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Case study

Addition of instrumented fusion to laminoplasty cannot suppress postoperative sagittal balance exacerbation

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1. Introduction

Recently, the concept of spinal sagittal balance was introduced and applied to the cervical spine. Cervical sagittal imbalance can lead to pain and impairment of activities of daily living (ADL) and quality of life (QOL) [1,2].

Laminoplasty (LMP) is widely used as a procedure to treat the posterior cervical spine [3–5]. LMP has several strong points: it is a technically independent procedure, simultaneous decompression can be obtained and spinal canal widening can be performed in patients with developmental spinal canal stenosis. In contrast, LMP has several shortcomings including postoperative neck or shoulder pain [6], and postoperative progression of kyphosis [7]. Especially, postoperative kyphosis is problematic because it can lead to neurological deterioration as a result of insufficient spinal cord decompression [8,9]. A posterior cervical approach is inevitably invasive for posterior musculature and the ligamentous complex, possibly resulting in aggravation of cervical alignment and sagittal balance [10,11].

Addition of posterior instrumented fusion to laminoplasty (posterior decompression with instrumented fusion; PDF) can prevent postoperative kyphosis [12–14]. Therefore PDF can improve the outcome of laminoplasty for cervical spondylotic myelopathy (CSM) with kyphotic cervical alignment and ossification of the posterior longitudinal ligament (OPLL) with thick ossification foci or kyphotic alignment, or both, and both pathologies can result in a worse outcome because of insufficient spinal cord decompression [15,16]. However, it is unclear whether PDF can prevent postoperative aggravation of cervical sagittal balance induced by LMP.

The aim of the present study was to elucidate the difference between LMP and PDF surgeries in postoperative alteration of cervical sagittal balance after posterior surgery.

2. Patients and methods

2.1. Patients

In the present study we retrospectively evaluated a total of 53 patients who underwent laminoplasty (LMP, $n = 30$) or posterior decompression with instrumented fusion (PDF, $n = 23$) in our institute from November 2003 to April 2013 and who were followed up for at least 2 years.

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Table 1
Demographic data of the patients. **: $p < 0.01$.

	LMP ($n = 30$)	PDF ($n = 23$)
Sex (male:female)	22:8	20:3
Age at surgery (years old)	62.8 (31–81)	65.7 (47–80)
Follow-up period (months)	40.4 ± 8.2	80.7 ± 27.9**
Pathologies		
OPLL	15	23**
CSM	12	0
Disk herniation	3	0

Table 2
Comparison of pre- and post-operative clinical and radiological assessments between the laminoplasty (LMP) and posterior decompression with instrumented fusion (PDF) groups. Data are presented as mean ± standard deviation. *: $p < 0.05$, **: $p < 0.01$.

	LMP	PDF
Clinical outcomes		
JOA score		
Pre-OP (points)	9.0 (2.5–14)	8.8 (5–16.5)
Post OP (points)	13.4 (9.5–17)	12.0* (5–15)
Increment (points)	4.2 (1–14.5)	3.5 (0–8)
Recovery rate (%)	53.1 ± 25.6	40.7 ± 25.3*
Neck pain (NRS)	4.2 ± 2.5	3.4 ± 2.9
NDI	13.8 ± 8.9	11.4 ± 7.4
EQ-5D	0.62 ± 0.18	0.68 ± 0.15
Radiological measurements		
C2-7 angle (°)		
Pre-OP	9.6 ± 6.2	0.9 ± 6.7**
Post-OP	2.9 ± 12.5	0.9 ± 7.8
Change	6.6 ± 9.5	0.0 ± 4.5**
C7 tilt (°)		
Pre-OP	24.0 ± 5.2	18.7 ± 6.7**
Post-OP	24.0 ± 7.7	21.2 ± 7.0
Change	0.0 ± 5.8	2.5 ± 6.0
CGH-C7 SVA (mm)		
Pre-OP	22.4 ± 12.7	26.2 ± 15.4
Post-OP	35.2 ± 17.5	40.9 ± 14.7
Change	12.8 ± 14.3	14.7 ± 16.9

The background data of patients from both groups are shown in Table 1. There was no significant difference in sex and age at surgery between the groups. The average follow-up period was significantly longer in the PDF group (80.7 ± 27.9 months) than in the LMP group (40.4 ± 8.2 months, $p < 0.01$, Student t test). Pathologies included ossification of the posterior longitudinal ligament (OPLL, 38 cases), cervical spondylotic myelopathy (CSM, 12 cases), and disk herniation (3 cases). The LMP group included 15 cases of OPLL, 12 cases of CSM, and 3 cases of disk herniation, whereas all of the patients in the PDF group had OPLL ($p < 0.01$, chi-square test).

