

## Original Article

# Limited laminectomy with lateral mass screw fixation versus normal laminectomy for multi-segment cervical spondylotic myelopathy: a comparative analysis

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**Abstract:** Objective: To compare the effectiveness of limited laminectomy with lateral mass screw fixation with that of laminectomy for patients with multilevel cervical spondylotic myelopathy (M-CSM). Methods: A total of 75 patients were enrolled as study objects. These patients were divided into two groups. The forty-one cases in Group A underwent limited laminectomies with lateral mass screw fixation and the 34 cases in group B received conventional laminectomies. The neurological function recovery index, the cervical range of motion (ROM) index, the cervical curvature index (CCI), the spinal drift distance, and the C5 nerve palsy and VAS (visual analogue scale) scores were compared between the two groups. Results: The operation times and intraoperative blood losses in Group B were significantly less than they were in group A ( $P<0.001$ ). The width and spinal drift distance in Group B were significantly higher than those in Group A, respectively (both  $P<0.001$ ). A statistical difference in the JOA (Japanese Orthopedic Association) scores could not be found between the two groups, and the postoperative VAS scores in Group A were significantly lower than those in Group B ( $P<0.001$ ). Compared with those in group B, the patients in Group A had a better recovery and maintenance of their CCI and ROM ( $P<0.001$ ). The occurrence of C5 nerve palsy in group A was lower than it was in Group B ( $P<0.05$ ). Conclusion: Compared with conventional laminectomy, limited laminectomy with lateral mass screw fixation can significantly promote neurological function recovery, limit excessive spinal cord back drift, and reduce C5 nerve palsy incidence and axial symptoms.

**Keywords:** Lateral mass screw fixation, laminectomy, cervical spondylotic myelopathy, palsy of the C5 nerve root

## Introduction

Cervical spondylotic myelopathy (CSM) is a common disease in spinal surgery which can cause numbness and weakness in the limbs, unstable walking, and even dysfunction of the bowel and bladder. Once a definite diagnosis is made, it is necessary to undergo a spinal decompression operation in a timely manner [1, 2]. CSM sometimes involves multiple segments; therefore, more often than not, such operation methods as double-door laminoplasty, laminectomy, and open door laminoplasty etc. are used for therapy [3-7]. In order to obtain stability in the short and long terms after the decompression, internal fixation devices have been continuously developed and have gradually come to have clinical applications. The lateral mass screw is a commonly used internal

fixation device, and it is mostly used for the reconstruction of cervical stability after laminectomies [8, 9]. The placement of lateral mass screws indeed increases the stability of the cervical spine and also makes spine surgeons get rid of their concerns about the cervical instability caused by extensive laminectomy during decompression operations. But a postoperative clinical follow-up found that the incidence rate of C5 nerve palsy and axial symptoms increased significantly [10, 11]. Some studies have found that an appropriate restriction of the width of a laminectomy can inhibit the excessive backward drift of the spinal cord, which does not affect the recovery of neurological function, yet it can significantly reduce the occurrence of C5 nerve paralysis [12]. However, it remains undetermined whether the limited laminectomy combined with lateral mass screw

fixation is superior to conventional laminectomy. Therefore, this study aimed to explore whether there are any significant differences in the indicators, such as the neurological function recovery, cervical range of motion (ROM), cervical curvature index (CCI), the spinal drift distance, C5 nerve palsy and axial symptoms between these two operation methods.

## Materials and methods

### General information

Seventy-five patients with multilevel cervical spondylotic myelopathy (M-CSM) in The No. 4 People's Hospital of Hengshui from February 2015 to January 2017 were enrolled as the research objects. The inclusion criteria were as follows: (i) diagnosis accorded with the diagnostic standard of CSM [13]; (ii) the number of compressive segments is more than three; (iii) the cardiopulmonary and brain functions of the patients are acceptable, and the blood sugar and blood pressure fall in the normal range after adjustment before surgery; (iv) the patients and their families were informed of the research plan and signed the informed consent form, and those who cooperated in treatment and follow-up. Exclusion criteria: (i) coagulation disorders, cervical dysplasia, and tumors, infection and fractures of the cervical vertebra; (ii) chest and lumbar spinal stenosis, cervical segmental instability or kyphosis; (iii) patients with mental disorders. The patients were assigned to Group A or Group B depending on the operative method selected according to each patient's preference. The patients from Group A underwent limited laminectomy with lateral mass screw fixation. The patients in Group B received conventional laminectomy with internal fixation. This study was approved by the Hospital Ethics Committee.

