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Research Article

THE CHANGES OF CERVICAL CURVATURE IN PATIENTS UNDERGOING MODIFIED POSTERIOR EXPANSIVE LAMINOPLASTY

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ABSTRACT

Purpose: The changes in the cervical curve were not well illustrated after treating by Modified posterior expansive laminoplasty (MPEL). Therefore, the aim of this study was to compare preoperative and postoperative cervical curve by measuring the radiographic index to detect whether there was a change in patients undergoing MPEL.

Methods: We conducted a prospective study of 126 patients who underwent MPEL. All the patients were divided into two groups: Group A (NON-OPLL patients) and Group B, Ossification of the posterior longitudinal ligament (OPLL patients). The last follow-up mean was 3 to 20(7.27±2.65) months. The cervical curvature index of the cervical spine was measured preoperatively and at the last follow-up in the lateral radiograph. A paired t-test was used to compare the differences between preoperative and post-operative cervical curve. Japanese Orthopedic Association (JOA) score was used to assess the clinical outcome. Regression analysis was used to analyze the relationship between cervical curvature index and JOA scores.

Results: The curvature index, mean SVA was changed significantly in both groups (A&B) at final follow-up $P<0.05$. On the other hand, the curvature index CA (Cobb angle) and T-1slope did not change significantly at final follow-up in both groups (A&B). Both group A and B demonstrated significant increases in JOA scores at final follow-up $P<0.05$.

Conclusions: Based on the currently available data, we evaluated various cervical radiological parameters to detect the changes in cervical curve post MPEL and found that the sagittal vertical axis (SVA) changed significantly after MPEL. There was no relationship between SVA and JOA scores improvement.

Keywords: Cervical curve, cervical myelopathy cases, Lateral radiograph, JOA scores, MPEL

INTRODUCTION

Modified posterior expansive laminoplasty (MPEL) is one of the effective surgical methods for treating cervical myelopathy cases. MPEL can provide a fully decompression and reserve the range of motion of cervical vertebrae. Cervical laminectomy may cause problems such as instability of the spine, kyphosis, and axial pain. MPEL is an effective alternative and is gradually applied in clinical practice. Its curative effect is definite, and it has become a routine procedure for the treatment of multi-segment cervical spondylosis and ossification of the posterior longitudinal ligament. MPEL help the preservation of the spinous process-ligament-muscle complex. Laminoplasty was developed by Japanese orthopedic surgeons from the 1970s to 1980s to overcome adverse conditions related to laminectomy. The term “laminoplasty” denotes several operative procedures in which vertebral lamina is reconstructed after opening the spinal canal. The word “ laminoplasty” most commonly means creating hinge(s) on which the lamina is lifted but not removed(1). Posterior surgical approaches for the decompression of the cervical spinal cord and nerve roots have been clearly established as safe and efficacious(2). Cervical spondylotic myelopathy(Cervical spondylotic myelopathy, CSM) is a degenerative disease and the most common cause of neurological dysfunction in the world(3). Ossification of the posterior longitudinal ligament(OPLL) results from the pathologic replacement of the posterior longitudinal ligament and can lead to spinal cord compression and neurological deterioration(4). Cervical myelopathy cases frequently require surgical treatment because its natural course results in poor clinical outcomes. Since laminoplasty achieves indirect posterior decompression, it is not suitable for patients with preoperative cervical kyphotic alignment, and, given the mechanism of cord compression, both preoperative and postoperative cervical lordosis are considered prerequisites for successful outcomes(5). Cervical laminoplasty was devised to avoid problems associated with laminectomy such as postoperative segmental instability, kyphosis, perineal adhesions, and late neurological deterioration(6). Various techniques of laminoplasty have since been developed after two prototype techniques: Hirabayashi’s open-door laminoplasty and Kurokawa's spinous process splitting (double door) laminoplasty. Recent laminoplasty techniques offer less invasive maneuvers to obtain a better functional outcome, but every operation is carried out based on the unchanged initial concept(7). In the present study, open-door laminoplasty was performed according to Hirabayashi’s method, with some modifications. MPEL technique was introduced by Professor Yan Jinglong (head of the orthopedic surgery department in the 2nd affiliated hospital of Harbin medical university). Our technique (MPEL) has good outcomes- because it can provide a fully decompression and reserve the range of motion of cervical vertebrae.

Recent studies have demonstrated the importance of cervical sagittal alignment, because neck pain and functional disability could be caused by loss of cervical lordosis, besides trauma, tumor, disc degeneration, soft tissue inflammation, etc (8). The neck curvature or cervical lordosis protects the neck from damage and irritation, reduces stress and strains on the spinal cord and spinal nerves. Cervical spine sagittal malalignment may be associated with worse clinical symptoms and poor outcomes in patients with degenerative cervical.

