Single-door cervical laminoplasty using titanium miniplates alone

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ABSTRACT

Purpose. To review outcome of 29 patients who underwent single-door cervical laminoplasty for myelopathy using titanium miniplates alone.

Methods. Records of 20 men and 9 women aged 35 to 79 (mean, 64.3) years who underwent single-door cervical laminoplasty for myelopathy using titanium miniplates alone were reviewed. A total of 125 laminae were opened; 97 of them were fixed with a titanium miniplate. In 19 patients, a 20-hole titanium miniplate bent to the contour of a lamina was used and fixed into 3 laminae at alternate levels. In the remaining 10 patients, the pre-contoured ARCH Laminoplasty System was used and fixed into all laminae. In most patients, screw fixation was unicortical, and no spacer or bone graft was used.

Results. The mean follow-up duration was 4 (range, 2–9) years. At one-year follow-up, the mean Japanese Orthopaedic Association (JOA) score improved from 9.2 to 13.2 (p<0.001). The mean JOA recovery rate was 64%. No patient had neurological deterioration. The mean anteroposterior diameter increased from 14.3 mm to 19.7 mm; the mean increase was 6.1 mm in the plated laminae and 5.3 mm in the unplated laminae (p=0.11). Out of the 125 laminae, there were 2 hinge non-unions in the unplated laminae, and 2 screw pullouts (not associated with plate loosening). No patient had penetration into the vertebral foramen or neuroforamen. Spring-back closure occurred in 5 (18%) of the 28 unplated laminae, with a mean of <3 mm loss of the initial expansion. Two patients developed transient C5 palsy presenting as shoulder abduction weakness. One patient had a delayed dural tear due to a sharp spike at the edge of the opened C6 lamina.

Conclusion. Single-door cervical laminoplasty using miniplates alone is a safe technique and achieves a high hinge union rate, good canal expansion, and neurological recovery.

Key words: laminoplasty; spinal cord diseases

INTRODUCTION

Expansive open-door laminoplasty is a common treatment for cervical myelopathy, particularly for...
multilevel disease, congenital spinal stenosis, and ossification of the posterior longitudinal ligament without instability or kyphotic deformity.4–6 To maintain the canal space of the laminae, stay sutures are used between the base of the spinous process and the facet joint capsule.1–3 Nonetheless, spring-back closure of operated laminae may occur and lead to neurological deterioration.7–10 Other methods to maintain the canal space of laminae include the use of bone struts, suture anchors, and hydroxyapatite or ceramic spacers. Titanium miniplates with or without bone strut or spacer provide immediate rigid fixation to prevent the spring-back closure of laminae.11 This study reviewed the outcome of 29 patients who underwent single-door cervical laminoplasty for myelopathy using titanium miniplates alone.

MATERIALS AND METHODS

Records of 20 men and 9 women aged 35 to 79 (mean ± standard deviation [SD], 64.3 ± 12.3) years who underwent single-door cervical laminoplasty for myelopathy using titanium miniplates alone between 2005 and 2012 were reviewed. Pathologies of the patients included cervical spondylotic myelopathy (n=19), ossification of the posterior longitudinal ligament (n=8), and central cord syndrome (n=2). A total of 125 laminae were opened; 97 of them were fixed with a titanium miniplate. In 19 patients operated before August 2011, a 20-hole titanium miniplate bent to the contour of a lamina was used (Fig. 1) and fixed into 3 laminae at alternate levels (Fig. 2a). In the remaining 10 patients operated on or after August 2011, the pre-contoured ARCH Laminoplasty System (Depuy Synthes, West Chester [PA], USA) was used and fixed into all laminae (Fig. 2b).

The patient was put under general anaesthesia and endotracheal intubation was used to avoid excessive neck extension. Fibreoptic intubation was used if the patient had a positive Lhermitte sign. A halo ring and 3 kg of traction was applied and the patient was positioned prone, with the neck in slight flexion. A posterior midline incision was made and paraspinal muscles were dissected to expose the cervical spine from the inferior portion of the C2 lamina to the superior portion of the C7 lamina (to T1 if for C3 to C7 laminoplasty). The poorer side of the lamina was opened for laminoplasty. The posterior and ventral cortices were burred to a thin rim at the

Figure 1 A 20-hole titanium miniplate is bent to the contour of a lamina.