The patients were followed up for 12 months through back-to-hospital treatments, medical record reviews, telephone calls, and outpatient reexaminations in order to record their JOA (Japanese Orthopedic Association) scores, VAS (visual analogue scale) scores, ROM, CCI, and C5 nerve root paralysis once every three months.

### Imaging examination

Before surgery and at 3 months and 12 months after surgery, X-ray, MRI and CT for cervical ver-

tebra in patients were conducted. An MRI examination can help to determine the compression segment of the spinal cord and the degree of compression and also assist in the development of the range of laminar decompression. Changes in the ROM and curvature can be observed from X-ray films, and CT scans can help to determine whether there is ossification of the posterior longitudinal ligament or any calcification in the intervertebral disc. The image measurement software is used to measure the average width of the vertebral plate cut =  $(a_1 + a_2 + a_3 + \dots + a_n)/n$  on the CT coronal surface [14]. The backward drift distance of the C5 level spinal cord is measured in the median sagittal position of the MRI, i.e. the length between the posterior superior margin of the C5 plate and the front margin of the dural sac (b); when there is ossified substance at the posterior margin of the vertebral plate, it is to measure the distance from the posterior margin of the ossified substance in the vertebral plate to the front margin of the dural sac. The cervical curvature changes are evaluated by the cervical curvature index (CCI): it first measures the distance between the posterior lower margins of the C2 and C7 plates, and it is named as a. Then, the vertical distances from the posterior lower margins of C3, C4, C5, and C6 to a are measured, respectively, and they're named  $a_1$ ,  $a_2$ ,  $a_3$ , and  $a_4$  respectively.  $CCI = (a_1 + a_2 + a_3 + a_4)/a \times 100\%$ . Two intersecting lines parallel to the posterior wall of the C2 and C7 vertebral bodies in flexion ( $\alpha$ ) and extension ( $\beta$ ) were measured. The range of motion (ROM) of the cervical curvature is a plus  $\beta$  [15].

### Outcome measures

Primary outcomes: the primary outcomes included C5 nerve paralysis, JOA and VAS score changes after surgery. At 12 months after surgery, the incidence of C5 nerve paralysis was examined. The diagnostic criteria for C5 nerve paralysis are as follows [16]: new deltoid and/or bicep paralysis with no obvious causes after the operation, most of which show the symptoms of mild muscle weakness, and a small number of patients may have sensory disturbances or intractable pain in the C5 dermatome. The neurological status of each patient was evaluated before and at 3 months and 12 months after surgery according to the Japanese Orthopedic Association (JOA) disability scale

**Table 1.** Comparison of the general data of the patients in the two groups

Parameters	Group A (n = 41)	Group B (n = 34)	t/ $\chi^2$	P value
Male/female	22/19	16/18	0.324	0.569
Average age (years)	56.3±13.8	57.1±14.5	0.244	0.807
Course of disease (months)	16.9±6.5	17.2±6.7	0.196	0.845
BMI (kg/m <sup>2</sup> )	23.9±0.8	23.7±0.6	1.203	0.233
Type of disease			0.195	0.978
Multi-segment disc herniation	17	13		
OPLL	10	8		
Spinal stenosis	6	5		
Disc herniation with hypertrophic ligamentum flavum	8	8		
Decompression segments			0.333	0.954
C3-7	15	12		
C3-6	9	7		
C3-5	6	4		
C4-7	11	11		
Main symptoms			0.883	0.643
Sensory disturbances	21	19		
Dyskinesia	15	13		
Dysuria and defecation	5	2		
Hypertension	8	7	0.013	0.908
Diabetes	6	4	0.132	0.716

Note: OPLL: ossification of the posterior longitudinal ligament; Group A: patients underwent limited laminectomy with lateral mass screw fixation; Group B: patients received conventional laminectomy with internal fixation.

(17-point method) [14]; the neurological recovery rate = (JOA score after surgery - JOA score before surgery)/(17 - JOA score before surgery) × 100%. Before and at 3 months and 12 months after surgery, the 10-score approach of the visual analogue scale (VAS) is used to evaluate the AS [17]. The axial symptoms (AS) are as follows: aches in the neck, shoulders and the back, accompanied by soreness, stiffness, heaviness, and muscle spasms.

