

# Double-Door Laminoplasty Using Autologous Spinous Process for the Management of Cervical Myelopathy

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**Summary:** We describe a technique of double-door laminoplasty for the management of cervical myelopathy using the autologous spinous process instead of an artificial spacer. The aims in the present study were to determine the fusion rate and the incidence rate of breakage in the autologous spinous process, and to assess its efficacy for cervical laminoplasty. Twenty-three patients of cervical myelopathy were treated with double-door laminoplasty followed by implantation of the autologous spinous process. The spinous process from C3 to C7 was resected, at 8 mm from the basal part of the spinous process. The autologous spinous process was made from the removed spinous process, and was implanted between each expanded laminae. Post-operative CT scanning determined the fusion rate between the expanded laminae and the autologous spinous process as 70.4% at 3 months, and 93.5% at 6 months, after the operation. There was no dissociation and no breakage in the autologous spinous process during the follow-up observation period. There were certain advantages to our technique including the high fusion rate and good stability in the autologous spinous process. In addition, this technique was less expensive than other techniques using an artificial spacer. These findings indicated that this technique was a reliable procedure for effectively treating of cervical myelopathy which are caused by multisegmental cervical canal stenosis.

**Key words** double-door laminoplasty, autologous spinous process, fusion rate

## INTRODUCTION

For the surgical treatment of multisegmental cervical canal stenosis, there are various surgical procedures available. The choice of procedure depends on many factors, including the cause of the spinal cord compression, the number of vertebral segments involved in the disease process, the cervical alignment, and the surgeon's familiarity with the technique [1]. The poor outcomes associated with cervical laminectomy have led to the development of the new technique of laminoplasty, for achieving posterior decompression, in Japan [2-8]. A number of modifications in laminoplasty have been reported. Double-door laminoplasty was introduced by Kurokawa et al. [9] in 1982, and has now been widely performed. In the original pro-

cedure, small bone blocks from the iliac crest were grafted to keep the split spinous processes separated, thereby providing a wider space for the spinal cord. However, this procedure causes some side effects such as donor site pain, a long operative duration, and significant blood loss. In order to avoid these problems, laminoplasty using spacers made of artificial materials such as hydroxyapatite (HA) then became popular. However, inadequate contact between the artificial spacer and the spinous process has been reported. The inadequate contact rate between them was about 30% [10-13]. Therefore new artificial spacers are being developed for improving good fusion rate.

We have been performing double-door laminoplasty using the autologous spinous process instead

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Abbreviations: CSM, cervical stenotic myelopathy; HA, hydroxyapatite; JOA, Japanese Orthopedic Association; OPLL, posterior longitudinal ligament; ROM, range of motion.

of an artificial spacer since 1988 [14]. A short length of the spinous process is resected, and then this removed spinous process is implanted between the expanded laminae. We have previously reported that the clinical outcome from this surgical technique was satisfactory [15]. But there is no report yet on the fusion rate and the incidence rate of breakage in the autologous spinous process within 6 months after operation. The purpose of the present study was to examine the fusion rate and the incidence rate of breakage in the autologous spinous process and to assess its efficacy for cervical laminoplasty.

## MATERIALS AND METHODS

### *Patient population*

Double-door laminoplasty has been performed for 23 patients involving 12 patients with cervical stenotic myelopathy (CSM), and 11 patients with ossification in the posterior longitudinal ligament (OPLL), in Kurume University Hospital, in the 6 months from January to June 2003. There were 18 men and 5 women, with an average age of 62.1 years (range 34-80 years). All patients presented lordotic or neutral curvature in the cervical spine, and no patient showed gross spinal instability.

