Clinical Trial/Experimental Study

Medicine®

OPEN

Relationship between cervical curvature and spinal cord drift distance after laminectomy via lateral mass screw fixation and its effect on clinical efficacy

Yong Liu, MD[a], Xiao-Zhe Zhou, MM[b], Ning Li, MD[c], Tong-Guang Xu, MM[a,*]

Abstract

Background: Laminectomy with lateral mass screw fixation (LCS) is considered an effective surgical procedure for cervical spondylotic myelopathy. However, varying degrees of loss of the cervical curvature were noted in some patients postoperatively. The aim of this study was to observe the relationship between cervical curvature and spinal drift distance after LCS and to determine its effect on neurological function, axial symptoms, and C5 palsy.

Methods: A total of 117 consecutive cervical spondylotic myelopathy patients with normal cervical curvature underwent LCS from April 2015 to May 2017 in our institution. Of these patients, 90 patients who accepted to undergo an integrated follow-up were enrolled in this study. The patients were divided into 3 groups based on their postoperative cervical curvature. In group A (28 patients), the cervical curvature became straight postoperatively (0°≤cervical spine angle≤5°); in group B (36 patients), the cervical curvature decreased (5°<cervical spine angle≤16.5°); and in group C (26 patients), the cervical curvature remained normal (cervical spine angle>16.5°). Spinal drift distance, neurological recovery, axial symptoms, and C5 palsy in the patients were recorded and analyzed.

Results: Postoperative measurements showed that there was no significant difference in laminectomy width between the groups ($P > .05$). The cervical spine angle was 2.7° ± 0.5° in group A, 11.2° ± 2.6° in group B, and 20.8° ± 4.1° in group C ($P < .05$), while the spinal drift distance was 1.2 ± 0.2 mm, 1.8 ± 0.4 mm, and 3.0 ± 0.5 mm, respectively ($P < .05$). The postoperative Japanese Orthopedic Association score was significantly increased in all groups ($P < .05$), and there was no significant difference between the groups at different time points ($P > .05$). However, significant differences were noted between the groups in axial symptoms ($P < .05$), which were analyzed via the visual analog scale score. The occurrence of C5 palsy in groups A, B, and C was 7.1% (2/28), 8.3% (3/36), and 11.5% (3/26), respectively ($P > .05$).

Conclusion: In LCS, the cervical curvature should be maintained at the normal angle to obtain a good spinal cord drift distance and a lower incidence of axial symptoms.

Abbreviations: CSM = cervical spondylotic myelopathy, CT = computed tomography, JOA = Japanese Orthopedic Association, LCS = laminectomy with lateral mass screw fixation, VAS = visual analog scale.

Keywords: axial symptoms, C5 palsy, cervical curvature, cervical spondylotic myelopathy, lateral mass screw fixation

1. Introduction

With the gradual aggravation of population aging globally, the incidence of cervical spondylotic myelopathy (CSM) is increasing. The main causative factors of CSM are a herniated intervertebral disk, hypertrophic osteophytes, and incrassate ligaments that compress the spinal cord, leading to numbness of the limbs, difficulty walking, and even bladder and bowel dysfunction. Surgical treatment should be performed soon after definite diagnosis. Currently, the main surgical methods are open door laminoplasty with titanium plate fixation[1,2] and laminec-

Editor: Luis Rafael Moscote-Salazar.

No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party directly or indirectly related to the subject of this manuscript.

The authors have no conflicts of interests to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

[a] Department of Orthopedics, The People's Hospital of Suzhou New District, Suzhou, Jiangsu, [b] Department of Orthopedics, Affiliated Hospital of Hebei University, Baoding, [c] Department of Minimally Invasive Spine Surgery, Tianjin Hospital, Tianjin, China.

[*] Correspondence: Tong-Guang Xu, Department of Orthopedics, the People's Hospital of Suzhou New District, No. 95 Huashan Road, New District, Suzhou City 215129, China (e-mail: yongshenspine@126.com).

How to cite this article: Liu Y, Zhou XZ, Li N, Xu TG. Relationship between cervical curvature and spinal cord drift distance after laminectomy via lateral mass screw fixation and its effect on clinical efficacy. Medicine 2021;100:36(e26220).