Figure 2 Cervical laminoplasty using (a) three 20-hole titanium miniplates for 3 laminae at alternate levels, and (b) the ARCH Laminoplasty System for all laminae.
junction of the lateral mass and lamina. The burr was directed at 45º and perpendicular to the lamina. The remaining ventral cortex and the ligamentum flavum were removed using a diamond burr and Kerrison rongeur. The ‘springiness’ of the laminae was evaluated to determine the amount of bone to be removed. Care was taken to avoid breaking the hinge. The interspinous ligament of the level both caudal and cephalic to the laminoplasty was divided, and the hinge side of the lamina was gently pushed away from the open side. The inferior C2 lamina can be undermined if the hinge cannot be opened after appropriate thinning of the ventral cortex on the hinge. Dural pulsations should be seen with adequate decompression. The hinge was maintained open with a titanium miniplate fixed to the lamina and the lateral mass, each with 2 mini-screws. In most patients, screw fixation was unicortical, and no spacer or bone graft was used. Postoperatively, a soft neck collar was worn for 2 weeks. Neck mobilisation exercises were allowed as pain improved.

At one-year follow-up, computed tomography (Fig. 3) was used to assess (1) hinge union (the bridging of both ventral and dorsal cortices by cortical or cancellous bone), (2) patency of the laminoplasty and screw pull-out, and (3) violation of neuroforamina or vertebral foraminae. Radiography was standardised by ensuring a 150-cm film-to-tube distance and centering on the C4 body (Fig. 4). The anteroposterior diameter of the spinal canal was measured using the Wolf method: from the middle of the posterior border of the vertebral body to the anterior border of the lamina. The anteroposterior diameter of the respective vertebrae were measured to correct for any difference in magnification. The canal expansion and any spring-back closure (>1 mm loss of the initial expansion) were assessed.

Figure 3  Computed tomography showing (a) hinge union defined by bridging of both ventral and dorsal cortices by cortical or cancellous bone, (b) intact ventral cortex on the hinge side, and (c) pullout of the lateral screw without plate loosening.

Figure 4  Radiographs of the cervical spine (a) before and (b) 6 months after cervical laminoplasty with titanium miniplates alone.
Neurological outcome was assessed using the Japanese Orthopaedic Association (JOA) score. The Hirabayashi JOA recovery rate was calculated as \( \frac{\text{post-JOA score} - \text{pre-JOA score}}{17 - \text{pre-JOA score}} \times 100\% \).

Results were compared using the paired Student’s \( t \) test. A \( p \) value of <0.05 was considered statistically significant.

RESULTS

The mean follow-up period was 4 (range, 2–9) years. At one-year follow-up, the mean±SD JOA score improved from 9.2±2.42 to 13.2±1.52 (\( p < 0.001 \)). The mean JOA recovery rate was 64\% (95\% CI, 36.6–90.5\%). No patient had neurological deterioration.

The mean±SD anteroposterior diameter increased from 14.3±1.6 mm to 19.7±2.1 mm; the mean increase was 6.1 mm in the plated laminae and 5.3 mm in the unplated laminae (\( p = 0.11 \)). The difference was not significant, probably owing to the connection of the adjacent laminae through the ligamentum flavum in a suspension bridge–like manner.

Out of the 125 laminae, there were 2 hinge non-unions in the unplated laminae, and 2 screw pullouts (not associated with plate loosening). No patient had penetration into the vertebral foramen or neuroforamen. Spring-back closure occurred in 5 (18\%) of the 28 unplated laminae, with a mean of <3 mm loss of the initial expansion. Two patients developed transient C5 palsy presenting as shoulder abduction weakness. One patient had a delayed dural tear due to a sharp spike at the edge of the opened C6 lamina.

