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Open-Door Laminoplasty Using Lateral Mass Anchoring Screws and Nonabsorbable Sutures in Patients with Multilevel Cervical Myelopathy

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Background: The purpose of this study was to evaluate the clinical usefulness of open-door laminoplasty using lateral mass anchoring screws and nonabsorbable sutures (ODLLM) for multilevel cervical myelopathy.

Methods: We retrospectively studied 30 patients who underwent ODLLM. Clinical evaluations were performed using a visual analog scale (VAS), Japanese Orthopaedic Association (JOA) score, and Neck Disability Index (NDI) preoperatively, at 1 year postoperatively, and at the last follow-up. Radiographic evaluation was done using cervical spine radiographs to measure changes in the lordotic angle and range of motion (ROM) preoperatively, at 1 year postoperatively, and at the last follow-up and computed tomography at 1 year postoperatively to measure the opening angle and anteroposterior diameter of the spinal canal.

Results: Significant improvement in VAS, JOA, and NDI was seen overall at 1 year after operation. However, there was no significant difference between 1 year after operation and the last follow-up. There were no significant changes in the lordotic angle and neck ROM. The mean opening angle of the opened lamina was measured as 39.04°. The mean anteroposterior diameter was significantly increased from 7.51 ± 1.79 mm before surgery to 13.98 ± 1.80 mm at 1 year of operation. Complications such as laminar reclosure and screw loosening were not observed in all cases.

Conclusions: The ODLLM was technically easy to perform and showed good results comparable to those of conventional techniques. It can be suggested that ODLLM is an appropriate treatment option for multilevel cervical myelopathy.

Keywords: *Cervical vertebrae, Spinal cord disease, Laminoplasty, Lateral mass screw*

Multilevel cervical myelopathy refers to functional impairment caused by compression of the cervical spinal cord due to various causes such as ossification of the posterior longitudinal ligament (OPLL) and degenerative disc disease. Characteristic symptoms include clumsiness, impaired fine movement of the hand, weakness of the hand, sensory abnormalities, and gait disturbance.[1,2] Although multilevel cervical myelopathy is unlikely to resolve spontaneously and the outcome of surgical treatment varies according to the timing of operation, the severity of the lesion, and the duration of the disease, most authors emphasize the importance of early surgical treatment before the development of irreversible changes in the spinal cord rather than conservative treatment.[3,4]

There are many surgical approaches and techniques for the treatment of cervical myelopathy, and the optimal method is still under investigation. When 3 or more levels are involved, the posterior approach is preferred, and laminectomy and laminoplasty are representative surgical methods. Laminectomy, which had widely been used for management of cervical myelopathy, was associated with some postoperative problems such as malalignment of the

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cervical spine and possibility of damage to the spinal cord resulting from total exclusion of the posterior structures.[5-7] Laminoplasty offers some advantages such as preserving natural biomechanical function of the neck, preventing laminar collapse, and demanding smaller degrees of reduction in the range of cervical motion. In 1977, Hirabayashi contrived open-door expansive laminoplasty, which is a comparatively simpler and safer surgical procedure than laminectomy, preventing complications by conserving the posterior features.[8-11]

The most important issue concerning laminoplasty is increasing and maintaining the space of the spinal canal, and various methods are used to suspend and augment the elevated lamina. The conventional Hirabayashi technique allows the suture to remain within the paraspinal muscles and the spinous process.[8,12] But reclosure of the opened lamina with neurologic worsening has been reported.[12,13]

Recently, titanium miniplates have been widely used in laminoplasty, and this procedure has the advantage of low incidence of laminar reclosure and good preservation of the opened lamina.[14] However, the surgical technique is complicated, the operation time is prolonged, and adverse effects such as fixation failure may occur.[12,15,16]

