Expansive Open-door Laminoplasty With Titanium Miniplate Versus Sutures

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abstract

Expansive laminoplasty is an effective treatment for cervical myelopathy. Since the design of classic open-door laminoplasty with the use of suture, the procedure has been modified to reduce complications such as restenosis, axial symptoms, and segmental motor paralysis. Expansive open-door laminoplasty with the use of titanium miniplate is becoming popular. It is effective in expanding spinal canal dimensions with good clinical efficacy. However, a lack of studies exist comparing titanium miniplate fixation with classical suture fixation.

We performed a retrospective study of 54 patients with cervical myelopathy. Twenty-nine patients (4 women and 25 men) receiving expansive open-door laminoplasty by titanium miniplate fixation were classified as the modified group, and 25 patients (5 women and 20 men) fixed with suture served as the control group. Clinical and radiologic outcomes were assessed. No significant differences were observed in Japanese Orthopaedic Association scores and the recovery rate of C5 palsy. The incidence of axial symptoms in the modified group was significantly lower than that in control group. Radiologic examination showed that postoperative C2-C7 lordosis and range of motion of the cervical spine in the modified group were preserved. No significant differences were observed in mean anteroposterior diameter and open angle in the 2 groups. Both surgical protocols were effective in preventing reclosure of open laminae. Furthermore, the modified laminoplasty was superior in reducing the incidence of axial symptoms and loss of cervical lordosis and range of motion.

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Drs Chen, Luo, Nalajala, Liu, and Yang have no relevant financial relationships to disclose.

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doi: 10.3928/01477447-20120327-24

Figure: Anteroposterior (A) and lateral (B) preoperative radiographs of a 47-year-old man in the modified group with cervical myelopathy associated with a 7-month history of numbness in the hands and unsteadiness of gait showing a 10° lordotic angle from C2-C7. Anteroposterior (C) and lateral (D) postoperative radiographs showing that open-door laminoplasty with titanium miniplate fixation effectively kept the lifted lamina open and preserved cervical alignment, and the lordotic angle from C2-C7 increased to 19°.
Expansive open-door laminoplasty is a well-established procedure that is effective for the treatment of cervical spondylotic myelopathy. However, patients have experienced complications such as axial symptoms, re-stenosis, and segmental motor paralysis. Since Hirabayashi et al devised classic open-door laminoplasty, the procedure has been modified. Miniplate fixation promises to prevent restenosis forever. In 1996, O’Brien et al adapted maxillofacial miniplates and screws for the purpose of securing the laminae in their new positions. The procedure is technically challenging because the assistant and primary surgeon must work together to hold the lamina and plate in place while drilling, tapping, and inserting the requisite screws. In an attempt to streamline the technique and increase its appeal to surgeons, titanium maxillofacial implants have been modified to better suit this purpose. Refined miniplates have entered the market in recent years. They are effective in expanding spinal canal dimensions with good clinical efficacy. However, a lack of studies exists comparing refined titanium miniplate fixation and classical suture fixation. The purpose of this retrospective study was to evaluate the clinical and radiologic results of titanium miniplate fixation compared with classical suture fixation in cervical expansive open-door laminoplasty.

**MATERIALS AND METHODS**

A retrospective analysis was performed on 29 patients with cervical spondylotic myelopathy who underwent the modified method of cervical laminoplasty with titanium miniplate fixation between January 2008 and September 2011. The modified group comprised 25 men and 4 women with a mean age of 61.2 years (range, 44-76 years). Mean preoperative Japanese Orthopaedic Association (JOA) score was 9.5 points. Decompression segment was C3-C7 in all patients. Three levels (C3, C5, C7) were fixed in 24 patients. All levels (C3-C7) were fixed in 5 patients.

Meanwhile, 25 patients who underwent the classical method of cervical laminoplasty during the same period served as the control. The control group comprised 20 men and 5 women with a mean age of 63.2 years (range, 45-80 years). Mean preoperative JOA score was 9.2 points. The patients received the same decompression segment.

C3 to C7 elevated laminae were fixed with suture in all patients. Patients with spinal cord injuries or myelopathy due to spinal cord tumors were excluded.