The changes of a cervical curve were not well illustrated after treating by our MPEL technique. The importance of normative global spinal and pelvic parameters for quality of life(Quality of life, QOL) has been established. The proper sagittal balance of the physiologically upright spine maintains alignment with minimum energy expenditure against the global axis of gravity. Global spinal imbalance in the sagittal plane may lead to the development of clinical symptoms and degenerative disease, which would require additional preoperative care of treated patients. However, relatively few publications have defined normative values for cervical thoracic sagittal balance. And even fewer have directly evaluated the influence of cervical segmental and regional balance on outcomes in cervical surgery(9).

Multiple publications studies have been suggested radiologic sagittal parameters including C2-C7 Cobb angle, T1slope, C2-C7SVA are useful in assessing the changes in cervical alignment. Schee et al provided a definition of the cervical sagittal vertical axis(C2-7SVA) that refers to the distance between a plumb line dropped from the centroid of C2(or dens) and the posterosuperior aspect of C7. This (C2-7SVA) parameter is expected to provide a measure of cervical regional balance. In the literature, the Cobb angle analysis(10,11) has been the method of choice for measurement of overall lordosis and kyphosis of the sagittal spinal curves on the lateral radiograph. Recently, the T1 slope (T1S) has emerged as a predictor of kyphotic alignment change after laminoplasty(12,13).

In recent year, a growing number of studies pay attention to the cervical alignment after laminoplasty. MPEL has good outcomes –cause it to provides a fully decompression and reserve the range of motion of cervical vertebrae. However, No one procedure has proven to be more effective than any other in terms of neurological outcome and cervical alignment. In our department, over 1500 patients with myelopathy or radiculopathy received operation using posterior laminoplasty (MPEL) technique. In this study, differences between preoperative and postoperative parameters were calculated respectively. The changes in the cervical curve were not well illustrated after treating by our posterior technique (MPEL). The objective of this study was to investigate the changes in the cervical curve in patients undergoing MPEL technique. Additionally, the Japanese Orthopedic Association (JOA) score was used to assess the clinical outcome. The relationship between cervical sagittal alignment parameters and JOA scores was evaluated.

MATERIALS AND METHODS

Patient Enrollment:

We prospectively reviewed the radiographs of 126 patients who underwent MPEL of the cervical spine at the Second Affiliated Hospital of Harbin Medical University in 6th department of orthopedic surgery between March 2017 and July 2018. We started the follow-up in October 2018 and collected and measured data. All the patients were divided into two groups: Group A (NON-OPLL patients) and Group B (OPLL patients). Our institution's ethics committee approved the study. The group with Non-OPLL included the patients with cervical disc herniation, cervical canal stenosis & cervical degenerative disc disease. The inclusion criteria were as follows: 1) Patient underwent laminoplasty for treating NON-OPLL(cervical disc herniation, cervical stenosis, cervical severe disc degeneration) & OPLL. Exclusion criteria were as follows: 2)Patients who underwent both anterior and a posterior operation 3)Patients diagnosed with an intracanal tumor, infection and cervical injury.4) Patients treated by hybrid approaches.5) Patients underwent an infection or reoperation .6)Cervical disc herniation of two segments and below. All of the operations were performed by, or under the supervision of, the head of department(Professor Yan Jinglong) of orthopedic surgery. The mean duration of follow-up was 3 to 20 (7.27±2.65)months. Twenty-six patients were men and eight were women With ages ranging from thirty-eight to seventy years(mean, 57 years) at the time of operations in group A.

Sixty-Six patients were men and twenty-five patients were women with ages ranging from thirty-five to eighty years (mean,56.9 years)at the time of operations. Non-OPLL(cervical disc herniation, cervical canal stenosis, cervical severe degenerative disc disease) was the diagnosis in thirty-four patients, and ossification of the posterior longitudinal ligament was the diagnosis in ninety-two.

