

# All levels versus alternate levels plate fixation in expansive open door cervical laminoplasty

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## ABSTRACT

**Background:** Expansive open door laminoplasty with the use of titanium miniplate is becoming popular. Usually, the plate is applied at each level to prevent re-closure of the opened lamina. However, it is also used at alternating levels (i.e., C3, C5 and C7) in clinical settings in order to reduce the cost. Whether they have any difference in clinical efficacy? There is a lack of comparative data between the two kinds of plate fixation in the literature.

**Materials and Methods:** 83 patients who underwent cervical laminoplasty with alternating levels plate fixation (51 patients in Group A) or all levels plate fixation (32 patients in Group B) between January 2008 and October 2012 were evaluated in our institute retrospectively. Clinical and radiologic outcomes were assessed.

**Results:** No statistical difference was found in the mean operation time, blood loss, incidence of significant axial symptoms and C5 palsy, preoperative anteroposterior diameter (APD) and preoperative Japanese Orthopedic Association score between the two groups. However, Group B showed a higher rate of neurologic recovery after surgery. Postoperative increased APD and open angle in Group B were significantly larger than Group A. The mean cost for Group B (12801 ± 460.6 USD) was higher than Group A (8906 ± 566.7 USD).

**Conclusions:** Despite the higher cost of all level fixation, it is more effective in maintaining the expansion of the spinal canal and can obtain better clinical improvement compared to alternating levels fixation.

**Key words:** Cervical myelopathy, laminoplasty, open door

**MeSH terms:** Spinal cord compression, compressive, myelopathy, cervical vertebrae

## INTRODUCTION

Expansive open\_door laminoplasty has been performed for posterior cervical surgery since 1973 in Japan. A sufficient “open-door” angle and enlargement of the spinal canal are critical for obtaining clinical improvement with laminoplasty, because the goal of posterior surgery is to provide sufficient space for the spinal cord to drift away from the anterior compression. However, because of the absence of rigid fixation, the classic laminoplasty commonly results in complications, including

secondary narrowing of the spinal canal and neurological deterioration over long term followup. The procedure has been modified to obtain rigid fixation.

Expansive open door laminoplasty with the use of titanium miniplate is becoming popular.<sup>1-5</sup> Usually, the plate is applied at each level to prevent re closure of the opened lamina. However, it is also used at alternating levels (i.e. C3, C5 and C7) in clinical settings in order to reduce the cost for the patients.<sup>4,5</sup> Whether they have similar clinical efficacy or not is questionable since there is a lack of comparative data between the two kinds of plate fixation in the literature. The purpose of this retrospective study was to evaluate clinical and radiologic results of all level plate fixations compared with alternating level plate fixation in cervical expansive open-door laminoplasty.

## MATERIALS AND METHODS

The study was approved by the Institutional Ethics Committee and all patients provided written informed consent for their participation.

83 patients with cervical spondylotic myelopathy (CSM) who underwent cervical laminoplasty with plate fixation between January 2008 and October 2012 were analyzed

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in this retrospective study. The decompression segments were C3–C7 in all patients. Three alternating levels (C3, C5, and C7) were fixed by plates in 51 cases (Group A). The other 32 patients with all levels plate fixation formed Group B. Patients with myelopathy due to a spinal cord tumor and spinal cord injury 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 deep tendon reflexes and spasticity due to multilevel spinal stenosis without radiculopathy.

### Operative procedures

All procedures were performed by a single surgeon (HLY). A posterior midline approach was used. C3–C6 spinous processes were shortened. 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 tendons were repaired at the end of the surgery.

The more severe side was taken 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. Drilling of the bony gutter on the hinge 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.

