

Comparison of Laminoplasty and Posterior Fusion Surgery for Cervical Ossification of Posterior Longitudinal Ligament

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Abstract

This prospective multicenter study formed by the Japanese Ministry of Health, Labour and Welfare at 27 institutions aimed to compare postoperative outcomes between laminoplasty (LM) and posterior fusion (PF) for cervical ossification of the posterior longitudinal ligament (OPLL). Controversy exists regarding the role of instrumented fusion in the context of posterior surgical decompression for OPLL. Among the 479 patients enrolled, 189 (137 and 52 patients with LM and PF, respectively) were included and evaluated using the Japanese Orthopaedic Association (JOA) scores, the JOA Cervical Myelopathy Evaluation Questionnaire (JOACMEQ), and radiographical measurements. Basic demographic and radiographical data were reviewed, and the propensity to choose a surgical procedure was calculated. Preoperatively, patient backgrounds, radiographical measurements (K-line or cervical alignment on X-ray, OPLL occupation ratio on computed tomography, and increased signal intensity change on magnetic resonance imaging), or clinical status (JOA score and JOACMEQ) after adjustments showed no significant differences. The overall risk of perioperative complications was lower in LM (odds ratio [OR] 0.40, $p = 0.006$), and C5 palsy was significantly lower in LM (OR 0.11, $p = 0.0002$) than in PF. The range of motion ($20.91^\circ \pm 1.05^\circ$ and $9.38^\circ \pm 1.24^\circ$, $p < 0.0001$) in patients with PF was significantly smaller than in those with LM. However, multivariable logistic regression analysis showed no significant difference in JOA score, JOA recovery rate, or JOACMEQ improvement at two years. In contrast, OPLL progression was greater in LM group than in the PF group (OR 2.73, $p = 0.0002$). LM and PF for cervical myelopathy due to OPLL resulted in comparable postoperative outcomes at two years after surgery.

Introduction

Ossification of the posterior longitudinal ligament (OPLL), defined as heterotopic bone formation in the posterior longitudinal ligament,[1] is a common cause of degenerative cervical myelopathy (DCM).[2] Surgical decompression is indicated in moderate and severe myelopathy (modified Japanese Orthopaedic Association (JOA) score ≤ 14)[3]; however, patients with OPLL are at a higher risk of perioperative complications than patients with other forms of DCM.[4] Surgical intervention includes anterior, posterior, or combined approaches, but the posterior approach is predominantly chosen for surgical treatment with multilevel decompression (≥ 3 segments) because of its high complication rate in anterior or combined approaches.

Posterior surgeries include laminoplasty (LP) and laminectomy with fusion (PF); however, the optimal technique remains debatable.[5, 6] LP is recognized as a standard technique for the treatment of cervical multi-segment DCM, and a preferable long-term outcome has been reported with its use in cervical OPLL compared to PF.[7–9] In contrast, however, some patients demonstrated poor results,[10] especially those who were K-line (-), and/or those with a high percentage of ossification occupation rate.[11–13] In addition, long-term follow-up has revealed increased ossification after LP, leading to reoperation.[14, 15] PF is another posterior procedure that has become widely used with the development of instruments. PF has a low risk of kyphotic change and ossification progression after surgery, and physicians believe that PF is preferable to LP in cases with severe ossification and/or in those that are K-line (-),[5] but sufficient

scientific evidence has not been accumulated. Systematic review and meta-analysis comparing these procedures showed equivalent postoperative results; however, the details were unclear because there are limited numbers of small-scale prospective studies.[5] In particular, the size and types of OPLL have a considerable impact on the severity of myelopathy and the postoperative course, which makes comparisons difficult. In other words, the two techniques must be compared equally, taking into account the higher chance of including severe cases in PF.

Thus, the objective of the present study was to compare postoperative outcomes between LP and PF for cervical OPLL in a propensity score-matched analysis to adjust for baseline factors and radiographical characteristics of spinal cord compression.

