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Focal Kyphotic Angle and Transverse Canal Area as the Predictors of Japanese Orthopaedic Association Score Improvement in Cervical Spondylotic Myelopathy Patient after Laminoplasty

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ABSTRACT

Introduction: Cervical Spondylotic Myelopathy (CSM) is a degenerative condition of the cervical spine that can lead to progressive neurological dysfunction. Laminoplasty is a commonly used procedure to treat this condition; however, the predictive factors contributing to postoperative clinical improvement require further investigation. This study aims to evaluate the roles of Focal Kyphotic Angle (FKA), Transverse Canal Area (TCA), age, and symptom duration as predictors of clinical improvement in CSM patients following laminoplasty.

Material and methods: Case-control study was conducted retrospectively from March to December 2024. Thirty-two CSM patients undergoing C3–C7 laminoplasty were categorized based on JOA scores (≥13 or <13). Age, symptom duration, focal kyphotic angle, and transverse canal area were analyzed using statistical methods, including chi-square tests.

Results: The results showed that an FKA < 7° was a significant predictor of clinical improvement compared to an FKA ≥ 7° (p<0.001; OR=33.00). Additionally, a TCA >167.92 mm was also found to significantly increase the likelihood of clinical improvement compared to a TCA <167.92 mm (p<0.001; OR=25.00). Symptom duration of less than one year was significantly associated with clinical improvement (p=0.005; OR=0.063). However, age under 60 years and symptom duration of less than one year were not significant predictors of clinical improvement (p=0.47; OR=1.66) (p=0.44; OR=1.8). Further multivariate analysis indicated that FKA < 7° and TCA >167.92 mm were the most influential predictors of clinical improvement (JOA score ≥ 13) in CSM patients post-laminoplasty. (p = 0,011 x^2= 0,509, df=2, p=0.775; sensitivity 81%, specificity 82% AUC=0,867, 95% CI: 0,734 – 1,001)

Conclusion: FKA < 7° and TCA >167.92 mm are important predictors of clinical improvement in CSM patients after laminoplasty. These findings may assist in optimizing surgical intervention planning.

Keywords: Cervical Spondylotic Myelopathy, Clinical Outcome Predictors, Focal Kyphotic Angle, Laminoplasty, Symptom Duration, Transverse Canal Area

INTRODUCTION

Cervical Spondylotic Myelopathy (CSM) is a neurological condition caused by cervical spine degeneration, leading to spinal cord compression and neurological symptoms. In severe cases, surgery such as laminoplasty is necessary to address progressive symptoms unresponsive to conservative treatment. CSM significantly reduces quality of life due to chronic pain and nerve dysfunction while increasing economic and social burdens through long-term healthcare costs and reduced productivity [1,2].

CSM is more common in individuals over 55 years old, with primary risk factors including disc degeneration, disc herniation, and hypertrophy of the ligamentum flavum. Spinal canal narrowing due to degenerative processes leads to motor impairment, limb weakness, and bladder dysfunction. Laminoplasty is an effective surgical option for relieving nerve compression while preserving spinal stability [2].

This study focuses on predictors of clinical improvement in CSM patients after laminoplasty, including transverse canal area, age, and symptom duration before surgery. A transverse canal area greater than 167.92 mm^2 and symptom duration of less than one year are significantly associated with better outcomes. A focal kyphotic angle of less than 7 degrees also correlates with improved Japanese Orthopaedic Association (JOA) scores. Advanced age over 60 years is strongly linked to cervical spine degeneration [3–6].

METHODS

The design of this study is case control, investigating on the age, the symptom duration, the Focal Kyphotic Angle, the Transverse Canal area as predictors in the improvement of Japanese Orthopaedic Association score in Cervical Spondylotic Myelopathy patients, assessing the outcome in a retrospective manner.

The research was conducted at RSUP Prof. Ngoerah Denpasar from March 2024 to December 2024, and patients were sampled and scored with JOA score and were categorized in accordance to the results with a cutoff of ≥ 13 or < 13. Records of age, duration of symptoms, through interview with the patient, and focal kyphotic angle and transverse canal area were obtained through records of Magnetic Resonance Imaging (MRI) examination. The data were then recorded and analyzed

Patient Selection

Patients selected for the study are patients that had undergone laminoplasty on C3-C7 levels with diagnosis of CSM. The patients were selected through purposive sampling and were further selected through the inclusion and exclusion criteria. The inclusion criteria include the presence of prior MRI examination, age of above 18, and patients with evaluated JOA score, which are then grouped accordingly. Patients with allergy or severe reactions upon surgery, patients with kyphotic deformity, patients with cognitive impairment, and pregnant patients were excluded from the study. A total of 32 patients were then included in the study, with 16 patients in each group.

Data Extraction

Data are obtained from prior medical records on patient having gone through laminoplasty due to CSM. The included patients were scored with the JOA score and grouped based on their scores with a cutoff of <13 to be included in the control group, and ≥ 13 to be grouped in the case group. The age distribution and categorization of symptom duration were obtained. The focal kyphotic angle and transverse canal area were also obtained through evaluation of the MRI.

