Lumbosacral interbody fusion using a biportal endoscopic technique for patients with multilevel severe degenerative lumbosacral spondylosis: Technical note and case presentations

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Abstract:

Background Open decompression and posterior interbody fusion are standard surgical interventions for multiple degenerative lumbosacral spondylosis (DLS). Despite their clinical efficacy, intraoperative and postoperative complications have led to the demand for a minimally invasive approach. A biportal endoscopic approach is an advanced minimally invasive surgical option.

Objective and Methods The data of two patients with multiple DLS who had undergone biportal endoscopic spine surgery (BESS) were retrospectively analyzed. Parameters such as the surgical difficulty, duration of operation, blood loss, length of hospital stay, and postoperative complications were reviewed. Pain and functionality were assessed using the Visual Analog Scale (VAS) and the Oswestry Disability Index (ODI), respectively.

Results Both patients were female and aged 75 and 73 years, respectively; they complained of back pain, claudication, pain and weakness in the lower extremities, and gait disturbance. The symptoms lasted 5 and 8 years, respectively. The multilevel BESS approach was applied bilaterally. Dissection, laminofacetectomy, decompression, excision, cage insertion, and screw implantation were performed. The operation durations were 170 and 160 minutes with blood loss of 500 mL and 650 mL, respectively. Back pain, leg pain, and ODI scores significantly improved; no false joints or additional neurological deficits were noted on follow-up.

Conclusions The presented BESS technique is a minimally invasive treatment option for patients with multiple DLS, which typically requires a complicated surgical approach. Randomized controlled studies with larger sample sizes and longer follow-up periods are needed to verify the superiority of this operation.

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Introduction

Degenerative lumbosacral spondylosis (DLS), with concomitant neurologic deficit and functional disabilities, is typically managed via surgery\(^1\). Despite the clinical efficacy of this approach, intraoperative and postoperative complications have led to the demand for a minimally invasive approach\(^2\).

Biportal endoscopic spine surgery (BESS) is being increasingly applied to discectomy and decompression surgery\(^3\). This method adheres to the minimally invasive principle; at the same time, it is designed to realize the essence of surgical intervention by securing an increased degree of freedom for the surgeon’s hand and a wide view suitable for complex bony vertebrae. Moreover, reports on its efficacy and safety are increasing\(^4\). The surgeon can adjust the anterior and posterior structures of the neural element through a posterior approach with the preservation of support structures. Bilateral multilevel application is also possible\(^5\).

It may seem unreasonable to apply a minimally invasive method to the extensive surgery of multilevel degenerative spondylolisthesis. However, the advantages of BESS may be valid for sufficient decompression and careful exploration. Reports on the feasibility of BESS interbody fusion in cases of lytic spondylolisthesis and single-level degenerative spondylolisthesis have been published\(^6\)-\(^8\).

Thus, here, we aim to describe a surgical technique of decompression and interbody fusion using the BESS and present clinical and radiological results in patients with severe multilevel DLS.

Methods

This retrospective case study was conducted in compliance with the Declaration of Helsinki and approved by the institutional review board. Informed consent was obtained from
both patients had two or more adjacent lesions requiring open decompression and multilevel fusion via conventional methods. Data were gathered retrospectively and analyzed after receiving approval from the institutional review board. The data were as follows: inpatient and outpatient medical charts, nursing records, surgical records, images, and logon records from hospital information systems.

Surgical techniques

The surgery was performed under general anesthesia. Intraoperatively, each patient’s blood pressure, heart rate, electrocardiogram, oxygen saturation, and respiratory rate were monitored. The patients were placed in a prone position. Their backs were gently flexed by placing the Wilson frame under the abdomen. The frame was fixed using a soft strap on the trunk and thighs for stabilization. The lumbosacral region was exposed, while the rest of the body was covered with sterile drapes. Sterility was observed throughout the procedure. The target site was identified under fluoroscopy, and incisions were made bilaterally based on the intervertebral disc levels for cage insertion.

