

# Influence of Preoperative Smoking Status on Clinical Outcomes of Laminoplasty in Patients With Degenerative Cervical Myelopathy: a Prospective Study

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## Research Article

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# Abstract

**Background:** Smoking is considered to be a risk factor for poor clinical outcomes after anterior cervical decompression and fusion surgery. However, it is unclear whether the preoperative smoking status has similar effects on clinical outcomes after laminoplasty. The current research is carried out to determine whether smoking status before laminoplasty affects clinical outcomes in patients with degenerative cervical myelopathy (DCM).

**Methods:** A series of consecutive patients undergoing laminoplasty to treat DCM at a single institution between April 2017 and April 2020 were included. The patients were divided into the following 3 groups: active smoking (AS), passive smoking (PS), and non-smoking (NS). The primary outcome was the recovery rate of JOA at the last follow-up. Secondary outcomes included JOACMEQ score and the NRS (Numerical rating scale) for neck and arm pain. Statistical analysis of among the three groups differences were performed with ANOVA, and multivariable regression analysis was undertaken to explore predictor variables.

**Result:** A total of 158 consecutive patients completed at least 6 months of follow-up. There were 108 men and 50 women. The mean ( $\pm$ standard deviation) age of this series was  $57.7 \pm 11.6$  years. The average recovery rate of JOA, the improvement in the NRS for neck and arm pain, and in each domain of JOACMEQ did not differ significantly among the three groups ( $P \geq 0.05$ ). When used 52.8% as the minimal clinically important difference (MCID) of the JOA recovery rate, active smokers (RR=0.950, 95%CI=0.740-1.220) and passive smokers (RR=0.830, 95%CI=0.540-1.277) had similar likelihoods of reaching MCID compared with non-smokers. Logistic regression revealed that age (OR=0.95, 95%CI=0.92-0.98,  $P=0.001$ ) and preoperative JOA (OR=0.85, 95%CI=0.75-0.95,  $P=0.004$ ) were risk factors of the recovery rate that did not reach MCID, but smoking status: AS (OR=0.56, 95%CI=0.21-1.47,  $P=0.24$ ), PS (OR=.087, 95%CI=0.43-1.76,  $P=0.70$ ), did not affect the clinical outcomes.

**Conclusion:** Over a follow-up period of at least 6 months, active smokers, passive smokers, and non-smokers had similar improvements in clinical outcomes after laminoplasty. Thus, smoking status was not found to be an independent predictor of clinical outcomes after laminoplasty.

## Background

Cervical open-door laminoplasty is a technique to decompress the spinal cord by expanding the spinal canal and preserving the posterior structure of the cervical spine. It has been widely used in the treatment of multisegmental degenerative cervical myelopathy (DCM) caused by ossification of the posterior longitudinal ligament (OPLL) or by spondylosis in cases with a narrow spinal canal [1–4]. Several patient factors are thought to influence the clinical outcomes after cervical surgery. These factors include gender, age, duration of disease, signal changes in the spinal cord on MRI, k-line status, pre-operative JOA (Japan Orthopaedic Association) and JOACMEQ (Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire) score, diabetes mellitus, smoking history, pre-operative sagittal alignment, and

severity of a preoperative neurological disability [5–10]. Among these factors, smoking is one of the more studied factors, no matter in which field. It is well known that smoking can cause cancer, cardiovascular disease, respiratory disease, and increase the morbidity and mortality of related diseases [11]. In addition to the diseases, smoking can also adversely affect surgical outcomes [12, 13]. In the field of the cervical spine, it has been reported that nicotine in tobacco promotes disc degeneration and myelopathy, which ultimately requires cervical spine surgery [14]. Continued smoking also increases the risk of perioperative complications, surgical site infections, and prolonged hospital stays. Patients who continue to smoke often fail to achieve satisfactory neurological recovery even after surgery [15, 16].