Clinical diagnosis was made by physical examination, plain radiography, computed tomography (CT), and magnetic resonance imaging. All patients presented with cervical myelopathy characterized by exaggerated tendon jerk in their extremities and spasticity due to multilevel spinal stenosis without radiculopathy.

**SURGICAL TECHNIQUE**

The patient was placed in the prone position, with the head secured in a U-shaped rigid device with craniumfixation to maintain the neck in a neutral position. A posterior midline approach and subperiosteum dissection were performed. The spinal process, lamina, and bilateral lateral mass were exposed. The paraspinal muscle of C2, especially the semispinalis, was preserved to prevent possible postoperative kyphosis. When detachment of the semispinalis at C2 was necessary, the muscle and tendon were repaired at the end of the surgery. Subsequently, the C3-C6 spinous processes were shortened.

Before laminoplasty, depending on the severity of radiculopathy, we chose the open and hinged sides. The more severe side was chosen as the open side so that an appropriate laminoforaminotomy could be performed. The other side served as the hinged side. The drilled gutter on the lateral margin of the lamina was first completed on the open side. A high-speed spherical cutting Burr was used to remove the outer cortex and cancellous bone. The retained groove bottom was resected using a diamond Burr or Kerrison rongeur with a thin blade. Drilling the bony gutter on the hinged side was slightly lateral compared with that on the open side to prevent the lamina from becoming unstable or dislodging. The ligamentum flavum above the cephalic level and below the caudal level of the en bloc were cut with Kerrison rongeurs to facilitate opening the lamina. Although the inner cortex was thinned, the spinous process was pushed carefully using repetitive movements.

The appropriate-sized laminoplasty plate (AO ARCH titanium miniplate; Synthes [Shanghai] Medical Device Trading Co Ltd, Shanghai, China) for each level was selected after the laminar door was opened. Then, the laminar hole and the lateral mass screws holes were made using the 2.0-mm depth-stopped drill bit. The relevant 2.0-mm screws were inserted to anchor the plate to the laminar and the lateral mass of the same level. The plate was adjusted toward the superior portion of the lateral mass to avoid penetrating the screws into the subjacent facet joint. Five-level (C3-C7) fixation was performed. If not accessible, plates were used at alternating levels (ie, C3, C5, and C7).

A cervical collar was applied for 4 weeks. Considering the stability of the elevated laminae, isometric and isotonic muscle contraction of the posterior neck was recommended to the patients as soon as possible postoperatively. Mean follow-up was 23.3±7.2 months (range, 12-37 months) in the modified group (Figure 1).

The same procedure was performed in the control group, but the laminae were elevated and secured to the facet joints using sutures at all levels. Bed rest was required for the first week postoperatively, and patients were allowed to walk with a cervical brace for 3 months. Mean follow-up was 25.8±8.5 months (range, 13-39 months) in the control group (Figure 2).
Clinical Evaluation

Operative time and intraoperative blood loss were compared between the modified and control groups. The neurologic evaluation was graded using the JOA scale. The recovery rate, which indicates the degree of normalization postoperatively, was calculated using Hirabayashi’s formula: (postoperative score – preoperative score) × 100/ (17 [full score] – preoperative score).

Local symptoms (pain and stiffness) (ie, axial symptoms) were evaluated using the 10-point visual analog scale (VAS) score at 12 months. Significant axial symptoms occurred in patients with a VAS ≥ 3 after laminoplasty. The 10-point VAS was ascertained by self-assessment. The analgesics used postoperatively were also evaluated. The symptoms were evaluated at ≥ 6 months postoperatively to avoid early complaints, which may be directly related to surgical intervention.

The incidence of postoperative segmental motor paralysis (ie, C5 palsy), was examined in both groups during the follow-up period.

Radiologic Evaluation

A straight line was drawn from the superior posterior aspect of the C2 vertebral body to the inferior posterior aspect of the C2 vertebral body and was extended inferiorly. Another line was drawn from the superior posterior aspect of the C7 vertebral body to the inferior posterior aspect of the C7 vertebral body and was extended superiorly. The angle between the 2 lines at their intersection was measured on pre- and postoperative radiographs. Computed tomography was used to measure the lamina elevation angle and to compare the postoperative anteroposterior (AP) diameter of the spinal canal with the results from the previous CT scan.