Step 1. Incision. Two portals were constructed as follows: the entry points were marked 1 cm above and 2 cm below the target intervertebral level (lower margin of the upper lamina) and 0.5 cm laterally from the spinous midline. The marked skin can be opened by 1 cm using the transverse incision method, providing low resistance to major movements of the inserted devices, thus reducing damage to the longitudinal muscle fibers. The cranial portal was used for continuous irrigation and endoscopy, and the caudal portal was used for the operating devices. Three sets of two portals have a total of eight incision lines bilaterally and sharing a caudal portal on the upper level and a cranial portal on the lower level (Fig. 1).

Step 2. Approach. After muscle exfoliation using a dissector, a 30-degree arthroscope with a 4 mm diameter was inserted into the target lamina. A continuous irrigation system was
connected and controlled to set a pressure of 50 mmHg. After ensuring a clear endoscopic view, an indicator was inserted into the caudal portal to identify the tip through the endoscopic view. Target points and instrument placement were confirmed through fluoroscopy.

**Step 3. Laminectomy and facetectomy.** The interlaminar ligament was resected 1–1.5 cm transversely. Partial laminectomy was performed using an elliptical arthroscopic burr. After inspecting the dura mater, the thickened ligamentum flavum (LF) was removed using a Kerrison punch. The neurovascular structures of the central canal and foramen were inspected. The endoscope was inserted deeply to check the subarticular annulus fibrosus, and the contralateral LF and epidural space were then inspected by rotating the 30-degree endoscope (Fig. 2). The total inferior articular process and partial superior articular process were subsequently removed using an osteotome and a chisel, thus securing the cage insertion space and root decompression. Bone fragments were picked up with straight mosquito.

**Step 4. Disc space preparation and cage insertion.** Approaching the subarticular annulus fibrosus, disc materials were removed through an incised hole of the herniated annulus. The cartilage of endplate was scraped to induce bone union using a curette and a reamer. The reserved intervertebral space enabled the direct entry and exploration of endoscope. A sufficient intervertebral space determines the cage size considering the last reamer size. A mixture of local bony fragments with demineralized bone matrix (DBM) was packed in the intervertebral space within the cage. In this process, the neuromuscular structures were protected through a retractor.

**Step 5. Contralateral decompression.** Once it was confirmed, through endoscopy and radiography, that the cage placement was stable, the contralateral LF was removed and decompression was added (Video 1). When the 30-degree endoscope was rotated 150 degrees axially at the level of posterior epidural space, the contralateral LF and dura mata were
identified. The contralateral recess decompression of LF removal using the punch enabled endoscopic identification of the contralateral traversing spinal root.

**Step 6. Re-operation of step 4 and 5 according to the target levels.** Since the intervertebral height was restored through these operating steps, the decompression was performed from the caudal level among the target levels to prevent a traction injury of nerve roots.

**Step 7. Percutaneous pedicle screw fixation.** Under radiography, a pedicle screw was advanced for posterior fusion. Reduction was tried during fixation, and the presence of vertebral body displacement was considered. The percutaneous pedicle screws were locked after all implants were repositioned.

**Step 8. Inspection before closing.** Bleeding and intact elements were closely monitored through endoscopic exploration. By examining the dural pulsation caused by normal breathing, the degree of decompression was evaluated through endoscopic observation. Once all the instruments were removed, a subfascial hemovac was inserted and the skin was apposed and sutured (Fig. 3).

**Step 9. Postoperative management.** Walking with a rigid brace was allowed on the day after surgery once stable vital signs were confirmed. The patients were discharged 3 to 5 days after surgery.

### 2.2 Case 1

A 75-year-old female patient with no history of trauma was admitted to the hospital with chronic hip pain, continuous radicular pain, and severe claudication that had lasted 5 years. She reported that even if she walked only ten steps, she felt calf pain and weakness, so she had to sit down and rest. She had been taking limaprost 5ug three times a day, 37.5 mg of tramadol and 325 mg of acetaminophen on an irregular basis for 10 months. In the last month, the buffrenorphine patch (10 ug per hour, total 10 mg) has been used every week, but
there has been no symptomatic improvement. A plain lumbosacral radiograph showed compression fractures of the 3rd, 4th, and 5th lumbar vertebrae with severe degenerative changes in the endplate and facet joints. On magnetic resonance imaging, L3/4, L4/5, and L5/S1 disc herniations and severe stenosis of the foramen and central canal were observed. Difficulty in ambulating for more than 30 meters was noted, and the extensor and flexor muscles of both ankles showed grade 4 muscle weakness. Previous surgical history included a partial gastrectomy for gastric cancer 2 years prior. She was taking an antihypertensive medication.