Two kinds of implants (ARCH plate, Synthes Inc., Wilmington, DE, USA and CENTERPIECE plate, Medtronic Sofamor Danek, Memphis, TN, USA) were randomized to be used in each patient. The appropriate size plate for each level was selected after the laminar door was opened. The plate was adjusted toward the superior portion of the lateral mass to avoid penetration of the screws into the subjacent facet joint. Five level (C3–C7) fixation was placed in Group B. In Group A, plates were used at alternating levels (i.e. C3, C5 and C7) in order to reduce the cost. A cervical collar was applied for 4 weeks. Considering the stability of the elevated laminae, isometric and isotonic muscle exercises of the posterior neck were recommended after surgery as soon as possible. The average followup period was  $25.7 \pm 8.6$  months (range 12–45 months) in Group A versus  $23.3 \pm 9.7$  months (range 12–44 months) in Group B.

Operation time and blood loss during surgery were compared between two groups. The neurologic evaluation was graded using the scale devised by the JOA. The rate of recovery, which indicates the degree of normalization after surgery, was calculated using Hirabayashi's formula:  $(\text{Postoperative score} - \text{preoperative score}) \times 100 / (17 [\text{full score}] - \text{preoperative score})$ .

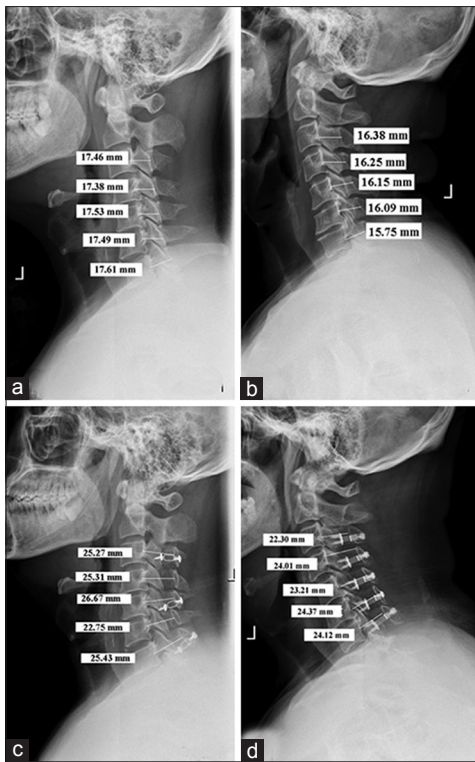
Axial symptoms were defined accordingly: <sup>6</sup> (1) Nuchal pain distributed over the posterior neck (2) shoulder pain, including pain of the suspensory muscles and (3) shoulder muscle spasm that is, stiffness and tension of the suspensory muscles. Axial symptoms were evaluated using the 10-point visual analog scale (VAS) score at 12 months. Significant axial symptoms occurred in patients with VAS  $\geq 3$  after laminoplasty. The 10 point VAS was ascertained by self assessment.

Segmental motor paralysis of C5, or the so called C5 palsy, has long been attributed to nerve root lesions caused either by premature surgical techniques or by the detachment of the laminar hinge by excessive drilling. The tethering effect on the nerve root induced by excessive posterior shift of the spinal cord after decompression is another hypothesized cause. The incidence of postoperative C5 palsy was examined in both the groups during the followup period. Clinical evaluation was done by two experienced spine surgeons.

Radiologic data was also analyzed. Preoperative anteroposterior diameter (APD) was measured using Wolf's method [Figures 1a and b].<sup>7</sup> Postoperative APD was measured from the middle of the posterior border of the vertebral body to the anterior cortex of the elevated lamina [Figures 1c and d]. The mean increased APD was determined by:  $([\text{Postoperative APD of C3} - \text{preoperative APD of C3}] + [\text{postoperative APD of C4} - \text{preoperative APD of C4}] + [\text{postoperative APD of C5} - \text{preoperative APD of C5}] + [\text{postoperative APD of C6} - \text{preoperative APD of C6}] + [\text{postoperative APD of C7} - \text{preoperative APD of C7}]) / 5$ . The CT scan was used to measure opening angle.<sup>4</sup> The open angle of CT scans is shown between the lines from hinge to the ends of the divided lamina at the open side [Figures 2 and 3].