Statistical Analysis

Data were presented as mean ± standard deviation. A t test with Welch correction was used for statistical analysis of the difference in the mean values between the 2
groups. The χ² test for independence was used to compare the incidence of postoperative axial symptoms between the modified and control groups.

**RESULTS**

**Clinical Evaluation**

Mean operative time was 150.3±31.8 minutes in the modified group and 148.2±37.7 minutes in the control group. Mean intraoperative blood loss was 375.9±107.4 mL in the modified group and 358.4±143.1 mL in the control group. No statistically significant difference was found in operative time and blood loss between the 2 groups (Table 1).

Mean JOA score in the modified group improved from 9.48±2.28 points preoperatively to 13.79±1.78 points at follow-up. In the control group, mean JOA score improved from 9.24±1.42 points preoperatively to 13.60±0.87 points at follow-up. The recovery rate was 57.48%±16.51% in the modified group and 56.10%±8.22% in the control group. No statistically significant difference was found in total postoperative JOA score or recovery rate between the 2 groups (Table 2).

Preoperatively, VAS scores were similar between the 2 groups (P>.05). The mean postoperative VAS score of 1.17 in the modified group was significantly lower than that of 2.44 in the control group. The incidence of significant axial symptoms (3/29) in the modified group was also significantly lower than that (9/25) in the control group at follow-up (P<.05). The analgesics used in the modified group were significantly less than those in the control group at follow-up (Table 2).

C5 paralysis developed in 2 of 25 patients in the control group compared with 2 of 29 in the modified group. No statistically significant difference was found in the incidence of C5 palsy between the 2 groups (P>.05). The C5 palsy developed 2 and 4 days postoperatively in the control group patients and 7 days and 1.5 months postoperatively in the modified group patients. Spontaneous recovery was observed in these 4 patients at 5, 6, 7, and 10 months postoperatively, respectively. Other complications included transient delirium in 5 patients and cerebrospinal fluid leakage in 3 patients, all of whom recovered without sequelae (Table 2).

**Radiologic Evaluation**

No statistically significant difference was found between mean preoperative lordotic angle in the modified group (18.93°±4.88°) and in the control group (19.32°±5.27°), whereas mean postoperative lordotic angle in the control group (17.44°±5.52°) was significantly smaller than that in the modified group (21.24°±5.85°) (P<.05) at 12-month follow-up. Postoperative cervical spine range of motion in the modified group was significantly well preserved compared with that in the control group (Table 3). Follow-up CT scans showed improvements in the AP diameter of the spinal canal in both groups (mean diameter increased from 7.51±1.79 to 13.98±1.80 mm in the modified group and from 7.42±0.99 to 14.47±1.40 mm in the control group). Mean open angle was 37.41°±6.43° and 39.04°±4.58° in the modified and control groups, respectively. No difference was found in the AP diameter and open angle between the 2 groups.

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<th>Parameter</th>
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<td>Age, y</td>
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<td>Surgical time, min</td>
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<td>Follow-up, mo</td>
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<td>Blood loss, mL</td>
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<table>
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<td>Preoperative</td>
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<td>Postoperative</td>
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<td>Recovery rate, %</td>
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<tr>
<td>VAS</td>
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<tr>
<td>Preoperative</td>
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<tr>
<td>Postoperative</td>
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<td>No. of axial symptoms at follow-up</td>
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<td>No. of C5 palsy at follow-up</td>
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<td>2/25</td>
<td>.877</td>
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</table>

Abbreviations: JOA, Japan Orthopaedic Association; VAS, visual analog scale.

aStatistically significant (P<.05).
Discussion

Expansive laminoplasty, a method using a posterior approach, is the treatment of choice for multiple level myelaradiculopathy.7-9 The JOA scoring system for cervical myelopathy is used in most studies to assess clinical outcome. Overall, the JOA score recovery rate after expansive laminoplasty is 50% to 70%, and no technique has achieved statistical superiority.1,10-12 The outcomes in our study are similar to those obtained by most studies. Mean preoperative JOA score of 9.48±2.28 in the modified group and 9.24±1.42 in the control group significantly improved to 13.79±1.78 and 13.60±0.87, respectively, at final follow-up. However, no significant difference was found in mean recovery rate of JOA score between the 2 groups.