In 1998, Wang et al.[17] described first the use of an anchoring system in 12 patients to settle the posterior components for the open position and reported that there was no failure. In 2007, Kim et al.[14] compared their modification method using a lateral mass screw and a wire with Hirabayashi's open-door laminoplasty and reported that the modified method was more advantageous for preserving the open window. In 2008, Chen et al.[18] introduced cervical laminoplasty using lateral mass anchoring screws and reported good results in improving the Japanese Orthopaedic Association (JOA) score and maintaining the opened lamina. In the above 3 reports, the modification method using an anchor system for the lateral mass or a lateral mass screw was found to have technical simplicity and the advantage of better maintaining the open window than the classic method. However, the study of Wang et al.[17] and the study of Chen et al.[18] have limitations of including a small series of subjects (only 12 and 5 patients, respectively) as they mentioned. The study of Kim et al.[14] had a mean follow-up of 19 months, which was not sufficient to assess the long-term prognosis, and only the JOA score was used as an indicator of clinical outcome.

On the basis of these previous reports, we thought that open-door laminoplasty using lateral mass anchoring screws and nonabsorbable sutures (ODLLM) would be a relatively easy and simple method to maintain the opened lamina. In this study, we studied more patients for a longer mean follow-up period than the 3 previous studies.

METHODS

Ethical Consideration

This study was approved by the Institutional Review Board of Ulsan University Hospital (IRB No. 2019-03-002). All patients gave informed consent to participate in this study.

Patients

We retrospectively reviewed 32 patients with cervical myelopathy (26 men and 6 women) who had undergone ODLLM from January 2008 to January 2015. Of these, 1 patient with a spinal cord tumor and 1 patient with rheumatoid arthritis were excluded from the study, and ultimately 30 patients were studied. All patients were followed up for at least 1 year.

Surgical Technique

All operations were performed by one spine specialist (JRC). The patient was placed on the operation table in the prone position, and the horseshoe headrest was used to immobilize the head. We performed aseptic draping from the occiput to the upper thoracic area and used the posterior approach. The incision continued along the median raphe down to the tips of the spinous processes from C2 to T1. Subperiosteal dissection was performed on the lateral portion of the lateral masses. Depending on the severity of symptoms, we decided which side of the lamina would be opened. In all cases, the modified Hirabayashi technique was performed. First, a lateral mass screw (OASYS polyaxial screw, 3.5 × 14 mm; Stryker, Kalamazoo, MI, USA) with a nonabsorbable suture (Ethibond, 48 mm 1/2c TAPERCUT; Ethicon, Somerville, NJ, USA) was inserted into the lateral mass of the hinged side (Fig. 1A and B). To open the laminae, we sequentially used a 3-mm spherical burr until the laminae were completely open (Fig. 1C). Once the bone separation was finished, the ligamentum flavum was resected by using a 1-mm Kerrison punch. The hinge was made with the 3-mm spherical cutting burr. The laminae were sequentially opened. A towel clip was used to grasp the spinous process and then rotated to create a hole, through which the nonabsorbable suture was passed. The suture was passed through the spinous process, and after the lamina was elevated to create an "open door," the nonabsorbable suture was firmly tied (Fig. 1D).[15] We tried to induce bone union between the hinge and lateral mass through an allogeneic bone graft to obtain a more stabilized window. The Philadelphia brace was