Received: 10 June 2019 / Received in final form: 7 May 2021 / Accepted: 17 May 2021

http://dx.doi.org/10.1097/MD.0000000000026220

tomy with lateral mass screw fixation (LCS).[3,4] According to the literature, a lateral mass screw can achieve simultaneous fixation of the middle and posterior columns of the cervical spine, and the fixation strength and the maintenance/correction of the cervical curvature were significantly better in patients who underwent LCS than in those who received the titanium miniplate with posterior column fixation alone.[1,4,5] However, Lin et al[1] suggested that the axial symptoms of LCS are more severe than those of open door laminoplasty (miniplate fixation) and the incidence of C5 palsy is higher. Moreover, in the patients who underwent LCS, the overall range of motion of the cervical spine was significantly lost after surgery.[1,5]

In clinical practice, we found that after LCS, radiographs showed different degrees of reduction or even straightening of the cervical curvature in some patients. We considered that this may be related to a lower position of the patients' head intra-operatively or a smaller angle of the pre-bent titanium rod. Therefore, it seems unclear whether the change in cervical curvature affects spinal cord drift distance and the clinical effect after surgery. Thus, the aim of this study was to observe the relationship between cervical curvature and spinal drift distance after LCS and to determine its effect on neurological function, axial symptoms, and C5 palsy.

2. Material and methods

2.1. Patients' information

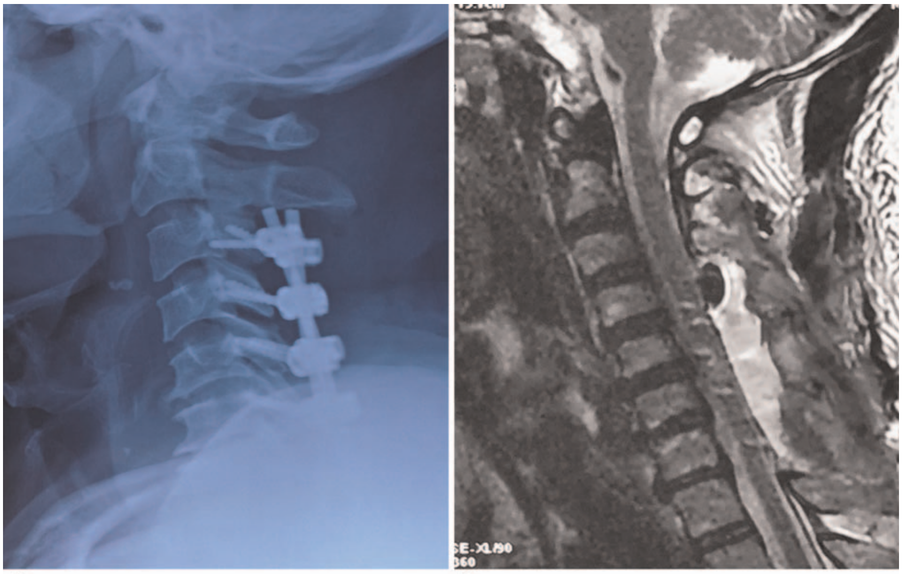
From April 2015 to May 2017, 117 consecutive patients who had normal cervical curvature were diagnosed with CSM in the People's Hospital of Suzhou New District. The patients underwent LCS for CSM treatment, and 90 patients were followed up for more than a year. Based on the degree of postoperative cervical curvature, the patients were divided into 3 groups. In group A, the cervical spine became straight ($0° \leq$ cervical spine angle $\leq 5°$) (Fig. 1); in group B, the cervical curvature decreased ($5° <$ cervical spine angle $\leq 16.5°$) (Fig. 2); and in group C, the cervical curvature remained normal (cervical spine angle $> 16.5°$) (Fig. 3). This study was approved by the Regional Ethics Committee of the People's Hospital of Suzhou New District. All clinical data were collected after the acquisition of written informed consent from the patients.

2.2. Surgical method

All operations were performed by the same surgeon. After successful induction of anesthesia, the patient's head was placed on the Mayfield head frame. A posterior median incision was made and the posterior neck muscles were peeled off using a high-frequency electrotome, revealing the spinous processes, the lamina, and facet joints. Next, a lateral mass screw (Medtronic Sofamor Danek, Memphis, TN) was embedded in the vertebral body, according to the Magerl technique.[4] If the lateral mass of C7 was small, we chose a thin and short lateral mass screw. A parallel slot was made at the transition of laminae and lateral block using a high-speed grinding drill, and until the internal cortex of the laminae was as thin as paper, the vertebral plate was lifted slowly using a towel clamp. The patient's head was raised and titanium rods were inserted in the u-shaped slot for the nail and then locked the nut. After placing the drainage tube, the wound was sutured layer by layer.