Although many studies have evaluated surgical outcomes in patients with cervical spondylotic myelopathy after cervical internal fixation [16–18], few studies have reported the effect of smoking status on surgical outcomes after cervical decompression surgery without fixation. There is no consensus in the literature on the effect of smoking on postoperative outcomes of cervical spine surgery. Most studies suggest that smoking has been associated with poor postoperative outcomes in anterior cervical discectomy and fusion and has also been associated with poor surgical outcomes in posterior cervical decompression and fusion [18–21]. However, some studies suggest that smoking is an independent predictor of poor postoperative outcomes after posterior cervical decompression and fusion [22]. Conversely, some studies have suggested that smoking is not an independent risk factor for adverse outcomes after posterior cervical decompression [5]. Therefore, whether smoking status is an independent risk factor for posterior cervical decompression has been the subject of continued debate in the literature.

Prior studies have shown that around 40% of children, 33% of non-smoking males, and 35% of non-smoking females worldwide were exposed to second-hand smoke [23]. Exposure to second-hand smoke is estimated to have caused 603 000 premature deaths and the number of disability-adjusted life-years (DALYs) lost due to exposure to second-hand smoke reached 10.9 million [23]. Previous research on second-hand smoke suggests that second-hand smoke is a mixture of smoke emitted when a cigarette or other tobacco product is burned, and smoke emitted from the lungs of smokers [23]. Nonsmokers unknowingly inhale tobacco products that remain in the air for hours after they are eliminated, and contain at least 250 chemicals known to be toxic to humans [23]. Some organizations have all concluded that exposure to second-hand smoke can cause illness and premature death in non-smokers [23]. As a result, many studies have explored the effects of passive smoking on domain-related diseases [24–26]. However, although a few studies have investigated the effects of smoking on clinical outcomes after posterior cervical decompression and fusion, no studies have directly examined the effects of passive smoking on clinical outcomes after cervical open-door laminoplasty, and it remains unknown whether smoking status impacts outcomes after cervical single-open door laminoplasty. The objective of this study was to determine whether smoking status before laminoplasty affects clinical outcomes in patients with DCM after open-door laminoplasty.

## Materials And Methods

## **Study population**

Our study design and reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement [27]. This prospective study was approved by the Research Ethics Committee of Guangdong Provincial People's Hospital. Patients who provided written informed consent and underwent cervical open-door laminoplasty for DCM at our hospital between April 2017 and April 2020 were enrolled. The Inclusion criteria were as follows: (1) Diagnosis of multilevel DCM with imaging findings and clinical symptoms; (2) Posterior cervical open-door laminoplasty without fusion. The exclusion criteria were as follows: (1) Patients with a history of stroke, Parkinson's disease, poliomyelitis, or other diseases that affect the neurological outcome; (2) Previous cervical surgery or traumatic spinal cord injury. After excluding 86 patients with basic information deficiencies, 177 patients met all the inclusion criteria and, among them, 158 patients were successfully followed up [insert Additional File 1].

The smoking status of patients was obtained by preoperative questionnaire, which contained data collected from the intake forms given to all patients at the initial visit. The research draws on the World Health Organization (WHO) global standard for smoking, where those who answered "Yes" to "Do you currently smoke tobacco?" were classified into the active smoking group (AS group). Patients who had never smoked before were asked, "How many days per week are you exposed to second-hand smoke usually?" Those who answered "none" were classified into the non-smoking group (NS group), and all others were classified into the passive smoking group (PS group) [28]. Besides, we also classified former smokers who did not smoke for a week before surgery into the NS group. After the surgery, active smokers were asked not to smoke, and those who were exposed to second-hand smoke were asked to maintain their distance from the smoke.

