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Clinical and radiography results of mini-plate fixation compared to suture suspensory fixation in cervical laminoplasty: A five-year follow-up study

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ABSTRACT

Objectives: Lamina closure is the most common reason for failure of unilateral open-door laminoplasty. Mini-plate fixation was designed to solve such problem. We assessed the clinical outcomes and radiography results of mini-plate fixation by comparing it with suture suspension fixation.

Patients and methods: This prospective study enrolled 57 patients with multi-segment cervical spondylotic myelopathy between January 2008 and March 2010. Thirty-four patients underwent laminoplasty with mini-plate fixation (mini-plate group) whereas 23 patients underwent laminoplasty with suture suspension fixation (suture group). The neurological function was measured with the Japanese Orthopedic Association (JOA) score. Cervical range of motion (ROM), C2–7 angle, and the spinal canal expansive parameters (anteroposterior diameter, Pavlov's ratio, cross-sectional area, and open angles) were evaluated.

Results: The mean follow-up time was 64 (60–82) months. There were no significant differences in preoperative JOA scores ($p = 0.191$), postoperative JOA scores ($p = 0.700$), preoperative cervical ROM ($p = 0.315$) and preoperative C2–7 angle ($p = 0.074$) between the two groups. Both groups had significant postoperative JOA improvement ($p < 0.05$). The mini-plate group had larger cervical ROM ($p = 0.041$) and C2–7 angle ($p = 0.040$) than the suture group at the final follow-up. Both groups showed significant improvement in the spinal canal expansive parameters immediately after the surgery. In the suture group, the parameters, such as anteroposterior diameter, Pavlov's ratio, cross-sectional area, and open angles, decreased along with time, mainly within the first 6 months following the operation. In the mini-plate group, these parameters remained unchanged. The spinal canal expansive parameters between the 2 groups were not significantly different immediately following the operation, but were significantly different at the final follow-up ($p < 0.05$). Three patients in the suture group displayed neurological deterioration due to lamina reclosure.

Conclusions: Laminoplasty by mini-plate fixation preserved more cervical ROM and better cervical alignment, maintained cervical spine canal expansive stability and effectively avoided lamina reclosure for a long-term follow-up.

1. Introduction

Expansive open-door cervical laminoplasty (EOLP) is a critical posterior decompression surgery for multi-segment cervical spinal canal stenosis caused by multilevel disk herniation (MDH), ossification of the posterior longitudinal ligament (OPLL), and congenital cervical canal stenosis (CCS) [1–3]. The technique was reported to be effective to gain neurologic recovery and could preserve the posterior structures of the cervical spine, decreases postoperative spinal deformities such as kyphosis or cervical spinal instability, and preserves cervical movement compared to multilevel corpectomy and multilevel laminectomy [1,3–5]. However, several complications have been observed after EOLP, including postoperative axial symptoms, C5 nerve palsy, and lamina reclosure. Lamina reclosure was reported to be a common yet serious complication that may result in neurological deterioration and require a secondary surgery. The incidence of lamina reclosure was reported to be 10.0–44.7% in the literatures [5–7]. In Wong's study, all the patients with lamina reclosure exhibited postoperative neurologic deterioration [7]. EOLP achieves decompression by lifting the lamina and expands the cervical spinal canal to allow the spinal cord to

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drift away from the anterior compression. It is critically important for EOLP to maintain a sufficient "open door" angle and spinal canal enlargement in order to achieve satisfactory neurological improvement [3–5].

In classic laminoplasty, the opened lamina is fixed by staying suture between the base of spinous process and the facet capsule or paraspinal muscle. The suture may cut out, break, or stretch over time, which may result in the failure of the fixation and closure of the laminae. The mini-plate fixation system, first introduced by O'Brien in 1996, was designed to keep the lamina open in a stable manner by offering the laminae immediately rigid fixation [8,9]. Some studies have reported the fixation was efficient to provide primary resistance against closure of the laminae and was superior to suture fixation in preserving cervical alignment and range of motion [4,10–13]. However, most of the reports were retrospective studies and the follow-up were short, which were incompetent to evaluate the medium or long term effect of mini-plate fixation in EOLP. The present study was undertaken to assess the long-term effect of mini-plate fixation by comparing it with suture suspension fixation with least 5-year follow-up.