2.3. Imaging evaluation

Data measurement was performed with Photoshop 8.0.1 mapping software. One week after surgery, posteroanterior and lateral radiographs of the cervical spine were taken in the neutral position, and the cervical spine angle was measured via the Harrison's method. Briefly, parallel lines were drawn from the posterior edges of the vertebral bodies of C2 and C7, and the acute angle formed between the 2 lines was measured (Fig. 3A).[6] If the C7 vertebra was shielded by the shoulder, the cervical



A B

Figure 1. Radiograph of a 58-year-old male patient in group A who underwent laminectomy with lateral mass screw fixation at C3–7. The cervical spine angle was 3.1° (A) and the spinal drift distance was 1.3 mm (B).

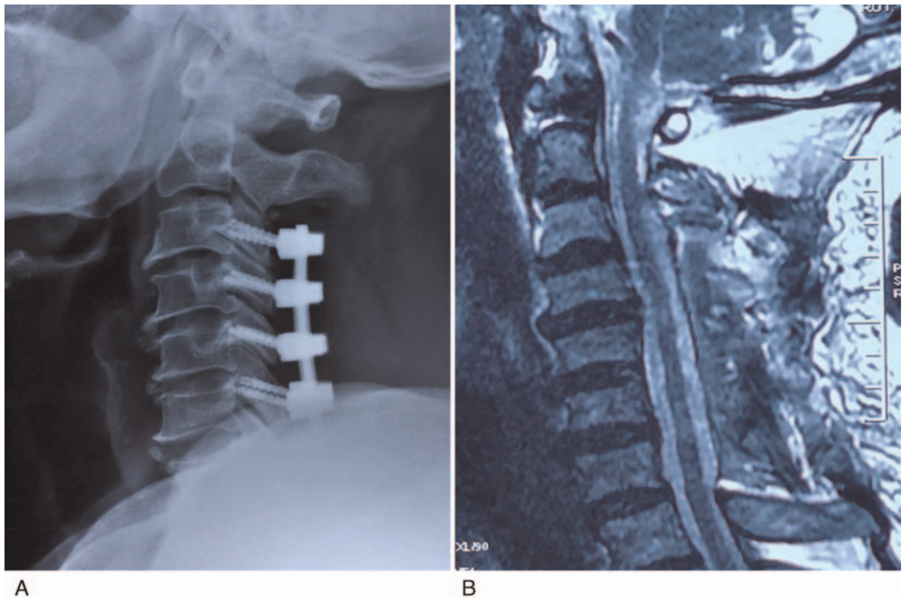


Figure 2. Radiograph of a 59-year-old female patient in group B who underwent laminectomy with lateral mass screw fixation at C3–7. The cervical spine angle was 11.8° (A) and the spinal drift distance was 2.2 mm (B).

lordosis was measured on a sagittal computed tomography (CT) image. Reconstructed CT scans of the posterior cervical structure were taken, and the mean laminectomy width was measured on coronal images–(a1 + a2 + a3 + ... an)/n (Fig. 4). The cervical spine was scanned with a high resolution of 1.5T (GE Signal HDi scanner), and the spinal drift distance at C5 level was measured on mid-sagittal T2-weighted images. The length of the posterior edge of the vertebral body of C5 and the midpoint of the spinal cord transverse diameter was measured. Spinal drift distance=postoperative distance (b) − preoperative distance (a).[4] In cases of ossification of the vertebral body, the distance between the posterior edge of the ossification and the midpoint of the spinal cord transverse diameter was measured. (Fig. 3B and C).

2.4. Clinical evaluation

The Japanese Orthopaedic Association (JOA) 17-point scoring system was used to evaluate the preoperative and postoperative neurological function of the patients.[1] The recovery rate was