She underwent biportal endoscopic decompression with 3-level interbody fusion on the L3 to S1 spine level through the unilateral biportal approach at each level. The duration of operation was 170 minutes, and blood loss was 500 mL. Postoperative MRI and x-ray images demonstrated an improvement in the lumbar lordosis, significant decompression of the neural structures, and well-placed implants (Fig. 4).

Ambulation with minimal assistance was initiated on the 3rd postoperative day. There was gradual relief of pain and claudication; 8.9 to 3.2 on the VAS of back pain, 7.4 to 1.5 on the VAS of leg pain, and 66.7% to 19.8% on the ODI 4 weeks post-surgery. Even if she walked more than 30 meters indoor, no previous pain or weakness occurred. There was no evidence of pseudoarthrosis or neurological deficits at the 1-year follow-up. At this time, she reported that she could walk about a distance (approximately 150 meters) of one bus stop without a rest. Acetaminophen was taken due to intermittent low back pain, but it did not exceed once a week.

2.3. Case 2

A 73-year-old female patient presented with chronic, radicular low back pain and severe claudication in both legs that had lasted 8 years. The symptoms were more dominant
on the right and were recently observed to worsen upon coughing. She had difficulty walking independently. She was able to move about five meters under a minimal assistance, but had to rest due to right severe leg pain and bilateral legs weakness. She was taking celecoxib 100 mg and Ginko Life Extract 40mg twice a day for one year, and was also taking oxycodon 5mg of irregularly to recent exacerbated pain. A plain lumbosacral radiograph showed degenerative malalignment of the 2nd to 5th lumbar vertebrae with severe degenerative changes in the endplate and facet joints. On magnetic resonance imaging, lumbar disc herniations and severe stenosis of the foramen and central canal were observed. The extensor muscles of both ankles showed grade 3 muscle weakness and the flexor muscles of both ankles and knees showed grade 4 muscle weakness. Electrophysiologic studies showed chronic bilateral L5 and S1 radiculopathies. She was taking antihypertensive and antiglycemic medications.

The patient underwent biportal endoscopic decompression with 3-level interbody fusion on the L2 to L5 spine level. The duration of operation was 160 minutes, and blood loss was 650 mL. Her scoliosis improved partially after surgery. Sufficient decompression was achieved through augmentation of the intervertebral and foraminal space (Fig. 5). She was able to walk with a rolling walker 2 days after surgery. After 4 weeks, her symptoms gradually improved: 8.1 to 2.8 on the VAS of back pain, 7.2 to 1.9 on the VAS of leg pain, and 58.2% to 11.8% on the ODI. She showed a dramatic improvement in claudication, allowing her to walk three times without a rest on the 20-meter-long tack in physical therapy room. No pseudoarthrosis or neurological deficits were observed, and the strength of the extensor muscles of both ankles was restored to grade 4 on follow-up 18 months after surgery. At this time, she reported that she had no difficulty walking and said she could climb a low-height hill. She mentioned that she often had low back pain with minimal to moderate intensity when walking continuously for more than 30 minutes outdoor, but the pain resolved after resting. She did not report taking any analgesics due to pain.
Discussion

Innovations in endoscopic instruments and surgical techniques have shifted the treatment paradigm for degenerative lumbar spine disease from open surgery to minimally invasive surgery. Various methods, depending on the approach, direction, and structural order of removal, are available. However, the principles of decompression and fusion maintain the concepts of open decompression with interbody fusion. Therefore, the principle of minimal invasiveness involves the restriction of unnecessary intervention; moreover, the intervention should not be inadequate for invasive resection, decompression, reduction, and fixation. Resection of the facet joint and annulus fibrosus is unavoidable in most minimally invasive techniques.

