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Image analysis of open-door laminoplasty for cervical spondylotic myelopathy: Comparing the influence of cord morphology and spine alignment

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ABSTRACT

Objectives: Previous studies have identified the factors affecting the surgical outcome of cervical spondylotic myelopathy (CSM) following laminoplasty. Nonetheless, the effect of these factors remains controversial. It is unknown about the association between pre-operative cervical spinal cord morphology and post-operative imaging result following laminoplasty. The goal of this study is to analyze the impact of pre-operative cervical spinal cord morphology on post-operative imaging in patients with CSM.
Methods: Twenty-six patients with CSM undergoing open-door laminoplasty were classified according to pre-operative cervical spine bony alignment and cervical spinal cord morphology, and the results were evaluated in terms of post-operative spinal cord posterior drift, and post-operative expansion of the antero-posterior dura diameter.
Results: By the result of study, pre-operative spinal cord morphology was an effective classification in predicting surgical outcome – patients with anterior convexity type, description of cervical spinal cord morphology, had more spinal cord posterior migration than those with neutral or posterior convexity type after open-door laminoplasty. Otherwise, the interesting finding was that cervical spine Cobb's angle had an impact on post-operative spinal cord posterior drift in patients with neutral or posterior convexity type spinal cord morphology – the degree of kyphosis was inversely proportional to the distance of post-operative spinal cord posterior drift, but not in the anterior convexity type.
Conclusions: These findings supported that pre-operative cervical spinal cord morphology may be used as screening for patients undergoing laminoplasty. Patients having neutral or posterior convexity type spinal cord morphology accompanied with kyphotic deformity were not suitable candidates for laminoplasty.

1. Introduction

Laminoplasty is an accepted, effective, and safe therapeutic strategy for patients with cervical spondylotic myelopathy (CSM) [1,2]. The clinical benefits are attributed to sufficient decompression for multi-segmental cervical lesions without obvious damage to spinal stability and mobility [3,4]. This surgical procedure enables cervical spinal cord posterior decompression by expanding the bony spinal canal and anterior decompression by drifting the cervical spinal cord from the anterior compressive lesions.

However, clinical outcome of laminoplasty is not always satisfactory and insufficient posterior drift of the cervical spinal cord is regarded as the major cause [5,6]. Several studies have tried to identify determinant factors affecting the surgical outcome of CSM following laminoplasty seriously, such as pre-operative cervical spine alignment, the space available at the cephalad levels, longitudinal distance index, and post-operative cervical spinal cord morphology [7–10]. Nonetheless, the effects of these identified factors on post-operative spinal cord posterior drift remain controversial. The association between pre-operative cervical spinal cord morphology and surgical outcome is never discussed by previous studies.

The purpose of this study is to investigate if pre-operative cervical spinal cord morphology as effective determinant in predicting surgical result. At the same time, this classification is compared with another common used – cervical spine bony alignment.

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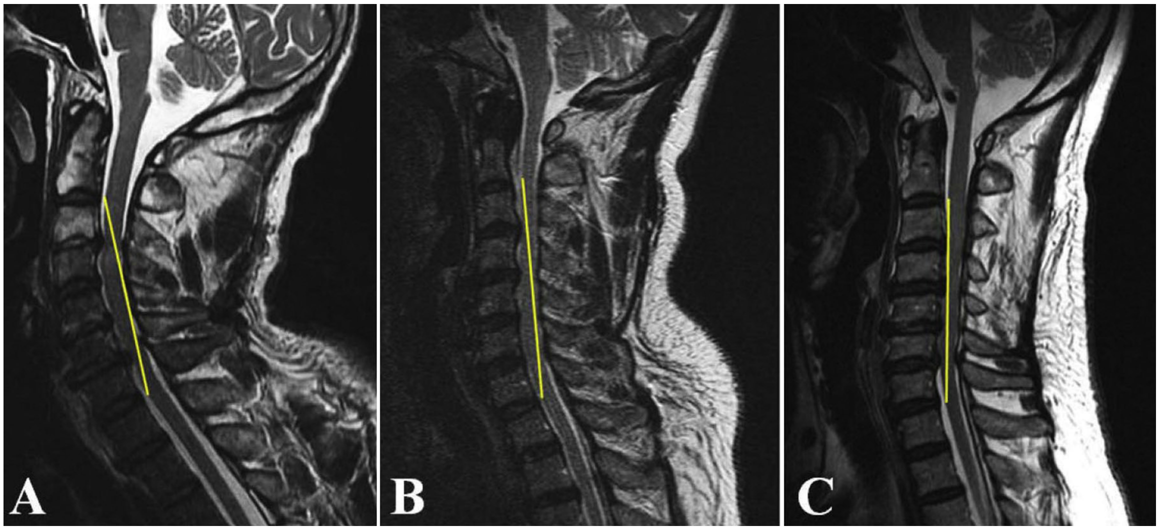

Fig. 1. One straight line linking two anterior points of the spinal cord at C2–3 and C7–T1 levels was drawn on T2-weighted images. While this line passed through posterior edge of the spinal cord, within the spinal cord or through anterior edge of the spinal cord, the spinal cord morphology was defined as anterior convexity type (A), neutral type (B), or posterior convexity type (C), respectively.