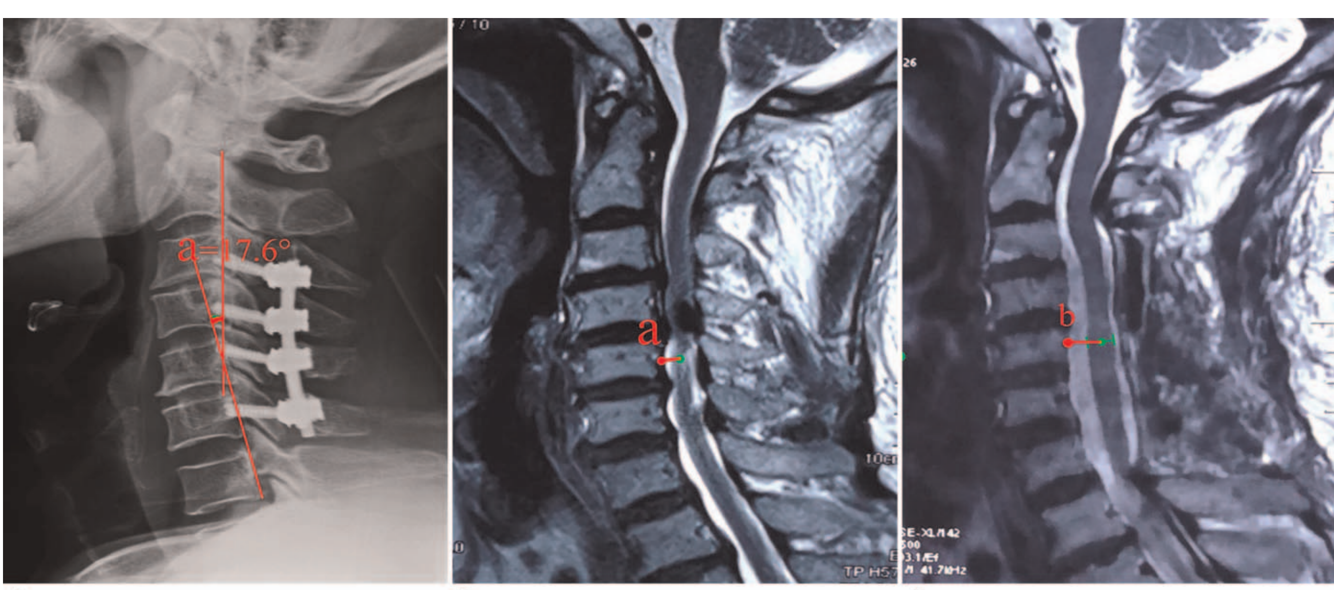


Figure 3. Radiograph of a 61-year-old male patient in group C who underwent laminectomy with lateral mass screw fixation at C3–6. The cervical spine angle was 17.6° (A) and the spinal drift distance was 3.2 mm (B, C).

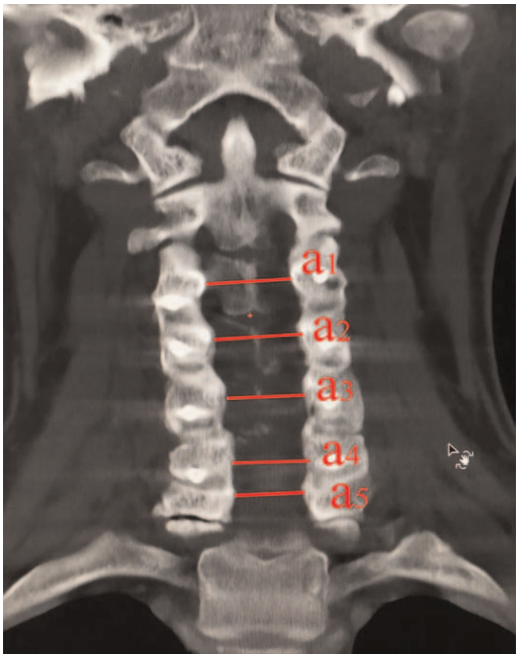


Figure 4. Schematic diagram of the mean laminectomy width.

calculated as: recovery rate = (postoperative JOA score − preoperative JOA score)/(17 − preoperative JOA score) × 100%. The diagnostic criteria for C5 palsy were new postoperative occurrence of paralysis of the deltoid and/or biceps brachii, manifesting mostly as mild myasthenia, because patients may present with comorbidities such as C5 dermatome sensory disturbances and intractable pain.[4] Axial symptoms[2] included cervicodorsal pain accompanied by varying degrees of stiffness, acid swelling, muscle spasm, and heaviness. Axial symptom severity was rated via the visual analog scale.

2.5. Statistical analysis

SPSS (Version 20.0 IBM, Chicago, IL) was used to conduct statistical analysis. Analysis of variance or paired *t* test was used to compare continuous variables. Categorical variables were compared via the X^2 test or via multiple nonparametric tests for independent samples. Two-sided *P* values of <.05 were considered statistically significant. Bonferroni correction was used for multiple between-group comparisons, and a difference with $P < .016$ was considered statistically significant.

