Uniportal full endoscopic spinous process–preserving laminectomy for bilateral decompression in cervical stenotic myelopathy: patient series

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BACKGROUND Endoscopic decompression for cervical stenotic myelopathy has several advantages over conventional open surgery. However, sometimes performing bilateral decompression, especially contralateral decompression, can be dangerous. The cervical spine has specific characteristics, including a shallower lamina angle and thinner lamina than the lumbar or thoracic lamina. These characteristics may cause cord compression when instruments approach the contralateral side of the lamina. This article introduces a novel surgical technique that can overcome the specificities of the cervical spine and discusses the efficacy and safety of uniportal full endoscopy for cervical decompression.

OBSERVATIONS Fourteen patients underwent uniportal full endoscopic spinous process–preserving laminectomy (ESP-L) for bilateral decompression of multilevel cervical stenotic myelopathy. The mean follow-up period was 13.44 months (range: 4–17 months). The preoperative and postoperative cervical spine angle and cervical range of motion did not differ significantly. The Japanese Orthopaedic Association score significantly improved postoperatively. The numeric rating scale scores significantly improved postoperatively. The mean duration of postoperative hospitalization was 2.3 days.

LESSONS ESP-L is a new, safe, effective, and noninvasive technique that can achieve complete decompression of multilevel cervical stenotic myelopathy.

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KEYWORDS uniportal; endoscope; cervical; stenosis; myelopathy

Cervical stenotic myelopathy, including cervical spondylotic myelopathy and ossification of the posterior longitudinal ligament (OPLL), are the most important causes of neurological deterioration. Surgical options include anterior cervical discectomy and fusion, corpectomy and fusion, posterior laminectomy with or without fusion, and laminoplasty. Conventional open surgeries are effective but have many disadvantages. Laminectomy and laminoplasty are extensive surgeries that can cause posterior extensor muscle injury, resulting in postoperative axial pain and loss of the cervical spine angle (CSA) and range of motion (ROM). Meanwhile, fusion surgery can cause loss of mobility at the surgical level, device failure, nonfusion, and adjacent segment disease.1 Recently, full endoscopic decompression has been performed for cervical spine disease and has several advantages, including a small skin incision, preservation of normal tissue, noninstrumental surgery, early recovery, short hospital stay, and maintenance of spinal structures. The cervical spine has a specific characteristic in that the angle of the lamina is shallower and the thickness of the lamina is thinner than those of the thoracic or lumbar lamina. Occasionally, these characteristics make surgery difficult and dangerous. When using instruments under the lamina to approach the contralateral side, cord compression can occur, which can result in postoperative neurological deficits. This article introduces a novel and safe technique for multilevel cervical stenotic myelopathy that reduces the hospital stay and postoperative neck and arm pain, accelerates recovery of neurological outcomes, and preserves the CSA and ROM postoperatively.

ABBREVIATIONS CRP = C-reactive protein; CSA = cervical spine angle; CT = computed tomography; EMG = electromyography; ESP-L = endoscopic spinous process–preserving laminectomy; ESR = erythrocyte sedimentation rate; JOA = Japanese Orthopaedic Association; MRI = magnetic resonance imaging; NCV = nerve conduction velocity; NRS = numeric rating scale; OPLL = ossification of the posterior longitudinal ligament; ROM = range of motion; WBC = white blood cell.

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Study Description

Data Collection

Between May 2021 and September 2022, 14 patients underwent uniportal full endoscopic spinous process-preserving laminectomy (ESP-L) for bilateral decompression to treat multilevel cervical spondylotic myelopathy. ESP-L was performed from C2 to C7 in 2 patients, from C2 to C6 in 1 patient, from C3 to C7 in 1 patient, from C2 to C5 in 1 patient, from C4 to C7 in 1 patient, from C3 to C5 in 1 patient, and from C5 to C7 in 7 patients. Radiological outcomes were assessed using the Cobb angle between C2 and C7 and cervical ROM. Clinical outcomes were assessed by the Japanese Orthopaedic Association (JOA) score and the neck and arm numeric rating scale (NRS). Preoperative and immediate postoperative inflammatory factors, such as the white blood cell (WBC) count, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) levels, were assessed. Statistical analysis was performed using the paired-sample t test via SPSS version 29.0 (Statistics Analysis for Windows, IBM Corporation), with a p value < 0.05 considered as significant.

