1. Introduction

Cervical laminoplasty has been widely used for the treatment of patients with cervical ossification of the posterior longitudinal ligament (OPLL) [1]. Since laminoplasty achieves indirect posterior decompression, it is not suitable for patients with preoperative cervical kyphotic alignment, and, given the mechanism of cord decompression, both preoperative and postoperative cervical lordosis are considered prerequisites for successful outcomes [2,3]. Thus, adequate decompression can be obtained when cervical lordosis is maintained, allowing the posterior shift of the cervical spinal cord after laminoplasty. Unfortunately, patients who undergo laminoplasty tend to exhibit a posterior change towards kyphotic alignment despite having sufficient lordosis preoperatively [4,5], which results in worse surgical outcomes of cervical laminoplasty [3].

Recently, the T1 slope (T1S) has emerged as a predictor of kyphotic alignment change after laminoplasty [4,6]. Moreover, it was reported that the degree of cervical lordosis decreases as the preoperative T1S increases, even in patients with initial lordotic cervical sagittal alignment. A more pronounced kyphotic alignment change by posterior structural injury after laminoplasty was reported in patients with higher T1S [6,7]. Thus, patients with high T1S are at greater risk of sagittal decompensation.

OPLL is a major cause of compressive myelopathy of the cervical spine. Although the clinical features of cervical OPLL are similar to those of other degenerative cervical compressive myelopathies, cervical OPLL has several unique characteristics. Specifically, cervical OPLL is characterized by the presence of a ventrally located compressive lesion that usually involves multiple levels. Therefore, maintenance of cervical lordotic alignment is even more important. Although it was reported that patients with cervical OPLL and higher T1S had more pronounced lordotic curvature before surgery and higher loss of cervical lordosis...
after surgery [8], few studies have attempted to correlate these findings with clinical outcomes [9].

The aim of the present study was to investigate the relationship of T1S with loss of cervical lordosis and surgical outcomes after laminoplasty for cervical OPLL. Additionally, we aimed to identify the role and clinical relevance of T1S as a predictor of postoperative kyphosis in patients with OPLL.

2. Materials and Methods

2.1. Patient population

We retrospectively reviewed the records of 35 consecutive patients (26 men and 9 women) with cervical OPLL who underwent double-door laminoplasty between December 2010 and March 2014 in our hospital.

The kyphosis line (K-line), which is drawn from the center of the canal at level C2 to the center of the canal at level C7, is widely used in making decisions regarding the surgical approach for patients with cervical OPLL [10]. In the present study, the indication for double-door laminoplasty was OPLL with K-line (+) in the neck neutral position. The inclusion criteria of the present study were diagnosis of OPLL, no previous history of cervical spine surgery, and no cervical spinal deformity resulting from fracture, tumor, infection, or congenital abnormality.

Computed tomography (CT) was performed to identify the presence of OPLL before surgery. The age at the time of surgery was 65.3 ± 10.7 years (age range, 48–81 years). All patients presented with symptoms and magnetic resonance imaging (MRI) findings consistent with myelopathy secondary to spinal cord compression by OPLL. All patients were followed up for more than 12 months, with a mean follow-up of 38.3 ± 23.8 months (range, 12–90 months).

2.2. Surgical technique for modified double-door laminoplasty

In the present study, double-door laminoplasty was performed according to Kurokawa’s method, with some modifications [11]. Specifically, the laminae were expanded one above and one below the OPLL level. The spinous processes were resected at the base, and the center of the laminae was cut using a thread-wire saw. Bilateral gutters were created as hinges at the border of the laminae and facets. After the halves of the laminae were elevated, the hydroxyapatite spinous process spacers were tied to bridge the bilateral edges of the laminae.

2.3. Postoperative considerations

On the second postoperative day, all patients were allowed to sit up and walk while wearing a soft collar, which was removed at 10 days after surgery. Afterwards, early cervical range-of-motion exercises were performed during rehabilitation.

2.4. Clinical assessment

We used the Japanese Orthopaedic Association (JOA) score to evaluate the severity of myelopathy preoperatively and at 12 months postoperatively. Postoperative improvement was evaluated in terms of the JOA score recovery rate, calculated by the Hirabayashi method as (postoperative JOA score − preoperative JOA score)/(17 − preoperative JOA score) × 100%, with a recovery rate of 100% indicating the best postoperative improvement. The multifactorial effects of variables such as sex, duration from onset to operation, and diabetes mellitus were also studied.

