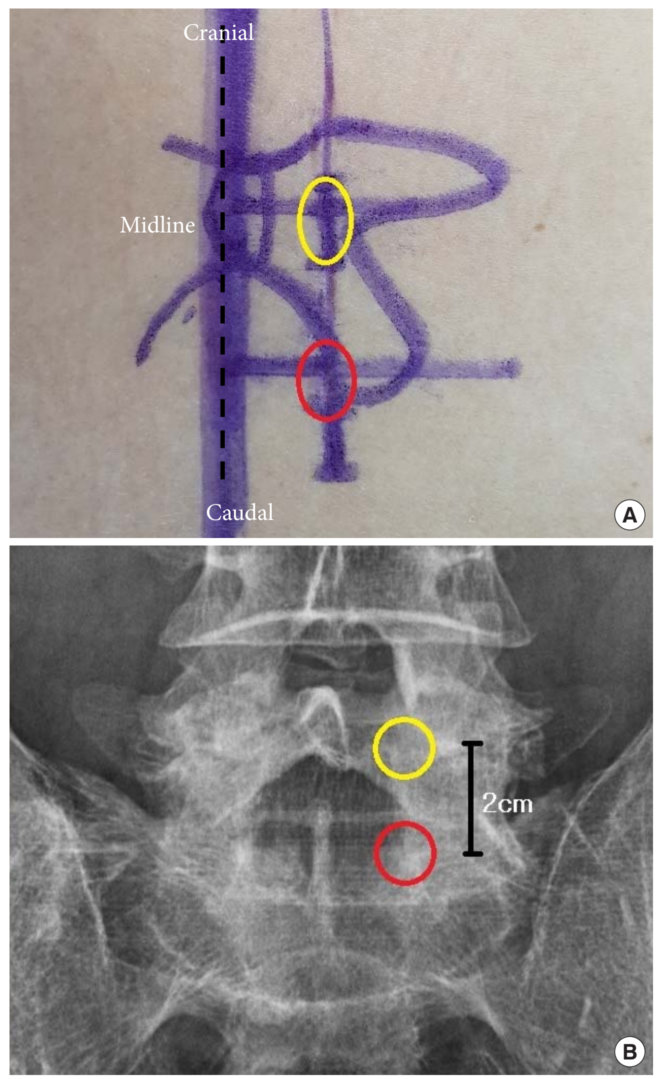

Fig. 4. Initial placement of two portals and related anatomy. (A) Skin marking for the placement of 2 portals. (B) Position of 2 portals on anteroposterior view of X-ray. Yellow circle: the site for placement of cranial portal. Red circle: the site for placement of caudal portal.

lying the lamina and ligamentum flavum was performed with a shaver. Following complete exposure of the targeted interlaminar space, an ipsilateral partial laminotomy was performed with a 3-mm drill or straight chisel. By manipulating and tilting the endoscope, undercutting of the medial base of spinous process and contralateral lamina was achieved. After contra-lateral decompressive bony work by drill, the ipsilateral and contralateral ligamentum flavum was removed with Kerrison punches and angled curette. The whole dorsal side of dural sac was visualized. Contralateral decompression was continued until the contralateral traversing nerve root was identified (Fig. 5A) (Supplementary video clip 1).

To decompress contralateral foraminal region, the endoscope was advanced to contralateral foraminal side. Partial resection of contralateral superior articular process (SAP) of S1 was performed with straight chisel (Fig. 6). The superior foraminal ligament was defined. An isolated cranial tip of SAP and superior foraminal ligament were removed with angled curette and up-

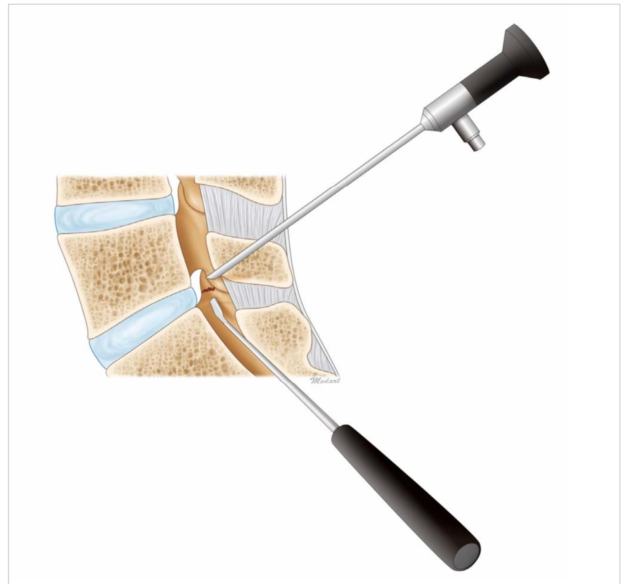

Fig. 6. Foraminal decompression by resection of cranial tip of superior articular process.