### *Operative technique*

The expansive double-door laminoplasty was performed by sagittal splitting of the spinous process, as developed by Kurokawa et al. [9]. The bilateral

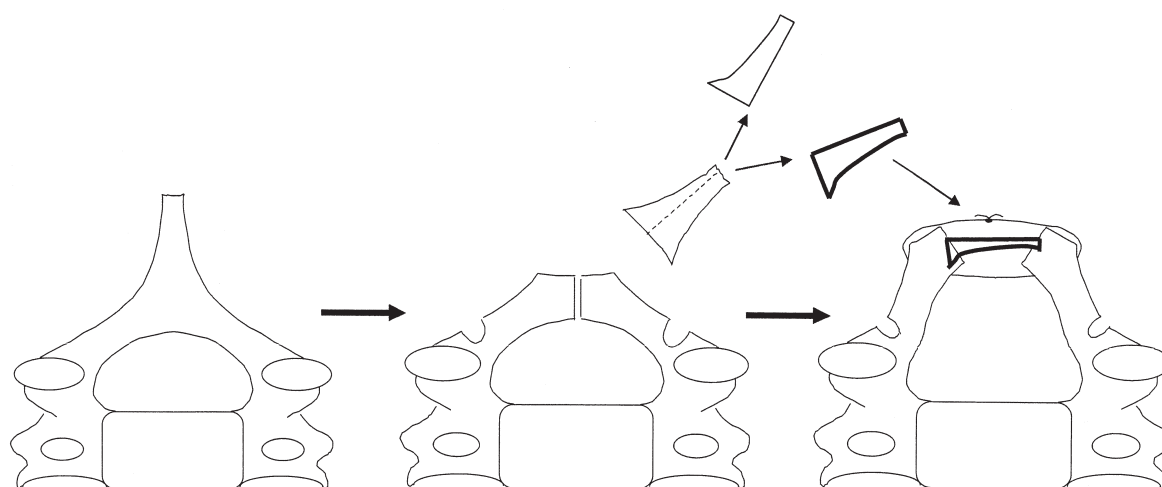
posterior neck muscles are dissected from the laminae to enlarge the surgical field. After exposing the muscles on one side, the spinous process is separated, and the spinous process, ligaments, and posterior neck muscles are exposed en bloc. Then, each spinous process from C3 to C7 is resected at 8 mm from the basal part of spinous process. The autologous spinous process about 10 to 15 mm long is made from the removed spinous process, and then implanted between each expanded lamina [14] (Fig. 1). After reconstruction of the laminae, the grafts are held in place with sutures that are passed through holes in the laminae made using a 1-millimeter burr. The average operative duration and blood loss are recorded.

### *Clinical evaluation*

The severity of preoperative clinical symptoms was determined using an evaluation score established by the Japanese Orthopedic Association (JOA score) (Table 1). The JOA scores were determined at just before the operation, and at 3 months and at 6 months after the operation.

### *Radiographic evaluation*

The range of motion (ROM) between flexion and extension of the cervical spine was measured at before the operation, and at 3 months and at 6 months after the operation, using lateral-view radiographs. The angle between the two lines extending from the posterior margins of the vertebral bodies of C2 and C7 was measured in maximum flexion, and



*Fig. 1.* The spinous processes are removed, and the remaining spinous process is split using a drill. Autologous spinous processes which are about from 10 to 15 mm long are made from the removed spinous processes and are implanted between the expanded laminae.

TABLE 1.  
Japanese orthopaedic association scoring system (17-2) for cervical myelopathy