Surgical Technique for MPEL:

We performed an MPEL(Expansive open-door laminoplasty of Hirabayashi) with some modifications. Operative procedure performed under general anesthesia. The patient kept in a prone position with abdominal suspension decompression. Pre-operative skin preparation done with Povidone-Iodine and lay a sterile towel. Mark C1~T1 posterior midline longitudinal incision. Skin, subcutaneous tissue, and supraspinous ligament were incised, and right C3-T1 paraspinal muscles, left paraspinal muscles, and C2 spinous process was dissected under periosteum. T1 anterior 1/3 and supraspinous ligaments were cut obliquely, and C3-7 spinous process was cut across at least 1cm, The attachment point of both muscles was cut off in the furcation part of C 2 spinous process, and the left side was exposed by removing the C3~ T1 paraspinal muscle with free spinous process on the other side of the periosteum, and exposing the left side of the vertebral plate. 1/3 of C2 and 1/3 of T1 were removed and decompress of C2 and T1 lamina was performed. Then cut off the lateral edge of C3-7 right lamina, drilling from the root of the spinous process to the right edge of the lamina, through the double 10 wire as the traction fixation line. Slowly lift the C3-C7 lamina on each side of the door axis, remove the ligamentum flavum at the edge of the lamina and the adhesion zone on the dural sac, and bite off the medial edge of the facetoid process, Full exposure of the dural sac and complete decompression of the dural sac (see the dural sac was moved backward and the pulsation was evident). The distal part of the spinous process and the right edge of the lamina were fixed by traction fixation line, and the C3-7 was fixed with the lateral edge of the lamina, The C2 spinous process and the T1 spinous process and the supraspinous ligament were fixed by suture of the twin-strand 10 silk thread, and the spinous process was suspended. A lot of normal salines was used to rinse repeatedly, and a negative pressure drainage tube was put in place to close the wound layer by layer, and the operation was completed. The drainage tube was removed 24-72 hours after the operation, and the neck brace was worn until 3 weeks after the operation. The surgical demonstration animation of MPEL is shown in the Figure-1. Intraoperative images of the MPEL is shown in Figure-2.

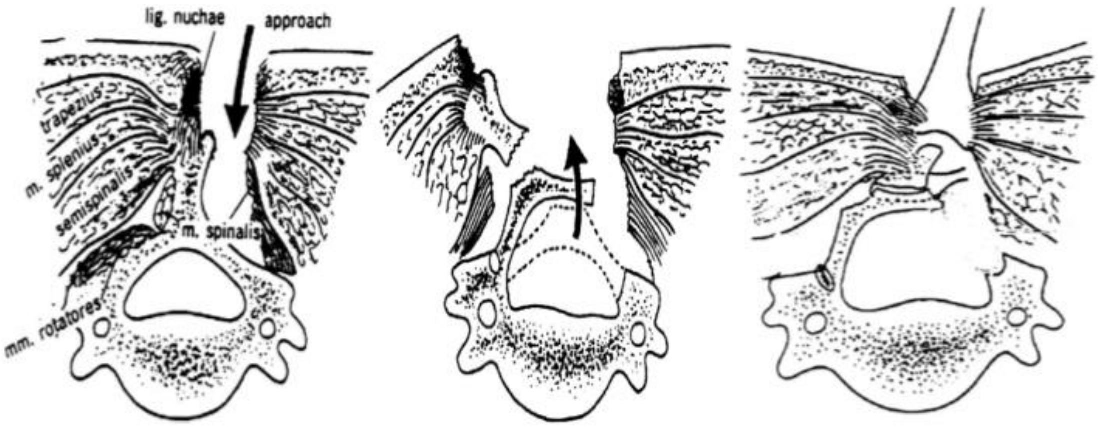

Figure 1: The surgical demonstration animation of MPEL.

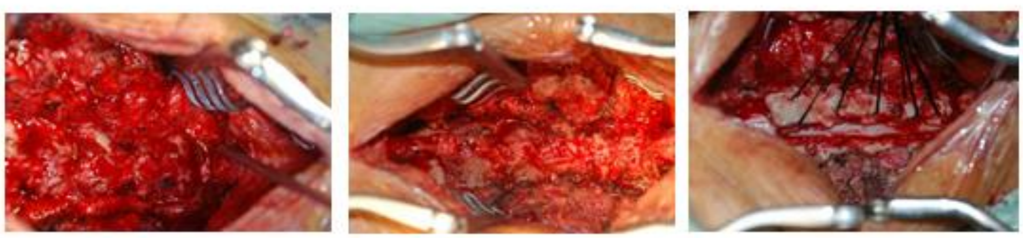

Figure 2: Intraoperative images of the MPEL

Radiologic Assessment:

Plain lateral radiographs of the cervical spine were made before the operation and at the last follow-up, with the patient in the upright position. Measurements were performed by Sketchup 2016 software. The Cobb angle from C2 TO C7 was used as a measure of the cervical alignment, which was defined as the angle formed by the inferior endplates of C2 and C7 in standing lateral radiographs. The C2–7 sagittal vertical axes (C2-7 SVA) was defined as the distance from the posterosuperior corner of C7 and the vertical line from the center of the C2 body.T1 slope(T1S) was measured as the angle between a horizontal line and the superior endplate of T1 on standing lateral radiograph. The mean values were applied for analysis. All radiographic measurements were performed by the authors. The measurement methods are summarized in Figure-3.