## **Surgical procedure**

All the operations were performed by four of our institution's spinal surgeons. The procedure of open-door laminoplasty was described in previous studies [6, 29–31]. The patient is placed in a prone neutral position, and then the C3 to C7 laminae are exposed by dissection of the bilateral paracervical muscles through a posterior midline incision. A high-speed burr is used to create grooves at the junction of the Lamina and facet joints, and the ventral cortex of one lamina was cut. Instead of being cut, the ventral cortex of the other lamina is grooved as a hinge, and the cut lamina of the opposite lamina is raised and secured in the expanded position with titanium miniplates and screws. The open-door laminoplasty procedure is plated alone and no bone graft or fusion equipment was placed on the hinge or the open side.

## **Clinical outcome parameters**

The primary outcome was the recovery rate of JOA at the last follow-up. Secondary outcomes included the JOACMEQ score and the NRS for neck and arm pain. The JOA score consists of six domain scores (upper and lower extremity motor function [4 points], upper and lower extremity sensory function [2 points], trunk sensory function [2 points], and bladder function [3 points]), and is used to evaluate the

severity of preoperative and postoperative cervical spondylotic myelopathy [32, 33]. The primary outcome was evaluated using the recovery rate described by Hirabayashi et al, as follows: recovery rate (%) = [post-operative JOA score – preoperative JOA score]/[17-pre-operative JOA score] × 100 [5, 34–37]. We used the MCID, which is defined as the smallest change that can be recognized as “clinically meaningful” by a patient, to evaluate the success of interventions. Previous studies have indicated that the MCID for JOA recovery rate is 52.8% [34, 38, 39]. Depending on whether the JOA recovery rate reaches the MCID, the patients were classified into either the recovery rate reached the MCID ( $\geq 52.8\%$  recovery rate) or the recovery rate did not reach the MCID ( $< 52.8\%$  recovery rate). Patients with JOA recovery rate  $\geq 52.8\%$  were counted. The JOACMEQ score consists of six subscores: upper extremity function, lower extremity function, bladder function, visual analogue scale (VAS) score of the upper extremity, VAS score of the body trunk, and VAS score of the lower extremity, which primarily evaluates patient-reported outcomes such as quality of life and function of the cervical spine, upper extremities, lower extremities, and bladder [29, 33]. We also prospectively collected demographic information (age, BMI, gender), medical history (symptom duration, history of diabetes and hypertension, OPLL), radiological data (C2-7 Cobb angle and K-line status on a neutral lateral view of the cervical spine, MRI T2 high intensity), and the numerical rating scale (NRS) for neck pain and arm pain before surgery and at the final follow-up (at least 6 months after surgery).

## **Radiological parameters**

The alignment of the cervical spine was assessed by measuring the C2-7 Cobb angle, defined as the angle between the inferior endplate of C2 and the inferior endplate of C7. The K-line is defined as a line connecting the C2 and C7 centers of the cervical spinal canal and is widely used to determine the surgical approach for patients with Ossification of the Posterior Longitudinal Ligament. According to the criteria proposed by Fujiyoshi et al., we divided patients with cervical OPLL into two groups: K-line (+) group that OPLL did not exceed the K-line and K-line (-) group that did exceed it. We recorded patients who showed high signal intensity at the compressed segment of the T2 weighted magnetic resonance images.

## **Statistical analysis**

Continuous variables and frequencies are expressed as means  $\pm$  standard deviation, and categorical variables are expressed as percentages. One-way analysis of variance (ANOVA) was used for normal distribution data, and the Kruskal-Wallis H test was used for non-normal distribution data. For each group, the pre-and postoperative JOA scores were assessed by paired t-test. The postoperative JOA scores among the three groups were compared using repeated-measures ANOVA. For patients with the JOA recovery rate unreached the MCID, the odds ratio with 95% confidence interval (CI) of each risk factor was calculated using univariate logistic regression analysis. The categorical recovery rate of JOA (whether the recovery rate reached the MCID) was used as a dependent variable. Age, duration of disease, and pre-operative JOA score were assigned as continuous independent covariates. Smoking status and OPLL were assigned as categorical independent covariates. Multivariate logistic regression with a forward stepwise procedure ( $P < 0.05$  for entry) was performed to identify correlations between risk factors for

those with the JOA recovery rate unreached the MCID. All statistical analyses were performed using SPSS version 26.0. P-values < 0.05 two tailed were considered significant.

