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Clinical Study

Addition of instrumented fusion after posterior decompression surgery suppresses thickening of ossification of the posterior longitudinal ligament of the cervical spine

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ABSTRACT

Laminoplasty (LMP) is a widely accepted surgical procedure for ossification of the posterior longitudinal ligament (OPLL) of the cervical spine. Progression of OPLL can occur in the long term after LMP. The aim of the present study was to determine whether addition of the instrumented fusion, (posterior decompression with instrumented fusion [PDF]), can suppress progression of OPLL or not. The present study included 50 patients who underwent LMP (n = 23) or PDF (n = 27) for OPLL of the cervical spine. We performed open door laminoplasty. PDF surgery was performed by double-door laminoplasty followed by instrumented fusion. We observed the non-ossified segment of the OPLL and measured the thickness of the OPLL at the thickest segment with pre- and postoperative sagittal CT multi-planar reconstruction images. Postoperative CT scan revealed fusion of the non-ossified segment of the OPLL was obtained in 4/23 patients (17%) in the LPM group and in 23/27 patients (85%) in the PDF group, showing a significant difference between both groups ($p = 0.003$). Progression of the thickness of the OPLL in the PDF group (−0.1 ± 0.4 mm) was significantly smaller than in the LMP group (0.6 ± 0.7 mm, $p = 0.0002$). The proportion of patients showing the decrease in thickness of OPLL was significantly larger in the PDF group (6/27 patients; 22%) than in the LMP group (0/23 patients; 0%, $p = 0.05$). In conclusion, PDF surgery can suppress the thickening of OPLL.

1. Introduction

Laminoplasty (LMP) is a widely accepted surgical procedure for ossification of the posterior longitudinal ligament (OPLL) of the cervical spine [1–4]. Thickening of OPLL can occur in the long term after LMP, possibly resulting in recurrence of spinal cord compression and deterioration of neurological symptoms [5,6].

Multislice CT scan has shown advantages for musculoskeletal imaging, including volumetric imaging and the ability to produce multi-planar reconstructions (MPR). By the acquisition of CT-MPR sagittal images, the precise morphology of the OPLL may be assessed, as distinct from plain radiographs or conventional axial CT scans, which have distinct limitations [7,8]. CT-MPR sagittal images of the OPLL can reveal a non-ossified segment of the ossification at the thickest segment of ossification foci, even if the ossification seems to be continuous when classified by plain radiography. The motion at the non-ossified segment of the OPLL may be highly correlated with aggravation of myelopathy [9]. Thickening of the OPLL often occurs at the non-ossified segment within the ossification foci.

Abumi first reported the addition of posterior instrumented fusion to LMP; and named it posterior decompression with instrumented fusion (PDF) [10]. The rationale of PDF is to achieve a better environment for neurological recovery by obtaining immediate stabilization at the non-ossified segment of the OPLL by the addition of posterior instrumented fusion. The stabilization obtained by PDF surgery can also reduce the mechanical stress on the non-ossified segment of the OPLL itself. However, it remains unclear whether the PDF surgery can suppress the progression of OPLL or not.

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The aim of the present study was to determine the suppressive effect of the instrumented fusion on thickening of OPLL.

2. Methods

2.1. Patient population

The present study included patients who underwent LMP or PDF for OPLL of the cervical spine from September 2005 to May 2013 at our institute. Patients whose follow-up was for less than 1 year or who did not receive follow-up CT scans at 1 year after surgery or later were excluded. Ultimately, the present study included a total of 50 patients (LMP 23 patients; PDF 27 patients). The patient background data are shown in Table 1.

2.2. Surgical procedures

We performed open door laminoplasty at C3–C6 (or C7). We applied a resected spinous process or hydroxyapatite spacer as a strut graft to maintain the elevation of laminae. PDF surgery was performed by double-door laminoplasty followed by instrumented fusion at C2–C7 (or T1). We applied pedicular screws at C2, C7, and T1, lateral mass screws at C3–C6, and C2 laminar screws in cases of a high-riding vertebral artery. After decompression, we applied rods to obtain *in situ* fixation without excessive correction of the cervical alignment.

2.3. Patients and methods

We observed the non-ossified segment of the OPLL and measured the thickness of the OPLL at the thickest segment with pre- and postoperative sagittal CT-MPR images [11,12]. The CT scans were acquired by continuous helical scanning (Aquilion 3; Toshiba Medical Systems, Tochigi, Japan) and sagittal plane image reconstruction was obtained using Vitrea software (Toshiba Medical Systems). Three consecutive sagittal images were acquired at 1 mm intervals, including a midsagittal slice. Non-ossified segment of the OPLL was defined as the discontinuation of the ossification foci detected by sagittal CT-MPR imaging. The thickness of the OPLL was measured as the thickest part of the OPLL in three consecutive slices by sagittal CT-MPR imaging. We also assessed cranial progression of OPLL in sagittal CT-MPR images. The most cranial end of the ossification foci was observed and cranial progression was defined as the subtraction between pre- and postoperative OPLL. Four experienced spinal surgeons independently observed the CT scans and performed measurements on two separate occasions at an interval of at least 3 days.