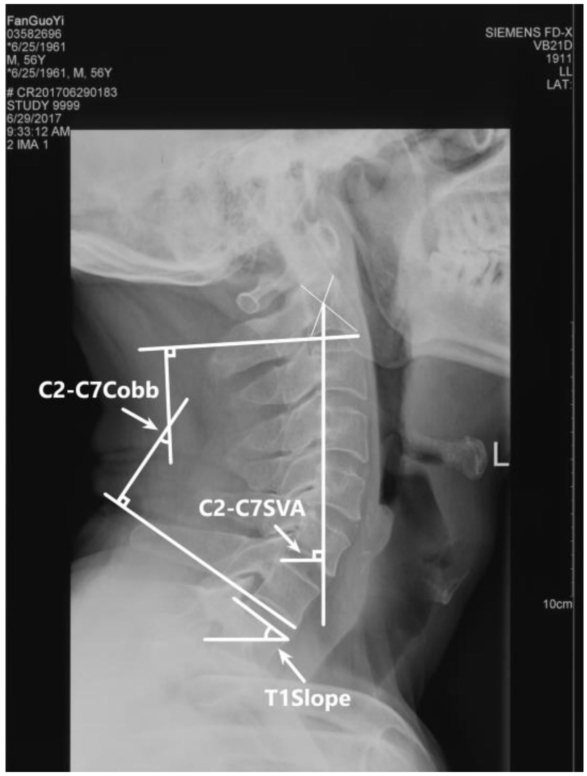

Figure 3: Measurements of radiological parameters

C2-7 Cobb angle: it was defined as the angle formed by the inferior end plates of C2 and C7.C2-7 sagittal vertical axis (SVA): it was defined the distance from the posterosuperior corner of C7 and the vertical line passing through the center of the C2 body. T1Slope: it was defined as the angle between a horizontal line and the superior plate of T1.

Clinical Assessment:

We used the Japanese Orthopedic Association (JOA) score to evaluate the severity of myelopathy preoperatively and at final follow-up. Preoperative JOA score was recorded, and the patients were followed up and the final follow-up JOA score was recorded. The Rate of the improved JOA score (RIS) was calculated (JOA score = (improved score/loss score) *100%).

Statistical Analysis:

All statistical analyses were performed with the statistical package for the social science (SPSS) 23.0 version. Preoperative and final follow-up values were compared with the use of the paired t-test. Furthermore, gender and age were compared between OPLL patients and NON-OPLL patients using the chi-squared test and t-test, respectively. Regression analysis was used to analyze the relationship between cervical curvature index and JOA scores. $P<0.05$ was considered significant.

RESULTS

Our study population consisted of 26 male and 8 female patients with ages ranging from thirty-eight to seventy-two years (mean, 57 years) in group A. In group B sixty-six male and twenty-five female patients with ages ranging from thirty-five to eighty years (mean, 56.9 years). A summary of the demographics is presented in Table 1. There was no difference in the gender distribution of the two groups (Non-OPLL & OPLL) of patients (P>0.27). Table 2 shows the gender distribution of the two groups of patients. We did Comparison of Age groups of Non-OPLL and OPLL patients. There was no difference in age between patients with both diseases (P>0.98). Table 3 shows the age comparison between the two groups of patients.

The radiological parameters C2-7cobb angle, C2-7SVA & T1S was used to define cervical curvature. The change in cervical curvature was defined as the difference between the post- and preoperative C2-7 Cobb angles, C2-7SVAs, and T-1 slope. Clinical outcomes were evaluated by using the Japanese Orthopedic Association (JOA) scores in preoperative and final follow-up patients.Radiographic parameters normal values reported in the literature were listed in Table 4 (14–16).

Group A (Non-OPILL):

Mean C2-7Cobb was 14.38° and 11.32° at pre-operative and last follow- up respectively. The C2-C7 mean difference was -3.06. The comparison between the preoperative and final follow-up C2-C7 Cobb angle at the neutral position showed no significant difference (P>0.05). Mean SVA was 21.47mm preoperatively and 28.14mm, at last, follow –up. The SVAd mean difference was 6.67mm. The comparison between the preoperative and final follow-up C2-C7 SVA at neutral position showed a significant difference(P<0.01). Mean T1S was 24.05° preoperatively and 24.17°, at last, follow up. The T1Sd mean was 0.12. The comparison between the preoperative and final follow-up T1slope at neutral position showed no significant difference (P>0.29). The changes C2-7 Cobb, C2-7 SVA & T1S, pre-to final value are summarized in Table 5.