## Results

All 158 consecutive patients were enrolled in this research and completed at least 6 months of follow-up, the mean follow-up time was  $20 \pm 10$  months. The mean ( $\pm$  standard deviation) age of this series was  $57.7 \pm 11.6$  years. There were 65 patients in the AS group, 23 patients in the PS group, and 70 patients in the NS group. In the AS group, 65 were male, 0 were female; in the PS group, 4 were male and 19 were female; and in the NS group, 39 were male and 31 were female. There was a statistically significant difference in the distributions of sex and age among the three groups (Table 1).

Table 1  
Clinical characteristics of patients

Parameters	AS group n = 65	PS group n = 23	NS group n = 70	P
Gender, n (%)				<0.01 <sup>#</sup>
Male	65(100)	4(17.4)	39(55.7)	
Female	0(0)	19(82.6)	31(44.3)	
Age (years)	$57.72 \pm 11.62$	$60.65 \pm 10.53$	$65.31 \pm 6.92$	<0.01 <sup>*</sup>
BMI (kg/m <sup>2</sup> )	$23.76 \pm 3.34$	$22.64 \pm 3.43$	$23.83 \pm 3$	0.276
Diabetes, n (%)	9(13.8)	5(21.7)	13(18.6)	0.59
Duration of disease(months)	$23.14 \pm 30.94$	$31.61 \pm 54.13$	$36.9 \pm 52.5$	0.21
Signal changes, n (%)	26(40)	8(34.8)	25(35.7)	0.84
OPLL, n (%)	16(24.6)	5(21.7)	28(40)	0.09
C2-7 Cobb angle(°)	$16.37 \pm 13.42$	$19.05 \pm 15.23$	$14.58 \pm 11.77$	0.377
K-line (-), n (%)	6(37.5)	1(20)	2(7.1)	0.02 <sup>*</sup>
* :post-hot tests showed that the average age of AS group was 7.59 years lower than that of the PS group(95% CI:3.27–11.92), the difference was statistically significant (P<0.001); the average age of AS group was 2.93 years lower than that of the NS group(95% CI:-3.16-9.02), the difference was not statistically significant (P = 0.49); the average age of NS group was 4.66 years lower than that of the PS group(95% CI:-10.7-1.37), the difference was not statistically significant (P = 0.16).				

The neurological function was measured by the JOA score. The mean preoperative JOA score was  $10.97(\pm 3.64)$  in the AS group,  $10.70(\pm 3.10)$  in the PS group,  $10.74(\pm 2.94)$  in the NS group, and the JOA scores had significant improvement at different postoperative time points (12-, 24-, and 36- months post-surgery) when compared to the baseline. No significant differences were found in JOA scores among the

three groups preoperatively and different time points after surgery (12-, 24-, and 36- months) (Table 2). When used the recovery rate to evaluate the primary clinical outcomes, we found that the average recovery rate of JOA (AS, 65%; PS, 52%; NS, 61%) did not differ significantly among the three groups. The improvements in each domain of JOACMEQ, including cervical spine function, upper extremity function, lower extremity function, bladder function, quality of life, and NRS for neck and arm pain, were similar among the three groups (Table 3).

Table 2  
Changes of JOA score before and after surgery

	AS group		PS group		NS group		P
	n	JOA score	n	JOA score	n	JOA score	
Before surgery	65	10.97 ± 3.6	23	10.70 ± 3.10	70	10.7 ± 2.94	0.9
1 year post-surgery	31	14 ± 1.57 <sup>a</sup>	8	14.38 ± 2.2 <sup>c</sup>	28	14.68 ± 2.1 <sup>b</sup>	0.51
2 years post-surgery	21	16.62 ± 0.8 <sup>a</sup>	4	12.5 ± 4.2	26	14.65 ± 2.15 <sup>b</sup>	<0.05
3 years post-surgery	5	16.8 ± 0.44 <sup>a</sup>	7	14.43 ± 1.62	12	14.50 ± 1.31 <sup>b</sup>	0.5

<sup>a</sup> Compared to AS group before surgery, P<0.05; <sup>b</sup> Compared to NS group before surgery, P<0.05; <sup>c</sup> Compared to PS group before surgery, P<0.05.