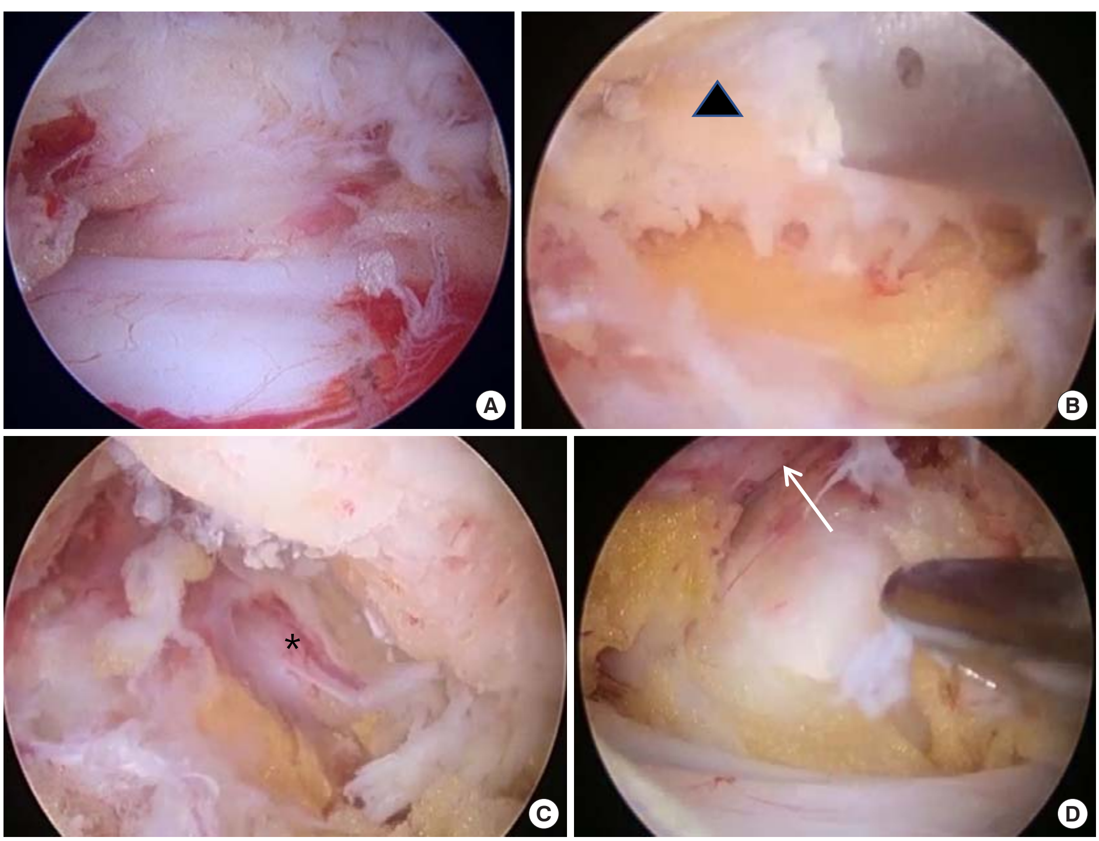

Fig. 5. Operative illustrations in endoscopic view. (A) Thecal sac and shoulder margin of contralateral traversing root was revealed. (B) Cranial tip of superior articular process (S1) is cut by angled chisel. (C) Decompressed L5 exiting root in contralateral side (left) is observed. (D) Decompressed L5 exiting root in primary ipsilateral side (right) is demonstrated. Black triangle: cranial tip of superior articular process. Asterisk: L5 exiting root (contralateral). White arrow: L5 exiting root (ipsilateral).