3. Results

According to measurements using Harrison's method, there were 28 patients in group A, 36 patients in group B, and 26 patients in group C. No statistical difference was noted between the 3 groups in indicators such as age, sex, duration of symptoms, operated segment, and follow-up period ($P > .05$) (Table 1).

The laminectomy width in groups A, B, and C was 21.6 ± 1.5 mm, 20.9 ± 1.3 mm, and 21.4 ± 1.5 mm, respectively, and there was no significant difference between the groups ($P > .05$). However, a significant difference was noted in cervical spine angle (groups A, B, and C: 2.7° ± 0.5°, 11.2° ± 2.6°, and 20.8° ± 4.1°, respectively) ($P < .05$). The spinal drift distance was 1.2 ± 0.2 mm, 1.8 ± 0.4 mm, and 3.0 ± 0.5 mm in groups A, B, and C, respectively ($P < .05$). Pairwise comparisons showed statistical differences between groups A and B, B and C, and A and C ($P < .05$) (Table 2).

The postoperative JOA score was significantly higher than the preoperative score in all groups ($P < .05$), and no significant difference was detected between the groups at different time points ($P > .05$). Axial symptoms were significantly different between the 3 groups ($P < .05$), and further comparisons showed statistical differences between groups A and B and groups A and C ($P < .05$), but no significant difference was noted between groups B and C ($P > .05$). The occurrence of C5 palsy in the 3 groups was 7.1% (2/28), 8.3% (3/36), and 11.5% (3/26), respectively, with no significant difference between the groups ($P > .05$) (Tables 2 and 3).

4. Discussion

Cervical curvature is a common radiographic feature, and changes in cervical curvature can accurately reflect the degree of cervical degeneration and changes in overall cervical function. Previous studies reported that cervical spine abnormality was an important index for the early diagnosis of cervical spondylosis, and the measurement value of the cervical curvature was an important criterion for evaluating the preoperative and postoperative function.[6,7] Harrison et al[8] found that the normal cervical curvature was >16.5°. The physiologic cervical curvature provides elasticity to the cervical spine, cushions stress, and absorbs shock to protect against cervical cord injury. There are many factors that maintain the balance of the normal cervical

Table 1

Comparison of related characteristics between the 3 groups.

	Group A (28 cases)	Group B (36 cases)	Group C (26 cases)	F/χ^2	*P* value
Sex					
Male	13	16	14	0.564	.75
Female	15	20	12		
Age (y)	56.1 ± 13.5	55.6 ± 12.2	57.2 ± 13.9	0.114	.89
Follow-up period (mo)	15.8 ± 3.6	17.0 ± 3.8	16.3 ± 3.9	0.818	.45
Operated segment					
C3–7	16	19	14	0.787	.50
C3–6	4	6	4		
C3–5	2	3	2		
C4–7	6	8	6		

Table 2

Comparison of imaging data and C5 palsy among the 3 groups.

Group	Cervical spine angle (°)	Laminectomy width (mm)	Spinal drift distance (mm)	C5 palsy [n,%]	
				Yes	No
Group A (28 cases)	2.7 ± 0.5	21.6 ± 1.5	1.2 ± 0.2	2 (7.1%)	26 (92.9%)
Group B (36 cases)	11.2 ± 2.6*	20.9 ± 1.3*	1.8 ± 0.4	3 (8.3%)	33 (91.7%)
Group C (26 cases)	20.8 ± 4.1*,†	21.4 ± 1.5*,†	3.0 ± 0.5	3 (11.5%)	23 (88.5%)
F/χ^2 value	289.585‡	2.077‡	152.119‡	0.344§	
P value	<.001	.131	<.001	.843 <.001	

* Compared with group A, $P < .016$.
† Compared with group B, $P < .016$.
‡ Analysis of variance.
§ χ^2 test.

curvature, including the coordination of cervical muscles, the tension of ligaments, the elasticity and height maintenance of the intervertebral disc tissue, and so on.[6,8] With the popularity of portable electronic products such as mobile phones and tablets, a large number of people maintain an incorrect cervical spine posture of bowing the head for extended periods, leading to the straightening of the cervical curvature. Therefore, patients with reduced cervical curvature are increasingly found in outpatient clinics. In addition, we found that the cervical curvature of some patients who underwent laminoplasty or laminectomy was lost in varying degrees, but it was not clear whether the loss of cervical curvature affected the postoperative clinical efficacy.