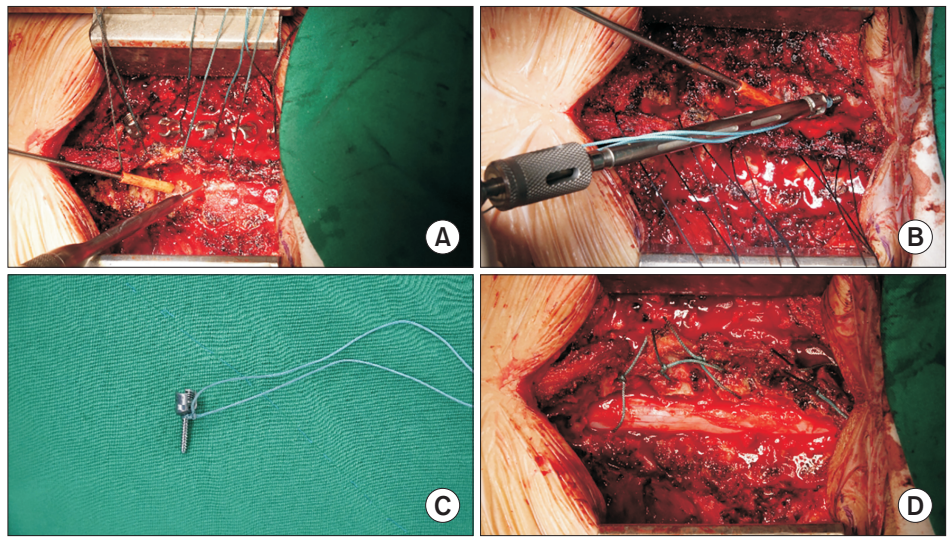

Fig. 1. (A) A lateral mass screw with a nonabsorbable suture. (B) The lateral mass screw with a nonabsorbable suture was inserted into the lateral mass of the hinged side. (C) We sequentially used a 3-mm spherical burr until the laminae were completely open. (D) The suture was passed through the spinous process. After the lamina was elevated to create an "open door," the nonabsorbable suture was firmly tied.

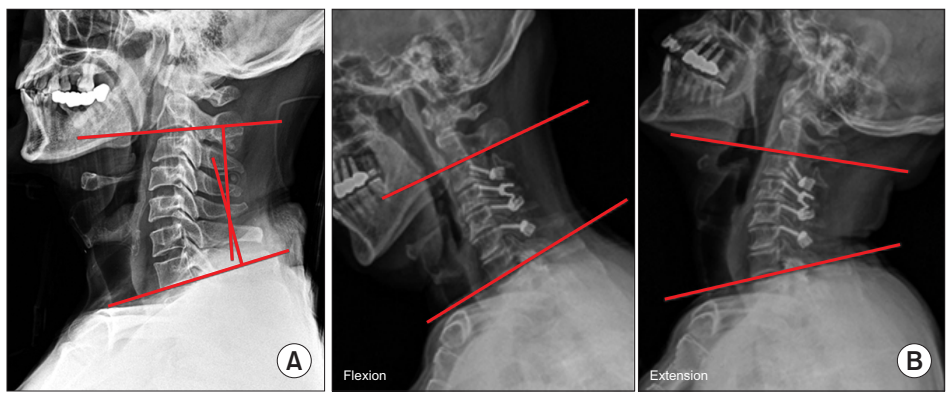

Fig. 2. (A) Cobb's method for measuring cervical lordosis. The cervical lordotic angle was measured as the angle formed by 2 lines drawn perpendicular to the lines parallel to the inferior endplates of C2 and C7. (B) The range of motion of the cervical spine was defined as the difference in the Cobb's angle measured in full flexion and extension on lateral radiographs.

applied for 6 weeks postoperatively to allow time for the bone to stabilize and the muscle to heal. We encouraged early ambulation in all patients by walking on the first postoperative day.

Clinical Evaluation

Clinical evaluation was performed using the VAS, JOA score, and Neck Disability Index (NDI) score measured preoperatively, 1 year postoperatively, and at the last follow-up. The occurrence of complications was also assessed until the last follow-up.[19,20]

Radiologic Evaluation

To evaluate the progress of kyphosis and preservation of range of motion (ROM), the lordotic angle (°) and neck ROM (°) between C2 and C7 were measured preoperatively, 1 year postoperatively, and at the last follow-up using cervical spine radiographs (Fig. 2). All patients underwent 1.5-mm axial reconstruction 3-dimensional computed tomography (3D CT) at the first year after surgery. The opening angle (°) of the opened lamina and the anteroposterior (AP) diameter (mm) of the spinal canal were measured on the 3D CT scans (Figs. 3 and 4). The occurrence of laminar reclosure, bony fusion of the hinge site, and screw loosening were also checked.