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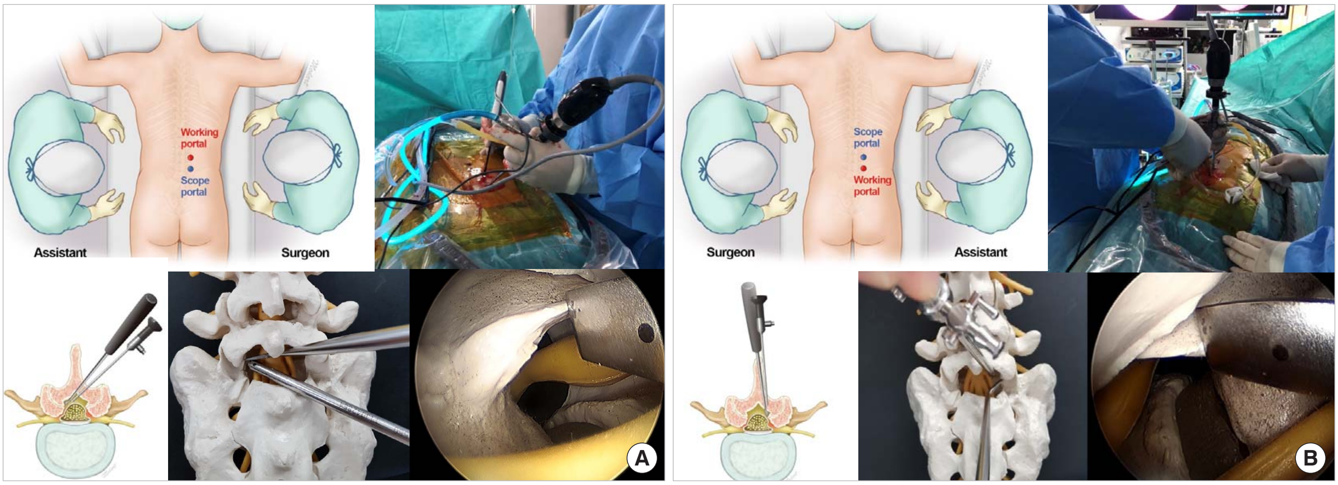

Fig. 7. Schematic illustration of operative setup and intraoperative angle of scope and instruments. (A) Contralateral approach from primary ipsilateral side (before switching). (B) Contralateral approach to primary ipsilateral side from switched contralateral side (after switching of operator's position and exchange of 2 portals).

bite pituitary forceps. Contralateral foraminal decompression proceeded until contralateral exiting root was exposed and restoration of pulsatility was observed (Fig. 5C) (Supplementary video clip 2). The surgeon could verify sufficient foraminal decompression by passing ball tip probe through foraminal canal.

After contralateral foraminal decompression was completed, surgeon changed his operative position to the opposite side across the operative bed. Endoscope and operative instruments were then reinserted through exchanged working and scope portals without new skin incision or another operation set-up (Fig. 7A, B).

Dorsal surface of dural sac and remnant ligament flavum and medial margin of laminectomy were identified in endoscopic view of primary ipsilateral side (contralateral side from switched surgeon's operative side). Operative procedure after switching operative position was performed with steeper operative trajectory compared to before switching. The use of more angled operative instruments via caudal working portal enabled successful decompressive procedure without difficulty (Fig. 7B). Further undercutting of ipsilateral remnant lamina was performed by drills and punches followed by removal of remnant ipsilateral ligamentous structures with punches and angled curettes. Ipsilateral traversing root was demonstrated. Primary ipsilateral SAP (contralateral SAP from switched surgeon's operative side) was resected using 5 mm 40° Hockey stick chisel (Figs. 5B, 7B) with the same method. Decompressed ipsilateral exiting root was visualized (Fig. 5D) (Supplementary video clip 3). After confirmation of complete decompression of bilateral exiting root, epidural bleeding was controlled by coagulation with radiofrequency probes. After a drain was inserted, operative wounds were closed with skin tape after removal of instruments and the endoscope.

3) Ethical statement

Written informed consent was obtained from all patients for publication and any accompanying images.

DISCUSSION

Symptomatic foraminal stenosis is thought to cause radiculopathy in approximately 10% of patients suffering from lumbar degenerative spondylosis.[17,18] A decrease in disc height, osteoarthritic degeneration of facet joints, cephalad subluxation of the SAP, buckling of the ligamentum flavum, and protrusion of annulus fibrosus may all contribute to foraminal stenosis.[2,17] There are 2 surgical treatment options for lumbar LFS: decompression without fusion and decompression with spinal fusion.[4-7] Lumbar interbody fusion surgery has been considered as the gold standard for LFS. However, several demerits and adverse consequences such as junctional problem, instrumental failure, pseudoarthrosis, and chronic back pain due to iatrogenic trauma have been reported. A facet preserving microscopic foraminal decompression technique using paraspinal approach was introduced to have successful clinical results. However, it also showed some limitations such as incomplete decompression, postoperative dysthesia, and postoperative instability due to excessive bony resection known to cause unfavorable clinical outcomes, needing fusion surgery eventually. To solve these problems, various minimally invasive techniques have been developed. Some authors have reported the use of a technique known as percutaneous endoscopic foraminoplasty.[9,18,19] Previous studies about endoscopic foraminoplasty have shown very promising surgical outcomes not only in the short term, but also in long-term follow-up assessments. However, it is technically demanding. In addition, it has the same weak points as simple decompressive procedure such as incomplete decompression and postoperative instability due to facet joint violation.