2.5. Radiological assessment

Cervical spine anteroposterior, lateral, flexion, and extension radiographs were taken preoperatively and at 12 months postoperatively. Lateral radiographs of the cervical spine were taken with the patient standing in a comfortable position, with the head facing forward and maintaining horizontal gaze. Cervical alignment was assessed in terms of the C2-C7 Cobb lordotic angle (LA), which was defined as the angle formed by the inferior end plates of C2 and C7.

B: T1 slope (T1S) was defined as the angle between a horizontal line and the superior end plate of T1.

C: C2-7 sagittal vertical axis (SVA) was defined as the distance from the posterosuperior corner of C7 and the vertical line passing through the center of the C2 body.

Fig. 1. Measurements of radiological parameters.

A: C2-7 lordotic angle (LA) was defined as the angle formed by the inferior end plates of C2 and C7.

B: T1 slope (T1S) was defined as the angle between a horizontal line and the superior end plate of T1.

C: C2-7 sagittal vertical axis (SVA) was defined as the distance from the posterosuperior corner of C7 and the vertical line passing through the center of the C2 body.

We investigated pre and postoperative C2-C7 Cobb LA, preoperative C2-C7 range of motion (ROM), loss of cervical lordosis, percentage of change in postoperative kyphosis, pre and postoperative C2-C7 SVA, change in C2-C7 SVA and occupying ratio of the OPLL. The parameters were calculated with the following formula: C2-C7 ROM (%) = (extension C2-C7 Cobb LA) − (flexion C2-C7 Cobb LA), loss of cervical lordosis (%) = (postoperative C2-C7 Cobb LA) − (preoperative C2-C7 Cobb LA), change in C2-C7 SVA (mm) = (postoperative C2-C7 SVA) − (preoperative C2-C7 SVA). The occupying ratio of the OPLL was defined as the greatest thickness of OPLL divided by the anteroposterior diameter of the bony spinal canal on a preoperative axial CT image. Two independent observers measured each parameter on images generated using a DICOM viewer on a DICOM workstation; the measurements were obtained using electronic calipers. In the present study, we investigated the reliability of the measurement techniques and found good to excellent intra- and inter-observer agreement for each parameter (Kappa > 0.70).

2.6. Statistical analysis

The statistical analysis was performed using StatView 5.0 software (SAS Institute Inc, Cary, NC, USA). Differences in the JOA score recovery rate and cervical lordosis were compared between patients with or without myelopathy using Student’s t-test. The relationship between the JOA score recovery rate and cervical lordosis was evaluated using Pearson’s correlation coefficient. A p-value of < 0.05 was considered significant.
All patients also underwent preoperative MRI performed using a 1.5-T Sigma MRI unit (Symphony; Siemens Medical Solutions, Erlangen, Germany). A modified grading system based on a protocol originally proposed by Yukawa et al. [14,15] was applied to assess the level was classified from Grade 0 to Grade 2 as follows: Grade 0, no increase in signal intensity; Grade 1, lightly (obscure) increased signal intensity; and Grade 2, intensely (bright) increased signal intensity. Intensely increased signal intensity (Grade 2) was defined as an intensity similar to that of the signal of cerebrospinal fluid (Fig. 2). These classifications were made by two independent observers. The concordance between the two observers in evaluating the signal change on T2-weighted images was good (Kappa > 0.76). The two observers established the final classification by consensus.

2.6. Statistical analysis

Data are presented as the number of subjects in each group or mean ± SD. Each independent variable was compared between the two groups using independent t test for continuous variables, and the chi test for categorical variable. To assess correlations between independent variables and dependent variable, we used Spearman correlation coefficients. Variables with a P value less than 0.10 in univariate analysis was considered for multivariate linear analysis. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) are presented with their respective P values. A value of P < 0.05 was accepted as significant.