2. Materials and methods

2.1. Patient demographics

A review of medical record in our institution was conducted following Institutional Review Board approval (IRB: 1-102-05-032). From January 2005 to December 2010, 152 patients undergoing open-door laminoplasty at our institution were analyzed retrospectively. Those with previous cervical spine surgery, incomplete or un-interpretable pre- or post-operative magnetic resonance imaging (MRI), different levels of posterior decompression and different diagnosis except CSM – including trauma, tumor and ossification of posterior longitudinal ligament (OPLL) were excluded to minimize the selection bias. Twenty-six patients (14 male) with CSM were included in the final analysis. Their levels of decompression were from C3 to C7 and mean age at the time of surgery was 63 years. The average time interval between pre- and post-operative MRI was 12 months.

2.2. Surgical technique used for open-door laminoplasty

The patient was fixed with a three-point Mayfield headrest to maintain mild flexion. A straight skin incision was made midline over the spinal process between C2 and T1 levels, followed by exposure of the laminae and bilateral facet joints from C3 to C7. The medial aspect of the facet complex at each level was identified as the landmark for making the troughs. A high-speed cutting burr (2 mm) was used to excise the outer cortex of the hinged side laminae first, followed by the outer and inner cortex of opened side laminae. A 1 mm Kerrison rongeur was used to complete the trough of the open side and the opened side laminae were gently elevated using scalp clip applying forceps. Titanium mini-plates were attached to the opened side laminae and to the ipsilateral lateral mass as fixation and augmentation of the enlarged spinal canal.

2.3. Radiologic assessments by MRI

2.3.1. Pre-operative cervical spine alignment

The alignment of the cervical spine in the neutral position, measured from C2 to C7 using Cobb's method, was recorded on T2-weighed mid-sagittal MRI before and after surgery. Cobb's angle >10° was defined as lordosis, between 0° and 10° as straight, and <0° as kyphosis [11].

2.3.2. Morphology of the cervical spinal cord

A straight line linking the two anterior points of the spinal cord at C2–3 and C7–T1 levels was drawn. If the straight line passed through the posterior edge of the spinal cord, the spinal cord was defined as anterior convexity type. If the line passed within the spinal cord or through the anterior edge of the spinal cord, the spinal cord was considered neural type or posterior convexity type, respectively (Fig. 1).

2.3.3. Posterior drift of the cervical spinal cord

The distance from the posterior edge of each vertebral body to the center of the spinal cord was measured from C3 to C7 on T2-weighed MRI (Fig. 2). The posterior drift of the spinal cord at each decompressed cervical level was determined by calculating the difference of pre- and post-operative distances measured by MRI.

2.3.4. Expansion of antero-posterior dura diameter

Expansion of the antero-posterior dura diameter, the result of increased bony spinal canal, was expressed by the difference of the maximal antero-posterior diameter of the dural sac at each decompressed cervical level before and after surgery (Fig. 3).

All of the patients were classified into groups according to two different classification – cervical spinal cord morphology and cervical spine bony alignment (Table 1). Using the definition of sagittal morphology of the spinal cord, patients with anterior convexity type (Group IA) were compared to those with neutral type or posterior convexity type (Group IB). Patients with cervical spine lordosis or Cobb's angle >10° (Group IIA) were compared to those with straight or kyphotic cervical spine, or Cobb's angle ≤10° (Group IIB) (Table 1).

2.4. Statistical analysis

All data were presented as the mean ± standard deviation (SD) and calculated using the IBM SPSS Statistics 20. For pre-operative