Other required data were collected through interview of the patient.

Data Analysis

Clinical parameters such as age and symptom duration before surgery will be evaluated using measures like mean, median, and standard deviation (SD). Statistical methods will be used to determine whether clinical and radiological factors serve as predictors of clinical improvement. Chi-square test will be conducted to evaluate relationship between focal kyphotic angle and the transverse canal area with the JOA score, focusing on how they relate to clinical outcomes.

RESULTS

A total of 32 patients were included, with an average age of 59.94 years. The majority of patients were over 60 years old (56.25%), and most were male (75%). Common comorbidities included diabetes (15.6%), hypertension (21.87%), heart disease (9.37%), history of malignancy (3.12%), and postoperative infection complications (6.25%). The average symptom duration was 9.13 months, with a mean focal kyphotic angle of 9.03° and a transverse canal area of 134.75 ± 38.74 mm².

Table 1. Chi-square test for Focal Kyphotic Angle on Cervical Spondylotic Myelopathy Patients

Variable	Control Group (JOA *score* ≥ 13) (n=16)	Case Group (JOA *score* < 13) (n=16)	p	OR (95% CI)
FKA: n(%)				
FKA < 7º	11(68,8)	1(6,3)	<0,001	33,00
FKA ≥ 7º	5(31,3)	15(93,8)		(3,36- 323,81)

Table 2 Chi-square test for Transverse Canal Area on Cervical Spondylotic Myelopathy Patients

Variable	Control Group (JOA *score* ≥ 13) (n=16)	Case Group (JOA *score* < 13) (n=16)	*p*	OR (95% CI)
TCA: n(%)				
TCA > 167.92 mm	10 (62,5)	1 (6,3)	<0,001	25,00
TCA ≤ 167.92 mm	6 (37,5)	15 (93,8)		(2,60-240,33)

Table 3 Chi-square test for Different Age Group on Cervical Spondylotic Myelopathy Patients

Variable	Case Group (JOA *score* < 13) (n=16)	Control Group (JOA *score* ≥ 13) (n=16)	*p*	OR (95% CI)
Age: n(%)				
< 60 years	6(37,5)	8(50)	0,47	1,66
≥ 60 years	10(62,5)	8(50)		(0,40 – 6,81)

Table 4 Chi-square test for Duration of Symptoms on Cervical Spondylotic Myelopathy Patients

Variable	Case Group (JOA *score* < 13) (n=16)	Control Group (JOA *score* ≥ 13) (n=16)	*p*	OR (95% CI)
Duration: n(%)				
< 1 years	10(62,5)	12(75)	0,44	1,80
≥ 1 years	6(37,5)	4(25)		(0.39 –8,21)

The statistical analysis found no significant differences in demographic variables, comorbidities, or surgical history between patients with JOA scores ≥ 13 and those with JOA scores < 13, suggesting no confounding variables in the study. Inferential analysis using the Chi-square test showed that a focal kyphotic angle of less than 7° was a significant predictor of clinical improvement after laminoplasty ($p<0.001$), with an odds ratio of 33.00, meaning patients with this condition were 33 times more likely to experience clinical improvement. Similarly, a transverse canal area greater than 167.92 mm² was identified as another significant predictor ($p<0.001$), with an odds ratio of

25.00. However, age under 60 years and symptom duration of less than one year were not significant predictors of clinical improvement.

Further multivariate logistic regression analysis confirmed that focal kyphotic angle < 7° and transverse canal area > 167.92 mm² were the only significant independent predictors of achieving JOA scores ≥ 13. However, when refining the model, transverse canal area > 167.92 mm² lost statistical significance (p = 0.064), leaving focal kyphotic angle < 7° as the sole predictor (p = 0.012). The final equation calculated that patients with a focal kyphotic angle ≥ 7° had a 17.06% probability of achieving a JOA score ≥ 13, whereas those with a focal kyphotic angle < 7° had an 81.96% probability.

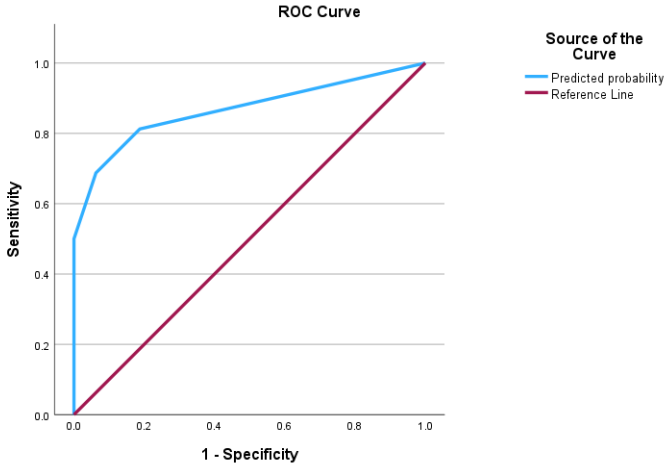
Table 5 Logistic Regression Test on Predictor Factors of JOA score ≥ 13 in CSM after laminoplasty