### Statistical analysis

Data were presented as means  $\pm$  standard deviation. A test with Welch correction was used for statistical analysis of the difference in the mean values between the two groups. The Chi-square test for independence was used in the comparison of incidence of postoperative axial symptoms and C5 palsy between Groups A and B. A  $P < 0.05$  was considered as statistically significant.



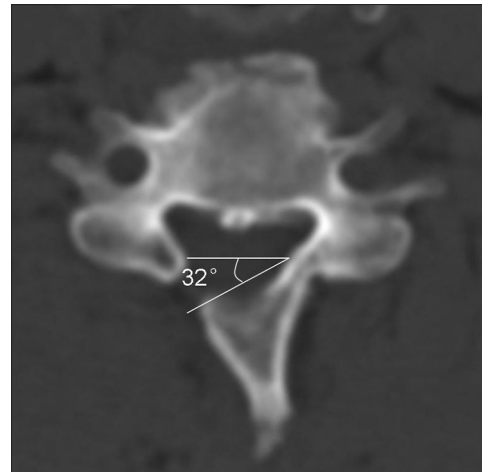
**Figure 1:** Preoperative X-ray showing (a) anteroposterior diameter measured using Wolf's method in Group A (b) anteroposterior diameter measured using Wolf's method in Group B (c) Postoperative X-ray illustrating the oval or teardrop silhouette of the elevated lamina, the increased anteroposterior diameter (APD) measurements, alternating levels (C3, C5 and C7) fixation and less increase of APD in C6 level (d) Postoperative lateral X-ray showing all levels (C3, C4, C5, C6 and C7) fixation and no significant difference of increased anteroposterior diameter in each level

## RESULTS

### Clinical evaluation

Group A consisted of 42 males and 9 females, the mean age was 62.3 years (range 44-85 years) and the mean preoperative Japanese Orthopedic Association (JOA) score was  $9.5 \pm 1.6$  points. Meanwhile, all levels (C3-C7) were fixed in 32 cases (Group B). Group B included 26 males and 6 females (with mean age 60.3 years (range 45-81 years)). The mean preoperative JOA score was  $9.6 \pm 1.5$  points. Blood loss was  $320.2 \pm 111.1$  ml and  $332.8 \pm 142.3$  ml in Groups A and B respectively ( $P > 0.05$ ). The mean operation time was  $153.7 \pm 38.1$  min and  $166.1 \pm 42.1$  min in Groups A and B respectively ( $P > 0.05$ ). However, the mean cost in Group B ( $12801 \pm 460.6$  USD) was higher than Group A ( $8906 \pm 566.7$  USD) ( $P < 0.05$ ) [Table 1].

Average JOA score in Group A improved from  $9.49 \pm 1.57$  points preoperatively to  $13.80 \pm 1.23$  points at the last followup. In Group B, average JOA score improved from  $9.63 \pm 1.48$  points preoperatively to  $14.22 \pm 0.75$  points at the last followup. The rate of recovery, which



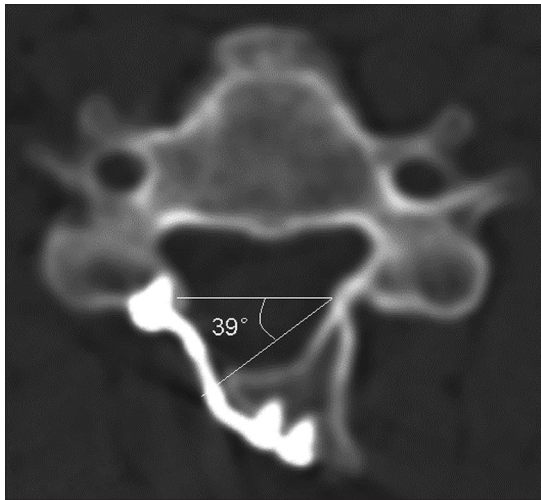
**Figure 2:** Postoperative computed tomography showing the open angle of  $32^\circ$  at C6 without plate fixation