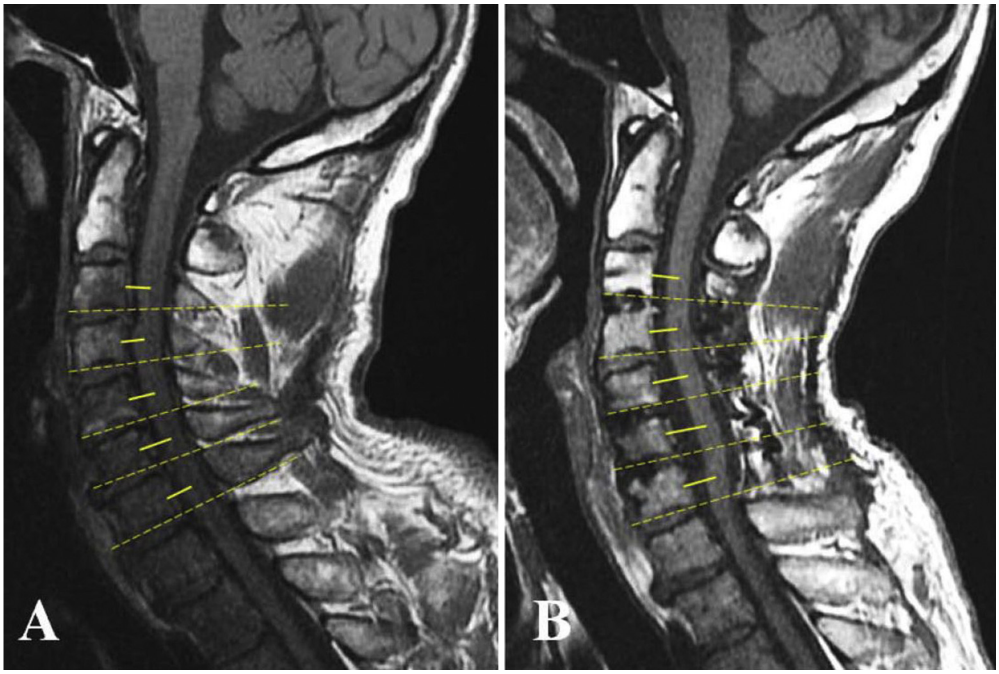

Fig. 2. The distance from posterior edge of vertebral body to the center of spinal cord at each decompressed cervical level was measured using T1-weighted images preoperatively (A) and postoperatively (B).

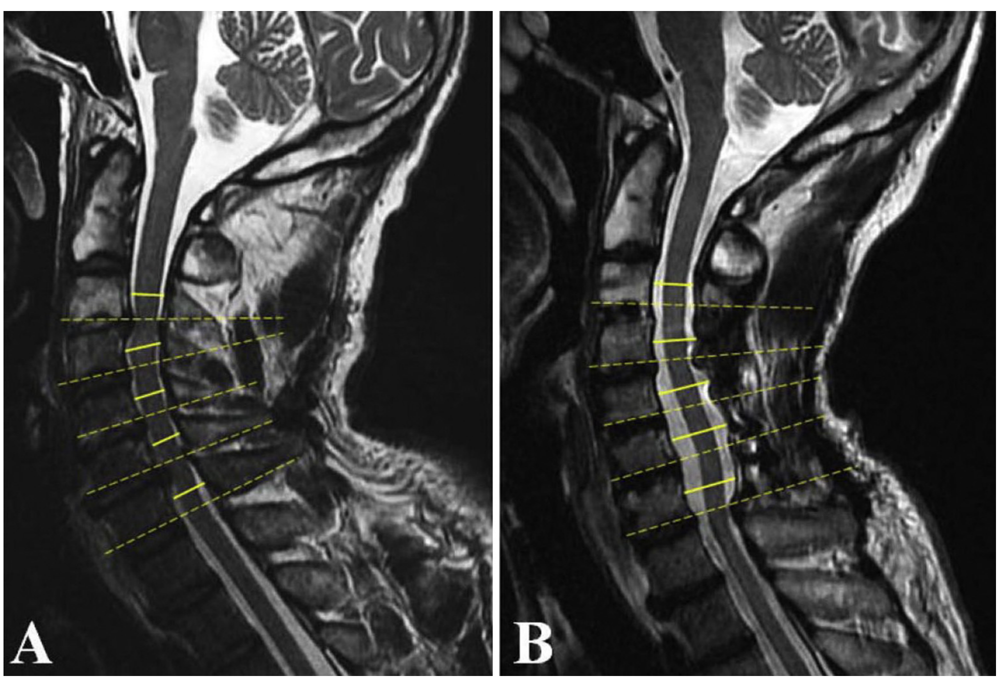

Fig. 3. The anteroposterior dura diameter at each decompressed cervical level was measured using T2-weighted images preoperatively (A) and postoperatively (B).

data, the non-parametric Mann–Whitney *U* test and Fisher's exact test were used to compare differences between groups. Paired *t* test was used to compare differences in imaging results before and after laminoplasty (data not shown). Repeated measure analysis of variance (Re-MANOVA) was used to examine the impact of pre-operative cervical morphology (including cervical spinal cord morphology and cervical spine alignment), level of decompression (from C3 to C7), and post-operative dynamic changes in MRI (including posterior drift of spinal cord and expansion of anteroposterior dura diameter). Statistical significance was set at $p < 0.05$.