3. Results

3.1. Comparison of clinical features and surgical outcomes according to preoperative T1S

Patients were divided into two groups according to whether T1S was above or below the average preoperative T1S (30.1 ± 6.9°; high-T1S vs. low T1S). Patient characteristics according to preoperative T1S are summarized in Table 1. T1S ranged from 31° to 49° in patients with higher preoperative T1S (high-T1S group, n = 18; T1S, 35.4 ± 4.8°), and from 17° to 29° in patients with lower preoperative T1S (low-T1S group; n = 17; mean T1S, 24.4 ± 3.4°). There were more male (high-T1S, n = 13; low-T1S, n = 13) than female patients (high-T1S, n = 5; low-T1S, n = 4) in both groups. The age at the time of surgery was 69.0 ± 7.5 years (age range, 57–81 years) in the high-T1S group and 61.4 ± 12.3 years (age range, 30–81 years) in the low-T1S group. Gender, age at the time of surgery, number of expanded laminae did not differ between the two groups. The clinical features and surgical outcomes are also showed. The following results were obtained: duration from symptom onset to operation (high-T1S, 27.3 ± 52.7 months; low-T1S, 17.0 ± 17.7 months; P > 0.05), preoperative JOA score (high-T1S, 10.8 ± 1.5; low-T1S, 10.9 ± 2.4; P > 0.05), postoperative JOA score (high-T1S, 13.6 ± 1.4; low-T1S, 14.0 ± 2.1; P > 0.05), JOA score recovery rate (high-T1S, 45.6 ± 11.9%; low-T1S, 50.3 ± 25.0%; P > 0.05), and incidence of diabetes mellitus (high-T1S, 12/18, 66.7%; low-T1S, 10/17, 58.8%; P > 0.05).

Table 1

Comparison of patient characteristics and surgical outcomes according to preoperative T1S.

<table>
<thead>
<tr>
<th>Variable</th>
<th>high-T1S</th>
<th>low-T1S</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients (n)</td>
<td>18</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>T1S (°) (range)</td>
<td>35.4 ± 4.8</td>
<td>24.4 ± 3.4</td>
<td></td>
</tr>
<tr>
<td>gender</td>
<td>13 males</td>
<td>13 males</td>
<td>n.s.</td>
</tr>
<tr>
<td>age at the time of surgery (years)</td>
<td>69.0 ± 7.5</td>
<td>61.4 ± 12.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>The number of expanded laminae</td>
<td>5.4 ± 1.5</td>
<td>4.6 ± 1.1</td>
<td>n.s.</td>
</tr>
<tr>
<td>duration from onset to operation (months)</td>
<td>27.3 ± 52.7</td>
<td>17.0 ± 17.7</td>
<td>n.s.</td>
</tr>
<tr>
<td>preoperative JOA score</td>
<td>10.8 ± 1.5</td>
<td>10.9 ± 2.4</td>
<td>n.s.</td>
</tr>
<tr>
<td>postoperative JOA score</td>
<td>13.6 ± 1.4</td>
<td>14.0 ± 2.1</td>
<td>n.s.</td>
</tr>
<tr>
<td>JOA score recovery rate (%)</td>
<td>45.6 ± 11.9</td>
<td>50.3 ± 25.0</td>
<td>n.s.</td>
</tr>
<tr>
<td>incidence of diabetes mellitus</td>
<td>66.7% (12/18)</td>
<td>58.8% (10/17)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

n.s.: not significant differences.

JOA indicates Japanese Orthopaedic Association.