Methods

This nationwide, multicenter, longitudinal study involved 28 academic institutions of the Japanese Multicenter Research Organization for Ossification of the Spinal Ligament formed by the Japanese Ministry of Health, Labour and Welfare. This study was approved by the Ethics committee of Tokyo Medical and Dental University (M2000-1963), and performed in accordance with the Declaration of Helsinki. All patients provided written, informed consent on entry into the registry. In total, 478 Japanese patients with cervical OPLL were prospectively enrolled from April 2015 to July 2017. Data were analyzed after obtaining approval from the Ethics Committee of all participating institutions. Patients were eligible for inclusion in the present study if they (1) were aged 20 years or older; (2) had imaging evidence of OPLL on computed tomography (CT) and spinal cord compression on magnetic resonance imaging (MRI); and (3) underwent surgery. All patients received surgical decompression for the cervical spine, and the attending surgeon dictated the surgical approach and the number of levels to decompress. A total of 369 cases were initially enrolled in this study, among which, 260 and 109 underwent LP and PF, respectively. We excluded 59 patients with preoperative comorbidities affecting neurological and lower limbs' function, including 25 patients with a thoracolumbar spine surgery, 15 with limb joint surgery, 5 with mental diseases with medications, 3 with Parkinson's disease, and 11 others; 34 patients with cervical spondylotic amyotrophy, spinal cord injury, or radiculopathy; and 39 patients with incomplete questionnaire data at two years after surgery were also excluded. In addition, 28 patients with incomplete radiographical followed-up data were excluded. Finally, the remaining 189 patients were included in the current study (Table 1).

Table 1

Demographic parameters, preoperative radiographical parameters and quality of life in the original sample (before weighting) of patients undergoing laminoplasty or posterior spinal fusion.

		Laminoplasty (n = 137)	Posterior spinal fusion (n = 52)	p
Age (y)		64.2 (11.6)	63.9 (10.6)	0.85
Sex	(male ratio: %)	70.1	73.1	0.68
Body mass index		25.0 (3.7)	26.4 (4.6)	0.03
Smoking history (%)		32.8	44.2	0.15
Duration of symptoms		46.5 (74.7)	40.9 (55.7)	0.63
Levels of surgery		3.4 (0.9)	4.9 (1.5)	< 0.0001
Comorbidities	diabetes mellitus (%)	29.2	40.4	0.14
	hypertension (%)	40.9	30.8	0.20
	malignancy (%)	5.8	5.8	0.99
	cerebrovascular disease (%)	7.3	3.8	0.39
	myocardial infarction (%)	2.9	7.7	0.16
	collagen disease (%)	0.7	3.8	0.17
Drug	anticoagulant	11.7	13.5	0.74
Radiographical measurements	cervical lordosis (°)	11.5 (11.4)	6.5 (11.4)	0.008
	range of motion (°)	26.3 (12.5)	24.9 (14.7)	0.50
	K-line (+/-) (%)	73	59.6	0.08
	thickness of ossification (mm)	4.9 (1.6)	6.3 (1.7)	< 0.0001
	spinal canal occupation ratio > 60% (%)	6.6	34.6	< 0.0001
	increased signal intensity on MRI (%)	85.4	90.4	0.37
JOA score		11.1 (2.5)	9.9 (3.2)	0.007

Summary statistics for continuous variables are means and standard deviations. JOA: Japanese Orthopaedic Association; JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; MRI: magnetic resonance imaging