3. Results

3.1. Part 1

Of the 26 patients, 10 (38.5%) had anterior convexity type spinal cord (Group IA) and 16 (61.5%) had neutral type or posterior convexity type spinal cord (Group IB). The mean value of pre-operative cervical spine Cobb's angle was $28.9 \pm 9.1^{\circ}$ in Group IA, and $8.2 \pm 8.0^{\circ}$ in Group IB, with statistically significant difference (Table 1). There were no significant differences in age at surgery, sex, pre-operative spinal cord distance between the posterior

Table 1
Pre-operative data by morphology.

	Spinal cord morphology		p value	Cervical alignment (Cobb's angle)		p value	Total
	A ($n=10$)	N and P ($n=16$)		>10° ($n=9$)	≤10° ($n=17$)		($n=26$)
Group	IA	IB		IIA	IIB		
Sex-Male	8 (80%)	6 (37.5%)	0.051	11 (64.7%)	3 (33.3%)	0.218	14 (53.8%)
Age (yr)	64.6 ± 13.0	61.4 ± 8.9	0.771	61.2 ± 11.5	65.2 ± 8.3	0.181	62.6 ± 10.5
Cobb's angle (°)	28.9 ± 9.1	8.2 ± 8.0	<0.001				16.2 ± 13.1
Spinal cord (N and P)				7 (41.2%)	9 (100.0%)	0.004	16 (61.5%)
Cord distance							
C3	7.4 ± 1.3	7.2 ± 0.9	0.937	7.3 ± 1.3	7.2 ± 0.7	0.751	7.3 ± 1.1
C4	7.5 ± 0.8	7.0 ± 1.2	0.291	7.5 ± 1.0	6.6 ± 1.0	0.045	7.2 ± 1.0
C5	7.0 ± 1.0	6.8 ± 1.2	0.895	6.9 ± 1.1	6.7 ± 1.1	1.000	6.9 ± 1.1
C6	7.4 ± 1.2	7.3 ± 1.0	0.895	7.4 ± 1.1	7.3 ± 1.2	0.751	7.4 ± 1.1
C7	7.4 ± 0.9	7.7 ± 1.0	0.444	7.4 ± 0.8	7.9 ± 1.1	0.367	7.6 ± 0.9
Dura diameter							
C3	10.0 ± 1.4	9.1 ± 0.7	0.066	9.5 ± 1.2	9.2 ± 0.7	0.711	7.4 ± 1.1
C4	9.3 ± 1.6	8.1 ± 1.0	0.051	8.8 ± 1.5	8.1 ± 1.1	0.312	8.5 ± 1.4
C5	9.3 ± 1.4	8.0 ± 1.3	0.058	8.8 ± 1.4	8.0 ± 1.4	0.312	8.5 ± 1.5
C6	9.8 ± 0.8	9.0 ± 1.4	0.154	9.4 ± 1.3	9.0 ± 1.2	0.458	9.3 ± 1.2
C7	10.6 ± 1.0	9.7 ± 1.5	0.169	10.2 ± 1.4	9.7 ± 1.5	0.634	10.0 ± 1.4

"*" Note: A, anterior convexity type, spinal cord; N, neutral type, spinal cord; P, posterior convexity type, spinal cord.

edge of the vertebral body to the center of the spinal cord, and anteroposterior dura diameter at each decompressed cervical level (from C3 to C7) between Groups IA and IB.

3.1.1. Association between pre-operative cervical spinal cord morphology and post-operative cervical spinal cord posterior drift

There was no statistically significant difference in the spinal cord posterior drift between Groups IA and IB ($p = 0.602$, Re-MANOVA) (Table 2). In Group IA, the influence of pre-operative cervical spine Cobb's angle on post-operative spinal cord posterior drift was not significant ($p = 0.971$). In Group IB, the influence was significant ($p = 0.005$) and remained significant even after adjustments for age and sex ($p = 0.036$) (Table 3).

The impact of different pre-operative cervical spine Cobb's angle on post-operative spinal cord posterior drift at each decompressed cervical level was expressed as graphs (Fig. 4). Between the two groups, different pre-operative cervical spine Cobb's angles (mean + 1 SD versus mean − 1 SD) has no significant impact on post-operative spinal cord posterior drift at each decompressed cervical level. In group IB, the amount of posterior drift was obvious at C4 and C6 levels; the most at C6 level ($p = 0.053$) (data not shown).