Maintaining the expansion of the spinal canal is critical in a successful laminoplasty. The conventional method of the expansive laminoplasty, as reported by Hirabayashi and Satomi,1,13 is used to make the suture stay in the spinous process and the paraspinal muscles and to avoid closure of the opened lamina. However, reclosure of the opened lamina with neurologic deterioration has been reported.11,13 In the modified technique, the elevated lamina was fixed to lateral mass anchoring screws at each level using nonabsorbable suture line. However, the dura mater was exposed outside of the spinal canal. The spinal cord is easily compressed by the postoperative scarring of adjacent tissue. Miniplate fixation efficiently prevents reclosure of the opened lamina efficiently. A meta-analysis of outcomes and complications in cervical laminoplasty revealed that restenosis from unintended laminoplasty hinge closure occurs in 0% to 34% of cases and is the most common cause of recurrent myelopathy. No hinge closure has been reported following plate fixation.14 In our results, reclosure of the opened lamina occurred in either group.

Stenosis owing to hinge reclosure or major surgery-related complications were not noted in either group, in contrast to previous reports. In our study, the mean open angle maintained in both groups may be explained by a relatively small patient sample and meticulous surgical procedures. A large study and long-term follow-up investigations will be necessary to evaluate this result.

Axial symptoms, such as pain and stiffness, are the most frequent complaints after cervical laminoplasty.6,15 Although increasing attention has been paid to the importance of axial symptoms6,16,17 the causes of the symptoms have not been fully clarified. However, 3 possible sources have been proposed: the nuchal muscle, facet joints, and nerve root.13,18 Axial symptoms were evaluated using the 10-point VAS score in our study. Our study demonstrated that the modified expansive open-door laminoplasty with miniplate fixation could reduce postoperative axial symptoms. This suggests that axial symptoms may be caused in part by musculature or facet joints.

The conventional method is used to make the suture stay in the spinous process and the paraspinal muscles and to avoid closure of the opened lamina. However, making a retention suture on the facet capsule may damage the capsule. Therefore, facet capsule suture and stretch may be a
possible cause of postlaminoplasty axial pain. The facet joint capsule should be kept intact to prevent the postoperative development of neck pain.

It is also important to ensure that postoperative exercises of the extension muscles are started early to maintain dynamic stability of the cervical spine and to avoid disuse atrophy of the paravertebral muscle. Our study suggests that early exercise of the posterior neck muscle is effective to minimize postoperative axial symptoms. Postoperative lordosis (lordotic angle) and range of motion of the cervical spine was better maintained in the modified group, which might be related to the functional maintenance of the paravertebral muscle as a result of early neck motion. Kawaguchi et al. encouraged early active ROM postoperatively to decrease the incidence of axial symptoms and loss of ROM. Their practice seemed to be effective because of the lower incidence of postoperative axial symptoms in the modified group compared with that in the control group. Further, a recent study by Fujibayashi et al. reported the important role of the paravertebral muscle in preventing postoperative axial symptoms after laminoplasty.

Segmental motor paralysis, or C5 palsy, occasionally occurs in patients treated with laminoplasty, and in studies in which C5 palsy is reported, the mean incidence is approximately 5% to 8%. In our study, no significant difference was found in the incidence of C5 palsy between the 2 groups. The exact etiology of this paralysis remains unclear; possible causes include the nerve root and spinal cord. Despite efforts to refine surgical techniques, the incidence of paralysis has not substantially decreased. No effective preventive measures have been established. Further study is necessary to elucidate the mechanism of segmental motor paralysis after cervical laminoplasty.

**CONCLUSION**

Although both fixation methods were effective in preventing reclosure of the opened laminae, the modified open-door laminoplasty using titanium miniplate fixation was effective in reducing the incidence of axial symptoms and loss of cervical curvature and ROM due to the benefit of early functional training. The modified method is beneficial for the postoperative status of patients undergoing cervical laminoplasty.

**REFERENCES**