Statistical Evaluation

Statistical analysis was performed using IBM SPSS ver. 21

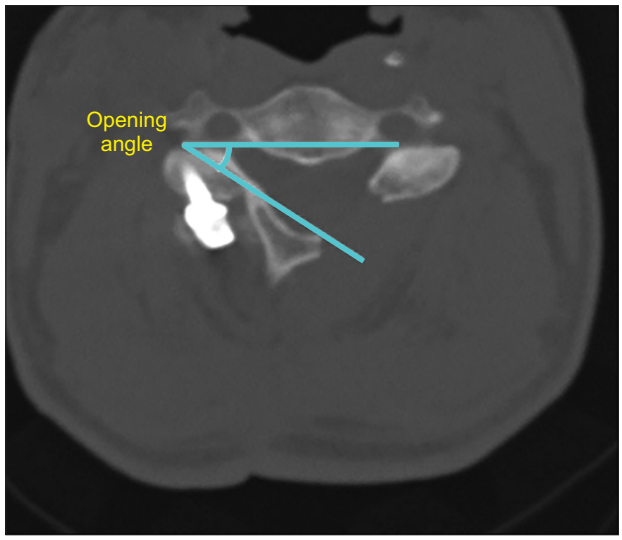

Fig. 3. The hinge opening angle was measured at each level, and the average value was calculated.

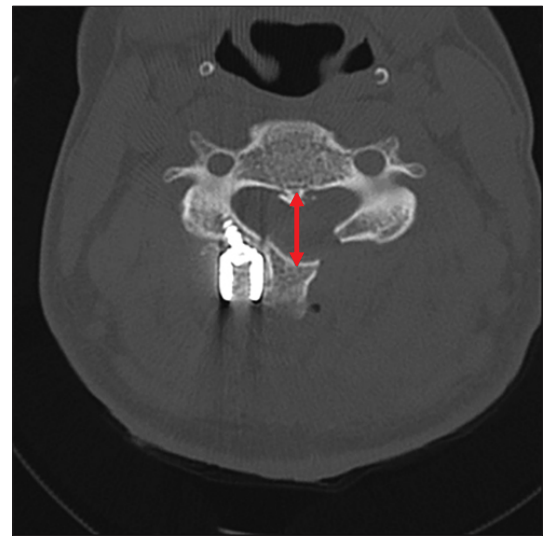

Fig. 4. The anteroposterior diameter of the spinal canal was measured at each level, and the average value was calculated.

Table 1. Patient Demographic and Clinical Data

Variable	Value
Age (yr)	60 ± 15
Sex (male : female)	25 : 5
Mean follow-up period (yr)	5.2 ± 4.7
Cause of spinal cord compression	
Ossification of posterior longitudinal ligament	22 (73.3)
Disc herniation	2 (6.7)
Combined	6 (20)
Level of laminoplasty	
C3–6	18 (60)
C3–7	8 (26.7)
C4–6	2 (6.7)
C3–5	2 (6.7)

Values are presented as mean ± standard deviation or number (%).

(IBM Corp., Armonk, NY, USA). A paired *t*-test was used to compare changes over time. Clinical and radiologic results were analyzed using a paired *t*-test. The significance level was set at $p < 0.05$.

RESULTS

Demographics

A total of 30 patients (25 men and 5 women) were studied (Table 1). Their mean age was 60.0 ± 8.6 years. Twenty-two patients had cervical myelopathy with OPLL, 2 patients had cervical myelopathy due to cervical disc herniation and, 6 patients had cervical myelopathy with OPLL and cervical disc herniation. All patients had symptoms such as numbness, sensory abnormality, clumsiness, unstable gait, and a positive Hoffman sign. All patients showed signal changes suggestive of cervical myelopathy on magnetic resonance imaging. The mean follow-up period was 5.2 ± 1.7 years.