Therefore, in this study, according to the definition of normal cervical curvature by Harrison et al,[8] we divided the enrolled patients into 3 groups, and we noted that the difference in cervical curvature did not affect neurological function recovery. Moreover, no significant difference was observed between the 3 groups in the preoperative versus postoperative JOA scores during the follow-up.

With adequate decompression of the spinal cord, the recovery of neurological function would be remarkable. It has been reported that the C5 segment is the largest part of the transverse diameter of the cervical spinal cord, and the average transverse diameter of the spinal cord is only 13 mm.[9,10] Therefore, sufficient decompression could be achieved if the laminectomy width exceeds the transverse diameter of the corresponding segment of the spinal cord.[11,12] In a study by Klement et al,[13] spinal cord decompression could be achieved with a laminectomy width of 23.1 mm. However, Radcliff et al[14] and Zhao et al[4] reduced the laminectomy width to 19 and 16.7 mm, respectively, and satisfactory recovery of neurological function was achieved. Intraoperative evaluation revealed that adequate decompression with a laminectomy width as long as the spinal cord can address cases of spinal cord swelling. In this study, the laminectomy width was more than 20 mm, which significantly exceeded the transverse diameter of the spinal cord, and the postoperative cervical curvature could only affect spinal cord drift distance, which does not affect the final decompression of the spinal cord.

However, it remains unclear why some patients had an abnormal cervical curvature postsurgically. We believe that, first, the intraoperative position of these patients may have been improper. The position of the head was lower than the trunk, additionally, the cervical spine had hypokinesis and lacked sufficient lifting. These postural changes reduced the cervical curvature after fixation.[15] Second, the curvature of the prebent titanium rod was inadequate. Third, the removal of the spinous process and vertebral plate resulted in considerable loss of the effective attachment points of the posterior cervical muscles; thus, the tension of these muscles that maintain the cervical curvature was weakened, resulting in the reduction or straightening of the physiological curvature of the cervical vertebra.[16–19]

Presently, experts focus on the preservation or reconstruction of the attachment points of muscles, including the preservation of muscle attachments on C2 and C7 during laminoplasty,[18] repair of the posterior deep extensor insertion to the C2 lamina during laminoplasty,[16] and muscle-preserving selective laminectomy.[19] These procedures could reduce atrophy of the posterior deep extensor muscle and maintain the tension behind the cervical vertebra. However, clinicians seem not to consider that an improper positional relationship between the head and trunk during surgery could also result in loss of cervical curvature. In our study, patients were placed in the prone position during posterior cervical surgery, and the head was fixed in a common head frame or the Mayfield head frame. To facilitate muscle

Table 3

Comparison of neurological function and axial symptoms among the 3 groups.

	JOA score			Recovery rate (%)	VAS score of axial symptoms	
	Preop	3 mo postop	Final follow-up		3 d postop	1 mo postop
Group A (28 cases)	7.5 ± 1.2	12.3 ± 2.6*	13.6 ± 3.1*	64.2 ± 12.5	5.1 ± 1.2	3.6 ± 0.6†
Group B (36 cases)	7.7 ± 1.1	12.8 ± 2.9*	13.8 ± 3.2*	65.6 ± 13.3	3.7 ± 0.7	2.4 ± 0.3†
Group C (26 cases)	7.4 ± 1.0	13.2 ± 3.0*	13.9 ± 3.1*	67.7 ± 14.1	3.3 ± 0.5	2.2 ± 0.2†
F value	0.599‡	0.683‡	0.065‡	0.472‡	34.800‡	101.609‡
P value	.551	.508	.937	.625	<.001	<.001

* Compared with preoperation, $P < .05$.
† Compared with 3 days postoperation, $P < .05$.
‡ Analysis of variance.

incision and exposure, the head was placed forward and downward, so that the cervical spine was straight or bent forward. If the head is not raised and the cervical curvature is not adjusted before fixation, an abnormal cervical curvature would result after surgery. In addition, the titanium system with a lateral mass screw provided sufficient strength and stiffness. The mechanical strength of the titanium rod was sufficient to change the physiological curvature of the cervical vertebra after serial fixation using a lateral mass screw. Therefore, the radian of the titanium rod was another key factor for determining cervical curvature.