3.1.2. Association between pre-operative cervical spinal cord morphology and post-operative expansion of the anteroposterior dura diameter

There was no statistically significant difference in the post-operative expansion between Groups IA and IB ($p = 0.124$, Re-MANOVA) (Table 2). In Group IA, the influence of pre-operative cervical spine Cobb's angle on post-operative expansion of the anteroposterior dura diameter was not significant ($p = 0.708$). In Group IB, the influence was significant ($p = 0.012$) but became insignificant ($p = 0.149$) after adjustments for age and sex (Table 4).

The impact of different pre-operative cervical spine Cobb's angles on post-operative expansion of the anteroposterior dura diameter at each decompressed cervical level was also discussed as graphs (Fig. 5). In Group IA, different pre-operative cervical spine Cobb's angle (mean + 1 SD versus mean − 1 SD) had no significant impact on post-operative expansion of the anteroposterior dura diameter at each cervical level. In Group IB, there was a significant impact at C6 ($p = 0.024$) and C7 ($p = 0.071$) levels (data not shown).

3.2. Part 2

Of the 26 patients, 9 (34.6%) had cervical spine lordosis (Group IIA) and 17 (65.4%) had either straight cervical spine or kyphosis (Group IIB). There were no significant differences in age at surgery, sex, pre-operative spinal cord distance between the posterior edge of the vertebral body to the center of the spinal cord, and anteroposterior dura diameter at each decompressed cervical level (from C3 to C7) between Groups IIA and IIB.

3.2.1. Association between pre-operative cervical spine alignment and post-operative spinal cord posterior drift

There was statistically significant difference in the post-operative spinal cord posterior drift between Groups IIA and IIB ($p = 0.039$, Re-MANOVA) (Table 2). In Group IIA, the influence of pre-operative cervical spine alignment on post-operative spinal cord posterior drift was not significant ($p = 0.393$). In Group IIB, the influence was significant ($p = 0.026$) but became non-significant ($p = 0.094$) after adjustments for age and sex (Table 3).

3.2.2. Association between pre-operative cervical spine alignment and post-operative expansion of the anteroposterior dura diameter

There was no statistically significant difference in the post-operative expansion of the anteroposterior dura diameter between Groups IIA and IIB ($p = 0.445$, Re-MANOVA) (Table 2) and the influence of pre-operative cervical spine alignment on the post-operative expansion of the anteroposterior dura diameter was not significant in both groups ($p = 0.174$ and $p = 0.555$, respectively) (Table 4).

4. Discussion

Open-door laminoplasty is a surgical technique recommended for patients with CSM. Expansion of the bony spinal canal and posterior drifting of the spinal cord are imaging results and it has been speculated that the degree of morphologic change is proportional to clinical improvement [8,12]. Whether insufficient indirect decompression after laminoplasty associated with the risk of poor clinical outcome remains debatable, several studies reveal that greater post-operative posterior spinal cord drift correlates with better clinical outcome [8,9,13,14]. Pre-operative cervical spine alignment, the space available at cephalad levels, longitudinal distance index, and some other factors are associated with spinal cord posterior drift after laminoplasty [7,8].

To date, there is no report to discuss the association between pre-operative cervical spinal cord morphology and post-operative imaging results following laminoplasty. The purpose of this study

Table 2
Comparisons of spinal cord posterior migration and antero-posterior dura diameter expansion, by morphology.

	Spinal cord morphology		p^1	Cobb's angle		p^1
	A (n = 10)	N and P (n = 16)		>10° (n = 9)	≤10° (n = 17)	
Group	IA	IB		IIA	IIB	
Cord migration						
C3	2.02 ± 2.09	1.66 ± 1.20		1.76 ± 1.81	1.79 ± 1.57	
C4	2.37 ± 1.26	2.34 ± 1.05		2.04 ± 1.15	2.35 ± 1.10	
C5	3.05 ± 2.19	2.20 ± 1.52	0.602	2.52 ± 2.00	2.52 ± 1.81	0.039
C6	2.72 ± 2.01	2.20 ± 1.17		2.68 ± 1.68	2.40 ± 1.53	
C7	1.91 ± 1.10	2.09 ± 1.10		2.11 ± 1.12	2.02 ± 1.07	
Dura expansion						
C3	2.14 ± 1.01	2.24 ± 1.19		2.15 ± 1.20	2.20 ± 1.10	
C4	4.18 ± 1.99	4.13 ± 1.84		4.43 ± 1.92	4.14 ± 1.86	
C5	3.98 ± 2.55	4.28 ± 2.02	0.124	4.38 ± 2.33	4.16 ± 2.19	0.445
C6	3.60 ± 2.70	4.56 ± 1.86		4.32 ± 2.51	4.18 ± 2.22	
C7	2.06 ± 1.81	3.97 ± 2.19		3.20 ± 2.40	3.23 ± 2.22	

Abbreviations: A, anterior convexity type, spinal cord; N, neutral type, spinal cord; P, posterior convexity type, spinal cord.
"*" p^1, repeated measure analysis of variance (Re-MANOVA).