Clinical Outcomes

Significant improvement in VAS, JOA score, and NDI was seen overall at 1 years after operation ($p < 0.05$). However, there was no significant difference between the last follow-up and 1 year after operation. On the VAS, pain was improved from 5.1 ± 2.2 preoperatively to 2.7 ± 0.9 at 1 year postoperatively and to 2.1 ± 1.6 at the last follow-up. The JOA score increased from 9.4 ± 3.3 preoperatively to 13.8 ± 2.2 at 1 year postoperatively and to 14.8 ± 2.4 at the last follow-up. The mean NDI was significantly reduced from 47.7 ± 5.2 preoperatively to 32.2 ± 2.1 at 1 year postoperatively and to 29.3 ± 2.2 at the last follow-up (Table 2).

Radiologic Outcomes

There were no significant changes in the lordotic angle and neck ROM. The lordotic angle was reduced from 11.9° ± 10.3° preoperatively to 10.6° ± 12.3° at 1 year postoperatively and 10.8° ± 10.3° at the final follow-up. Neck ROM was 44.3° ± 10.1° preoperatively, 41.8° ± 15.7° at 1 year postoperatively, and 41.2° ± 10.5° at the final follow-up

Table 2. Comparison of Functional Indexes before and after Surgery

Variable	Preoperative	1-Year Postoperative	*p*-value*	Last follow-up	*p*-value†
VAS	5.1 ± 2.2	2.7 ± 0.9	0.001‡	2.1 ± 1.6	0.326
JOA	9.42 ± 3.3	13.8 ± 2.2	0.031‡	14.8 ± 2.4	0.514
NDI	47.7 ± 5.2	32.2 ± 2.1	0.023‡	29.3 ± 2.2	0.431

Values are presented as mean ± standard deviation.
VAS: visual analog scale, JOA: Japanese Orthopaedic Association, NDI: Neck Disability Index.
*Paired *t*-test for preoperative and 1-year postoperative data. †Paired *t*-test for 1-year postoperative and last follow-up data. ‡Statistically significant.

Table 3. Changes in Neck Range of Motion and Lordotic Angle between C2 and C7

Variable	Preoperative	1-Year Postoperative	*p*-value*	Last follow-up	*p*-value†
Lordotic angle (°)	11.9 ± 10.3	10.6 ± 12.3	0.527	10.8 ± 10.3	0.726
Range of motion (°)	44.3 ± 10.1	41.8 ± 15.7	0.338	41.2 ± 10.5	0.514

Values are presented as mean ± standard deviation.
*Paired *t*-test for preoperative and 1-year postoperative data. †Paired *t*-test for 1-year postoperative and last follow-up data.

Table 4. Average Value of the Opening Angle and Narrowest AP Diameter of the Spinal Canal

Variable	Preoperative	1-Year Postoperative	*p*-value*	Last follow-up	*p*-value†
Opening angle (°)		39.04 ± 6.43		38.35 ± 6.21	0.672
AP diameter (mm)	7.51 ± 1.79	13.98 ± 1.80	0.001‡	13.32 ± 1.68	0.591

Values are presented as mean ± standard deviation.
AP: anteroposterior.
*Paired *t*-test for preoperative and 1-year postoperative data. †Paired *t*-test for 1-year postoperative and last follow-up data. ‡Statistically significant.

(Table 3). On 3D CT at 1 year postoperatively, the mean opening angle was measured as 39.04° ± 6.43° (range, 30.1°–45.7°), no laminar reclosure and screw loosening were observed in all cases. The mean AP diameter was significantly increased from 7.51 ± 1.79 mm before surgery to 13.98 ± 1.80 mm at 1 year postoperatively ($p < 0.05$) and 13.32 ± 1.68 at the final follow-up (Table 4). In 1 case, there was a hinge fracture, but there was no restenosis or neurological symptoms due to union of the lamina and lateral mass (Fig. 5). In all cases, bony union was observed between the lateral mass and the lamina.

Complications

In 1 case, superficial wound infection occurred at the incision site and drainage was performed once. There were no other complications such as lamina reclosure, screw loosening, neurological deterioration, and axial symptoms.

