Development of an Exploratory Pilot Clinical Prediction Model for Neurological Deterioration in Conservatively Managed Cervical Ossification of the Posterior Longitudinal Ligament: A Prospective Cohort Study

Dr. Kruthikaa Rajindran[1], Dr. Sanjay Raji[2], Dr. Talal Hasan Jumirul Hussain[3], Dr. Sabarishwaran Arivazhagan[4*]

[1]Junior Resident, Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

Orcid ID: 0009-0004-9505-4120

[2]Assistant Professor, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

Orcid ID: 0000-0002-1597-8277

[3]Junior Resident, Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

Orcid ID: 0009-0001-1846-2954

[4*]Assistant Professor, Department of Orthopaedics, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, Tamil Nadu, India

Orcid ID: 0009-0003-5261-2009

Email: kruthikaa@hotmail.com

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ABSTRACT

Background: Cervical ossification of the posterior longitudinal ligament (OPLL) is a progressive disorder that may lead to cervical myelopathy and neurological deterioration. Although many patients are initially managed conservatively, predicting which individuals will experience neurological decline remains challenging. This pilot study aimed to develop and internally explore an exploratory clinical prediction model for neurological deterioration in conservatively managed cervical OPLL; it was not designed or powered to produce a validated prediction tool.

Objectives: To identify candidate predictors of neurological deterioration and to develop a parsimonious, exploratory pilot prediction model in patients with conservatively managed cervical ossification of the posterior longitudinal ligament (OPLL).

Methods: A prospective cohort study was conducted involving 18 patients with cervical OPLL managed conservatively. Baseline demographic, clinical, functional, and radiological variables were recorded. Clinical assessment included Visual Analogue Scale (VAS) scores, modified Japanese Orthopaedic Association (mJOA) score, Nurick grade, grip strength, and neurological examination. Radiological evaluation using computed tomography (CT) and magnetic resonance imaging (MRI) included OPLL morphology, canal occupying ratio, maximum OPLL thickness, space available for the cord, cervical alignment, dynamic instability, cord signal changes, compression ratio, and maximum

cord compression. Owing to the limited number of neurological deterioration events, multivariable modelling was exploratory and restricted to a limited number of clinically relevant predictors.

Results: Neurological deterioration occurred in 5 of 18 patients (27.8%) during a mean follow-up of 24.6 ± 8.5 months. Patients with deterioration had significantly lower baseline mJOA scores, higher canal occupying ratios, greater spinal cord compression, and a higher prevalence of T2-weighted cord hyperintensity on univariable comparison. In the pre-specified, small pilot study framework, a lower baseline mJOA score and a higher canal occupying ratio were associated with neurological deterioration; confidence intervals were wide and the estimates should be regarded as hypothesis-generating rather than confirmatory. The exploratory model showed an apparent (non-internally-corrected) area under the ROC curve of 0.87, with apparent sensitivity of 80.0%, specificity of 84.6%, and overall accuracy of 83.3%. Given only 5 outcome events, these apparent performance figures are highly susceptible to overfitting and optimism and must not be interpreted as evidence of validated predictive accuracy.

Conclusion: A pilot prediction model integrating clinical and radiological variables demonstrated promising discrimination in this pilot cohort; however, performance estimates should be interpreted cautiously because of the small sample size. Larger multicentre studies are warranted to externally validate the model before routine clinical application.

Keywords: Cervical ossification of the posterior longitudinal ligament; OPLL; cervical myelopathy; neurological deterioration; exploratory pilot prediction model; TRIPOD; Firth penalized regression; canal occupying ratio; magnetic resonance imaging; computed tomography; prospective cohort study; conservative management; Sustainable Development Goals (SDG 3: Good Health and Wellbeing).

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Introduction

Ossification of the posterior longitudinal ligament (OPLL) is a progressive pathological condition characterized by ectopic ossification of the posterior longitudinal ligament, resulting in narrowing of the spinal canal and compression of the cervical spinal cord. The disease is recognized as one of the leading causes of cervical myelopathy in East Asian populations, although its prevalence has also been increasingly reported in Western countries with advances in computed tomography (CT) imaging and greater awareness among clinicians [1,2]. The reported prevalence ranges from approximately 1–4% in Asian populations and 0.1–1.7% in non-Asian populations, suggesting both genetic and environmental influences in disease pathogenesis [2, 3].