Contralateral approach using microscopic or endoscopic system has also been introduced to treat lumbar degenerative diseases.[12,16,20] Bilateral decompression of spinal canal by staged contralateral approaches with different skin incision and operative trajectories (named microscopic tubular crossing laminotomy technique) has also been reported,[21] showing that the contralateral approach has advantages of minimal injury of soft tissues and the facet joint.

BES was first reported in 1996 for the treatment of lumbar discectomy.[22] Since then, many clinical trials have been performed with successful outcomes in various surgical indications.[13,14,16,23,24] Two portals are independent, separated and exchangeable, so that surgeons can maneuver many surgical instruments efficiently as they use in a conventional surgery.

In the 2 cases described in the present report, efforts were made to overcome limitations of previous technique and secure the virtue of minimal invasive spinal surgery by BES. By switching operator's position and placement of primary 2 portals, the step to make additional skin incision or operative trajectories was unnecessary. Using endoscopic contralateral approach in bilateral direction resulted in successful bilateral foraminal decompression while minimizing injury to not only soft tissue such as paravertebral muscle and fascia, but also surrounding structures associated with segmental stability such as facet joint and ligaments.

Such efforts to pursue the way of minimal invasive surgical method were rewarded with postoperative good surgical outcome. The same advantages previously reported in endoscopic spinal surgery[19,25,26] were also confirmed in the current cases. Both patients were satisfied with less postoperative back pain, minimal operative scar (Fig. 8), short hospital stay (2 days), and early return to previous routine work. Another advantage in surgeon's perspective was no need for additional approach or staged operative work, leading to shorter operative time (first case, 85 minutes; second case, 90 minutes) and less surgical burden compared to previous other surgeries such as simple decompression with bilateral approach and fusion surgery.

The following several factors might have facilitated such successful results in the current cases. First, characteristics of endoscope in spinal surgery might have played a role. The endoscope with thin and long shape can make variable operative angle by tilting and rotation. It's structural property enabled mul-