Aging initiates disc degeneration through dehydration and fragmentation of the nucleus pulposus. Degeneration affects the distribution and balance of the load on the annulus fibrosus. The accumulated load causes structural problems such as a break in annular continuity, instability of intervertebral joints, thickening of central canal ligaments, and a decrease in the height of the intervertebral foramen; thus, a vicious cycle develops. Multiple structural factors make the clinical symptoms more complex and more susceptible to nerve damage than single-cause lesions (e.g., herniated discs).

Surgical decompression should be considered for significant neurological deficits. Options include decompression with extensive osteotomy, and fusion as an additional treatment. Studies on surgical outcomes were subjected to Cochrane review, which revealed a lack of high-quality evidence. Case reports showed favorable surgical outcomes with low complication rates.

Reports on biportal endoscopic spine surgery are increasing as this method allows sufficient decompression and wide exploration of the conventional method under the
principle of minimal invasiveness. If performed on severe stenosis, favorable outcomes can be expected, as the BESS is applicable to multilevel lesions. Selective decompression through the posterior approach can minimize the incision site, and the direct approach to the annulus fibrosus enables real-time confirmation of the insertion pathway of the interbody cage. Further, it makes it possible to reduce the burden of the fixators and rods through the supporting role of the remnant bony structure.

Here, we report the trial of BESS for the surgical treatment of multilevel degenerative spondylolisthesis with concomitant radiculopathies and claudication. The two patients had poor prognostic factors, namely greater blood loss due to the large incision site, old age, and multilevel complicated bony malformations, while undergoing open surgery. Selective decompression of severe intervertebral foramen stenosis was indicated to prevent the additional neurological complications that can occur while securing lordosis during fusion. There were additional advantages such as removal of the herniated disc at the same annulus as well as insertion of a cage and feasible annuloplasty; moreover, the multilevel approach was possible. Clinical outcomes showed remarkable pain reduction, fewer complications, and early ambulation. Daily activities improved gradually, without pseudoarthrosis or additional neurological deficits during follow-up. There was high patient satisfaction with the surgery. Attention to the delayed operation time is necessary. Constant irrigation pressure to secure the field of endoscopic view during manipulation can cause neurological damage. Evidence of increased intraoperative epidural pressure has been reported. The intraoperative irrigation pressure should be kept below 50 mmHg; further, if possible, neurological monitoring is recommended.

Conclusion

Reports on the type, severity, and incidence of complications as well as the
effectiveness of surgery are necessary through analysis of more cases. The BESS method can be applied to multiple degenerative spondylosis because it is minimally invasive and, at the same time, secures the degree of freedom of the surgeon’s hand and provides a sufficient operative view.

**Patient Consent**

The patients have consented to the submission of the case report to the journal.

**Conflict of Interest**

None declared.

**References**

6. Heo DH, Son SK, Eum JH et al. Fully endoscopic lumbar interbody fusion using a percutaneous unilateral biportal endoscopic technique: technical note and preliminary


Fig. 1. Overview of biportal endoscopic spine surgery for multilevel degenerative lumbosacral spondylosis (target levels: L2/3, L3/4, and L4/5). Three sets of two portals have a total of eight incision lines bilaterally, sharing a upper caudal portal and a lower cranial portal.

Fig. 2. Endoscopic views on the L3/4 epidural space. Left: The dura mater, sleeve, and spinal nerve (closed arrowhead) placed over the annulus (open arrowhead). The dotted line is the resected lamina. Right: Contralateral epidural space. The arrow points at the foraminen.

Fig. 3. The sutured skin of the portals and inserted subfascial catheters to hemovacs immediately after surgery. Eight incisions were placed bilaterally and the target levels are L2/3, L3/4, and L4/5.

Fig. 4. Pre- and post-operative images of the case 1. A and B: Preoperative simple spine images. C and D: Preoperative spine MRIs. E and F: Simple spine images three months after the surgery.

Fig. 5. Pre- and post-operative images of the case 2. A and B: Preoperative simple spine images. C and D: Preoperative spine MRIs. E and F: Simple spine images one month after the surgery.
Video 1. Endoscopic view during total discectomy and cage insertion in BESS for L4/5 interbody fusion.