Axial symptoms are the most common complications in laminoplasty and laminectomy, with a reported incidence of 5.2% to 80%. The main manifestations of axial complications are cervicodorsal pain accompanied by discomfort such as stiffness, tension, and soreness of the neck muscles.[20] Presently, the specific mechanism of axial symptoms remains unclear. Previous studies reported that axial symptoms may be related to factors such as the destruction of spinous process and muscle attachment points, the destruction of articular capsule, the atrophy of posterior cervical muscles, change in cervical curvature, and the instability of vertebral segments.[2,5,15–20] Therefore, it seems unclear whether the occurrence of axial symptoms is related to a change in cervical curvature. In a study by Du et al,[21] which the surgical procedures of laminoplasty, laminectomy, and LCS were compared, the authors found that loss of cervical curvature was related to the degree of neurological recovery and the severity of axial symptoms. In the present study, the visual analog scale scores of axial symptoms in group A were significantly higher than those in groups B and C. The cervical lordosis in group B was smaller than that in group C, but no significant difference was found in the occurrence of axial symptoms between the groups. This indicated that loss of cervical curvature could cause worsening of axial symptoms. The current research suggests that a slight loss of cervical curvature will not worsen axial symptoms. There may be a critical point of cervical curvature reduction at which axial symptoms are induced. More studies are needed to confirm this critical point.

C5 nerve paralysis is another very common complication of laminectomy. Several studies have reported that it was related to an increase in tension and the excessive traction of the C5 nerve root after backward spinal cord drift.[14,15,22] Nerve root palsy was induced by mechanisms such as ischemia and hypoxia, segmental spinal cord disorder, embolism, reperfusion injury, and iatrogenic nerve root compression.[3–5,11–15,22–24] Radcliff et al[14] found that the spinal cord drift distance at the C5 level was 5.1 mm in patients with C5 palsy, which was significantly greater than that in patients without nerve paralysis. Tsuji et al[24] found that a larger postoperative space anterior to the spinal cord was positively correlated with a higher incidence of C5 palsy. Thus, some expert surgeons opt for selective laminoplasty combined with laminectomy and internal fixation to prevent the postoperative occurrence of C5 nerve paralysis, and the principle is to limit excessive backward spinal cord shift.[25] In the present study, the spinal cord drift distances in groups A and C were 1.2 $\pm$ 0.2 mm and 3.0 $\pm$ 0.5 mm, respectively, and the occurrence of C5 palsy was 11.5% and 7.1%, respectively, with no statistical difference observed in the incidence of C5 palsy. We considered that since the cervical curvature in group C was the largest and yet the spinal cord drift distance was only 3.0 mm, which was significantly smaller than that in the study by Radcliff et al (5.1 mm), the degree of spinal cord drift was not sufficient to cause a significant difference in the occurrence of C5 palsy.

There were some limitations to our study. First, due to the small sample of patients enrolled, the number of cases in each group was small, and statistical bias may be present. Second, in patients where the C7 vertebra were shielded by the shoulder, the cervical spine angle had to be measured on CT images. Errors in cervical lordosis assessment in the supine (for CT) and standing positions (for X-ray) may also exist. Therefore, in the future, we plan to expand the sample size and improve the measurement method to circumvent the above-mentioned problems.

5. Conclusions

In LCS, the head should be raised properly and the titanium rod should be adequately bent before fixation to achieve recovery of cervical curvature. A cervical spine with normal curvature will obtain a better spinal cord drift distance and a lower incidence of axial symptoms after LCS. Further, a cervical spine with normal curvature is associated with a low incidence of C5 palsy and better neurological recovery.

Author contributions

Conceptualization: Xiao-zhe Zhou.
Data curation: Yong Liu.
Investigation: Xiao-zhe Zhou, Ning Li, Tong-guang Xu.
Software: Yong Liu.
Supervision: Xiao-zhe Zhou, Tong-guang Xu.
Writing – original draft: Tong-guang Xu.