DISCUSSION

Cervical myelopathy is one of the most common progressive spinal cord disorders in patients older than 55 years. Degenerative cervical disc disease and OPLL are the main causes of cervical myelopathy. Symptoms of cervical myelopathy include sensory abnormalities, clumsiness, and gait disturbances due to weakness in the lower limbs, which progress slowly over a period of months. In particular, fine motor movements of the hands (chopsticks maneuvers and buttoning) are most affected.[1,2,21] Most patients with cervical myelopathy do not experience spontaneous relief and the neurologic symptoms tend to worsen over time.[21] Therefore, many authors recommend early surgical treatment before the irreversible changes of the spinal cord become apparent.[3,4]

The ideal surgical method is not always obvious and continues to be investigated. Surgical methods can be classified into the anterior approach and posterior approach.

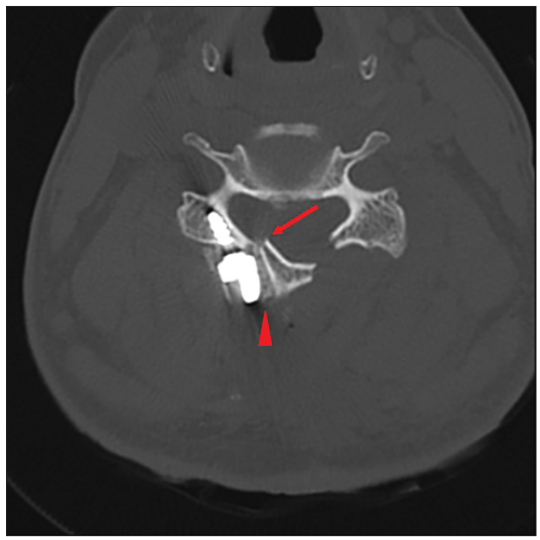

Fig. 5. A case of complete hinge fracture. The arrow indicates complete hinge fracture, and the arrowhead indicates bony union of the lamina and lateral mass.

The posterior approach is usually performed for lesions in the posterior segment and multilevel compression involving more than 3 segments. In the past, cervical laminectomy was the most widely used technique in the posterior approach. It enables direct decompression of the posterior lesions but may result in kyphotic deformity or segmental instability. Laminectomy with fusion offers increased segmental stability compared to laminectomy alone, but this may also lead to complications related to screw fixation and adjacent segment disease.[1,5,6,22] Recently, laminoplasty is widely used in patients with multilevel cervical myelopathy. Laminoplasty can preserve the natural cervical biomechanical motion of the cervical spine, enables decompression of multiple levels, and is a relatively simple procedure compared to laminectomy or anterior approach.[9-11,23]

There are many laminoplasty techniques including the French door, Z-plasty, double-door, and open-door laminoplasty, and these techniques have been reported to prevent the disadvantages of laminectomy.[1,10,11] The most important step in laminoplasty is to significantly expand the spinal canal, and various methods have been attempted to maintain the enlarged space. The classic Hirabayashi procedure fixes the spinous process to the paraspinal muscle to maintain the opened lamina. Since several cases of recurrence of neurological symptoms due to restenosis of the spinal canal had been reported, Hirabayashi devised a method of ligating the spinous process to the facet joint capsule; however, this new method caused damage to the joint capsule and led to instability of the cervical spine. In addition, in a neurophysiologic study, [24] capsule stretching activated nociceptors, which may cause continuous neck pain. Therefore, studies have suggested that ligation of the facet joint capsule of the spine may be the cause of postoperative neck pain after laminoplasty.[9,10,16,24]

As an alternative, O'Brien et al.[16] proposed a method to fix the lamina and lateral mass using a titanium miniplate, and it is widely used as it is effective in preventing restenosis. The use of metal plates, however, may result in prolonged operation time because of its technical complexity and postoperative fixation failure.[12,13,16]

Chen et al.[13] performed a retrospective study comparing 2 groups with expansive laminoplasty using titanium miniplates and facet joint suturing. Both procedures were effective in preventing reclosure of the opened lamina. The JOA score, AP diameter, and open angle were not significantly different between the 2 groups. The incidence of axial symptoms was significantly lower in the titanium mini-plate group than in the facet joint suturing group. Moreover, titanium miniplates were reported to be effective in reducing loss of cervical lordosis and ROM reduction.

