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Image analysis of open-door laminoplasty for cervical spondylotic myelopathy: Comparing the influence of cord morphology and spine alignment

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ABSTRACT

Objectives: Previous studies have identified the factors affecting the surgical outcome of cervical spondylotic myelopathy (CSM) following laminoplasty. Nonetheless, the effect of these factors remains controversial. It is unknown about the association between pre-operative cervical spinal cord morphology and post-operative imaging result following laminoplasty. The goal of this study is to analyze the impact of pre-operative cervical spinal cord morphology on post-operative imaging in patients with CSM.
Methods: Twenty-six patients with CSM undergoing open-door laminoplasty were classified according to pre-operative cervical spine bony alignment and cervical spinal cord morphology, and the results were evaluated in terms of post-operative spinal cord posterior drift, and post-operative expansion of the antero-posterior dura diameter.
Results: By the result of study, pre-operative spinal cord morphology was an effective classification in predicting surgical outcome – patients with anterior convexity type, description of cervical spinal cord morphology, had more spinal cord posterior migration than those with neutral or posterior convexity type after open-door laminoplasty. Otherwise, the interesting finding was that cervical spine Cobb's angle had an impact on post-operative spinal cord posterior drift in patients with neutral or posterior convexity type spinal cord morphology – the degree of kyphosis was inversely proportional to the distance of post-operative spinal cord posterior drift, but not in the anterior convexity type.
Conclusions: These findings supported that pre-operative cervical spinal cord morphology may be used as screening for patients undergoing laminoplasty. Patients having neutral or posterior convexity type spinal cord morphology accompanied with kyphotic deformity were not suitable candidates for laminoplasty.

1. Introduction

Laminoplasty is an accepted, effective, and safe therapeutic strategy for patients with cervical spondylotic myelopathy (CSM) [1,2]. The clinical benefits are attributed to sufficient decompression for multi-segmental cervical lesions without obvious damage to spinal stability and mobility [3,4]. This surgical procedure enables cervical spinal cord posterior decompression by expanding the bony spinal canal and anterior decompression by drifting the cervical spinal cord from the anterior compressive lesions.

However, clinical outcome of laminoplasty is not always satisfactory and insufficient posterior drift of the cervical spinal cord is regarded as the major cause [5,6]. Several studies have tried to identify determinant factors affecting the surgical outcome of CSM following laminoplasty seriously, such as pre-operative cervical spine alignment, the space available at the cephalad levels, longitudinal distance index, and post-operative cervical spinal cord morphology [7–10]. Nonetheless, the effects of these identified factors on post-operative spinal cord posterior drift remain controversial. The association between pre-operative cervical spinal cord morphology and surgical outcome is never discussed by previous studies.

The purpose of this study is to investigate if pre-operative cervical spinal cord morphology as effective determinant in predicting surgical result. At the same time, this classification is compared with another common used – cervical spine bony alignment.

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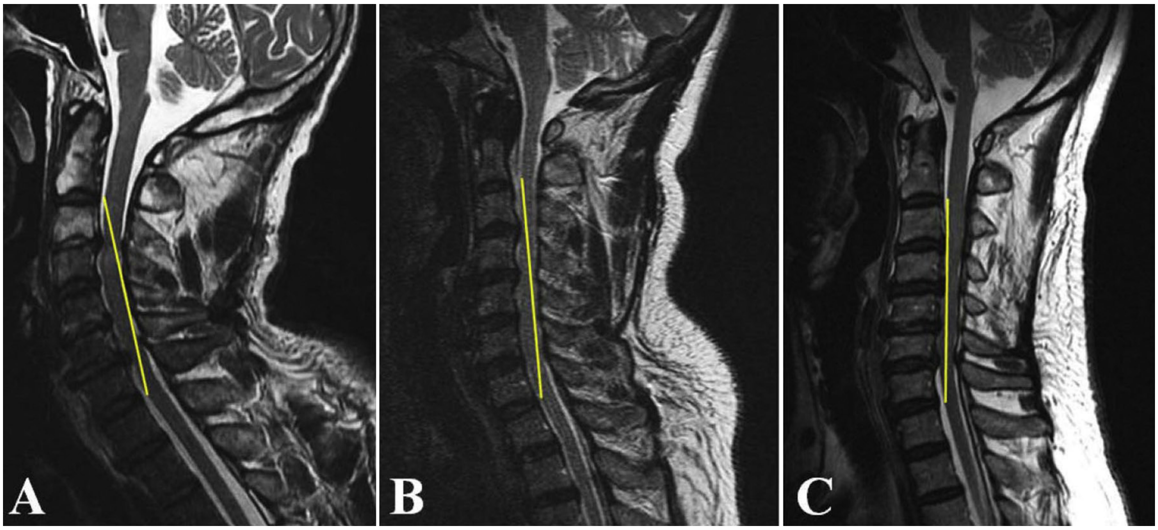