References

[1] Lin X, Cai J, Qin C, et al. Comparison of clinical outcomes and safety between laminectomy with instrumented fusion versus laminoplasty for the treatment of multilevel cervical spondylotic myelopathy. Medicine (Baltimore) 2019;98:e14651.
[2] Chen H, Liu H, Deng Y, et al. Multivariate analysis of factors associated with axial symptoms in unilateral expansive open-door cervical laminoplasty with miniplate fixation. Medicine (Baltimore) 2016;95: e2292.
[3] Ma L, Liu FY, Huo LS, et al. Comparison of laminoplasty versus laminectomy and fusion in the treatment of multilevel cervical ossification of the posterior longitudinal ligament: a systematic review and meta-analysis. Medicine (Baltimore) 2018;97:e11542.
[4] Zhao YJ, Cheng C, Chen HW, et al. Limited laminectomy and foraminal decompression combined with internal fixation for treating multi-segment cervical spondylotic myelopathy: does it effectively improve neurological function and prevent C5 palsy? Medicine (Baltimore) 2018;97:e13327.
[5] Yuan W, Zhu Y, Liu X, et al. Postoperative three-dimensional cervical range of motion and neurological outcomes in patients with cervical ossification of the posterior longitudinal ligament: cervical laminoplasty versus laminectomy with fusion. Clin Neurol Neurosurg 2015;134: 17–23.
[6] Harrison DE, Harrison DD, Troyanovich SJ, et al. A normal spinal position: it's time to accept the evidence. J Manipulative Physiol Ther 2000;23:623–44.
[7] Iyer S, Nemani VM, Nguyen J, et al. Impact of cervical sagittal alignment parameters on neck disability. Spine (Phila Pa 1976) 2016;41:371–7.
[8] Harrison DD, Troyanovich SJ, Harrison DE, et al. A normal sagittal spinal configuration: a desirable clinical outcome. J Manipulative Physiol Ther 1996;19:398–405.
[9] Ko HY, Park JH, Shin YB, et al. Gross quantitative measurements of spinal cord segments in human. Spinal Cord 2004;42:35–40.
[10] Sherman JL, Nassaux PY, Citrin CM. Measurements of the normal cervical spinal cord on MR imaging. AJNR Am J Neuroradiol 1990; 11:369–72.

[11] Radcliff K. C5 palsy and cervical laminectomy width. What is the right answer? Spine J 2016;16:468–9.
[12] Bydon M, Macki M, Aygun N, et al. Development of postoperative C5 palsy is associated with wider posterior decompressions: an analysis of 41 patients. Spine J 2014;14:2861–7.
[13] Klement MR, Kleeman LT, Blizzard DJ, et al. C5 palsy after cervical laminectomy and fusion: does width of laminectomy matter? Spine J 2016;16:462–7.
[14] Radcliff KE, Limthongkul W, Kepler CK, et al. Cervical laminectomy width and spinal cord drift are risk factors for postoperative C5 palsy. J Spinal Disord Tech 2014;27:86–92.
[15] Liu T, Kong J, Zou W, et al. The correlation study of C5 nerve root palsy and common body position in posterior total laminectomy decompression and instrumentation. Turk Neurosurg 2016;26:280–5.
[16] Qi Q, Chen Y, Ling Z, et al. Modified laminoplasty preserving the posterior deep extensor insertion into c2 improves clinical and radiologic results compared with conventional laminoplasty: a meta-analysis. World Neurosurg 2018;111:157–65.
[17] Healy AT, Lubelski D, West JL, et al. Biomechanics of open-door laminoplasty with and without preservation of posterior structures. J Neurosurg Spine 2016;24:746–51.
[18] Secer HI, Harman F, Aytar MH, et al. Open-door laminoplasty with preservation of muscle attachments of C2 and C7 for cervical spondylotic myelopathy: retrospective study. Turk Neurosurg 2018;28:257–62.
[19] Nori S, Shiraishi T, Aoyama R, et al. Muscle-preserving selective laminectomy maintained the compensatory mechanism of cervical lordosis after surgery. Spine (Phila Pa 1976) 2018;43:542–9.
[20] Wang M, Luo XJ, Deng QX, et al. Prevalence of axial symptoms after posterior cervical decompression: a meta-analysis. Eur Spine J 2016; 25:2302–10.
[21] Du W, Wang L, Shen Y, et al. Long-term impacts of different posterior operations on curvature, neurological recovery and axial symptoms for multilevel cervical degenerative myelopathy. Eur Spine J 2013;22:1594–602.
[22] Krätzig T, Mohme M, Mende KC, et al. Impact of the surgical strategy on the incidence of C5 nerve root palsy in decompressive cervical surgery. PLoS One 2017;12:e0188338.
[23] Blizzard DJ, Gallizzi MA, Sheets C, et al. The role of iatrogenic foraminal stenosis from lordotic correction in the development of C5 palsy after posterior laminectomy and fusion. J Orthop Surg Res 2015;10:160.
[24] Tsuji T, Matsumoto M, Nakamura M, et al. Factors associated with postoperative C5 palsy after expansive open-door laminoplasty: Retrospective cohort study using multivariable analysis. Eur Spine J 2017;26:2410–6.
[25] Kim GU, Lee GW. Selective blocking laminoplasty in cervical laminectomy and fusion to prevent postoperative C5 palsy. Spine J 2019;19:617–23.