In 1998, Wang et al.[17] first reported 12 patients with expansive open-door laminoplasty using a suture anchor system. They described it as a simple and useful way to expand the sagittal diameter of the spinal canal and maintain the extended space. In 2007, Yang et al.[25] performed laminoplasty using a suture anchor in 27 patients, with a mean follow-up of 38 months. The procedure was effective in expanding and maintaining the sagittal diameter of the spinal canal. The JOA score and the Nurick score were also significantly improved, and complications such as neurological deterioration and lamina reclosure were reduced. In 2008, Chen et al.[18] reported on expansive open-door laminoplasty using lateral mass anchoring screws performed on 5 patients with a mean follow-up of 14.5 months. Although the number of patients was small, they reported that the technique was easy and simple to perform and could provide firm fixation for maintaining the opened lamina.

Based on these reports, we thought that ODLLM is an easy and simple technique that can be used to expand and maintain the spinal canal. The current study was performed on a relatively large number of 30 patients with a mean follow-up of 5.2 years. Clinically, JOA score, NDI, and VAS were significantly improved. Radiologically, the AP diameter of the spinal canal was increased and the opened lamina was well maintained at 1 year postoperatively. In addition, there was no significant change in the lordotic angle of the cervical spine, and the range of neck motion was relatively well preserved. In addition, there

were no complications such as lamina reclosure, fixation failure, axial symptoms, and neurological deterioration, which had been reported in previous procedures. Therefore, we suggest the expansive open-door laminoplasty using lateral mass anchoring screws as a useful treatment option for multilevel cervical myelopathy.

Unfortunately, there were some limitations of this study. First, due to the retrospective design, the study has a lower level of evidence than prospective studies. Second, because there was no control group, quantitative comparison could not be performed. Third, although the mean follow-up period was long, the specific follow-up period varied among patients.