		Laminoplasty (n = 137)	Posterior spinal fusion (n = 52)	p
JOACMEQ	cervical function	63.0 (27.7)	53.8 (31.0)	0.0501
	upper limb function	71.9 (21.9)	64.1 (30.2)	0.051
	lower limb function	56.3 (29.2)	49.2 (30.6)	0.14
	bladder function	73.3 (20.0)	72.0 (26.7)	0.71
	quality of life	44.6 (17.3)	43.1 (20.0)	0.62
Visual analog scale	pain or stiffness in the neck or shoulder	37.7 (32.0)	50.0 (30.6)	0.02
	tightness in the chest	9.7 (20.9)	13.0 (20.3)	0.03
	pain or numbness in the arms or hands	58.4 (31.1)	68.8 (25.8)	0.046
	pain or numbness from chest to toe	40.8 (33.4)	51.4 (29.8)	0.33
Summary statistics for continuous variables are means and standard deviations. JOA: Japanese Orthopaedic Association; JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; MRI: magnetic resonance imaging				

Data collection

Data were collected for each participant, including demographic information, symptomatology, causative pathology, and surgical summary. Functional impairment, disability, and quality of life (QOL) were also evaluated preoperatively and at 24 months postoperatively. Basic demographic and clinical data, including age, sex, diabetes status, body mass index (BMI), smoking history, and disease duration, were collected for each patient.

Evaluation

Clinical assessments

Clinical status was evaluated using the cervical Japanese Orthopaedic Association (JOA) score and the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ) preoperatively and at two years post-surgery. The JOA recovery rate was calculated as follows: $(\text{postoperative JOA} - \text{preoperative JOA}) / (17 - \text{preoperative JOA}) \times 100$. [16] The minimum clinically important difference (MCID) of the JOA score and the JOA recovery rate were defined as 2.5 points and 52.8%, respectively. [17] The JOACMEQ includes 24 questions covering the domains of cervical function,

upper limb function, lower limb function, bladder function, and QOL.[18, 19] Scores for each domain were calculated according to official guidelines and range from 0 to 100 points, with a higher score indicating better health status. The JOACMEQ also incorporates visual analog scale (VAS) scores for pain or stiffness in the neck or shoulder, tightness in the chest, pain or numbness in the arms or hands, and pain or numbness from chest to toe. We evaluated improvement of JOACMEQ in each of its five domains. Clinically significant improvement was defined if 1) the patient answered all the questions necessary to calculate the functional score of a domain and an increase of ≥ 20 points was obtained for that score, or 2) the functional score after treatment was > 90 points, even if answers for any unanswered questions was considered to be the worst possible choice.

Each attending surgeon was also required to record all adverse events throughout the study period. A central panel of investigators classified each adverse event as related to surgery; any discrepancies among reviewers were resolved by consulting source documents. Perioperative complications were defined as surgery-related events occurring within 30 days of surgery.

Radiographical assessments

The most compressed level and the presence of a signal intensity change in the spinal cord were also investigated on mid-sagittal MRI.

The number of ossification levels (longitudinal extent of OPLL), K-line (positive or negative),[6] JOA welfare classification (continuous, segmental, mixed, and circumscribed),[4] spinal canal occupation ratio of OPLL on axial CT at the maximum cord compression level, and signal intensity change on T2 weight MRI were investigated.

The cervical lordotic angle (C2–7 angle) and range of motion (ROM) in flexion-extension were also measured using tangential lines drawn on the posterior edge of the C2 and C7 vertebral bodies on lateral radiographs taken in a neutral position.

Statistical analysis

Propensity score methods were used to estimate treatment effects of observational data in the present study. A backward elimination logistic regression model was fitted to estimate the probability of treatment assignment, including all the relevant baseline variables with p-values less than 0.25. In order to balance the distribution of baseline variables between treatment groups, a pseudo sample was created by weighting standardized inverse probability of treatment, in which we replaced extreme values of weight with those of the 1st and 99th percentiles. The Student t-test and Chi-square test were used to compare differences in means and proportions, respectively, of baseline covariates in the weighted sample. The covariates that were found to be different between the two groups with p-values less than 0.05 were further adjusted in the generalized linear model to compare treatment effects 30 days and 2 years after the operation. We calculated odds ratios (ORs) and the 95% confidence intervals (95% CIs) for the dichotomized indices taking PF as the reference, and mean differences for the continuous variables adjusted for age, sex, and unbalanced variables. A two-sided p-value less than 0.05 was considered

statistically significant. Statistical analysis was conducted using SAS version 9.4 (SAS Institute. Inc, Cary, NC, USA).