Regarding final follow-up radiographic changes in the sagittal parameters of total materials, C2-7SVA changed from 21.47mm preoperatively to 28.14 mm at the last follow up. The changes in the pre- and postoperative C2-7SVA values were 6.67mm. The difference was significant (P<0.05). Parameter C2-7Cobb angle changed from 14.38° preoperatively to 11.32° at the last follow up. The changes in the pre- and postoperative C2-7Cobb angle value were -3.05°. The difference was nonsignificant (P>0.05). Parameter T1S changed from 24.05° preoperatively to 11.32° at the last follow up. The changes in the pre- and final follow-up T1S value were 0.12°. The difference was non-significant. Among three parameters measuring the curvature of the cervical spine, only C2-7SVA (sagittal vertical axis) was changed at the final follow-up so we hypothesize the operation has an effect on the SVA parameter according to our findings. The findings indicate that SVA was a good predictor of postoperative curvature changes of the cervical spine in the NON-OPLL (cervical disc herniation, cervical stenosis, severe degenerative disc disease) patients. Hence, SVA can be a predictor of postoperative curvature changes in the cervical spine post laminoplasty.

Mean JOA score was 10.55 preoperatively and 15.70 at last follow-up. The JOAd score means the difference was 5.14. The comparison between the preoperative and final follow-up JOA score was statistically significant (P<0.05). The JOA RIS was 81.99±23.15 in group A. The JOA score for this group was improved at the final follow up with a significant difference. The changes JOA score, pre- to final are summarized in Table 6.

SVAd exhibited no correlation with JOA improvement scores: here, SVAd is a subtracting the SVA preoperative mean value from the SVA final follow-up mean value. We conducted linear regression analysis to see the correlation between SVAd and JOA improvement scores. Regression results superimposed on SVAd and JOA improvement scores mean data. The regression results showed no relationship observed between SVAd and JOA improvement scores(Correlation coefficient=0.028). There was no relationship or very weak relationship observed between SVAd and JOA improvement score. The relationship between SVAd and JOA improvement shown in Figure-4.

SVAd exhibited no correlation with JOA final scores: Here, SVAd is a subtracting the SVA preoperative mean value from the SVA final follow-up mean value. We conducted linear regression analysis to see the correlation between SVAd and JOA final scores. Regression results covered on SVAd and JOAfinal scores mean data. Regression results showed no relationship observed between SVAd and JOA final scores. There was no relationship or very weak relationship observed between SVAd and JOA final score(Correlation coefficient=0.095). The relationship between SVAd and JOA final shown in Figure-5.

SVA pre- exhibited no correlation with JOA final scores: Here SVApre is a mean value before the laminoplasty. We conducted linear regression analysis to see the correlation between SVApre and JOA final scores. Regression results covered on SVApre and JOA final scores mean data. Regression results showed there was no relationship or very weak relationship observed between SVApre and JOA final scores(Correlation coefficient=0.018). The relationship between SVApre and JOA final scores shown in Figure-6.

SVApre exhibited no correlation with JOA improvement scores: Here SVApre is a mean value before the laminoplasty. We conducted linear regression analysis to see the correlation between SVApre and JOA improvement scores. Regression results superimposed on SVApre and JOA improvement scores mean data. The results showed there was no relationship or very weak relationship observed between SVA pre- and JOA improvement scores(Correlation coefficient=0.174). The relationship between SVA pre- and JOA improvement scores shown in Figure-7.

Group B (OPLL):

44eMean C2-7Cobb was 12.74° preoperatively and 12.58° at last follow-up. The C2-C7 CObb mean difference was 0.16°. The comparison between the preoperative and final follow-up C2-C7 Cobb angle at the neutral position showed no significant difference (P>0.05). Mean SVA was 19.14mm preoperatively and 29.03 mm, at last, follow –up. The mean difference of C2-C7 SVA was 9.89. The comparison between the preoperative and final follow-up C2-C7 SVA at neutral position showed a significant difference (P<0.05). Mean T1S was 21.39° preoperatively and 24.91° at last follow-up. The T1Sd mean difference was 0.49°. The comparison between the preoperative and final follow-up T1slope at neutral position showed no significant difference (P>0.05). The changes C2-7 Cobb, C2-7 SVA & T1S, pre-to final value are summarized in Table 7.

Among three parameters measuring the cervical curvature of the cervical spine, only C2-C7 SVA showed significant changes at final follow-up. We hypothesize the operation had an effect on C2-C7SVA on the other hand, Cobb and T1S showed no significant difference on final follow-up.

Mean JOA score was 10.63 preoperatively and 15.31 at last follow-up. The JOAd score means the difference was 4.695. The comparison between the preoperative and final follow-up JOA score was statistically significant ($P<0.05$). The JOA RIS was 74.05±27.43 in group B. The JOA score for this group was improved at the final follow up. The changes JOA score, pre- to final are summarized in Table 8.