Secondary outcomes: the secondary outcomes included the operation time, intraoperative blood loss, laminectomy width, and drift distance of the C5 horizontal spinal cord after surgery. The ROM and CCI changes before and at 3 months and 12 months after surgery were also compared between Group A and Group B.

#### Statistical methods

SPSS 19.0 software was used for the statistical analysis. The measurement data were represented as the means ± standard deviations, and independent sample t-tests were utilized for the between-group comparisons. The com-

parison of the repeated measurement data in the groups was analyzed with repeated measures ANOVA with post hoc Bonferroni pairwise tests. The count data were expressed as the rate and analyzed using  $\chi^2$  tests.  $P < 0.05$  was considered to be significantly different.

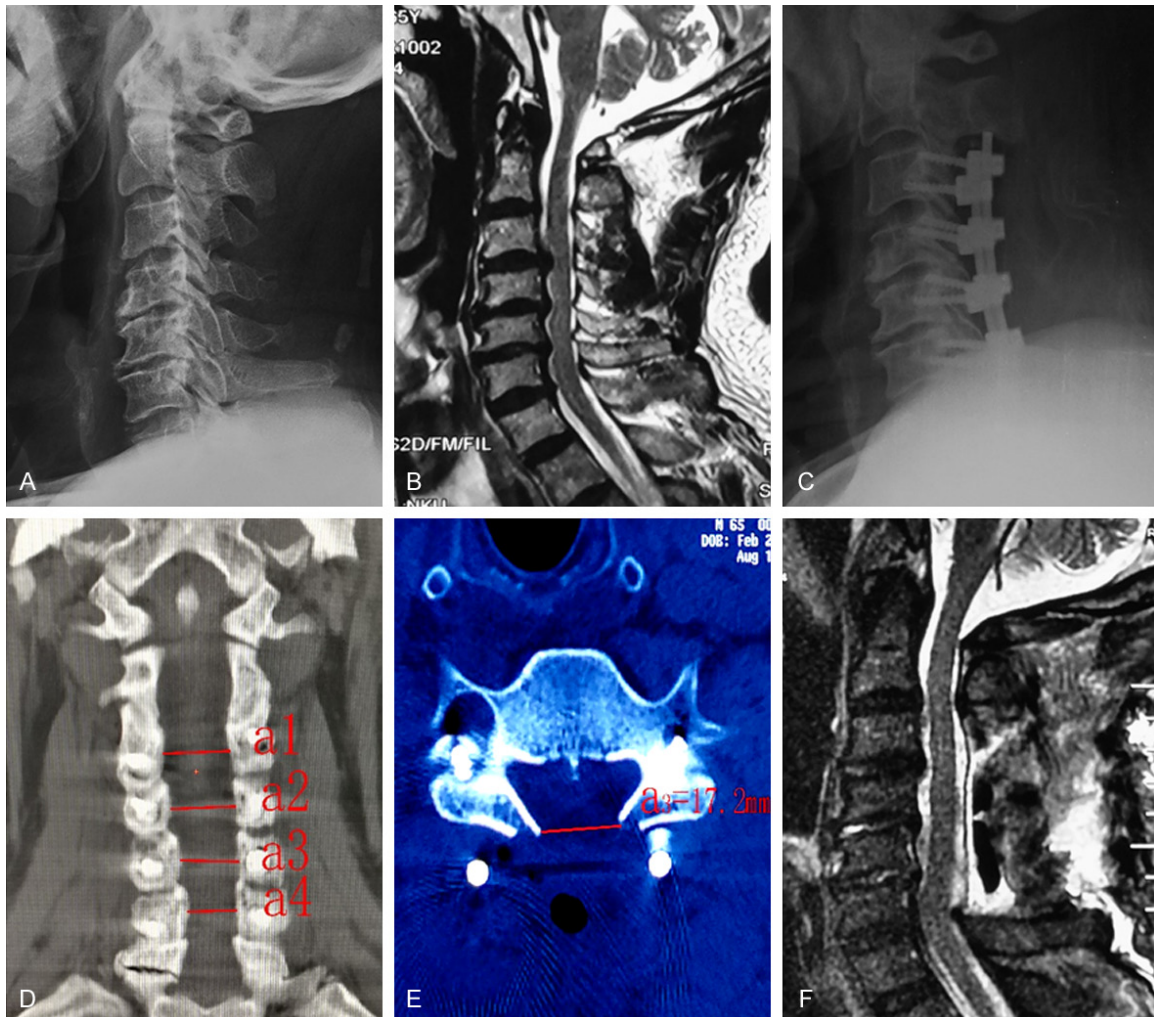
## Results

### Comparison of the baseline data between the two groups

As shown in **Table 1**, there were no significant differences in terms of gender, age, course of the disease, pathogenic factors, or decompression segments between the two groups (all  $P > 0.05$ ). All the patients underwent successful surgical operations. The representative imaging examinations of the patients before and after surgery are seen in **Figures 1** and **2**.

### Comparison of the intraoperative conditions between the two groups

As shown in **Figure 3**, in Group A, the operation time is (128.5±27.1) min, and the amount of