Table 3
Influence of pre-operative cervical spine Cobb's angle on post-operative spinal cord posterior migration after adjustment for age and sex.

Group		Unadjusted			Adjusted		
		Wilks' Λ^1	F^2	p value	Wilks' Λ^1	F^2	p value
IA	Spinal cord: A						
	Cobb's angle	0.915	0.116	0.971	0.896	0.087	0.980
	Sex	0.412	1.785	0.269	0.362	1.323	0.426
	Age	0.839	0.240	0.904	0.736	0.269	0.881
IB	Spinal cord: N and P						
	Cobb's angle	0.291	6.713	0.005	0.353	4.127	0.036
	Sex	0.916	0.252	0.902	0.629	1.329	0.331
	Age	0.504	2.706	0.086	0.639	1.272	0.349
IIA	Cobb's angle >10°						
	Cobb's angle	0.730	1.109	0.397	0.827	0.523	0.722
	Sex	0.728	1.118	0.393	0.731	0.920	0.490
	Age	0.722	1.157	0.377	0.738	0.887	0.506
IIB	Cobb's angle ≤10°						
	Cobb's angle	0.096	9.427	0.026	0.048	9.886	0.094
	Sex	0.635	0.576	0.697	0.242	1.569	0.425
	Age	0.722	0.384	0.811	0.686	0.228	0.902

"*" Note: A, anterior convexity type, spinal cord; N, neutral type, spinal cord; P, posterior convexity type, spinal cord.
Wilks' Λ^1, Wilks's lambda distribution.
F^2, F distribution.

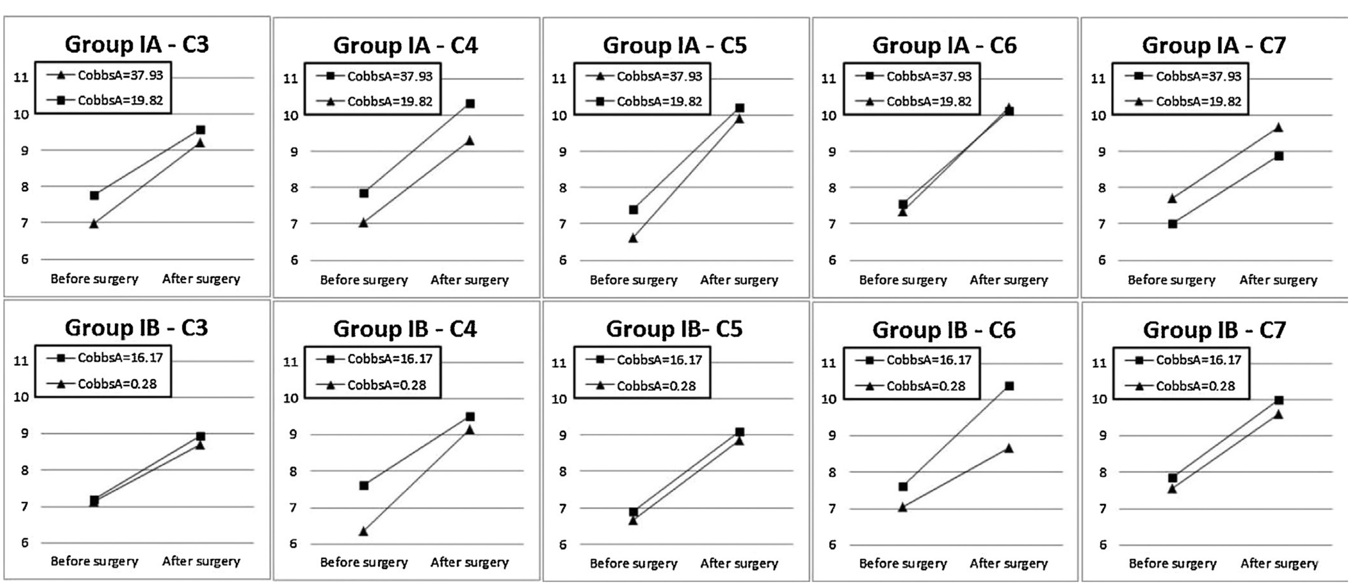

Fig. 4. The impact of different preoperative cervical spine bony alignments, Cobb's angle (mean + 1 SD versus mean – 1 SD), on the postoperative cord posterior migration was expressed at each decompressed cervical level in group IA and IB. Different Cobb's angle had no influence from C3 to C6 in group IA (upper), but it did have an influence in group IB (lower), especially on C6 (Cobb's angle in group IA: 28.9 ± 9.1; Cobb's angle in group IB: 8.2 ± 8.0). Vertical axis denoted millimeters of drift.