	Group A	Group B
Number of patients	34	92
Sex		
Male	26	66
Female	8	25
Age(years)	38-72 (Average 57)	35-80 (Average 56.9)
Diagnosis	NON-OPLL	OPLL
Surgical approach	Hirabayashi(MPEL)	Hirabayashi(MPEL)
Final follow-up period	3 to 20(7.8±2.3) months	3 to 20(7.8±2.3) months

Table 1: Patients demographics

Table note: OPLL indicates ossification of the posterior longitudinal ligament & MPEL indicates modified posterior expansive laminoplasty.

	MALE	FEMALE	χ2	P
NON-OPLL	28	6	1.21	0.271
OPLL	67	25		

Table 2: Comparison of the Gender distribution of the two groups of patients (male, female)

Table note: There was no difference in gender between patients with both diseases.

	MEAN	STD	NUMBER	t	P
NON-OPLL	57	8.1	34	-0.02	0.98
OPLL	56.96	9.75	92		

Table 3: Comparison of Age groups of patients(years)

Table note: There was no difference in age between patients with both diseases.

	The normal subject in Iyer et al; study	The normal subject in Yokoyama et al; study	The normal subject in Jon et al; study
Numbers of subject	115	220	50
COBB	12.2 ± 13.6	13.9 ± 14.2	17.3 ± 9.3
SVA	21.3 ± 12.1	20.2 ± 11	25.97 ± 5.9
T1S	26.1 ± 9	24.6 ± 7.5	25 ± 5.9

Table 4: Radiographic parameter normal values of asymptomatic subjects in literature. Cobb angle (unit:°), C2-C7SVA (unit:mm),T1slope unit(:°)

Variable	Preop Mean	Final Mean	Δ	Std.	95% CI of Mean	t	P
COBB	14.38	11.32	-3.06	8.88	-3.06±8.88	2.01	0.05
SVA	21.47	28.14	6.67	14.31	6.67±14.31	-2.72	0.01
T1S	24.05	24.17	0.12	7.05	0.12±7.05	-0.1	0.29

Table 5: Comparison of the preoperative and final follow-up Cobb angle (unit: °), C2-C7SVA (unit: mm), T1slope unit(:°) of NON-OPLL(Group A)

Table note: Abbreviations: Δ = postoperative mean value –final mean value. The SVA P value reflects the significance of the difference in postoperative curve change. The operation had an effect on the SVA.

Number	PreMEAN	Final Mean	Δ	JOA RIS	Std.	Mean(95% CI)	t	P
34	10.55	15.7	5.14	81.99±23.15	2.69	5.14±2.69	-11.12	0.01

Table 6: Comparison of the preoperative and final Japanese Orthopedic Association (JOA) score of NON-OPLL (Group A) JOA score improvement rate (JOA RIS), unit:%)

Table note: Abbreviation: Δ=final mean JOA value-preoperative mean JOA value. The JOA score was improved at the final follow up with significance difference (p<0.05). It means that the operation has improved results.

Variable	Preop Mean	Final Mean	Δ	Std.	95% CI of Mean	t	P
COBB	12.74	12.58	-0.15	9.89	-0.15±9.89	0.15	0.88
SVA	19.14	29.03	9.89	12.62	9.89±12.62	-10.18	0.01
T1S	25.39	24.65	-0.49	7.47	-0.49±7.47	0.63	0.53

Table 7: Comparison of the preoperative and final follow-up Cobb angle (unit: °), C2-C7SVA (unit: mm), T1slope unit(:°) of OPLL(Group B)

Table note: Abbreviation: Δ=final mean value-preoperative mean value. The SVA P value reflects the significance of the difference in postoperative curve change. The operation had an effect on the SVA.

Number	PREOP MEAN	FINAL MEAN	Δ	JOA RIS	Std.	95% CI of Mean	t	P
92	10.63	15.31	4.69	74.05±27.43	2.78	4.69±2.78	-16.16	0.01

Table 8: Comparison of the preoperative and final Japanese Orthopaedic Association (JOA) score of OPLL (GroupB). JOA score improvement rate (JOA RIS), unit:%)

The JOA score was improved at the final follow up with significance difference ($p<0.05$). It means that the operation has improved results.