LMP was an open-door type laminoplasty with a strut bone graft of hydroxyapatite spacer (Tsuji–Ito method). PDF was a double-door type laminoplasty followed by instrumented fusion using a screw–rod system from C2 (C3) to C7 (T1). Patients with less than 4 levels of fusion were excluded from the present study.

2.2. Methods

Pre- and postoperative Japanese Orthopedic Association (JOA) scores were assed as a measure of clinical outcome [17]. The change of JOA score was calculated by subtraction of preoperative JOA score from postoperative JOA score. JOA score recovery rate was calculated using the following formula: change of JOA score (postoperative JOA score – preoperative JOA score) divided by preoperative JOA score deficiency (full JOA score (17 points) – preoperative JOA score) × 100 (%). Neck pain was evaluated using a numerical rating scale (NRS; 0 having no pain and 10 having the worst imaginable pain) at final follow-up visit. ADL were evaluated using the Japanese version of the Neck Disability Index (NDI) and QOL was assessed with the Japanese version of the Euro-QOL 5-dimensions (EQ-5D) at final follow-up visit.

C2–C7 angle (angle between inferior endplates of the C2 and C7 vertebrae; cervical lordosis was expressed as a positive value, and kyphosis was expressed as a negative value), C7 tilt (angle between the upper endplate of the seventh cervical vertebra and horizontal line) and the center of the gravity head-C7 sagittal vertical axis (CGH-C7 SVA, distance between the perpendicular line from the anterior edge of the external auditory canal and the center of the C7 vertebral body; a parameter for cervical sagittal balance) were measured from plain lateral radiographs of the cervical spine in a neutral position obtained while the patients were standing. We employed C7 tilt instead of T1 tilt, which is widely used for measurement of the reflection of thoracic and lumbar vertebrae, because the measurement of T1 tilt was difficult in several cases because of shoulder interruption on lateral radiograms [18].

C2–C7 angle, C-SVA, and C7 tilt were measured before surgery and at final follow-up visit. The alteration of C2–C7 angle (dC2–C7 angle), C7 tilt (dC7 tilt), and CGH-C7 SVA (dCGH-C7 SVA) were defined as the subtraction of post- and preoperative values and an increase between the values was expressed as a positive and a decrease was expressed as a negative value.

2.3. Statistics

Statistical analyses were performed using a Student t test for comparison of clinical outcome measures and measurements of imaging studies between groups. Power analyses were performed to calculate statistical power for each analyses using Student t test. Pearson's correlation coefficient was used to compare each cervical sagittal balance parameter and differences between clinical outcomes. We considered $p < 0.05$ as significant. Correlation coefficients were considered as follows: −1.000 to −0.600 strong negative correlation, −0.599 to −0.400 moderate negative correlation, −0.399 to −0.200 weak negative correlation, −0.199 to +0.199 no correlation, +0.200 to +0.399 weak positive correlation, +0.400 to +0.599 moderate positive correlation, and +0.600 to +1.000 strong positive correlation. All the analyses were conducted using JMP version 10.0.2 (SAS Institute, Cary, NC).

3. Results

3.1. Clinical outcome

The average preoperative JOA score was 9.0 points (2.5–14 points) in the LMP group and 8.8 points (5–16.5 points) in the PDF group, showing no significant difference between the groups ($p = 0.35$). The average postoperative JOA score in the LMP group was 13.4 points (9.5–17 points), which was significantly higher than that in the PDF group (12.0 points; 5–15 points) ($p = 0.02$). The average increment of JOA score was 4.2 points (1–14.5 points) in the LMP group and 3.5 points (0–8 points) in the PDF group. There was no significant difference between the LMP and PDF groups in change of JOA score ($p = 0.18$). The average JOA score recovery rate was significantly higher in the LMP group (53.1 ± 25.6%) than in the PDF group (40.7 ± 25.3%, $p = 0.04$).

Neck pain measured by NRS was 4.2 ± 2.5 in the LMP group and 3.4 ± 2.9 in the PDF group, showing no significant difference between the groups ($p = 0.16$). The average NDI score was 13.8 ± 8.9 in the LMP group and 11.4 ± 7.4 in the PDF group. There was no significant difference in NDI score between the groups ($p = 0.15$). The average utility index of QOL measured by EQ-5D