indicates the degree of normalization after surgery, is calculated using Hirabayashi's formula:  $(\text{Postoperative score} - \text{preoperative score}) \times 100 / (17 [\text{full score}] - \text{preoperative score})$ . There is an advantage of using the recovery rate that we can compare the treatment result of this study to the previous reports. The rate of recovery was  $57.42 \pm 13.23\%$  for Group A and  $62.16 \pm 8.24\%$  for Group B. Statistical difference in the rate of recovery was found between the two groups. Group A had a lower rate of recovery than Group B [Table 2 and Figure 4].

No significant statistical difference was found in the incidence of axial symptoms between Group A (5/51) and Group B (3/32) ( $P > 0.05$ ). C5 paralysis developed in 4 of 51 patients in Group A compared with 4 of 32 in Group B. There was no statistical difference in the incidence of C5 palsy between two groups ( $P > 0.05$ ) [Table 2]. Spontaneous recovery of C5 palsy was observed in the cases during followup. Other complications include transient delirium in 6 patients and cerebrospinal fluid leakage in 4. All of these recovered without sequelae.

### Radiologic evaluation

Followup lateral cervical spine X-rays showed that there were improvements in APD of the spinal canal in both the groups (mean diameter increased from  $15.54 \pm 1.52$  mm to  $22.52 \pm 2.97$  mm in Group A and from  $15.80 \pm 1.60$  mm to  $23.89 \pm 2.58$  mm in Group B). However, increased APD in Group A ( $6.90 \pm 2.45$  mm) was significantly lower than that in Group B ( $8.09 \pm 2.20$  mm) ( $P < 0.05$ ). The mean open angle of CT scans was  $35.43^\circ \pm 3.99^\circ$  and  $38.00^\circ \pm 2.45^\circ$  in Groups A and B, respectively. Statistical difference was found in increased APD and open angle between the two groups after surgery ( $P < 0.05$ ) [Table 3]. All hinged sides had bony fusions. Re closure of the opened lamina didn't occur in both the groups.



**Figure 3:** Postoperative computed tomography showing the open angle of 39° at C5 with plate fixation

**Table 1: Patients demographic data**

Demographic data	Group A	Group B	P
Age (year)	63.4±9.8	57.6±11.7	0.178
Operative time (min)	151.9±39.1	169.5±43.2	0.109
Time of followup (min)	23.2±7.5	22.8±7.3	0.838
Blood loss (ml)	325.7±115.6	342.9±155.1	0.623
Cost (USD)	8906±566.7	12801±460.6	0.000

Values are means±SD. SD=Standard deviation

**Table 2: Clinical data, axial symptoms and C5 palsy at the final followup**

Clinical evaluation	Group A	Group B	P
Pre JOA score	9.49±1.57	9.63±1.48	0.698
Post JOA score	13.80±1.23	14.22±0.75	0.091
JOA recovery rate (%)	57.42±13.23	62.16±8.24	0.047*
Incidence of axial symptoms	5/51	3/32	0.949
C5 palsy	4/51	4/32	0.484

Values are means±SD. \*Statistically significant:  $P < 0.05$ . JOA=Japan Orthopedic Association, SD=Standard deviation

**Table 3: Mean of APD and open angle at the final followup**

Radiologic evaluation	Group A	Group B	P
Pre APD (mm)	15.54±1.52	15.80±1.60	0.464
Post APD (mm)	22.52±2.97	23.89±2.58	0.035*
Increased APD (mm)	6.90±2.45	8.09±2.20	0.027*
Open angle (°)	35.43±3.99	38.00±2.45	0.002*

Values are means±SD. \*Statistically significant:  $P < 0.05$ . APD=Anteroposterior diameter, SD=Standard deviation