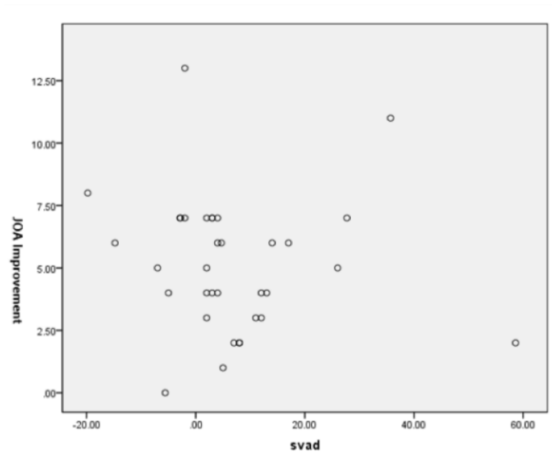

Figure 4: NON-OPLL(Group A): SVAd correlations with JOA improvement scores in linear regression analysis. There was no relationship SVA d and JOA improvement scores, i.e. r=0.028.

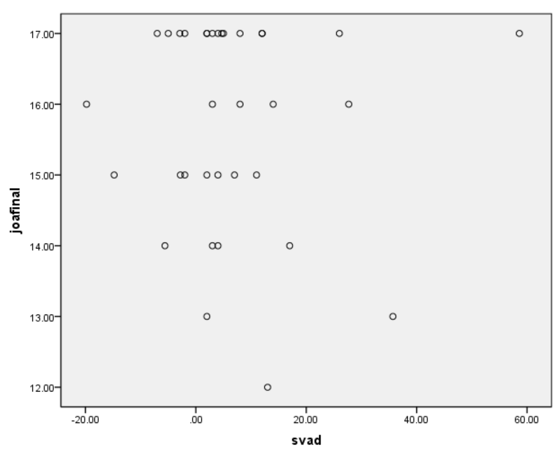

Figure 5: NON-OPLL(Group A): SVAd correlations with JOA final scores in linear regression analysis. There was no relationship SVA d and JOA final scores, i.e. r=0.095.

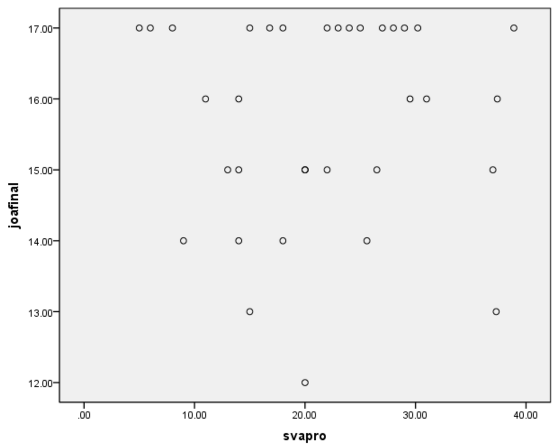

Figure 6: NON-OPLL (Group A): SVApre correlations with JOA final scores in linear regression analysis. There was no relationship SVA pre and JOA final scores, i.e. r=0.018.

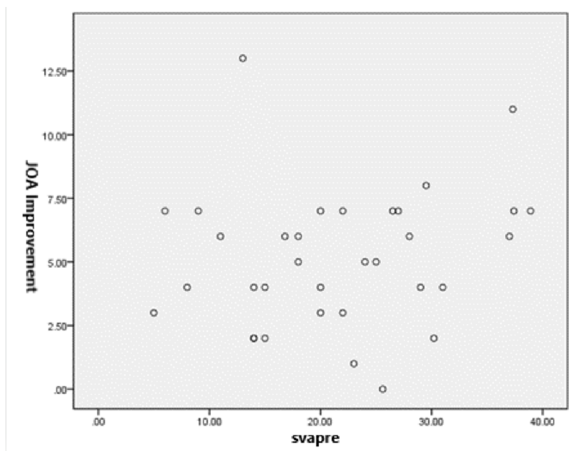

Figure 7: NON-OPLL (Group A): SVApre correlations with JOA improvement score in linear regression analysis. There were a negligible relationship SVA pre and JOA improvement scores, i.e. r=0.174