Predictors	B Coefficient	SE	Wald Statistics	p	Exp(B)	Odds Ratio (95%CI)
Step 1						
Constant	-0.975	0,831	1,379	0,333	0,281	
Age (1)	-0,249	1,088	0.052	0.819	0,78	0.092-6,582
Duration (1)	-1,245	1,316	0,895	0,344	0,288	0,022-3,796
Focal Kyphotic Angle (1)	3,524	1,423	6,131	0,013	33,911	2,084-551,718
Transverse Canal Area (1)	2,524	1,364	3,425	0,064	12,483	0,861-180,897
Step 2						
Constant	-1,039	0,787	1,743	0,187	0,354	
Duration (1)	-1,271	1,313	0,936	0,33	0,281	0,021-3,681
Focal Kyphotic Angle (1)	3,445	1,370	6,326	0,012	31,349	2,139-459,419
Transverse Canal Area (1)	2,498	1,35	3,425	0,064	12,161	0,863-171,421
Step 3						
Constant	-1.581	0,643	6,045	0,014	0,206	
Focal Kyphotic Angle (1)	3,081	1,214	6,442	0,011	21,788	2,017-235,297
Transverse Canal Area (1)	1,853	1,074	2,976	0,085	6,381	0,777-52,401

The Hosmer-Leme show test confirmed the model's good calibration, and further analysis using the ROC curve demonstrated strong predictive accuracy, with 81% sensitivity and 82% specificity (AUC = 0.867).

Table 6 Area Under Curve of the ROC curve Test Results for Multivariate Logistic Regression Analysis

Area	Std. Error	*p*	95%CI
0,867	0,068	<0,001	0,734 – 1,001



Graph 1. The ROC curve Test Results for Multivariate Logistic Regression Analysis

DISCUSSION

This study examined various factors that may predict clinical outcomes in patients with Cervical Spondylotic Myelopathy (CSM) following laminoplasty. The average age of participants was 59.94 ± 9.03 years, with the majority (56.25%) being over 60 years old. Male patients were predominant, making up 75% of the study group. These findings align with prior research by Oh et al., which identified a correlation between CSM and older age, particularly in men [7].

The study found that a Focal Kyphotic Angle (FKA) of less than 7° was a predictor of improved clinical outcomes post-laminoplasty. This result was supported by previous studies, including Wu et al., who found that focal kyphosis in CSM patients correlated with the severity of myelopathy symptoms, particularly in cases of severe disc herniation. Cheng et al. also showed that changes in FKA before and after surgery influenced clinical improvement. However, Acharya et al. reported different findings, indicating that preoperative kyphotic curvature did not significantly impact postoperative JOA scores. Despite this, the current study accepted the hypothesis that FKA < 7° predicts better clinical outcomes, as statistical analysis showed a significant difference ($p < 0.05$) [8–10].

Additionally, the study found that a Transverse Canal Area (TCA) greater than 167.92 mm² was a predictor of better clinical outcomes. This is consistent with previous research by Zhang et al., who demonstrated a relationship between preoperative spinal canal area and improved JOA scores. Kong et al. also found that a narrower cervical canal was associated with persistent lower extremity symptoms post-surgery. Conversely, Hamburger et al. argued that preoperative TCA alone does not predict surgical outcomes but emphasized the importance of expanding the canal area to achieve better results. The current study supported the hypothesis that TCA > 167.92 mm² is a predictor of improved outcomes, as statistical analysis showed a significant difference ($p < 0.05$) [11–13].

However, the study found that being under 60 years old was not a predictor of better clinical outcomes after laminoplasty. This aligns with a systematic review by Tetreault et al., which concluded that age did not significantly predict good or excellent outcomes based on JOA scores. In contrast, studies by Nagoshi et al. and Sun et al. suggested that younger patients experienced better postoperative functional improvement. Despite these contrasting findings, the current study accepted the null hypothesis, as statistical analysis showed no significant difference ($p > 0.05$) [14–16].

Similarly, the study determined that symptom duration of less than one year was not a predictor of clinical improvement. Loh et al. found that while longer symptom duration affected intraoperative motor evoked potential (MEP) improvements, it did not impact functional outcomes based on modified JOA scores. However, Machino et al. identified a shorter symptom duration (< 6 months) as the only significant predictor of a JOA score improvement ≥ 2.5 points. Other studies, including Sun et al. and Yoon et al., also found that longer symptom duration negatively correlated with recovery. Despite these findings, the current study accepted the null hypothesis, as statistical analysis showed no significant difference ($p > 0.05$) [16–19].

CONCLUSION

This study found that Focal Kyphotic Angle (FKA) < 7° and Transverse Canal Area (TCA) > 167.92 mm² are significant predictors of improved JOA scores in CSM patients post-laminoplasty at RSUP Prof. Dr. Ngoerah, while age under 60 years and symptom duration < 1 year were not. Among these, FKA < 7° had the strongest influence on clinical recovery (JOA ≥ 13). However, limitations such as a retrospective design, small sample size, reliance on JOA scores, and uncontrolled external factors affect generalizability. Future prospective studies with longer follow-ups are needed to confirm these findings and explore additional outcome predictors.

Declaration by Authors
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