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<b>I. Motor function</b>	
1. Finger	0 = Unable to feed oneself with any tableware including chopsticks, spoon or fork, and/or unable to fasten buttons of any size 1 = Can manage to feed oneself with a spoon and/or fork but not with chopsticks 2 = Either chopsticks-feeding or writing is possible but not practical, and/or large size buttons can be fastened 3 = Either chopsticks-feeding or writing is clumsy but practical, and/or cuff buttons can be fastened 4 = Normal
2. Shoulder and elbow (evaluated by MMT score of the deltoid or biceps muscles, whichever is weaker)	- 2 = MMT 2 or less, - 1 = MMT 3, - 0.5 = MMT 4, 0 = MMT 5
3. Lower extremity	0 = Unable to stand up and walk by any means 0.5 = Able to stand up but unable to walk 1.5 = Able to walk without support but with a clumsy gait 2 = Walks independently on a level but needs support on stairs 2.5 = Walks with independently when going upstairs, but needs support when going downstairs 3 = Capable of fast walking but clumsy 4 = Normal
<b>II. Sensory function</b>	
A. Upper extremity	0 = Complete loss of touch and pain sensation 0.5 = 50% or less normal sensation and /or severe pain or numbness 1 = More than 60% normal sensation and/or moderate pain or numbness 1.5 = Subjective numbness of a slight degree without any objective sensory deficit 2 = Normal
B. Lower extremity	Same as A
C. Trunk	Same as A
<b>III. Bladder function</b>	
	0 = Urinary retention and/or incontinence 1 = Sense of retention and/or dribbling and/or thin stream and/or incomplete continence 2 = Urinary retardation and/or pollakiuria 3 = Normal

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Total score for a normal individual = 17, MMT : manual muscle test

in extension. The sum of these two angles was defined as the ROM.

#### CT evaluation

At three months and at six months after the operation, a CT scan was taken to determine the fusion rate between each expanded lamina and the autologous spinous process. Helical CT scanning was performed to examine each expanded lamina including the autologous spinous process, with 3-mm collimation. The gantry was placed parallel to each lamina. All laminae were then divided into 2 classes; Group A with bony fusion, and Group B with non-fusion (Fig. 2). Three independent observers evaluated the

bone fusion at both side of 115 opened laminae (total 230 points) from 23 patients. Bony fusion was concluded to have been achieved when 2 of the 3 observers agreed.

#### RESULTS

The average JOA score was  $9.68 \pm 2.6$  points (range from 4.5 to 13.5 points) before surgery,  $12.95 \pm 2.6$  points (range from 9.5 to 16.5 points) at 3 months, and,  $13.06 \pm 2.4$  points (range from 10.5 to 16.5 points) at 6 months after the operation (Fig. 3A). The recovery rate was  $43.8 \pm 24.5$  at 3 months, and  $49.1 \pm 23.7$  at 6 months. No postoperative

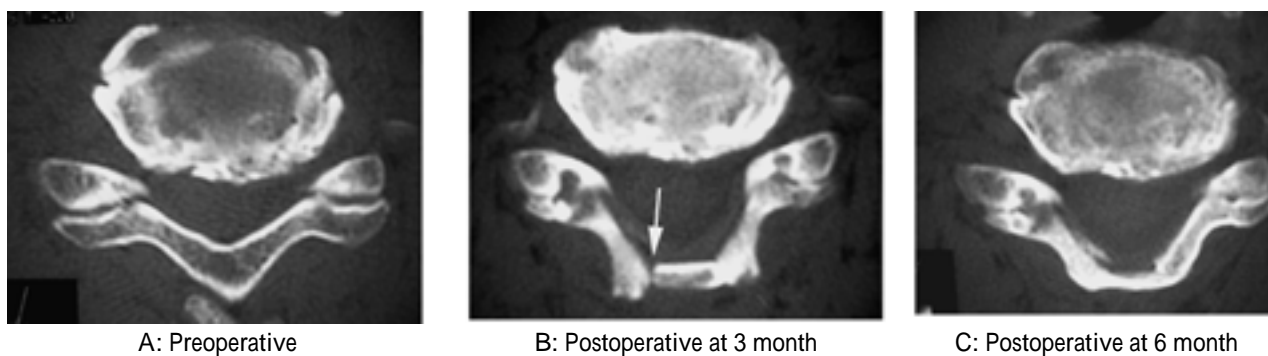


Fig. 2. Preoperative (A), postoperative at 3 months (B) and at 6 months (C) CT scans of the fifth cervical vertebral level of a patient with OPLL. The right expanded lamina of Fig. 2B shows a clear space between the autologous spinous process and the bone (arrow), and was categorized into Group B as non-fusion. The left expanded lamina of Fig. 2B and Fig. 2C show no space between them with new bone formation, and were categorized into Group A as fusion.