Results

Table 2 showed demographic parameters, preoperative radiographical parameters and QOL in the weighed sample (post propensity score matching) of patients undergoing LP or PF. There was no significant difference in age, sex, BMI, duration of symptoms, smoking history, or anticoagulant drug use. With respect to comorbidities, although there was no significant difference in diabetes mellitus, hypertension, malignancy, myocardial infarction, or collagen disease, the frequency of cerebrovascular disease was higher in the LP group than in the PF group (7.4% and 1.4%, respectively, $p = 0.04$). Baseline radiographical measurements were not significantly different between groups, as assessed by cervical lordosis, ROM, K-line, thickness of ossification, spina canal occupation ratio of the OPLL > 60%, or increased signal intensity on MRI. Baseline functional status and QOL were also not significantly different, as assessed by JOA score or JOACMEQ. The two exceptions were the bladder function score in JOACMEQ, which was significantly higher in the PF group than in the LP group (mean (standard deviation, SD) of 79.7 (33.6) compared with 72.8 (20.5); $p = 0.03$) and VAS pain or numbness in the arms or hands in JOACMEQ, which was significantly higher in the PF group than in the LP group (mean (SD) of 68.0 (32.8) compared with 59.9 (32.4); $p = 0.048$).

Table 2

Demographic parameters, preoperative radiographical parameters, and quality of life in the weighed sample of patients undergoing laminoplasty or posterior spinal fusion.

		Laminoplasty	Posterior spinal fusion	p
Age (yr)		64.3 (11.9)	66.7 (14.7)	0.13
Sex	(male ratio: %)	70.7	67.4	0.55
Body mass index		25.0 (3.7)	24.8 (5.4)	0.75
Smoking history (%)		33.2	37.2	0.50
Duration of symptoms		44.4 (75.1)	41.9 (81.7)	0.80
Levels of surgery		3.5 (0.9)	3.6 (2.3)	0.96
Comorbidities	diabetes mellitus (%)	30.6	35.3	0.43
	hypertension (%)	41.6	36.9	0.45
	malignancy (%)	6.1	4.1	0.47
	cerebrovascular disease (%)	7.4	1.4	0.04
	myocardial infarction (%)	3.2	4.6	0.55
	collagen disease (%)	1.5	1.7	0.87
Drug	anticoagulant	11.8	7.2	0.21
Radiographical measurements	cervical lordosis (°)	11.6 (11.8)	10.4 (14.4)	0.42
	range of motion (°)	26.2 (12.7)	25.6 (24.0)	0.80
	K-line (+/-) (%)	73.6	65.2	0.14
	thickness of ossification (mm)	5.1 (1.7)	5.3 (2.8)	0.34
	spinal canal occupation ratio > 60% (%)	8.6	13.2	0.24
	increased signal intensity on MRI (%)	86.2	92.0	0.14
JOA score		10.9 (2.6)	10.6 (4.4)	0.55
JOACMEQ	cervical function	61.8 (28.0)	57.0 (44.1)	0.24
	upper limb function	70.5 (22.3)	65.1 (45.6)	0.15

Summary statistics for continuous variables are means and standard deviations. JOA: Japanese Orthopedic Association; JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; MRI: magnetic resonance imaging

		Laminoplasty	Posterior spinal fusion	p
	lower limb function	54.9 (29.6)	50.7 (47.4)	0.35
	bladder function	72.8 (20.5)	79.7 (33.6)	0.03
	quality of life	44.0 (17.5)	41.8 (32.6)	0.43
Visual analog scale	pain or stiffness in the neck or shoulder	39.0 (33.0)	41.4 (46.1)	0.59
	tightness in the chest	9.7 (21.9)	8.3 (26.2)	0.63
	pain or numbness in the arms or hands	59.9 (32.4)	68.0 (32.8)	0.048
	pain or numbness from chest to toe	42.2 (34.4)	47.5 (52.9)	0.29
Summary statistics for continuous variables are means and standard deviations. JOA: Japanese Orthopedic Association; JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; MRI: magnetic resonance imaging				