## DISCUSSION

Cervical spondylotic myelopathy is a neurological disorder caused by narrowing of the spinal canal due to degenerative changes in the cervical spine (i.e., hypertrophic changes in facet joints and vertebral bodies, herniation of cervical intervertebral discs or swelling of the ligamentum flavum).<sup>8</sup> Surgical intervention is indicated in severe and progressive cases or when conservative treatment is ineffective. Cervical laminoplasty is a suitable treatment option in many patients



**Figure 4:** Postoperative sagittal magnetic resonance imaging T2W showing insufficient decompression at C6 level with alternate levels (C3, C5 and C7) fixation

with cervical myelopathy caused by multilevel spinal cord compression.<sup>9</sup> Since Hirabayashi *et al.*<sup>10</sup> devised the classic “open-door” laminoplasty, it has been a well established procedure and been considered to be effective for the treatment of CSM. However, spinal specialists and patients have been plagued by complications such as secondary narrowing of the spinal canal, axial symptoms and segmental motor paralysis.

Maintaining the expansion of the spinal canal is critical in a successful laminoplasty. The conventional method is to make the suture stay within the spinous process and the paraspinal muscles and to avoid closure of the opened lamina. Restenosis or spring back of the open door, whereby the lamina closes back on the spinal cord, has been reported to result in neurological deterioration.<sup>11-13</sup> Later, modified methods developed to keep the door “open”. Presence of miniplate fixation is promising to prevent re closure of the opened lamina efficiently.<sup>5,14,15</sup> A meta analysis of complications in laminoplasty revealed that restenosis from unintended closure of the laminoplasty hinge occurred in 0-34% and no hinge closure had been reported after plate fixation.<sup>15</sup>

Indeed, the plates applied at each level (C3–C7) can prevent collapse of elevated laminae efficiently. Depending on the local anatomy, plates are also used at alternating levels (i.e., C3, C5, and C7) in clinical settings in order to reduce the cost for the patients. Whether they have unequal efficacy in enlargement of the spinal canal, is unreported in literature. In our study, increased APD and open angle in Group A were significantly lower than that in Group B at followup. The possible reasons are that unfixed levels (C4 and C6) still have the risk of closure of open angle in Group A, which has been demonstrated from our previous study.<sup>16</sup>

A sufficient open angle and enlargement of the spinal canal are critical for obtaining clinical improvement with laminoplasty, because the goal of posterior surgery is to provide sufficient space for the spinal cord to drift away from the anterior compression. Clinical outcomes are always associated with space provided for posterior shift of the spinal cord after laminoplasty. Sodeyama *et al.*<sup>17</sup> suggested that enough space for a posterior shift of the spinal cord of > 3 mm leads to good recovery of myelopathic symptoms. In our study, lower rate of recovery was found in Group A associated with lower enlargement of the spinal canal, because lower enlargement of the spinal canal allowed less space for the spinal cord to drift away from the anterior compression, especially when anterior massive lesion occurs mainly at unfixed levels. In the long run, inadequate opening of the lamina is one of the important reasons for revision surgery.<sup>18</sup> In this way, unfixed levels lacking adequate ability of maintaining enlargement of the spinal canal may limit neurological recovery rate in Group A.

One limitation of the current study is its retrospective and unrandomized design. In addition, the APD measurements were done on the X-rays rather than on CT, which would have been more precise. Although all level fixation had a higher rate of neurological improvement, these patients did not obtain a better neurological status than alternating level counterparts at followup. However, the mean followup time of our manuscript is about 2 years, while in the cited articles, the followup is about 4 years.<sup>11-13</sup> Further prospective randomized control trial with advanced CT examination through long term followup are needed to verify our findings.

## CONCLUSION

Despite higher cost of all level fixation, it is more effective in maintaining the expansion of the spinal canal and can obtain better clinical improvement compared to alternating level fixation.

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