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Clinical Study

Relationship between T1 slope and loss of lordosis after laminoplasty in patients with cervical ossification of the posterior longitudinal ligament

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Abstract

BACKGROUND CONTEXT: Laminoplasty is a major surgical method used to treat patients with cervical ossification of the posterior longitudinal ligament (OPLL). Sometimes, patients with cervical OPLL demonstrate postoperative kyphosis despite sufficient preoperative lordosis. Recently, the impact of T1 slope has emerged as a predictor of kyphotic alignment change after laminoplasty. However, the relationship between T1 slope and postoperative cervical alignment change is not yet fully established.

PURPOSE: The goals of the present study were to investigate the relationship between T1 slope and loss of cervical lordosis (LCL), and to identify the role of T1 slope as a predictor of postoperative kyphosis after laminoplasty in patients with OPLL.

STUDY DESIGN: This is a retrospective case study.

PATIENT SAMPLE: Between January 2011 and January 2012, 64 consecutive patients who underwent cervical laminoplasty for OPLL were enrolled (male:female ratio=47:17; mean age=55.9 years). Cervical spine lateral radiographs in neutral, flexion, and extension were taken before surgery and at 2-year follow-up.

OUTCOME MEASURES: The C2–C7 Cobb angle, cervical range of motion (ROM), T1 slope, neck tilt, and C2–C7 sagittal vertical axis (SVA) were measured from lateral radiographs of the cervical spine preoperatively and postoperatively at 2-year follow-up.

METHODS: Patients were divided into two groups according to preoperative T1 slope, and the postoperative cervical alignment change was compared between the groups. Postoperative kyphosis and LCL incidence were also evaluated at 2-year follow-up. The relationships between postoperative cervical alignment change and preoperative variables, including age, T1 slope, cervical ROM, C2–C7 SVA, and T1 slope minus C2–C7 Cobb angle (T1S–CL), were investigated.

RESULTS: Patients were divided into two groups above and below median preoperative T1 slope (23.2°). There were no differences in age, sex, type of OPLL, or operation level between the two groups. Patients with higher preoperative T1 slope demonstrated significantly more lordotic preoperative cervical alignment (p=.001). Patients with higher preoperative T1 slope were more likely to exhibit postoperative LCL (p=.03), and when it occurred the degree of LCL was greater (p=.06). In multiple linear regression analysis, higher T1 slope (B=0.414, p=.04) and lower T1S–CL (B=–0.412, p=.03) were significantly associated with more postoperative LCL. In spite of these results, postoperative kyphosis did not occur more frequently in patients with higher T1 slope (p=.64).

FDA device/drug status: Not applicable.

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CONCLUSIONS: Patients with higher T1 slope had more lordotic curvature before surgery and demonstrated more LCL at 2-year follow-up. Cervical alignment was compromised after laminoplasty, and the degree of LCL was correlated with preoperative T1 slope. After laminoplasty for cervical OPLL, patients with higher T1 slope tended to exhibit a greater LCL yet did not drift into frank postoperative kyphosis.

Keywords: Cervical laminoplasty; Cervical OPLL; Kyphotic alignment change; Postoperative kyphosis; T1 sagittal angle; T1 slope

Introduction

It is important to assess preoperative sagittal alignment in patients with cervical ossification of the posterior longitudinal ligament (OPLL) that is amenable to posterior decompression surgery. Laminoplasty is an effective posterior surgical method for the treatment of multilevel OPLL or OPLL involving the C2. Preoperative lordosis of the cervical spine is a prerequisite for laminoplasty, and maintaining postoperative lordosis is also important for spinal cord decompression [1]. Despite sufficient preoperative lordosis, laminoplasty often diminishes lordosis and straightens the cervical spine [2]. Therefore, it is important to investigate the preoperative risk factors related to kyphotic alignment change after laminoplasty.

Recently, T1 slope (T1S) has emerged as a predictor of kyphotic alignment change after laminoplasty [3–6]. More marked kyphotic alignment change by posterior structural injury after laminoplasty was reported in patients with higher T1S [4,7]. Several previous studies have reported that the concept of T1S was similar to the relationship among pelvic incidence (PI), sacral slope, and lumbar lordosis [4,8]. As a constant morphological parameter not influenced by posture, these previous reports defined the thoracic inlet angle (TIA) as the angle formed by a line from the center of the T1 upper end plate (T1UEP) vertical to the T1UEP, and a line connecting the center of the T1UEP and the upper end of the sternum. As an orientation parameter influenced by posture, the T1S was defined as the angle formed between the horizontal plane and the T1UEP. Neck tilt (NT) was defined as the angle formed by a line drawn in the upper end of the sternum and a line connecting the center of the T1UEP and the upper end of the sternum. Geometrically, a formula, TIA=T1S+NT, was developed, similar to "PI=sacral slope+pelvic tilting" [4,5,8–11]. The parameters TIA, NT, and T1S have constant morphological values within an individual and significantly influence the sagittal balance of the cervical spine [6,8,11–13]. Among these parameters, T1S or T1 sagittal angle is known to be useful in evaluating sagittal balance, and it was most strongly correlated with the C2–C7 sagittal vertical axis (SVA) [10]. However, there have been few studies concerning the relationship of T1S with kyphotic alignment change after laminoplasty.

Ossification of the posterior longitudinal ligament is a major cause of compressive myelopathy of the cervical spine. Although the clinical features of cervical OPLL are similar to those of cervical spondylotic myelopathy or cervical disc herniation, it also has unique characteristics. Cervical OPLL involves a ventrally located compressive lesion, usually involves multiple levels, and even more frequently involves C2 than other degenerative diseases. In such cases, laminoplasty is the only treatment option. Therefore, understanding the relationship between perioperative sagittal balance and updated parameters such as TIA, NT, and T1S is important. It is also critical to understand the significance of such updated parameters and to determine their relationship to postoperative kyphosis after laminoplasty in patients with OPLL.

The goals of the present study were to investigate the relationship between T1S and loss of cervical lordosis (LCL), and to identify the role of T1S as a predictor of postoperative kyphosis in patients with OPLL.

Methods

Patient population

Between January 2011 and January 2012, 170 patients underwent decompression surgery for cervical OPLL at our hospital. Among them, 79 who had undergone posterior laminoplasty were initially selected. Sixty-four consecutive patients were included in the present study and finished the 2-year follow-up. Inclusion criteria were (1) diagnosis of OPLL, (2) no previous history of cervical spine surgery, and (3) no cervical spinal deformity resulting from fracture, tumor, infection, or congenital abnormality. Computed tomography was performed to identify the presence and the type of OPLL in all patients before surgery. In the present study, all patients underwent expansive open-door laminoplasty using a plate fixation system. For all C2 levels, dome-shaped undercutting of the axis was performed, but complete osteotomy of the C2 spinous process was not performed. In all cases, the interspinous ligaments were preserved during surgery, and no laminectomy procedures were performed at any operating level. Postoperatively, all patients were taught to wear a Philadelphia neck collar for 4 weeks.

Radiographic assessment

Cervical spine anteroposterior, lateral, flexion, and extension radiographs were taken preoperatively and postoperatively at 2-year follow-up. Lateral radiographs of the cervical spine were taken in a comfortable standing position, with the patient's head facing forward for horizontal gaze.