2. Materials and methods

2.1. Patients

The current prospective study included the patients who were diagnosed with cervical canal stenosis and underwent EOLP in West China Hospital between January 2008 and December 2009. Exclusion criteria included: sudden spinal injury, preoperative cervical kyphosis or instability, revision surgery, and anterior–posterior hybrid surgery. The patients were well informed the advantages and disadvantages of the two different procedures without bias before the surgery. After the thorough explanation, the patients would decide which procedure to choose. The patients who chose to undergo the laminopalsty with mini-plate fixation were classified as the mini-plate group. And the patients who chose to undergo the laminopalsty with the suture suspension technique were classified as the suture group.

2.2. Surgical technique

After receiving general endotracheal anesthesia, the patient is positioned prone and a midline cervical incision is made to expose the laminae, spinous processes, and the medial facet joints from C2 to C7. The supra-spinous and inter-spinous ligaments are cut between C2 and C3 and between C7 and T1. The spinous processes are then amputated. The opening side is made on the side with more symptoms by completely cutting the laminae off along the medial margin of the facet joints. On the hinge side, only the dorsal cortex and the cancellous bone are removed. The lamina is opened carefully with the remove of the adhesions of dural mater, ligamentum flavum, and laminae.

For the patients in the mini-plate group, an appropriately sized Centerpiece mini-plate (CenterpieceTM Plate Fixation System; Medtronic Sofamor Danek, USA) was inserted by fitting the cut edge of the lamina into the laminar shelf of the plate. The lateral portion of the plate was then placed downwards at the edge of the lateral mass. We inserted two 7-mm screws to anchor the plate to the lateral mass and two 5-mm screws to anchor the plate to the laminae. For the patients in the suture group, the opened laminae were fixed using Hirabayashi's classic open-door laminoplasty techniques, where the sutures (1-0, Mersilk; Ethicon, USA) were placed through the facet capsule on the hinge side and through the spinous processes to help maintain cervical canal expansion.

The patients in the mini-plate group were encouraged to perform neck exercises with a soft collar, within their pain tolerance, beginning 2 weeks after the surgery. The patients in the suture group were supposed to avoid superfluous cervical movements for 3 months until the soft collars came off.

2.3. Clinical evaluation

Clinical evaluations were performed before surgery and at every follow-up visit. The Japanese Orthopedic Association (JOA) score was used to assess the neurological function, and the recovery rates were calculated according to the formula: recovery rate = (JOA score after surgery − JOA score before surgery)/(17-JOA score before surgery) × 100% [14]. The axial symptoms, C5 palsy and other complications were recorded. The VAS (Visual Analogue Score) and NDI (The Neck Disability Index) were used to evaluate the pain severity and daily activities of the neck. The SF36 questionnaires (the 36-item health survey questionnaire) were used to evaluate the quality of life.

2.4. Radiography evaluation

Radiological examinations, including X-ray films and CT scans, were performed before the surgery and at every postoperative follow-up visit. MRI scans were used when neurological recovery was not progressing well. The anteroposterior diameter (AP), C2–7 angle, and the cervical range of motion (ROM) were measured with X-rays radiographs [15] (Figs. 1 and 2). Pavlov's ratios were then calculated [16]. The C2–7 angle referred to the angle between a line vertical to the inferior aspect of the C2 body and a line vertical to that of the C7 body on neutral lateral radiographs. ROM was obtained by the summation of the C2–7 angles on flexion and extension lateral radiographs. The cross-sectional area of the cervical spinal canal and the open angles for each vertebra were measured with CT scans (Fig. 3). The lamina reclosure was defined as a 10% decrease in Pavlov's ratio at two consecutive follow-up time points. All these measurements were performed three times by one of the authors and an independent experienced musculoskeletal radiologist to reduce the intra- and interobserver bias.

2.5. Statistical analysis

Statistical analysis was performed using SPSS version 19.0 software (SPSS Inc., IL, USA). Continuous variables were presented as mean ± SD. The paired Student's *t*-test and chi-square test were performed for analyzing the differences between the two groups. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. General data

The study consisted of 57 patients, including 41 males and 16 females with a mean age of 61 (range 41–81) years. There were 34 patients in the mini-plate group, including 24 males and 10 females, with a mean age of 60 (range 41–81) years and 23 patients in the suture group, including 17 males and 6 females, with a mean age of 63 (range 44–78) years. The mean follow-up time for all the patients was 64 (60–82) months. The operative level was C4–7 for one patient in mini-plate group, C3–6 for one patient in suture group and C3–7 for all the other patients. There were no significant differences in gender, age, diagnose type, medical co-morbidities, operative time, blood loss, perioperative complications and the preoperative JOA score between the mini-plate group and the suture group (Table 1).