Table 3

The improvements of JOA, JOACMEQ, and NRS for neck and arm between pre-operative and at the last follow-up among the three groups

	AS(n = 65)	PS(n = 23)	NS(n = 70)	p-value
	Mean(SD)	Mean(SD)	Mean(SD)	
Improvement in JOACMEQ				
Neck function	8.31 ± 16.16	5.87 ± 12.49	12.57 ± 17.00	0.138
Upper extremity function	16.38 ± 20.28	10.17 ± 11.82	17.90 ± 17.95	0.213
Lower extremity function	24.22 ± 28.59	17.26 ± 22.61	17.59 ± 18.31	0.217
Bladder function	12.40 ± 21.46	8.30 ± 17.47	9.09 ± 18.41	0.536
Quality of life	15.00 ± 8.95	14.61 ± 11.33	15.13 ± 9.72	0.975
Improvements of NRS for neck	-1.86 ± 3.14	-2.46 ± 3.15	-2.04 ± 2.92	0.532
Improvements of NRS for arm	-2.28 ± 3.49	-2.00 ± 3.08	-1.74 ± 3.06	0.767
Recover rate of JOA(%)	65.09 ± 34.78	52.20 ± 34.84	60.93 ± 31.12	0.278
AS: Active smoking, NS: Non-smoking, PS: Passive smoking, JOA: Japanese Orthopaedic Association, JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire, NRS: Numerical rating scale.				

When used 52.8% as the MCID of the JOA recovery rate, the patients were classified into either the recovery rate reached the MCID ( $\geq 52.8\%$  recovery rate) or the recovery rate did not reach the MCID ( $< 52.8\%$  recovery rate). Forty-three patients (66.2%) in the AS group reached the MCID, 12 patients (52.2%) in the PS group reached the MCID, and 44 patients (63.0%) in the NS group reached the MCID. Univariate logistic regression analysis showed that age (OR, 0.946; 95%CI, 0.915–0.978,  $P = 0.001$ ) and preoperative JOA score (OR, 0.845; 95%CI, 0.754–0.946,  $P = 0.004$ ) were risk factors for recovery rate that unreachd MCID (Table 4). Multivariate logistic regression analysis further demonstrated that age (OR, 0.933; 95%CI, 0.897–0.97,  $P < 0.001$ ) and preoperative JOA (OR, 0.797; 95%CI, 0.698–0.911,  $P = 0.001$ ) were independent risk factors for recovery rate that did not reach the MCID, and that smoking status was not a risk factor for recovery rate that did not reach the MCID (Table 5). A separate analysis showed that active smokers (RR = 0.950, 95%CI = 0.740–1.220) and passive smokers (RR = 0.830, 95%CI = 0.540–1.277) had similar likelihoods of reaching the MCID as non-smokers.

Table 4  
Risk Factors for recovery rate did not reach the MCID (Less than 52.8% in JOA Recovery Rate): Results of univariate analysis

	Odds ratio	95% Confidence interval	p-value
Age	0.946	0.915 to 0.978	0.001
Sex	1.925	0.97 to 3.8	0.061
Duration of disease	0.999	0.992 to 1.006	0.768
Pre-operative JOA score	0.845	0.754 to 0.946	0.004
OPLL	1.238	0.62 to 2.47	1.238
Active smoking	0.558	0.212 to 1.467	0.237
Passive smoking	0.866	0.427 to 1.755	0.689