Surgical Technique

All surgeries were performed with the patient under general anesthesia and lying prone in a uniportal full endoscopic fashion. We used a 150-mm working length, 2 × 15-mm irrigation channel and a 7.3-mm outer diameter, 4.7-mm working channel endoscope (iLESSYS Pro, Joimax, Inc.). On the Wilson frame, the neck of the patient was slightly flexed and fixed. A skin incision was created over the center of the pathology in the lateral C-arm view, immediately lateral to the spinous process. A sharp incision using a knife was created from the skin to the fascial layer, followed by sequential blunt dilation to the lamina. An oblique-type working tube was inserted via a dilator, and an endoscope was introduced through the working tube. The lamina was exposed laterally to the medial border of the facet joint, and the base of the spinous process was exposed medially. An ipsilateral approach was used, and resection was initiated at the spinolaminar junction that proceeded to the contralateral spinolaminar junction through the base of the spinous process (Fig. 1A). When the entire base of the spinous process was drilled out, it became movable (Fig. 2A). The freed spinous process was pushed away to the contralateral side and the contralateral lamina was observed (Fig. 2B). At that time, the instrument angle was almost perpendicular but not shallow (Fig. 2C), allowing us to approach the contralateral lamina from the posterior side and not from underneath the lamina. This made it a safe approach for the contralateral side (Fig. 1B). We then performed an ipsilateral laminectomy and removed the contralateral lamina up to the point where it overlapped with the cranial and caudal lamina, known as the contralateral V-point (Fig. 2D). When performing bilateral laminectomy, we removed the ipsilateral and contralateral ligamentum flavum in 1 piece en bloc. If the pathologies were multilevel, the same procedure was repeated at every pathological level. Foraminotomy was performed at the affected level in patients who presented with radiculopathy. The approach to the contralateral pathology is safe and easy; therefore, we can easily decompress the contralateral foramen from the posterior side (Fig. 2E and F). After adequate decompression, cord pulsation and fluctuation of the thecal sac due to water pressure were confirmed. A drain was then inserted through the working tube. The skin was closed using a subcutaneous stitch and skin glue.

Illustrative Case 1: Cervical Spondylotic Myelopathy

A 59-year-old man presented with lower extremity motor weakness that gradually progressed over 7 months. Cervical magnetic resonance imaging (MRI) showed C2–C7 central stenosis with a C3–C4–C5 cord signal change (Fig. 3A). There was a small OPLL at the level of the C6 and C7 vertebral bodies. Electromyography (EMG) and nerve conduction velocity (NCV) studies showed myelopathy. ESP-L was performed from C2 to C7, involving total laminectomy from C3 to C6 with undercutting of the C2 and C7 laminae. The intraoperative C-arm showed the endoscopic probe touching the C2 and C7 laminae. However, the surgical field did not even touch the C2 and C7 spinous processes, which are the insertion points of the stabilization muscle (Fig. 3B). Postoperative sagittal magnetic resonance imaging (MRI) showed complete cord decompression from C2 to C7. Axial MRI showed full bilateral decompression of the cord at each level (Fig. 3C). Lateral radiography revealed preserved spinous processes (Fig. 3D). Computed tomography (CT) showed totally resected bilateral laminae and undermined C2 and C7 laminae (Fig. 3E). Postoperatively, the JOA score improved from 13 to 16, the neck numeric rating scale (NRS) score was 1, and all inflammatory factors were within normal ranges. The patient was discharged on postoperative day 4. A photograph taken when the patient visited the hospital as an outpatient showed a postoperative wound scar. One incision measuring 0.9 cm was used for the 5-level cervical decompression (Fig. 3F).