Table 4
Influence of pre-operative cervical spine Cobb's angle on post-operative dura antero-posterior diameter expansion after adjustment for age and sex.

Group		Unadjusted			Adjusted		
		Wilks' Λ[1]	F^2	p value	Wilks' Λ[1]	F^2	p value
IA	Spinal cord: A						
	Cobb's angle	0.694	0.551	0.708	0.768	0.227	0.907
	Sex	0.613	0.788	0.579	0.555	0.602	0.689
	Age	0.449	1.534	0.321	0.423	1.024	0.513
IB	Spinal cord: N and P						
	Cobb's angle	0.338	5.393	0.012	0.505	2.208	0.149
	Sex	0.635	1.579	0.248	0.612	1.428	0.301
	Age	0.498	2.776	0.081	0.633	1.302	0.340
IIA	Cobb's angle >10°						
	Cobb's angle	0.612	1.906	0.174	0.697	1.085	0.415
	Sex	0.918	0.267	0.893	0.955	0.116	0.974
	Age	0.540	2.554	0.093	0.595	1.700	0.226
IIB	Cobb's angle ≤10°						
	Cobb's angle	0.537	0.862	0.555	0.029	16.456	0.058
	Sex	0.654	0.530	0.723	0.581	0.360	0.825
	Age	0.095	9.555	0.025	0.005	103.966	0.005

"*" Note: A, anterior convexity type, spinal cord; N: neutral type, spinal cord; P: posterior convexity type, spinal cord.
Wilks' Λ[1], Wilks's lambda distribution.
F^2, *F* distribution.

is to investigate if pre-operative cervical spinal cord morphology as crucial determinant in predicting surgical outcome. All patients selected in this study have the same levels of posterior decompression, from C3 to C7, to avoid the measurement bias, because different range of posterior decompression will influence the degree of postoperative morphologic change. Otherwise, the imaging finding of each decompressed cervical level is recorded and analyzed separately in our study. Previous studies calculated the sum of imaging change in each decompressed cervical level as the radiologic measurement over the entire decompressed cervical levels for patients with different range of posterior decompression. Morphological change over the entire cervical spine following laminoplasty is complicated, not only because of spinal cord posterior drift or bony spinal canal expansion, but also due to lordosis or kyphosis over the cervical sagittal alignment, decrease in range of motion, and other possible factors yet to be determined. Different decompressed cervical levels are unevenly distributed over the entire decompressed range. Thus, in this study, post-operative image results, including spinal cord posterior drift and expansion of the anteroposterior dura diameter, at each decompressed cervical level are used as particular indicators representing latent variables of the whole dynamic change following laminoplasty.

Traditionally, spine surgeons are taught that patients with kyphotic deformity are not suitable candidates for laminoplasty. However, it is not uncommon to observe that some patients having kyphotic deformity get clinical improvement after laminoplasty. In addition to kyphosis, there must be one or some unidentified factor taking influence on patient selection actually. In this study, the patients are divided into the anterior convexity type and those with neutral or posterior convexity type based on the pre-operative cervical spinal cord morphology. Patients with the anterior convexity type have much more spinal cord posterior migration than those with the neutral or posterior convexity type, but there is no significant difference between two groups. The interesting finding is that cervical spine Cobb's angle influences post-operative spinal cord posterior drift on patients with neutral or posterior convexity type,