Table 5  
Risk Factors for recovery rate did not reach the MCID (Less than 52.8% in JOA Recovery Rate): Results of multivariate analysis

	Odds ratio	95% Confidence interval	p-value
Age	0.933	0.897 to 0.970	<0.001
Pre-operative JOA score	0.797	0.698 to 0.911	0.001

## Discussion

This prospective study evaluated the effect of smoking status on the clinical outcomes of patients with DCM after laminoplasty. Our results demonstrated that the AS, PS, and NS groups had similar improvements in clinical outcomes at least 6 months after expansive open-door laminoplasty. These results suggest that smoking status is not an independent predictor of clinical outcomes.

The relationship between smoking status and clinical outcomes after laminoplasty for patients with DCM has not been thoroughly investigated. There is still no agreement in the literature on the effect of smoking status on clinical outcomes from different surgical approaches to the cervical spine. Previous studies have demonstrated that smoking status negatively impacted the overall clinical outcomes of anterior cervical spine surgery, mainly the recovery of nerve function. However, the effect of smoking on the success rate of fusion is still under debate, although most studies concluded that smoking status did not affect the fusion rate [17, 18, 20, 40]. The effect of smoking on the clinical outcomes of posterior approach cervical surgery remains controversial, with some studies have shown that smoking adversely affects clinical outcomes after posterior cervical fusion [22, 41]. In contrast, Nagoshi et al. showed that current smokers exhibited functional restoration and neck pain reduction after cervical posterior

decompression compared with current non-smokers [21]. Besides, for posterior cervical fusion, there have been studies on the rate of fusion that have shown that smoking status does not affect posterior cervical fusion [15]. Because of the non-fusion characteristics of laminoplasty, the effect of smoking on the fusion rate was not investigated in this study. Our results showed that despite a statistically significant increase in JOA scores among the three groups, the recovery rate of JOA was slightly higher in the AS group compared with the NS group, which is partly consistent with Nagoshi's findings that smoking status did not negatively affect the clinical outcomes [21].

However, confounding factors such as age, preoperative JOA, and duration of disease may contribute to this outcome. To explore the influence of different confounding factors on the JOA recovery rate, the patients were classified into either the recovery rate reached the MCID ( $\geq 52.8\%$  recovery rate) or the recovery rate did not reach the MCID ( $< 52.8\%$  recovery rate) according to whether the recovery rate of JOA reached the MCID (52.8% of the JOA recovery rate). Univariate logistic regression analysis showed that age and preoperative JOA were risk factors for the recovery rate of JOA unreached the MCID, but neither active smoking nor passive smoking was a risk factor for that compared with nonsmokers. Multivariate logistic regression with a forward stepwise procedure ( $P < 0.05$  for entry) was performed to identify correlations between risk factors for those with the JOA recovery rate unreached the MCID. The result also showed that age and preoperative JOA were the independent risk factors for the recovery rate of JOA unreached the MCID but smoking status was not an independent risk factor for that. Similarly, previous studies have also shown that age, but not smoking, is a risk factor for posterior cervical spine surgery, which is partially consistent with our results [21, 42–44]. In our study, smoking status was not found to be an independent predictor of clinical outcomes. Therefore, we consider that laminoplasty is equally for active, passive, and non-smokers with multilevel cervical diseases.

Previous research has shown that for patients with cervical spondylotic myelopathy, there was no statistically significant improvement in patient-reported outcomes within one year of the anterior surgical approach compared to the posterior surgical approach. Expansive open-door laminoplasty not only yields better outcomes than anterior fusion or posterior fusion surgery but also reduces the use of outpatient medical services [45]. Besides, expansive open-door laminoplasty is less costly during hospitalization than posterior fusion surgery [46]. The effect of smoking on the fusion rate should also be considered, whether anterior fusion or posterior fusion surgery. Therefore, based on our findings and previous research findings, we recommend that patients who are active smokers or passive smokers should be given preference for expansive open-door laminoplasty if both anterior and posterior cervical spine surgery is an option.