**Figure 1.** A male patient in Group A underwent a limited laminectomy with lateral mass screw fixation and had an imaging examination before and after the operation. A: An X-ray showed that the cervical curvature became straight, indicating severe degeneration; B: A preoperative MRI showed the protrusion of an intervertebral disc in the C3-7 segments and spinal stenosis; C: The C3-6 segments after limited laminectomy with lateral mass screw fixation were changed; D: A schematic diagram of the laminectomy width was performed; E: The laminectomy width of C5 was 17.2 mm; F: At 3 months after surgery, an MRI showed that the spinal cord decompression was sufficient and the drift distance of the C5 horizontal spinal cord was 2.3 mm; Group A: the patients underwent limited laminectomy with lateral mass screw fixation.

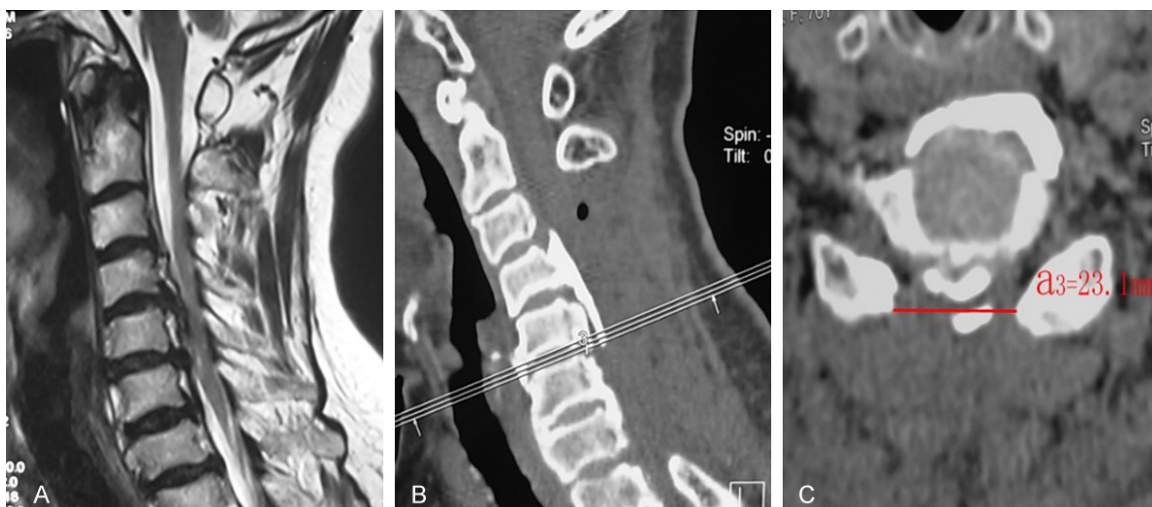
intraoperative hemorrhage is  $(294.8 \pm 31.0)$  mL, while the corresponding values in Group B were  $(96.3 \pm 17.9)$  min and  $(263.9 \pm 23.7)$  mL, respectively. Significant statistical differences could be found ( $P < 0.001$ ). The width of the laminectomy in Group A was  $(16.9 \pm 2.5)$  mm and the width in Group B was  $(22.6 \pm 2.9)$  mm. A statistical significance difference existed between the groups ( $P < 0.001$ ); the drift distance of the C5 horizontal spinal cord in Group A was  $(2.3 \pm 0.5)$  mm, and the drift distance in Group B was  $(3.9 \pm 0.8)$  mm, and a statistically significant dif-

ference was found between Group A and Group B ( $P < 0.001$ ).