DISCUSSION

Following the introduction of the laminoplasty, many studies described postoperative curve remains the same as the cervical spine(17).The result of the present study suggests that C2-C7 sagittal vertical axis(SVA) parameter can be a predictor of postoperative curve changes. Some studies reported that T1slope(T1S) can be a predictor of postoperative kyphotic changes in the cervical spine post laminoplasty(18) however in the present study T1slope(T1S) was no statistically significant difference at the final follow-up curve. Several reports have suggested that comparison of the preoperative and postoperative no statistically significant difference in C2-7cobb angle(19) same in the present study C2-7cobb angle was no statistically significant at the final follow-up. There is no advanced research has been conducted on cervical alignment to characterize the global relationships in the spine. The reason for this is that cervical spinal curve varies, the motion of the cervical spine associated with the range is large, the connection between cervical alignment and thoracic kyphosis is weaker than that between the lumbar and pelvic regions, and the cervical region segments are often afflicted with myelopathy(20). There is already known of the strong correlation between pelvic incidence and lumbar lordosis, but there are unexplored questions about cervical curvature. The value of normative global spinal and pelvic parameters for quality of life has been accepted. The appropriate sagittal balance of the physiologically upright spine maintains alignment with minimum energy expenditure contra the global axis of gravity. Global spinal imbalance in the sagittal plane may lead to the development of clinical symptoms and degenerative disease, which could require further perioperative care treated patients(21). The cervical region is the spinal segment with the highest mobility, also to be responsible for supporting the weight of the head, it is susceptible to a series of pathologies that can remarkably compromise the quality of life and cause functional disorder(22). The sagittal alignment of the cervical spine is an important factor involved in deformity, degenerative diseases, surgical planning, and postoperative recovery(23).In this study, we focused on regarding postoperative radiographic changes in the sagittal parameters from preoperatively to the last follow-up. The C2-7Cobb angle, C2-7SVA & T1slope are all relevant factors of cervical sagittal alignment, but no consensus has been reached so far. Laminoplasty is popular in patients with myelopathy in whom the cord is compressed at multiple levels. Our study showed that the laminoplasty (MPEL) has an effect on the C2-7SVA parameter. The C2-7SVA is an important parameter for evaluating cervical sagittal balance. According to the previous studies, the C2-C7SVA values in asymptomatic normal volunteers are maintained in a tight range within 20mm(24). Several studies have suggested that radiographic parameter normal value of asymptomatic subject in literature. In the Iyer et al; study cobb(°) was 12±13.6, SVA (mm) was 21.3±12.1 and T1S(°)was 26.1±9(14).In the Yokoyama et al; study cobb(°) was 13.9±14.2, SVA(mm) was 20.2±11 & T1S(°) was 24.6±7.5(15). In Jon et al study cobb(°) was 17.3±9.3, SVA(mm) was 25.97±5.9 & T1S(°) was 25±5.9(16).Consistent with a previous study, the mean C2-C7SVA value in the current study in patients with NON-OPLL was 21.47mm & 28.14mm at preoperative & last follow-up respectively. The mean C2-C7SVA value in the current study in patients with OPLL was 19.14mm & 29.03mm at preoperative and last follow-up respectively. Japanese study average C2-C7SVA(19.9 ±12.4 mm) in Japanese myelopathy patients was smaller than Smith's (32.3 ± 14.5mm) in North American myelopathy patients even though both were determined in myelopathy patients. The reason for that might be racial differences(25).Some authors have reported that cervical sagittal imbalance defined on the C2-7SVA will adversely affect the surgical outcome for cervical myelopathy(26). Some studies have shown that C2-7SVA affects outcomes after laminoplasty for myelopathy cases(26). A cervical spine with large C2-7SVA may be vulnerable of damage to the posterior elements because the posterior elements of the cervical spine could prevent the kyphotic alignment of structures that have been exposed to mechanical stress-induced sagittal imbalance(26). Although the association between cervical spine curve and whole spine sagittal balance is controversial, cervical alignment is thought as a compensatory mechanism to maintain equilibrium and the forward gaze of the head(27)

Our study had a number of limitations. First, data are limited to the upper level of the spine and the short follow-up interval. Cervical sagittal alignment may have worsened over a longer follow-up, suggesting that studies with longer follow-up are warranted to confirm our diagnosis. In addition, we did not investigate the compensation of global alignment or the contribution of the thoracic, lumbar, and pelvic spine. Ideally, evaluation of whole-spine sagittal alignment by using the full-length standing radiographs would have been done. We believe the problem of cervical malalignment is associated with the compensation of global alignment. Each patient has different C2-C7 Cobb angle, T1s and C2-C7SVA representing various combinations of cervical regional alignment and global spinal balance. Each parameter is regarded as a useful parameter for predicting the changes of cervical curve undergoing laminoplasty. Although our statistical comparisons demonstrated only C2-C7 SVA was the parameter changes significantly to assess the cervical curvature postoperatively.

CONCLUSIONS

Based on the currently available data, we evaluated various cervical radiological parameters to detect the changes in cervical curve post MPEL and found that the sagittal vertical axis (SVA) changed significantly after MPEL. On the other hand, there was no relationship between SVA and JOA scores improvement.

This study had several limitations. First, data are limited to the upper level of the spine. The relatively short-term follow-up and small sample size are additional limitations. Further discussion is needed in the future for determining the impact of cervical C2-7SVA on myelopathy in patients.

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