Overall, perioperative complications were significantly lower in the LP group than in the PF group (17.0% and 29.7%, respectively, $p = 0.02$). In particular, C5 palsy was significantly more infrequent in the LP group than in the PF group (3.9 % and 19.9 %, $p = 0.0002$); however, there was no significant difference in dural tear, wound disruption, wound infection, or revision surgery. Multivariable logistic regression analysis showed overall complications (OR 0.40, 95% CI 0.21–0.77, $p = 0.006$) and C5 palsy (OR 0.11, 95% CI 0.03–0.34, $p = 0.0002$) were significantly lower in the LP group than in the PF group (Table 3).

Table 3

Logistic regression analysis for complications and revision surgery in the weighed sample of patients undergoing laminoplasty or posterior spinal fusion

	OR	95% CI	p
Overall complications	0.40	0.21–0.77	0.006
C5 palsy	0.11	0.03–0.34	0.0002
Dural tear	1.99	0.28–14.1	0.49
Wound disruption	0.26	0.02–3.62	0.32
Deep wound infection	0.54	0.11–2.60	0.44
Superficial wound infection	0.24	0.03–1.73	0.16
Revision surgery	0.31	0.01–11.10	0.52
Weighted for IPTW and further adjusted for baseline age, sex, VAS "pain or numbness in the arms or hands", preoperative JOACMEQ "bladder function", preoperative comorbidity "cerebrovascular disease"			
IPTW: inverse probability of treated weighting; JOACMEQ: the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; OR: odds ratio; CI: confidence intervals; VAS visual analogue scale			

Patients achieved similar postoperative functional and QOL outcomes on JOA score, JOA recovery rate, and JOACMEQ score (Table 4). There were also no significant radiographical differences between groups (Table 4). ROM and JOACMEQ cervical function score were significantly smaller in the PF group compared to the LP group (20.91 ± 1.05 and 9.38 ± 1.24 , $p < 0.0001$; 67.64 ± 2.78 and 55.46 ± 3.29 , $p = 0.005$, respectively) (Table 4). Multivariable logistic regression analysis showed no significant difference in JOA score $>$ MCID, JOA recovery rate $>$ MCID, or clinically significant improvement in JOACMEQ (Table 5). The percentage of patients with progression in the thickness of OPLL was significantly higher in the LP group than in the PF group (56.0% vs. 30.5% in PF; OR 2.73, 95% CI 1.60–4.67, $p = 0.0002$) (Table 5).

Table 4

Two years postoperative radiographical parameters and quality of life in the weighed sample of patients undergoing laminoplasty or posterior spinal fusion.

		Laminoplasty	Posterior spinal fusion	p
Radiographical measurements	cervical lordosis (°)	9.69 (1.10)	7.66 (1.30)	0.24
	range of motion (°)	20.91 (1.05)	9.38 (1.24)	< 0.0001
	thickness of ossification (mm)	6.11 (0.54)	4.80 (0.64)	0.12
JOA score		13.73 (0.21)	13.72 (0.25)	0.97
JOA RR		45.84 (3.08)	51.15 (3.65)	0.27
JOACMEQ	cervical function	67.64 (2.78)	55.46 (3.29)	0.005
	upper limb function	80.45 (1.76)	77.53 (2.08)	0.29
	lower limb function	63.44 (2.44)	56.19 (2.89)	0.058
	bladder function	77.19 (1.62)	76.12 (1.92)	0.67
	quality of life	53.63 (1.64)	50.77 (1.94)	0.27
Visual analog scale	pain or stiffness in the neck or shoulder	35.85 (2.78)	38.18 (3.29)	0.59
	tightness in the chest	9.94 (1.80)	7.80 (2.13)	0.89
	pain or numbness in the arms or hands	39.84 (2.70)	44.20 (3.20)	0.30
	pain or numbness from chest to toe	33.10 (2.83)	34.78 (3.35)	0.70