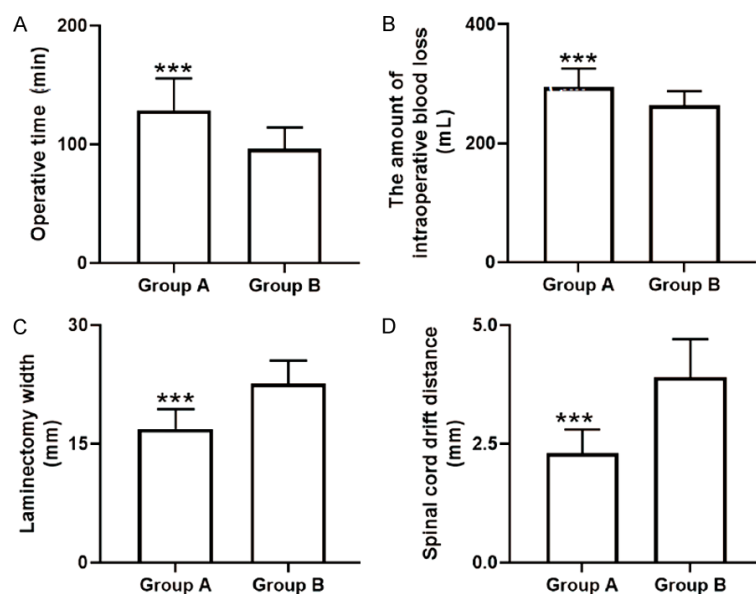
#### *Comparison of the JOA and VAS scores between the two groups*

As shown in **Table 2**, there were no significant differences in the JOA and VAS scores before the surgery ( $P > 0.05$ ). Compared with before the surgery, the JOA and VAS scores after the surgery in both groups were significantly increased, with significant statistical differences (all  $P < 0.05$ ). No significant statistical differ-





**Figure 2.** A female patient in Group B underwent a total laminectomy in, and she underwent an imaging examination before and after the operation. A: The preoperative MRI indicated that the spinal cords were compressed in the C3-7 segment, and calcification formed behind the vertebral body with low-signal intensity; B: CCI was significantly lost at 13 months after the C3-7 total laminectomy; C: The laminectomy width of C5 was 23.1 mm; Group B: the patients received a conventional laminectomy with internal fixation; CCI: cervical curvature index.



**Figure 3.** The intraoperative conditions were compared between the two groups. Compared with Group B, \*\*\* $P < 0.001$ . A: Operative time; B: Intraoperative blood loss; C: Laminectomy width; D: Spinal cord drift distance; Group A: patients underwent limited laminectomy with lateral mass screw fixation; Group B: patients received conventional laminectomy with internal fixation.

ence existed for the JOA and VAS scores among the different time points after surgery in each group. At each time point after surgery, there was no difference in the JOA scores between the two groups, but significant statistical differences could be found for the VAS scores between the two groups ( $P < 0.001$ ).

#### Comparison of the ROM and CCI between the two groups

As shown in Table 3, there were not any significant differences in the ROM or CCI before the surgery ( $P > 0.05$ ). Compared with those before surgery, the ROM in Group A and the CCI in both groups after surgery are significantly changed, and there are significant statistical differences (all  $P < 0.05$ ). No significant statistical difference existed in the ROM or CCI among the different time points after surgery in each group. At each time point after the surgery, there were significant differences in the ROM and CCI in the two groups ( $P < 0.001$ ).

#### Comparison of the incidence of C5 nerve root paralysis between the two groups

In Group A, C5 nerve root paralysis occurred in 2 patients, so the incidence rate was 4.9% (2/41); in Group B, there were 7 cases of C5 nerve root paralysis, so the incidence rate was 20.6% (7/34). There is a significant statistical