Illustrative Case 2: OPLL

A 61-year-old man presented with lower extremity motor weakness that gradually progressed over 6 months. Cervical MRI showed C3–C4–C5–C6 central stenosis with a C3–4 cord signal change (Fig. 4A). CT revealed a large OPLL extending from C2 to C7 (Fig. 4B). Radiographs showed the OPLL at the posterior vertebral body (Fig. 4C). EMG-NCV showed myelopathy. ESP-L was performed from C2 to C7, total laminectomy was performed from C3 to C6, and the C2 and C7 laminae were undercut. The intraoperative C-arm showed endoscopic probe touched the undermined lower lamina of C2 and the upper lamina of C7, respectively (Fig. 4D). Postoperative sagittal MRI revealed complete decompression of the cord from C2 to C7 (Fig. 4E). Postoperatively, the JOA score improved from 13 to 16, the neck NRS score was 1, and all
inflammatory factors were within normal ranges. The patient was discharged on postoperative day 4. A photograph taken when the patient visited the hospital as an outpatient showed a postoperative wound scar. One incision measuring 0.8 cm was used for the 5-level cervical decompression (Fig. 4F).

Results

Overall Clinical Information

The mean patient age was 61.8 years (range: 46–72 years), and the mean preoperative period for cervical myelopathy was 4.2 years (range: 0.5–15 years). The mean follow-up period was 13.44 months (range: 4–17 months). The mean treated level of surgery was 3.2 (range: 3–5). The mean duration of the postoperative hospitalization was 2.3 days.

Radiological Outcomes

The mean preoperative and postoperative CSAs were (mean ± standard deviation) 14.16° ± 12.02° and 13.04° ± 11.58°, respectively; the difference was not statistically significant. The mean preoperative and postoperative ROMs were 43.61° ± 10.76° and 45.43° ± 9.44°, respectively; the difference was not statistically significant.

Clinical Outcomes

The mean preoperative and postoperative JOA scores were 9.60 ± 2.76 and 14.20 ± 2.30, respectively; the difference was statistically significant (p < 0.01). The mean recovery rate was 66.91% ± 18.59%. Neck and arm pain were evaluated using the NRS (range: 0–10, with 0 indicating no pain and 10 indicating the worst pain imaginable). Preoperative neck pain was 6.83 ± 1.52, whereas immediate postoperative neck pain significantly decreased to 1.42 ± 0.69 (p < 0.01). Additionally, preoperative arm pain was 5.67 ± 2.45, whereas immediate postoperative arm pain significantly decreased to 1.42 ± 0.90 (p < 0.01).

Inflammatory Factors

The mean preoperative and postoperative day 1 WBC counts were 6916.67 ± 1883.82 and 9333.33 ± 1584.20 cells/μL, respectively. Although the postoperative WBC counts increased significantly, they were all within the normal range, except in 1 patient whose postoperative WBC count increased to 11,600 cells/μL. The mean preoperative and postoperative day 1 CRP levels were 2.13 ± 1.74 and 2.67 ± 1.39 mg/dL, respectively; the increase was not significant. The CRP level was within the normal range, except in 1 patient whose CRP was 4.9 mg/dL. The mean preoperative and postoperative day 1 ESR levels were 13.58 ± 11.13 and 13.67 ± 5.09 mm/hr, respectively; the change was not significant. In all patients, the postoperative ESR was within the normal range.

Discussion

Observations

Until the 1960s, total laminectomy was performed for posterior cervical decompression, resulting in the eventual progression of kyphotic deformity, instability, and neurological deterioration.3–8 To avoid these complications, laminoplasty was developed.9 Currently, laminoplasty is widely performed for multilevel cervical stenotic myelopathy. However, its complications include postoperative posterior neck pain and reduced ROM.10,11 To preserve cervical stability and
ROM, it is important that the integrity of the paraspinal extensor muscles, especially that of the multifidus and semispinalis cervicis muscles, is maintained. Cervical multifidus muscles originate from the C4–C7 articular facet and insert at the C2–C4 spinous process. Semispinalis cervicis muscles originate from the transverse process of the 7 upper thoracic vertebrae and insert at the tips of the C2, C7 spinous process strongly, with much smaller insertions on C3–C6. Because the insertion points of the stabilizing muscles are on the spinous process and not on the lamina, preserving the tip of the spinous process is important for maintaining cervical stability. In conventional surgery, the length of the skin incision is the same as the length of the pathology, and all muscles between the skin and the pathology must be stripped from the spinous process. However, uniportal full endoscopic surgery requires only 1 entry point and can be used to treat the entire length of the pathology from C2 to C7 without stripping any extensor muscles. In cases of myelopathy, the multifidus and semispinalis cervicis do not need to be stripped from C2 or C7 by undercutting these laminas, even if the upper end of the laminectomy is C2 or the lower end of the laminectomy is C7. With our technique, the instruments do not contact the C2 or C7 spinous process, which is an important insertion point of stabilizing muscles (Figs. 3B and 4D).