3.2. Comparison of radiographic parameters according to preoperative T1S

The values of radiographic parameters are summarized in Table 2. The following results were obtained: preoperative C2-C7 Cobb LA (high-T1S, 19.8 ± 13.5°; low-T1S, 7.9 ± 10.5°; P = 0.007), preoperative C2-C7 Cobb LA (high-T1S, 16.1 ± 14.9°; low-T1S, 10.9 ± 11.3°; P > 0.05), preoperative C2-C7 ROM (high-T1S, 26.3 ± 13.1°; low-T1S, 35.0 ± 18.0°; P > 0.05), loss of cervical lordosis (high-T1S, 3.7 ± 9.5°; low-T1S, −3.0 ± 8.4°; P = 0.034), change in postoperative kyphosis (high-T1S, 2/18, 11.1%; low-T1S, 3/17, 17.6%; P > 0.05), preoperative C2-C7 SVA (high-T1S, 33.6 ± 11.9 mm; low-T1S, 29.5 ± 14.4 mm; P > 0.05), postoperative C2-C7 SVA (high-T1S, 35.2 ± 14.3 mm; low-T1S, 32.5 ± 17.1 mm; P > 0.05), change in C2-C7 SVA (high-T1S, 1.6 ± 8.3 mm; low-T1S, 3.0 ± 12.8 mm; P > 0.05), occupying ratio of the OPLL (high-T1S, 49.1 ± 18.6%; low-T1S, 41.0 ± 16.3%; P > 0.05) and preoperative MRI grade (high-T1S, 1.0 ± 0.8 mm; low-T1S, 0.8 ± 0.7 mm; P > 0.05). The two groups differed only in
Correlation of preoperative T1S with radiological parameters

Preoperative C2-C7 Cobb LA (°) and loss of cervical lordosis (°) were significantly correlated to preoperative T1S (Fig. 3A, B), whereas postoperative C2-7 LA, pre-operative C2-C7 ROM, pre and postoperative C2-C7 SVA, the change in C2-C7 SVA did not.

Univariate and Multiple linear regression analysis of the relationship between JOA score recovery rate and preoperative measurements

Of clinical and radiological parameters, age at operation, change in C2-C7 SVA and preoperative MRI grade were significant variables (P < 0.10) associated with JOA score recovery rate, whereas, duration from onset to operation, number of expanded laminae, pre and postoperative C2-C7 LA, pre-operative C2-C7 ROM, pre and postoperative C2-C7 SVA, occupying ratio of the OPLL and preoperative MRI grade were not significant variables (Table 3). Age at operation, change in C2-C7 SVA and preoperative MRI grade were finally included in multivariate linear regression analysis. Multivariate analysis showed that the preoperative MRI grade (OR = −9.985, P = 0.015) was related to JOA score recovery rate (Table 4).

Table 2
Comparison of radiographic parameters according to preoperative T1S.

<table>
<thead>
<tr>
<th></th>
<th>high T1S (upper half)</th>
<th>low T1S (lower half)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>preoperative C2-C7 Cobb LA (°)</td>
<td>19.8 ± 13.5*</td>
<td>7.9 ± 10.5</td>
<td>0.007*</td>
</tr>
<tr>
<td>postoperative C2-C7 Cobb LA (°)</td>
<td>16.1 ± 14.9</td>
<td>10.9 ± 11.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>preoperative C2-C7 ROM (°)</td>
<td>26.3 ± 13.1</td>
<td>35.0 ± 18.0</td>
<td>n.s.</td>
</tr>
<tr>
<td>loss of cervical lordosis (°)</td>
<td>3.7 ± 9.5</td>
<td>3.0 ± 8.4</td>
<td>0.034*</td>
</tr>
<tr>
<td>change in postoperative kyphosis</td>
<td>11.1% (2/18)</td>
<td>17.6% (3/17)</td>
<td>n.s.</td>
</tr>
<tr>
<td>preoperative C2-C7 SVA (mm)</td>
<td>33.6 ± 11.9</td>
<td>29.5 ± 14.4</td>
<td>n.s.</td>
</tr>
<tr>
<td>postoperative C2-C7 SVA (mm)</td>
<td>35.2 ± 14.3</td>
<td>32.5 ± 17.1</td>
<td>n.s.</td>
</tr>
<tr>
<td>change in C2-C7 SVA</td>
<td>1.6 ± 8.3</td>
<td>3.0 ± 12.8</td>
<td>n.s.</td>
</tr>
<tr>
<td>occupying ratio of the OPLL (%)</td>
<td>49.1 ± 18.6</td>
<td>41.0 ± 16.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>preoperative MRI grade</td>
<td>1.0 ± 0.8</td>
<td>0.8 ± 0.7</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

n.s.: not significant differences.
T1S: T1 slope.
LA: lordotic angle.
ROM: range of motion.
SVA: sagittal vertical axis.
OPLL: ossification of the posterior longitudinal ligament.
MRI: magnetic resonance imaging.
* P < 0.05.

terms of preoperative C2-C7 Cobb LA and loss of cervical lordosis.