**Table 2.** Comparison of the neurologic function and axial symptoms of the patients in the two groups

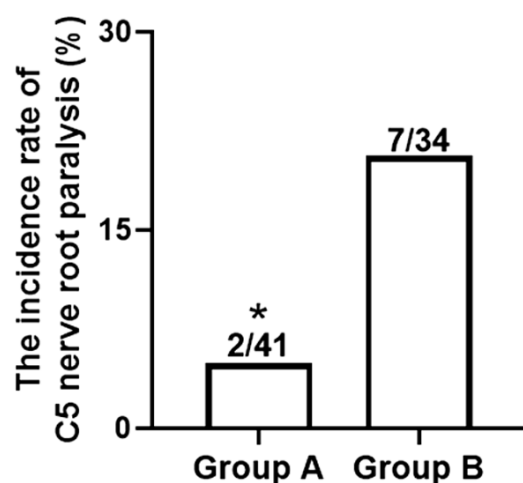
Groups	Group A	Group B	P value
JOA score			
Before surgery	7.6±2.2	7.5±2.0	0.839
3 months after surgery	12.6±3.0*	13.1±3.3*	0.6565
12 months after surgery	13.6±3.4*	13.9±3.5*	0.708
Recovery rate (%)	64.5±12.6	68.3±14.1	0.227
VAS score			
Before surgery	1.8±0.4	1.6±0.3	0.233
3 months after surgery	3.9±1.2*	5.7±1.7*	<0.001
12 months after surgery	2.6±0.8*	4.4±1.2*	<0.001

Note: compared with the preoperative level, \*P<0.05. Group A: patients underwent limited laminectomy with lateral mass screw fixation; Group B: patients received conventional laminectomy with internal fixation; JOA: Japanese Orthopedic Association; VAS: visual analogue scale.

**Table 3.** Comparison of the postoperative imaging data between the two groups

Groups	Group A	Group B	P value
ROM (°)			
Before surgery	51.6±11.0	49.9±10.6	0.500
3 months after surgery	25.9±6.5*	45.8±9.7	<0.001
12 months after surgery	26.4±6.8*	47.1±9.9	<0.001
CCI (%)			
Before surgery	21.5±3.4	22.7±3.6	0.143
3 months after surgery	26.2±5.4*	19.5±3.2*	<0.001
12 months after surgery	25.3±4.6*	17.4±3.0*	<0.001

Note: compared with the preoperative level, \*P<0.05. ROM: cervical range of motion; CCI: cervical curvature index; Group A: patients underwent limited laminectomy with lateral mass screw fixation; Group B: patients received conventional laminectomy with internal fixation.



**Figure 4.** The incidence rate of C5 nerve root paralysis was compared between the two groups. Compared with Group B, \*P<0.05; Group A: the patients underwent a limited laminectomy with lateral mass screw fixation; Group B: the patients received a conventional laminectomy with internal fixation.

difference in the incidence of C5 nerve root paralysis in the two groups ( $\chi^2 = 4.344$ ,  $P = 0.037$ ), see **Figure 4**.

## Discussion

Laminectomy of the cervical vertebra is considered to be an indirect decompression of the spinal canal. It increases the sagittal and transverse diameters of the spinal canal mainly through different extents of laminectomy, which also increases the effective volume of the spinal canal. With the effect of the bow-string principle, the spinal cord can “drift” backwards, thereby relieving the spinal cord compression for the purpose of promoting neurological recovery [18, 19]. Compared with anterior direct decompression, posterior laminectomy has a lower risk, a wider exposure range, a wider field of view and is easy to operate, which can solve the multi-segment spinal cord compression problem by increasing the laminectomy segments [20]; however, after a total laminectomy, cervical curvature loss and kyphosis deformity are prone to occur and are related to the resection of spinous processes, ligament tissue, and lamina [21]. Therefore, it is especially important to restore and maintain cervical curvature by placing the internal fixation during the operation. Du et al. adopted the approach of lateral mass screw fixation

in total laminectomy to correct patients’ cervical curvature problems, and the CCI recovers significantly from preoperative ( $8.4\pm2.5$ )% to postoperative ( $19.3\pm2.1$ )% [22]. In posterior cervical operations, the internal fixation of the lateral mass screw is a powerful tool for the treatment of cervical spondylotic myelopathy with cervical instability and the correction of sagittal/coronal imbalance [23]. In this study, the patients in Group A received limited laminectomies with lateral mass screw fixation, while the patients in Group B were simply treated with total laminectomies. The results showed that the operative times and intraoperative blood losses in Group A were more than they were in Group B, and this is because of the placement of the lateral mass screws. Nevertheless, the postoperative imaging data shows that the patients in Group A achieved a better recovery in terms of their cervical curvature, which was well maintained during follow-up vis-

its; the cervical curvature of the patients in Group B was significantly lost. The results are in accordance with Healy et al.'s study [24]. The deficiency is that long-segment fixation and fusion were performed on the patients in Group B, whose postoperative ROM is significantly lost. In the simple total laminectomy, the resection of the spinous processes and lamina can cause a large loss of the attachment points of the posterior cervical muscles, so that the tensile stress of the cervical curvature is obviously weakened, and also the cervical curvature is gradually straightened and even kyphosis occurs. Therefore, for elderly patients who have undergone cervical degeneration, the placement of internal fixations, especially lateral mass screws, is an ideal method to maintain the cervical curvature.