We assessed Japanese Orthopedic Association (JOA) score pre- and postoperatively, and the recovery rate was calculated by the following formula: obtained points (i.e., postoperative JOA score minus preoperative JOA score) divided by the preoperative defect points (i.e., maximum score (17) points minus the preoperative JOA score). We compared the recovery of JOA score between the groups. Correlation between the progression of OPLL and JOA score recovery was assessed in both groups. The operative time, estimated blood loss and perioperative complications were compared between both groups by clinical records.

Statistical analyses were performed using a Student *t*-test for comparison of the OPLL thickness, JOA score (pre- and postoperative JOA scores, acquired score and recovery rate), operative time and estimated blood loss. A Pearson correlation coefficient for progression of OPLL and JOA score recovery, and a Fisher exact test for the ratio of fusion of the non-ossified segment of OPLL. Intraclass correlation coefficients (ICC) were used to determine the interobserver and intraobserver reliabilities of the CT measurement [13]. $P < 0.05$ was considered significant.

Table 1
Background data of study patients who underwent laminoplasty (LMP) or posterior decompression with instrumented fusion (PDF) for ossification of the posterior longitudinal ligament (OPLL) of the cervical spine, from September 2005 to May 2013. JOA = Japanese Orthopedic Association, Pre-op = pre-operative

	LMP (n = 23)	PDF (n = 27)
Sex (male: female)	20: 3	23: 4
Age at surgery	59.8 ± 10.2	63.7 ± 11
Follow up	47.2 ± 29.3	45.4 ± 32.6
Pre-OP JOA score (points)	8.4 ± 3.1	7.9 ± 2.3
Post-OP JOA score	12.8 ± 0.7	11 ± 0.6
Acquired JOA score (points)	4.2 ± 0.8	3.1 ± 0.8
Recovery rate of JOA score (%)	44.3 ± 7.4	32.2 ± 7.1
Type of OPLL		
Continuous	0	1
Mixed	9	10
Segmental	14	16
Operative time (min)	187 ± 37	384 ± 30**
Estimated blood loss (g)	215 ± 232	801 ± 185
Perioperative complications		
Dural tear	0	1
Surgical site infection	0	1
Segmental palsy	1	1

3. Results

ICC analyses showed that intra-rater reliability ($R^2 = 0.87$) and inter-rater reliability ($R^2 = 0.96$) were almost ideal. Postoperative CT scan revealed fusion of the non-ossified segment of the OPLL was obtained in 4/23 patients (17%) in the LPM group and in 23/27 patients (85%) in the PDF group, showing a significant difference between both groups ($p = 0.003$). All the patients showing fusion of the non-ossified segment of the OPLL in the LMP group also showed fusion of corresponding laminae. Cranial progression was observed in both groups and there was no significant difference between groups (2.7 ± 1.3 mm in the LMP group and 1.8 ± 0.9 mm in the PDF group; $p = 0.56$). The average thickness of the OPLL was 6.2 ± 1.6 mm in the LMP group and 6.9 ± 1.8 mm in the PDF group preoperatively and 6.9 ± 1.7 mm in the LMP group and 6.7 ± 1.8 mm in the PDF group postoperatively. Progression of the thickness of the OPLL in the PDF group (−0.1 ± 0.4 mm) was significantly smaller than in the LMP group (0.6 ± 0.7 mm, $p = 0.0002$, Fig. 1). Not only suppression of the progression, but also a decrease in thickness of the OPLL was observed in some patients. The proportion of patients showing the decrease in thickness (more than 0.5 mm) of OPLL was significantly larger in the PDF group (6/27 patients; 22%) than in the LMP group (0/23 patients; 0%, $p = 0.05$). There was no significant difference in JOA score recovery between the two groups. There was no significant correlation between the clinical outcome and decrease in thickness of the OPLL. The present series did not include patients who needed revision surgery as a result of progression of OPLL in either group. Operative time was significantly longer in the PDF group compared with the LMP group ($p < 0.01$, Table 1) and estimated blood loss tend to be larger in the PDF group ($p = 0.07$, Table 1). There was no significant difference in perioperative complications between both groups (Table 1). CT-MPR sagittal images of representative patients are shown in Figure 2.

4. Discussion

The present result showed that PDF surgery not only suppressed thickening of the OPLL, but may also decrease thickness of the OPLL. The exact mechanism underlying the decrease in thickness of the OPLL after PDF surgery remains unclear. Mechan-