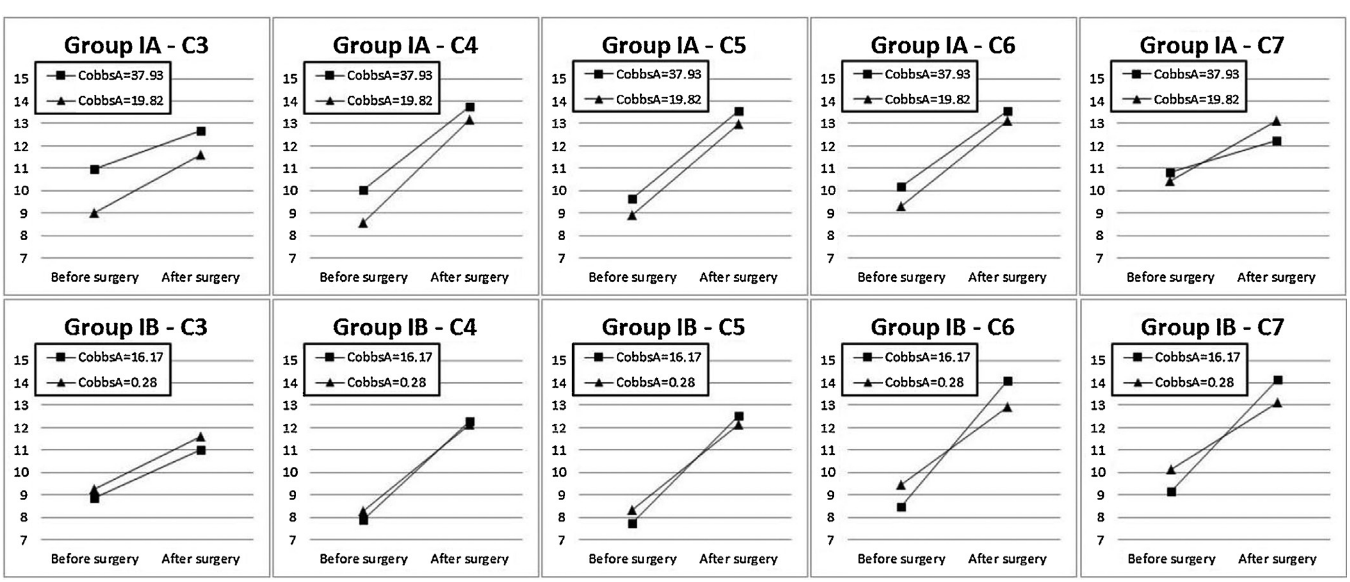

Fig. 5. The impact of different preoperative cervical spine bony alignment, Cobb's angle (mean + 1 SD versus mean − 1 SD) on the postoperative expansion of anteroposterior dura diameter was expressed at each decompressed cervical level in group IA and IB. Different Cobb's angle had no influence from C3 to C6 in group IA (upper), but it did have an influence in group IB (lower), especially on C6 and C7 (Cobb's angle in group IA: 28.9 ± 9.1; Cobb's angle in group IB: 8.2 ± 8.0). Vertical axis denoted millimeters of drift.

not anterior convexity type. In short, for patients with neutral type or posterior convexity type, those with more lordosis in their pre-operative cervical alignment have more post-operative spinal cord posterior drift. Based on this observed finding, it can be concluded that preoperative cervical spine bony alignment, Cobb's angle, plays an important role in predicting surgical outcome for patients with neutral or posterior convexity type. However, this relationship does not exist for patients with anterior convexity type. There is no significant difference in the expansion of the anteroposterior dura diameter among patients with different spinal cord types. Regardless of the kind of cervical cord morphology, different cervical spine Cobb's angles have no impact on the post-operative expansion of the anteroposterior dura diameter.

In patients with the neutral or posterior convexity type spinal cord morphology, the key point of different post-operative spinal cord posterior drift at different Cobb's angles is at C4 and C6 level. Moreover, the obvious change over expansion of the anteroposterior dura diameter at different Cobb's angles is at the C6 and C7 level.

As an index of sagittal alignment of the cervical spine, the patients are further divided into two groups: those with Cobb's angle $>10^{\circ}$ (lordosis) and Cobb's angle $\leq 10^{\circ}$ (straight and kyphosis). There is a significant difference in the post-operative spinal cord posterior migration between these two groups. After adjustments for age and sex, cervical spine Cobb's angle has no impact on post-operative imaging result after laminoplasty, regardless of pre-operative cervical spine alignment (kyphosis, straight, or lordosis). This finding is compatible with previous studies [9,15].

Morphologic change of the cervical spinal cord following laminoplasty involves not only posterior decompression by spinal canal expansion but also anterior tethering by anchoring of the spinal cord at the cranial and caudal edges of the laminae, dentate ligament traction, and other unknown factors. This may explain the continuing debate regarding the effect of pre-operative cervical spine bony alignment on the post-operative spinal cord posterior drift and clinical outcomes. Finally, this study harbored limitation in the number of patients; further prospective study enrolling larger sample size from multi-centers is warranted. The findings here corroborate the value of pre-operative cervical spinal cord morphology as a screening condition for patients with CSM for selecting surgical candidates for laminoplasty.

In conclusion, laminoplasty is an effective treatment for CSM but not for all CSM patients. This study offers a new perspective while approaching patients with CSM – using pre-operative cervical spinal cord morphology as a screening tool for selecting candidates of laminoplasty. Patients with the neutral or posterior convexity type spinal cord morphology accompanied with kyphotic deformity are not suitable surgical candidates for laminoplasty. On the other hand, patients with anterior convexity type spinal cord morphology, regardless of cervical spine Cobb's angle, would benefit from sufficient post-operative spinal cord posterior drift following laminoplasty.

Conflicts of interest

None declared.

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