In the cervical spine, approaching the contralateral side under the spinous process and lamina may lead to surgical failure. First, the angle of the cervical lamina is shallower than that of the lumbar or thoracic lamina; if the contralateral lamina is approached, cord compression may result. Therefore, the contralateral side is approached under the contralateral spinous process (Fig. 4C).
compression can occur. Even a 5-mm-thick instrument can be used to compress the cord (Fig. 5A). If the mass in the anterior pathology is large, such as a huge OPLL or a large and protruding herniated disc, the possibility of cord compression increases. The thoracic or lumbar lamina is thicker than the cervical lamina, and both have adequate spaces for the safe removal of the ventral part of the lamina; therefore, the instrument can safely approach from the posterior side of the thecal sac without removing the entire lamina. However, the cervical lamina has inadequate space even after removing the ventral part of the lamina; thus, there is the possibility of compressing the cord with the instrument without complete lamina removal.

Second, in the case of endoscopic surgery, the skin entry point functions as a pivot point. To appropriately decompress the contralateral pathology through the underlying lamina, the angle of the instrument needs to be the same as that of the cervical lamina. Hence, the tilt angle causes the skin incision to move laterally. As the angle of the cervical lamina is shallow, the pivot point must be moved more laterally than the thoracic or lumbar spine (Fig. 5B). However, the endoscope is fixed at the skin entry point, and the instrument cannot be tilted appropriately, although the skin and muscles have some mobility. An insufficient angle can result in insufficient decompression. Although the operation starts with a more...
lateral entry point, which can improve the angulation of the endoscope, there is still a risk of cord compression by the instrument (Fig. 5B). Therefore, to completely and safely decompress the cervical spine, the entire base of the spinous process must be removed and approached from the posterior side. Sometimes, if a patient has a very wide spinous process base that covers almost the width of the thecal sac, the spinous process will have adequate space to approach the contralateral side from the posterior aspect. At that time, the cervical unilateral approach for bilateral decompression—namely, the over-the-top procedure—could be performed safely as in the case of the thoracic and lumbar spine.

ESP-L does not come into contact with the paraspinal muscles; therefore, it can maintain the integrity of the stabilizing muscles from origin to insertion. By moving the freed spinous process to the contralateral side, a contralateral laminectomy for complete decompression can be safely performed. Additionally, the procedure is water-based, which prevents thermal injury to the spinal cord. This noninstrumental procedure can also avoid risks such as spinal cord injury caused by dislodged or misplaced implants.

ESP-L is a good alternative for treating multilevel cervical stenotic myelopathy without severe kyphosis, especially when the pathology involves C3 or C6. During laminoplasty or laminectomy, if the pathology involves C3 or C6, there is a possibility of damaging some part of the C2 or C7 muscles to manipulate the C3 or C6 lamina and spinous process appropriately. Moreover, if foraminal pathology is present on 1 side at different levels and crosses to the other side, ESP-L can safely and easily approach both sides and effectively decompress the pathology. However, if the pathology involves bilateral foraminal disease at the same level or severe kyphosis or instability, fusion surgery is the preferred treatment option.

To the best of our knowledge, this is the first reported method for the treatment of cervical stenotic myelopathy. This method is safe and noninvasive and can achieve complete decompression.

Lessons
ESP-L is a minimally invasive surgery that achieves complete decompression while maintaining spinal stability during the treatment of cervical stenotic myelopathy. This new endoscopic technique can be a promising alternative to conventional surgery for cervical stenotic myelopathy.

References

Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
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