3.3. Correlation of preoperative T1S with radiological parameters

Preoperative C2-C7 Cobb LA (R = 0.462, P = 0.002) and loss of cervical lordosis (R = 0.326, P = 0.036) were significantly correlated to preoperative T1S (Fig. 3A, B), whereas postoperative C2-7 LA, pre-operative C2-C7 ROM, pre and postoperative C2-C7 SVA, the change in C2-C7 SVA did not.

3.4. Univariate and Multiple linear regression analysis of the relationship between JOA score recovery rate and preoperative measurements

Of clinical and radiological parameters, age at operation, change in C2-C7 SVA and preoperative MRI grade were significant variables (P < 0.10) associated with JOA score recovery rate, whereas, duration from onset to operation, number of expanded laminae, pre and postoperative C2-C7 LA, pre-operative C2-C7 ROM, pre and postoperative C2-C7 SVA, occupying ratio of the OPLL and preoperative MRI grade were not significant variables (Table 3). Age at operation, change in C2-C7 SVA and preoperative MRI grade were finally included in multivariate linear regression analysis. Multivariate analysis showed that the preoperative MRI grade (OR = −9.985, P = 0.015) was related to JOA score recovery rate (Table 4).

Table 3
Univariate analysis between JOA score recovery rate and clinical and radiological parameters.

<table>
<thead>
<tr>
<th></th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>age at operation</td>
<td>0.040</td>
</tr>
<tr>
<td>incidence of diabetes mellitus</td>
<td>0.178</td>
</tr>
<tr>
<td>duration from onset to operation</td>
<td>0.743</td>
</tr>
<tr>
<td>The number of expanded laminae</td>
<td>0.794</td>
</tr>
<tr>
<td>preoperative C2-C7 Cobb LA</td>
<td>0.110</td>
</tr>
<tr>
<td>postoperative C2-C7 Cobb LA</td>
<td>0.278</td>
</tr>
<tr>
<td>loss of cervical lordosis</td>
<td>0.481</td>
</tr>
<tr>
<td>preoperative C2-C7 ROM</td>
<td>0.566</td>
</tr>
<tr>
<td>preoperative C2-C7 SVA</td>
<td>0.142</td>
</tr>
<tr>
<td>postoperative C2-C7 SVA</td>
<td>0.958</td>
</tr>
<tr>
<td>change in C2-C7 SVA</td>
<td>0.078</td>
</tr>
<tr>
<td>preoperative MRI grade</td>
<td>0.010</td>
</tr>
<tr>
<td>occupying ratio of the OPLL</td>
<td>0.291</td>
</tr>
<tr>
<td>preoperative T1S</td>
<td>0.714</td>
</tr>
</tbody>
</table>

* P < 0.05.
P = 0.015 were related to JOA score recovery rate (Table 4).

4. Discussion

Recent studies have reported the usefulness of T1S in evaluating sagittal balance in patients with cervical myelopathy who underwent laminoplasty. Although the importance of T1S is beginning to be recognized, few reports have investigated the role of T1S [6,9] and consensus is lacking. It was reported that preoperative cervical lordosis is positively correlated with T1S (i.e., cervical lordosis increases with T1S), and that kyphotic alignment change by posterior structural injury after laminoplasty would be more marked in patients with higher T1S [6]. However, another study reported that cervical sagittal balance was compromised after laminoplasty, and the degree of aggravation of sagittal imbalance was not correlated with preoperative T1S, which did not show any postoperative differences [9]. Therefore, the role of T1S as a predictor of postoperative kyphosis has been unclear and inconclusive. In the present study, our results in patients with cervical OPLL...
who underwent laminoplasty suggest that preoperative cervical lordosis is indeed positively correlated with T1S (i.e., increases with increasing T1S), and moreover that loss of cervical lordosis was much greater in patients with high T1S than in those with low T1S. Greater effort by the posterior neck muscles may be required to maintain horizontal gaze in patients with high T1S. Because laminoplasty is a posterior method, it results in severe damage to posterior structures including the lamina, nuchal ligament, and posterior neck muscle, which help to prevent kyphotic alignment changes [6]. In other words, muscle effort is easily compensated by disruption of the posterior cervical structures by cervical laminoplasty. Therefore, the preservation of posterior cervical muscles and ligaments is very important for maintaining cervical lordosis postoperatively [16,17]. Experienced surgeons recommend preservation of the paraspinal muscles at C2 and C7 during cervical spine surgery because the integrity of these muscles plays an important role in preventing postoperative instability and neck pain [21].