Surgeons need to understand when smokers should stop smoking before surgery and for how long during follow-up. Previous studies have shown that 4–8 weeks of smoking cessation before surgery can significantly reduce perioperative complications and the incidence of secondary surgery [47, 48]. Although the evidence for the appropriate duration of smoking cessation before spine surgery remains incomplete, our study also suggests that preoperative smoking status is not an independent predictor of clinical outcomes after laminoplasty, but to prevent perioperative complications and the incidence of

secondary surgery, it should be recommended to stop smoking at least 4 weeks before surgery [12, 13]. As for the quitting time after the surgery, some studies show that angiogenesis takes 3–4 weeks after the operation, which can create a good environment for tissue repair and bone healing [12]. Besides, Glassman et al also showed that patients who quit smoking for more than six months had a higher rate of returning to work [49]. While further research is needed to determine the length of time that smoking cessation continues after cervical spine surgery, a smoking ban of at least six months after surgery may be beneficial.

Our study has several limitations that deserve attention. First, this study has a relatively small sample size and a relatively short minimum follow-up of 6 months. Previous studies have examined the effect of smoking on recovery after cervical spine surgery, some with a similar minimum follow-up time, and some with a minimum follow-up time of 3 months; thus, our follow-up time can be compared to previous studies reliably [15, 20]. Second, We did not analyze changes in the signals of the spinal cord after surgery in patients with preoperative magnetic resonance imaging (MRI) T2-weighted high signal change (T2HSC) in the spinal cord. However, previous studies have shown that postoperative T2 MRI outcomes can be classified into three categories: T2HSC regression, non- T2HSC regression, and enlargement of T2HSC. And patients with regression of T2HSC in the spinal cord after surgery will likely have a better prognosis. [50] Third, we did not take into account the distribution of a smoking amount in the groups of smokers. Further research with long-term follow-up of a large sample is needed to further clarify the impact of smoking status on postoperative outcomes of single open-door laminoplasty in patients with DCM.

## Conclusion

During at least 6 months of follow-up after an open-door laminoplasty, active smokers, passive smokers, and non-smokers had similar improvements in clinical outcomes. Smoking status was not found to be an independent predictor of clinical outcomes and JOA scores after laminoplasty. As open-door laminoplasty is the most common procedure to manage multisegmental degenerative cervical myelopathy, and the result of our study will help spinal surgeons to guide the selection of surgical schemes for patients with multisegmental degenerative cervical myelopathy. And more importantly, understanding the effect of preoperative smoking status on clinical outcomes after laminoplasty will be helpful for specialized patient consultation and preoperative education.

## Abbreviations

DCM: Degenerative cervical myelopathy; JOA: Japanese Orthopedic Association; JOACMEQ: Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire; NRS: Numerical rating scale; VAS: Visual analogue scale; OPLL: Ossification of the posterior longitudinal ligament; MCID: Minimal clinically important difference; ANOVA: Analysis of variance; BMI: Body mass index; AS group: Active smoking; NS group: non-smoking group; PS group: Passive smoking group

# Declarations

## Ethics approval and consent to participate

The Research Ethics Committee of the institute approved this investigation (No.GDREC 2020152H) and all investigations were conducted in conformity with ethical principles of research. The patients were informed about the details of the study and provided written informed consent before study enrollment. Informed consent was obtained from all the participants, and procedures were conducted according to the Declaration of Helsinki.

## Consent for publication

Not applicable

## Availability of data and materials

All data analysed during the current study are available from the corresponding author on reasonable request.

## Competing interests

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## Authors' contributions

QD was responsible for collecting, analyzing and interpreting the data, and writing the manuscript. CC,CL, and XZ contributed to reviewing the accuracy of the data and revising the manuscript. XH,RZ collected the data. GL and YC contributed to the study design and conception, and revision of the manuscript. All authors read and approved the final manuscript.

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