In conclusion, ODLLM is a simple, safe, and clinically and radiologically successful surgical method. With the technique, it was possible to secure the opening angle, firmly fix the opened lamina, and effectively prevent restenosis. There were no complications such as lamina reclosure, screw loosening, axial symptoms, and neurological deterioration. Based on these results, it can be suggested that ODLLM is an appropriate surgical option for the treatment of multilevel cervical myelopathy.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Bakhsheshian J, Mehta VA, Liu JC. Current diagnosis and management of cervical spondylotic myelopathy. Global Spine J. 2017;7(6):572-86.
2. Law MD Jr, Bernhardt M, White AA 3rd. Cervical spondylotic myelopathy: a review of surgical indications and decision making. Yale J Biol Med. 1993;66(3):165-77.
3. Sampath P, Bendebba M, Davis JD, Ducker TB. Outcome of patients treated for cervical myelopathy: a prospective, multicenter study with independent clinical review. Spine (Phila Pa 1976). 2000;25(6):670-6.
4. Yoshimatsu H, Nagata K, Goto H, et al. Conservative treatment for cervical spondylotic myelopathy: prediction of treatment effects by multivariate analysis. Spine J. 2001;1(4):269-73.
5. Lee CH, Lee J, Kang JD, et al. Laminoplasty versus laminectomy and fusion for multilevel cervical myelopathy: a meta-analysis of clinical and radiological outcomes. J Neurosurg Spine. 2015;22(6):589-95.
6. van Geest S, de Vormer AM, Arts MP, Peul WC, Vleggeert-Lankamp CL. Long-term follow-up of clinical and radiological outcome after cervical laminectomy. Eur Spine J. 2015;24 Suppl 2:229-35.
7. Pandita N, Gupta S, Raina P, et al. Neurological recovery pattern in cervical spondylotic myelopathy after anterior surgery: a prospective study with literature review. Asian Spine J. 2019;13(3):423-31.
8. Hale JJ, Gruson KI, Spivak JM. Laminoplasty: a review of its role in compressive cervical myelopathy. Spine J. 2006;6(6 Suppl):289S-298S.
9. Hirabayashi K, Satomi K. Operative procedure and results of expansive open-door laminoplasty. Spine (Phila Pa 1976). 1988;13(7):870-6.
10. Hirabayashi K, Toyama Y, Chiba K. Expansive laminoplasty for myelopathy in ossification of the longitudinal ligament. Clin Orthop Relat Res. 1999;(359):35-48.
11. Roselli R, Pompucci A, Formica F, et al. Open-door laminoplasty for cervical stenotic myelopathy: surgical technique and neurophysiological monitoring. J Neurosurg. 2000;92(1 Suppl):38-43.
12. Liu FY, Ma L, Huo LS, et al. Mini-plate fixation versus suture suspensory fixation in cervical laminoplasty: a meta-analysis. Medicine (Baltimore). 2017;96(5):e6026.
13. Chen G, Luo Z, Nalajala B, Liu T, Yang H. Expansive open-door laminoplasty with titanium miniplate versus sutures. Orthopedics. 2012;35(4):e543-8.
14. Kim YS, Yoon SH, Park HC, et al. Techinical modification and comparison of results with Hirabayashi's open-door laminoplasty. J Korean Neurosurg Soc. 2007;42(3):168-72.
15. Patel CK, Cunningham BJ, Herkowitz HN. Techniques in cervical laminoplasty. Spine J. 2002;2(6):450-5.
16. O'Brien MF, Peterson D, Casey AT, Crockard HA. A novel technique for laminoplasty augmentation of spinal canal area using titanium miniplate stabilization: a computerized morphometric analysis. Spine (Phila Pa 1976). 1996;21(4):474-83.
17. Wang JM, Roh KJ, Kim DJ, Kim DW. A new method of stabilising the elevated laminae in open-door laminoplasty using an anchor system. J Bone Joint Surg Br. 1998;80(6):1005-8.
18. Chen HC, Chang MC, Yu WK, Wang ST, Liu CL, Chen TH. Lateral mass anchoring screws for cervical laminoplasty:

preliminary report of a novel technique. J Spinal Disord Tech. 2008;21(6):387-92.

19. Song KJ, Choi BW, Choi BR, Seo GB. Cross-cultural adaptation and validation of the Korean version of the neck disability index. Spine (Phila Pa 1976). 2010;35(20):E1045-9.
20. Yonenobu K, Abumi K, Nagata K, Taketomi E, Ueyama K. Interobserver and intraobserver reliability of the japanese orthopaedic association scoring system for evaluation of cervical compression myelopathy. Spine (Phila Pa 1976). 2001;26(17):1890-4.
21. Edwards CC 2nd, Riew KD, Anderson PA, Hilibrand AS, Vaccaro AF. Cervical myelopathy. current diagnostic and treatment strategies. Spine J. 2003;3(1):68-81.
22. Anderson PA, Matz PG, Groff MW, et al. Laminectomy and fusion for the treatment of cervical degenerative myelopathy. J Neurosurg Spine. 2009;11(2):150-6.
23. Abdullah KG, Yamashita T, Steinmetz MP, et al. Open-door cervical laminoplasty with preservation of posterior structures. Global Spine J. 2012;2(1):15-20.
24. Cavanaugh JM, Lu Y, Chen C, Kallakuri S. Pain generation in lumbar and cervical facet joints. J Bone Joint Surg Am. 2006;88 Suppl 2:63-7.
25. Yang SC, Yu SW, Tu YK, Niu CC, Chen LH, Chen WJ. Open-door laminoplasty with suture anchor fixation for cervical myelopathy in ossification of the posterior longitudinal ligament. J Spinal Disord Tech. 2007;20(7):492-8.