Values are means and standard errors. Weighted for IPTW and further adjusted for baseline age, sex, VAS pain or numbness in the arms or hands, preoperative CMEQ bladder function, preoperative comorbidity cerebrovascular disease

JOA: Japanese Orthopaedic Association; JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; IPTW: inverse probability of treated weighting; VAS visual analogue scale

Table 5

Logistic regression analysis for postoperative functional outcome and progression of OPLL in in the weighed sample of patients undergoing laminoplasty or posterior spinal fusion

		OR	95% CI	p
JOA score > MCID		0.98	0.57–1.68	0.94
JOA RR > MCID		0.88	0.50–1.53	0.64
Clinical improvement of JOACMEQ	cervical function	1.05	0.58–1.87	0.88
	upper limb function	1.04	0.57–1.89	0.90
	lower limb function	1.75	0.89–3.44	0.11
	bladder function	1.16	0.59–2.28	0.67
	quality of life	1.88	0.95–3.70	0.07
Progression of OPLL		2.73	1.60–4.67	0.0002
Weighted for IPTW and further adjusted for baseline age, sex, VAS [pain or numbness in the arms or hands], preoperative JOACMEQ [bladder function], preoperative comorbidity [cerebrovascular disease]				
JOA: Japanese Orthopaedic Association; JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; OR: odds ratio; CI: confidence intervals; OPLL: ossification of the posterior longitudinal ligament; MCID: minimum clinically important difference; IPTW: inverse probability of treated weighting; VAS visual analogue scale				

Discussion

This nationwide, multicenter, prospective study provides a comprehensive evaluation of the relative efficacy of LP and PF for patients with cervical OPLL. Comparable improvement was observed among patients with OPLL in both surgical procedures two years post-operation. The exceptions to this were the JOACMEQ cervical function scores and the cervical ROM on X-ray (Table 4), which were lower and smaller in the patients with PF than in those with LP. In contrast, logistic regression analysis revealed no clinically significant difference in the improvement of JOACMEQ cervical function (Table 5), and thus this difference might have a limited effect on the outcome of cervical function.

A relatively high incidence of surgical complications for cervical OPLL compared with other forms of DCM has been reported; neurologic deficit and neck pain are common in posterior procedures.[4, 20] In the current study, the overall complication rate (OR 0.40) and C5 palsy (OR 0.11) was significantly lower in LP compared with PF. Although the pathology of postoperative C5 palsy is still debated, iatrogenic foraminal stenosis and larger posterior shift of the spinal cord might be associated with a higher risk of C5 palsy in PF.[21, 22] Takemitsu et al. reported that the higher risk of postoperative C5 palsy with posterior instrumentation was 11.6 times greater than that without instrumentation,[23] and this relative risk was similar to the current result. However, the actual incidence of C5 palsy after posterior procedures

remains unclear with some retrospective studies having reported it as 0–30% and 2.6–50% in LP and PF, respectively.[21–25] This prospective study, however, demonstrated that the risk of C5 palsy was 10 times higher in posterior instrumentation; thus, prophylactic foraminotomy might be recommended to reduce C5 palsy in cases with PF.[24, 25]

Neck pain was reported as another common postoperative complication in cervical OPLL, compared with other forms of DCM,[4] and postoperative cervical kyphotic alignment might be associated with neck pain. Few studies have compared these complications between different posterior procedures in cervical OPLL. However, pain or stiffness in the neck or shoulder was comparable in the two procedures (Table 4). Prior to the current study, we hypothesized that postoperative kyphotic alignment change was more frequent in LP than in PF, which might be associated with postoperative neck pain. There were, however, no differences in radiographical alignment and degree of postoperative neck pain between groups. Machino et al. reported that the kyphotic alignment change after laminoplasty was observed in 7.2% of 457 cases with preoperative lordotic alignment, and the incidence of postoperative kyphotic change was relatively low.[26] Although kyphotic change after LP was reported in another report,[27] cervical alignment is maintained in the majority of cases if patient selection is appropriate.