This study also reported that the average resection width of the lamina in Group A was significantly narrower than the average resection width of the lamina in Group B. The results are similar to those reported by Klement et al. [25]. In that study, the laminectomy width of C3-7 was within the range of 18.5-23.3 mm (22.3 mm on average), and the neurological function is ideally restored after the operation. However, there were not any differences in the JOA scores at each time point in Group A and Group B. This is because that the purpose of the enlarged laminectomy is to solve the compression in the "lateral crypt" on the medial side of the vertebral pedicle and on both sides of the cervical spinal cord, but most of the cervical spondylotic myelopathy is located in the central tube rather than the lateral crypt, and a more extensive laminectomy beyond the transverse diameter of the spinal cord will not affect the recovery of the neurological function, which is closely related to the postoperative axial symptoms and the occurrence of C5 nerve palsy. It has been reported that the transverse diameter of the spinal cord in the C5 segment is the largest, yet it is only 15.5 mm, and that in other segments it sequentially decreases [26, 27]. Therefore, in order to have the cervical spinal cord obtain sufficient decompression, the resection width of the lamina needs to be at least greater than the transverse diameter of the spinal cord of the corresponding segment.

Axial symptoms (AS) is one of the most common complications of cervical operations. It

has been reported in the literature that its incidence rate is between 5.2% and 61.5%. It is mainly characterized by soreness in the neck and back, and may be accompanied by neck stiffness and tension as well as soreness and discomfort [28]. The mechanism of its formation is still unclear, but it may be related to muscle-ligament complex injury, posterior neck muscle atrophy, joint capsule destruction, cervical curvature change, cervical stability loss, or other factors. Therefore, domestic and foreign scholars have tried to reduce AS by means of surgical improvement, strong internal fixation, and rehabilitation exercises, all of which have achieved good results. However, C5 nerve palsy is most likely to occur after a total laminectomy. This is because, after the sagittal sequence of the cervical spine restores to lordosis, the spinal cord is more likely to "drift" backwards under the action of the bowstring principle, thereby significantly increasing the tension of the nerve root, while the spinal cord at the top of the bowstring has the largest backshift distance, making the C5 nerve root excessively stretched; then, nerve root paralysis occurs under the influence of multiple factors such as nerve root ischemia and hypoxia, segmental spinal cord disorder, embolism effect, and reperfusion injury [29]. In a study by Radcliff et al. [26], the spinal drift distances of patients with C5 nerve palsy are 5.1 mm and 5.2 mm at C5 and C6 respectively, which are significantly higher than the drift distances of patients without paralysis. Du et al. found that the decompression of the posterior wall of the C5 intervertebral foramen can significantly reduce the incidence of C5 nerve palsy [22]. In this study, the drift distances of the spinal cords in Group A were less than the drift distances in Group B. At each time point after surgery, the VAS scores in Group A were less than they were in Group B. And compared with Group B, the patients in Group A had a lower incidence of C5 nerve palsy. Takeuchi et al. also reported similar results [30]. It is concluded that limited laminectomy combined with lateral mass screw fixation can reduce the incidence of postoperative axial symptoms and C5 nerve paralysis.

In summary, compared with conventional laminectomy internal fixation, limited laminectomy with lateral mass screw fixation has more advantages. Limited laminectomy can avoid an

excessive backward drift of the spinal cord without affecting the recovery of the postoperative neurological function. Lateral mass screw fixation can restore and maintain cervical curvature. Although the combination of the foregoing reduces ROM, this can significantly reduce the occurrence of C5 nerve palsy and axial symptoms. However, there are some limitations to our study, including the small sample size, the lack of long-term follow-up results and the fact that this was not a randomized controlled trial. More long-term follow-up studies are needed for validation of the long-term outcomes of limited laminectomy with lateral mass screw fixation.

## Disclosure of conflict of interest

None.

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