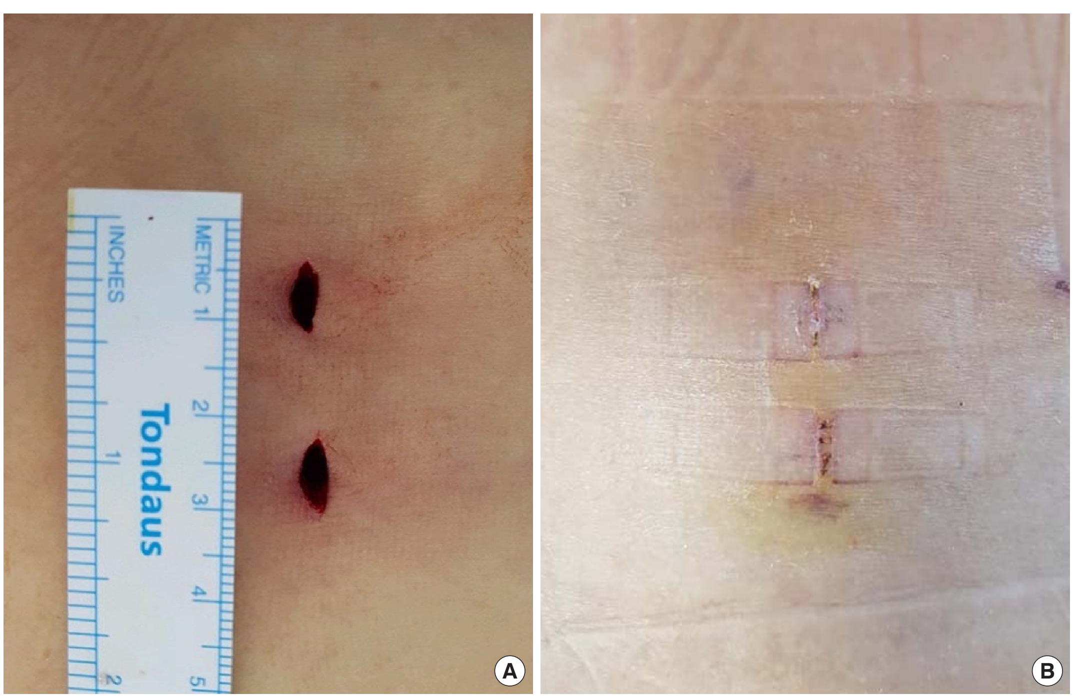

Fig. 8. Postoperative wound. (A) Immediately after operation. (B) Seven days after operation.

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tidirectional access to operative target in relative narrow space of spinal canal with magnified operative view. This cannot be implemented in microscopic tubular retractor system. Such unique characteristics of endoscope allowed oblique access to far contralateral foraminal region with good operative vision for exiting root decompression and direct reapproach to primary ipsilateral foraminal area with different operative angles via primary two tiny portals by only switching surgeon's position. Second, unconstrained use of effective instruments such as angled chisel, curette, and up-bite pituitary forceps might have contributed to such successful results in the current cases. In current cases, surgeon could use various kinds of surgical instruments without limitation through the working portal which provided relatively large space to use the operative instruments. Removal of cranial tip of SAP was easily achieved with specially designed angled instruments under well-visualized endoscopic view. These were key factors of successful foraminal decompression in the current cases.

Although we acquired successful surgical results with only resection of cranial tip of SAP for bilateral foraminal stenosis, this technique could not be applied to all kinds of bilateral LFS. Foraminal stenosis is composed of variable pathologies. The use of this technique might be restricted to cases of foraminal stenosis due to disc space collapse, pedicle kinking, accompanying extraforaminal lesions and osteophytes in shoulder portion of exiting root. Optimal surgical indication of this technique would be stable foraminal stenosis by bucking of facet capsule, subluxation, or hypertrophied SAP with preserved disc. In particular, it would be the most suitable surgical method for the lesions of the bilateral foraminal stenosis that accompanies lesions in the central canals that were difficult to solve in transforaminal approach. This technique should be performed for selected cases by preoperative careful decision making with CT, MRI, and dynamic X-ray.

The efficacy of this technique should not be generalized to all spine surgeons either. Steep learning curve and technical difficulty are drawbacks of endoscopic spine surgery.[27,28] Although authors achieved successful outcome in the current cases, the operator of this study is an expert who has performed over 500 cases of BES. Operative field of primary ipsilateral region from switched operative position is relatively narrow, requiring steep operative angle. Sometimes, surgeon should use 30° endoscope in order to overcome limited operative view. Unmastered use of angled chisel in such limited endoscopic view may induce injury to neural structures and result in unfavorable clinical outcome. Thus, surgeons should try this technique after they overcome the learning curve of BES with a lot of surgical experiences and after they are familiar with the use of angled endoscopic instruments.

One great advantage of this technique is that it can preserve the facet joint by only resecting the cranial tip of SAP via oblique approach from the contralateral side. There are many previous articles about the usefulness of contralateral approach to minimize injury of the facet joint.[13,22,23,29] However, there is rare report about the influence of bilateral contralateral approach on segmental stability. The evidence of postoperative instability was not observed until 8 months after the operation in the current cases. Further follow up evaluation is necessary to prove the efficacy of bilateral contralateral approach to preserve segmental stability.

CONCLUSION

BES with switching technique is one of good surgical options to treat bilateral foraminal stenosis without additional skin incision or surgical trajectory. It can minimize operative injury of segmental structures including facet joint and provide favorable clinical outcome to selected patients.

CONFLICT OF INTEREST

The authors have nothing to disclose.

SUPPLEMENTARY MATERIALS

Supplementary video clips 1–3 can be found via
https://doi.org/10.14245/ns.1836330.165.v1,
https://doi.org/10.14245/ns.1836330.165.v2,
https://doi.org/10.14245/ns.1836330.165.v3.

Supplementary video clip 1. Video clip demonstrating the process of contralateral decompression to expose the thecal sac and contralateral traversing root.

Supplementary video clip 2. Video clip demonstrating the process of contralateral L5 exiting root decompression.

Supplementary video clip 3. Video clip demonstrating the process of ipsilateral L5 exiting root decompression.

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