With respect to functional and QOL outcomes at two years, there were significant differences in the average scores on the JOACMEQ cervical function domain and cervical ROM on X-ray (Table 4). The cervical function of the JOACMEQ is based on the results of four questions about activities of daily living that require neck up-and-down and rotation.[19] PF reduced ROM, which might be associated with its lower cervical function score in the JOACMEQ. Although JOACMEQ has criteria for determining whether these differences are clinically meaningful improvements, multivariate analysis showed no significant differences in postoperative improvement of cervical function. Therefore, the effect on the QOL was considered to be limited, though there was a numerical difference. Furthermore, although the perioperative complication of C5 palsy was frequent in PF, the majority of C5 palsy cases improved at two years. Therefore, this complication was not associated with significant negative outcomes at two years post-surgery.

Although reoperation for the progression of OPLL after LP was not observed in the two postoperative years reviewed in the current study, revision surgery around 10 years after LP has been reported.[14, 15] OPLL progression is commonly observed after LP[7, 8]; 70% of patients showed an increase in OPLL size 10 years after surgery.[15] The size of ossification commonly increases in young adults, those with continuous- or mixed-type OPLL, and those with kyphotic alignment change.[14, 15] Thus, there is a possibility of long-term deterioration in the QOL, and careful follow-up is mandatory.

Strengths and limitations

The findings of this study are likely to be more generalizable than findings from single-center studies since patients were prospectively enrolled at 24 multicenter sites. The large number of recruitment sites allowed us to evaluate outcomes for 189 patients with OPLL and LP or PF. In addition, we evaluated

outcomes using different radiographical and questionnaire tools, allowing for a comprehensive assessment of surgical outcomes in patients with OPLL.

This study has several limitations. First, a 26% attrition rate was observed at the two-year time point. Second, this is not an international study, and clinical outcomes depending on racial differences could exist. Third, a standardized surgical protocol was not utilized across centers and decisions about the approach, number of decompressed levels, and use of instrumentation and fusion were made at the discretion of the attending surgeon. Some baseline covariates were unbalanced between the two treatment groups in the weighted sample, and there may be residual systematic differences for other measured and unmeasured baseline covariates, which may yield a biased estimate of treatment effects. Although a backward elimination logistic regression model was used for baseline adjustment, PF was performed in more severe cases with less cervical lordosis or with larger spinal canal occupation of OPLL compared with LP. Therefore, a future prospective large-scale multicenter international study is needed to validate the current results.

In conclusion, cervical LP and PF provides almost comparable functional and QOL improvements at two years after surgery, although perioperative complications were higher in PF.

Declarations

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Author contributions

H.N., S.I., T.Y., M.K., Y.L., and H.Y. designed the study; H.N., S.I., T.Y., S.E., K.S., K.K., Y.N., T.H., K.W., K.K., K.F., A.K., T.F., T.K., Y.N., Y.O., N.N., K.A., M.T., K.M., H.N., K.M., S.M., T.K., K.Y., S.K., S.K., T.O., S.I., S.F., H.K., H.K., and M.K. collected the data; H.N., S.I., T.Y., M.K., Y.L., and H.Y. analyzed and interpreted the data; H.N., S.I., T.Y., M.K., Y.L., and H.Y. wrote the initial draft of the manuscript; H.N., Y.L., and H.Y. performed the statistical analyses. M.Y., A.O., and Y.K. supervised the study. M.M., M.Y., and A.O. acquired the funding. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

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