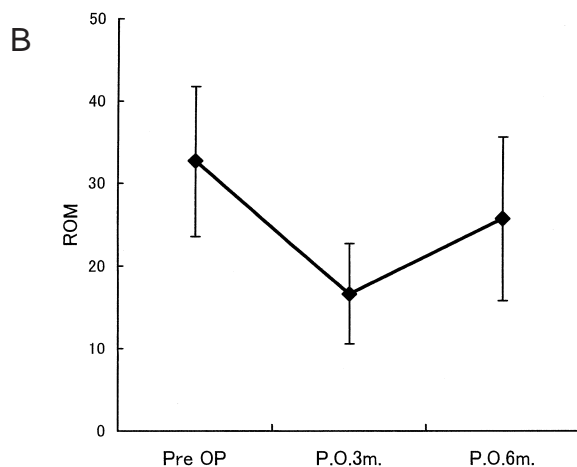
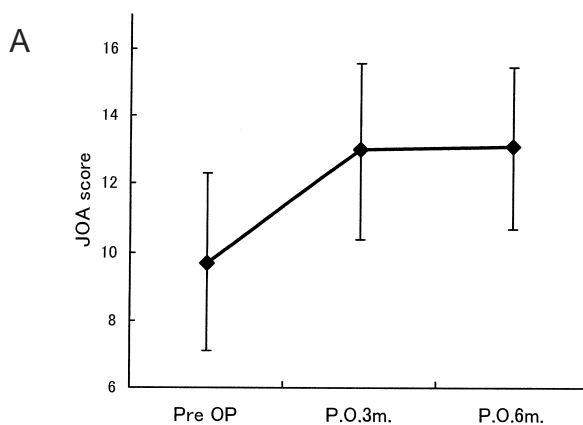


Fig. 3. A, Changes in the JOA score over time in patients. The average preoperative JOA score of  $9.68 \pm 2.6$  (mean  $\pm$  SD) increased to  $12.95 \pm 2.6$  at 3 months after surgery and to  $13.06 \pm 2.4$  at 6 months. B, Changes in the ROM of the cervical spine over time in patients. The average ROM of  $32.7 \pm 9.1$  (mean  $\pm$  SD) decreased to  $16.7 \pm 6.1$  at 3 months after surgery and then increased to  $25.8 \pm 9.9$  at 6 months.

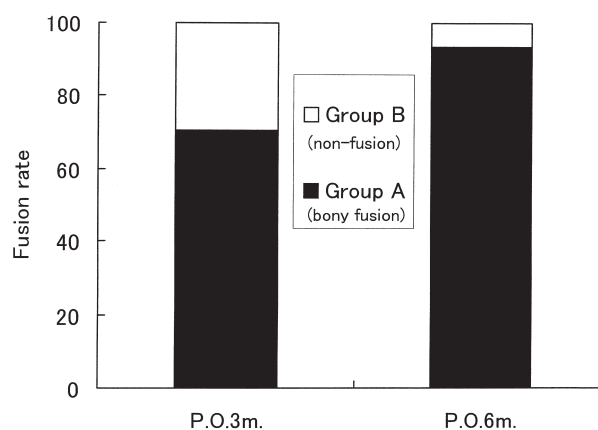


Fig. 4. The status of bone fusion after surgery. The fusion rate between the expanded lamina and the autologous spinous process was 70.4% at 3 months after the operation. The fusion rate at 6 months after the operation was 93.5%. There was no dissociation and no breakage in the autologous apinuous process during the follow-up observation period.

deterioration in symptoms was seen in any patient.

The average ROM of the cervical spine was  $32.7 \pm 9.1$  at pre-operation. The average ROM after the operation was  $16.7 \pm 6.1$  at 3 months, and  $25.8 \pm 9.9$  at 6 months (Fig. 3B).

Post-operative CT scanning was used to investigate the reconstructed laminae at 3 and at 6 months after the operation. The fusion rate between each expanded lamina and the autologous spinous process was 70.4% (162 of 230) at 3 months, and 93.5% (215 of 230) at 6 months (Fig. 4). There was no dissociation, and no breakage in the autologous spinous process during the 6 months of the follow-up period.