DISCUSSION

Single-door cervical laminoplasty is relatively safe, as it approaches the cervical spinal cord from its lateral side that is usually less compressed. It is technically easier, as it does not require a midline split as in double-door laminoplasty. Nonetheless, single-door laminoplasty may result in damage to the epidural venous plexus and more intra-operative bleeding. Double-door laminoplasty approaches the cervical spinal cord from the dorsal side that is relatively less vascular. It also maintains bone-tissue symmetry and enables a return to more normal biomechanics of the cervical spine. However, it is technically demanding to insert the T-saw and the spinal cord is at risk when there is substantial ossification of the posterior longitudinal ligament; it is also difficult to perform foraminotomy if needed. Single-door and double-door cervical laminoplasty yield similar clinical results.\(^{5,14}\) Stay sutures placed at each lamina level through the base of the spinous process and the facet joint capsule and surrounding muscle fascia are simple, but the suture can stretch, loosen, or cut through with time and lead to the spring-back closure phenomenon.\(^{1,3}\)

Between postoperative one week and 6 months, there is a 10\% decrease in anteroposterior diameter and opening angle in operated laminae.\(^{7}\) At one year, segments with high-grade cord compression have a greater decrease in anteroposterior diameter and opening angle. In one study, 10\% of cervical laminoplasty patients developed spring-back closure with neurological deterioration.\(^{8}\) In another study, 34\% of patients developed spring-back closure (10\% loss of the initial increase in the canal to vertebral body ratio); the JOA score and recovery rate tended to decrease in patients with spring-back closure after a mean of 5 years.\(^{9,10}\)

Ossification of the posterior longitudinal ligament can progress even after surgery, particularly in patients aged younger than 50 years with mixed and continuous types of ossification.\(^{15,16}\) The use of the titanium miniplate is effective in maintaining the canal space of operated laminae.\(^{11,17,18}\) Other methods to maintain the canal space of laminae include the use of suture anchors, bone struts, hydroxyapatite or ceramic spacers. However, suture anchors cannot completely eliminate the problems associated with sutures. Spacers and bone grafts can re-create a complete lamina arch, but are limited by the spinous process size, donor-site morbidity, difficulty in obtaining exact carpentry to hold the graft in place, and partial resorption.\(^{18,19}\) Other rarer complications include fracture of the spacers and delayed dural lacerations from anterior displacement of the spacers.\(^{19-22}\) Plate breakage is unlikely, as the plates do not cross motion segments. In one study of plate-only laminoplasty, at one year the hinge non-union rate was 7\% and the screw pullout rate was 2.3\%, but there was no plate dislodgement or laminoplasty closure.\(^{18}\)

The major risks of lateral mass screw fixation are damage to the vertebral artery, spinal nerves, or facet joints. Unicortical purchase eliminates the risk of damaging neurovascular structures.\(^{23}\) Although bicortical purchase has been reported to have a 30\% higher pullout resistance (350 N vs. 272 N),\(^{24}\) other studies have reported no significant difference in the pullout strength\(^{25}\) or significant difference only in the presence of a destabilising laminectomy.\(^{26}\) The pullout strength is much lower in plating for laminoplasty.
than for fusion (crossing motion segments). In a systematic review, the incidence of radiculopathy was only 0.19% per screw and 1.36% per patient.27

Plating in conjunction with use of bone struts or spacer may provide better arch reconstruction, but is associated with longer operating times.28 In our study, the miniplate-alone construct achieved a high hinge union rate and re-created a stable laminar arch, without additional allografts.

In a study of association between opening size for laminoplasty and increase in sagittal canal diameter and canal area, an opening size for laminoplasty of 10 to 12 mm could lead to an increase of 4 to 5 mm in the sagittal canal diameter and an increase of 90 to 120 mm² in canal area.29 Although neurological improvement correlated poorly with the degree of canal expansion, no patients with a postoperative canal area of >1.6 cm² had a JOA score of <12.30 Unplated laminae expand less than plated laminae.17

CONCLUSION

Single-door cervical laminoplasty using miniplates alone is a safe technique and achieves a high hinge union rate, good canal expansion, and neurological recovery.

DISCLOSURE

No conflicts of interest were declared by the authors.