Fig. 1. One straight line linking two anterior points of the spinal cord at C2–3 and C7–T1 levels was drawn on T2-weighted images. While this line passed through posterior edge of the spinal cord, within the spinal cord or through anterior edge of the spinal cord, the spinal cord morphology was defined as anterior convexity type (A), neutral type (B), or posterior convexity type (C), respectively.

2. Materials and methods

2.1. Patient demographics

A review of medical record in our institution was conducted following Institutional Review Board approval (IRB: 1-102-05-032). From January 2005 to December 2010, 152 patients undergoing open-door laminoplasty at our institution were analyzed retrospectively. Those with previous cervical spine surgery, incomplete or un-interpretable pre- or post-operative magnetic resonance imaging (MRI), different levels of posterior decompression and different diagnosis except CSM – including trauma, tumor and ossification of posterior longitudinal ligament (OPLL) were excluded to minimize the selection bias. Twenty-six patients (14 male) with CSM were included in the final analysis. Their levels of decompression were from C3 to C7 and mean age at the time of surgery was 63 years. The average time interval between pre- and post-operative MRI was 12 months.

2.2. Surgical technique used for open-door laminoplasty

The patient was fixed with a three-point Mayfield headrest to maintain mild flexion. A straight skin incision was made midline over the spinal process between C2 and T1 levels, followed by exposure of the laminae and bilateral facet joints from C3 to C7. The medial aspect of the facet complex at each level was identified as the landmark for making the troughs. A high-speed cutting burr (2 mm) was used to excise the outer cortex of the hinged side laminae first, followed by the outer and inner cortex of opened side laminae. A 1 mm Kerrison rongeur was used to complete the trough of the open side and the opened side laminae were gently elevated using scalp clip applying forceps. Titanium mini-plates were attached to the opened side laminae and to the ipsilateral lateral mass as fixation and augmentation of the enlarged spinal canal.

2.3. Radiologic assessments by MRI

2.3.1. Pre-operative cervical spine alignment

The alignment of the cervical spine in the neutral position, measured from C2 to C7 using Cobb's method, was recorded on T2-weighed mid-sagittal MRI before and after surgery. Cobb's angle $>10^\circ$ was defined as lordosis, between 0° and 10° as straight, and $<0^\circ$ as kyphosis [11].

2.3.2. Morphology of the cervical spinal cord

A straight line linking the two anterior points of the spinal cord at C2–3 and C7–T1 levels was drawn. If the straight line passed through the posterior edge of the spinal cord, the spinal cord was defined as anterior convexity type. If the line passed within the spinal cord or through the anterior edge of the spinal cord, the spinal cord was considered neural type or posterior convexity type, respectively (Fig. 1).

2.3.3. Posterior drift of the cervical spinal cord

The distance from the posterior edge of each vertebral body to the center of the spinal cord was measured from C3 to C7 on T2-weighed MRI (Fig. 2). The posterior drift of the spinal cord at each decompressed cervical level was determined by calculating the difference of pre- and post-operative distances measured by MRI.

2.3.4. Expansion of antero-posterior dura diameter

Expansion of the antero-posterior dura diameter, the result of increased bony spinal canal, was expressed by the difference of the maximal antero-posterior diameter of the dural sac at each decompressed cervical level before and after surgery (Fig. 3).

All of the patients were classified into groups according to two different classification – cervical spinal cord morphology and cervical spine bony alignment (Table 1). Using the definition of sagittal morphology of the spinal cord, patients with anterior convexity type (Group IA) were compared to those with neutral type or posterior convexity type (Group IB). Patients with cervical spine lordosis or Cobb's angle $>10^\circ$ (Group IIA) were compared to those with straight or kyphotic cervical spine, or Cobb's angle $\leq 10^\circ$ (Group IIB) (Table 1).

2.4. Statistical analysis

All data were presented as the mean $\pm$ standard deviation (SD) and calculated using the IBM SPSS Statistics 20. For pre-operative