The average operative duration was  $130 \pm 25.7$  min. Making the autologous spinous process from the removed spinous process took less than 5 min. The sagittal splitting using the burr from C3-C7 took about 5-10 min. There was no cord injury, and no rupture in the dura mater. The average blood loss during the operation was  $166.5 \pm 92.7$  gms.

## DISCUSSION

Laminoplasty for multisegmental cervical canal stenosis has been widely performed instead of multi-level laminectomy to avoid segmental instability, kyphosis, perineural adhesions, and late neurological deterioration [2-8]. Double-door laminoplasty devised by Kurokawa et al. [9] has become widely performed in Japan. In the original procedure, small bone blocks from the iliac crest were grafted to keep the split spinous processes separated. To relieve door site pain, reduce operative duration, and reduce the blood loss, several types of artificial spacers have been tried for double-door laminoplasty [11-13,16, 17]. However, inadequate contact between the artificial spacer and the spinous process has been reported, and the inadequate contact rate has continued to be about 30% [10-13]. Recently, Iguchi et al. [18] have described the use of a high-porosity HA spacer that resulted in an improved union rate between these spacers and the split spinous processes. But even using this high-porosity HA, the union rate was only 47.4% at 1 year after the operation. In comparison, the fusion rate between the expanded lamina and the autologous spinous process achieved in our series was 70.4% at only 3 months after the operation, and this increased to 93.4% at 6 months after the operation. A high fusion rate is important for stability in the autologous spinous process at an early stage after the operation. Iguchi et al. [18] also reported breakage in 7 spacers (4.4%); 5 spacers broke within 3 months, and another 2 within 1 year after the operation. Our study showed no breakage and no displacement during the whole follow-up period of 6 months. Having achieved bony union in 93.4% within the first six months, it remains unlikely that breakage or displacement will occur in our series.

The technique of double-door laminoplasty has a number of theoretical and practical operative advantages. First, the posterior arch can be reconstructed symmetrically. Second, the enlargement in the spinal canal is constantly maintained by the bone grafts or spacers. Third, troublesome hemorrhage from the arborizing lateral epidural veins is avoided because

there are few veins in the dorsal midline epidural space. But the principal disadvantage in the midline spinous process-splitting technique is the technical difficulty, related to a high risk for cord injury during the sagittal splitting using a burr [19]. It is difficult for the surgeon to feel when the endpoint (at the posterior arch of spinal canal) has been dissected or not because of resistance in the long spinous process during the sagittal splitting using the burr, especially at C6 and C7. In our technique, the spinous process from C3 to C7 was resected at 8 mm from the basal portion, so the cutting distance was short, and the operator can see the cutting point directly. When the resection is short then the surgeon is more able to perform accurate and complete cutting. These points are important to avoid the risk to cord injury during sagittal splitting using a burr. In our series, there was no cord injury, and no rupture in the dura mater. The short cutting distance was easy and avoided the risk to cord injury as described.

Various laminoplasty techniques have been described [1]. The mean recovery rate after laminoplasty has been about 55%, based on the JOA Scale, with a mean decrease in cervical ROM of about 50%. The recovery rate at 6 months in our series was 49.1%, and the decrease in ROM was 78.8%. At  $33 \pm 19$  months after the operation, the recovery rate in our series was  $53 \pm 28\%$  and the decrease in ROM was 50% [15]. These results have indicated the superior outcome using this technique in comparison with other techniques.

In addition to these advantages, this technique is less expensive than techniques using an artificial spacer.

## CONCLUSION

We have observed clear advantages in the technique using the autologous spinous process, including a high fusion rate, good stability in the autologous spinous process, ease and safeness, and satisfactory outcomes. The technique of double-door laminoplasty using the autologous spinous process instead of an artificial spacer is a reliable and effective treatment for multisegmental cervical canal stenosis.

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