Many reports have demonstrated that improper sagittal alignment is a major source of pain, disability, and poor health [18,19]. Indeed, proper global sagittal spinal alignment and balance are critical in maintaining an energy efficient, pain free, and upright posture [20]. In patients with cervical kyphotic deformity who undergo laminoplasty, the spinal cord could be compressed by OPLL tethering at the apex of kyphosis. Cervical kyphosis or malalignment after laminoplasty has been associated with poor clinical outcomes [3]. In contrast, there are some reports that cervical kyphosis is not related to neurological outcomes. Specifically, Iwasaki et al. observed deterioration of cervical alignment due to kyphosis, but there was no significant difference in surgery-related outcomes between patients with lordotic, straight, or kyphotic alignment [22]. Although we attempted to correlate clinical outcomes with T1S, we found that the rate of JOA score recovery was similar between the high-T1S and low-T1S groups. Based on our observation that preoperative MRI grading and preoperative JOA scores did not differ significantly between patients with high and low T1S, we may conclude that the preoperative deviation of the spinal cord was comparable between the groups. However, despite the fact that there were no significant between-group differences preoperatively, postoperative cervical lordosis was maintained in patients with high T1S even though the loss of cervical lordosis was higher than that in patients with low T1S. The decompressive effect of laminoplasty is theoretically more prominent in lordotic alignment, which perhaps results in greater improvement. Interestingly, a previous report found no correlation between clinical outcomes after laminoplasty and preoperative cervical lordosis [23]. In the present study, multivariate analysis showed that the preoperative MRI grade were only related to JOA score recovery rate and other radiological parameters were not related. Preoperative cervical lordosis was high, and loss of cervical lordosis was larger in patients with high T1S, whereas preoperative cervical lordosis was low, and loss of cervical lordosis was smaller in patients with low T1S. As a result, there were no significant between-group differences regarding the rates of postoperative kyphotic change, maintenance of cervical lordosis, and JOA score recovery. However, if the size of OPLL becomes larger, a small change of cervical alignment may affect the surgical results. In the present study, the average occupying ratio of the OPLL was less than 50% and we did not investigate larger OPLL cases. Iwasaki et al. reported that laminoplasty is effective and safe for most patients with occupying ratio of OPLL less than 60% [24]. Further studies are necessary to elucidate the relationship between the surgical results and the size of OPLL and loss of cervical lordosis after cervical laminoplasty.

We also found no significant differences between pre- and postoperative C2-C7 SVA in either group, indicating compensation of global alignment in the thoracic, lumbar, and pelvic spine. We therefore conclude that cervical alignment would easily become kyphotic in patients with global malalignment that could not be compensated for.

Several limitations of the present study should be acknowledged, including its retrospective design. Additionally, the mean follow-up period was 38 months, which is relatively short. Cervical sagittal alignment may worsen in time, suggesting that studies with longer follow-up are warranted to confirm our conclusions. In addition, we did not investigate the compensation of global alignment or the contribution of the thoracic, lumbar, and pelvic spine. We believe the problem of cervical malalignment is associated with the compensation of global alignment. Moreover, although our statistical comparisons demonstrated no between-group differences in clinical parameters, our sample size is small and a larger sample size is necessary to elucidate a solid conclusion.

5. Conclusion

Despite its limitations, the present study demonstrated that preoperative cervical lordosis was high and postoperative loss of cervical lordosis was larger in patients with high T1S, whereas preoperative cervical lordosis was low and postoperative loss of cervical lordosis was smaller in patients with low T1S. Although the degree of alignment compromise is correlated with the preoperative T1S, the preoperative T1S was not related to JOA score recovery rate and the preoperative MRI grade was only related to JOA score recovery rate. However, further studies are needed to determine the clinical and radiological effects of T1S after cervical laminoplasty for cervical OPLL.

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Conflict of interests

None.

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None.

References