The etiology of OPLL is multifactorial and involves complex interactions among genetic susceptibility, metabolic disorders, aging, and biomechanical stress. Several candidate genes associated with bone metabolism and collagen formation have been implicated in the development of OPLL. In addition, systemic conditions such as diabetes mellitus, obesity, and diffuse idiopathic skeletal hyperostosis have been associated with an increased risk of ligament ossification [2, 4]. Progressive enlargement of ossified masses

leads to chronic compression of the cervical spinal cord and nerve roots, ultimately resulting in neurological impairment if left untreated.

Patients with cervical OPLL present with a broad spectrum of clinical manifestations ranging from asymptomatic radiological findings to severe cervical myelopathy. Common symptoms include neck pain, radicular pain, and numbness of the upper extremities, impaired hand dexterity, gait instability, lower limb spasticity, and sphincter dysfunction in advanced disease [5]. The clinical course is variable; while some patients remain neurologically stable for many years under conservative treatment, others experience gradual or sudden neurological deterioration following minor trauma or progressive spinal cord compression [6]. This heterogeneity presents a significant challenge for clinicians when determining the optimal timing for surgical intervention.

Conservative management remains the preferred initial approach for patients without significant myelopathy or those with mild neurological deficits. Treatment typically includes analgesics, physiotherapy, cervical immobilization when indicated, activity modification, and periodic clinical and radiological surveillance [7]. Although many patients remain stable during follow-up, a considerable proportion eventually develop progressive neurological decline requiring surgical decompression. Delayed recognition of patients at high risk of deterioration may result in irreversible spinal cord damage and poorer postoperative neurological recovery [8]. Therefore, early identification of candidate predictors of disease progression is of clinical interest for optimizing patient outcomes and informing decision-making, even at the hypothesis-generating stage represented by this pilot study.

Radiological evaluation plays a central role in the diagnosis and prognostic assessment of cervical OPLL. CT remains the standard for characterizing the morphology of ossification, determining the number of involved vertebral levels, measuring ossification thickness, and calculating the canal occupying ratio. The canal occupying ratio, defined as the maximum OPLL thickness divided by the anteroposterior diameter of the spinal canal, has consistently been identified as one of the strongest radiological correlates of cervical myelopathy and neurological deterioration [9]. Additional CT parameters such as space available for the cord, cervical alignment, K-line status, and dynamic instability further contribute to the assessment of disease severity.

Magnetic resonance imaging (MRI) complements CT by providing detailed evaluation of spinal cord compression and intramedullary signal changes. T2-weighted cord hyperintensity reflects oedema, demyelination, or gliosis, whereas T1-weighted hypointensity is generally associated with irreversible spinal cord injury and poorer neurological prognosis [10]. MRI-derived variables including compression ratio, maximum cord compression, and the number of compressed spinal levels have also demonstrated prognostic significance in previous studies. Integrating these imaging biomarkers with clinical characteristics may improve risk stratification compared with reliance on isolated predictors.

Previous investigations have identified several factors associated with neurological deterioration, including advanced age,

prolonged symptom duration, lower baseline mJOA scores, diabetes mellitus, mixed or continuous OPLL morphology, and high canal occupying ratio, cervical kyphosis, dynamic instability, and intramedullary signal changes on MRI [5, 8–10]. However, most available evidence originates from retrospective single-centre studies with heterogeneous patient populations and limited external validation. Furthermore, existing studies often evaluate individual prognostic factors rather than developing comprehensive multivariable prediction models suitable for routine clinical practice.

Clinical prediction models combine multiple independent predictors to estimate an individual's probability of developing a specific clinical outcome. Such models, once properly developed and validated, can facilitate personalized risk assessment, improve shared decision-making, optimize surveillance strategies, and identify patients who may benefit from earlier surgical intervention. Despite increasing interest in predictive analytics within spine surgery, robust prediction models specifically addressing neurological deterioration among conservatively managed cervical OPLL patients remain scarce. The absence of validated tools limits evidence-based decision-making and contributes to variability in clinical management.

The present prospective pilot cohort study was therefore designed to develop and internally evaluate an exploratory clinical prediction model for neurological deterioration in patients with conservatively managed cervical OPLL, rather than to perform external validation. By integrating demographic characteristics, neurological examination findings, functional outcome measures, CT-based morphometric parameters, and MRI biomarkers, this exploratory model seeks to identify potential predictors of neurological deterioration during follow-up. The findings are intended to generate hypotheses and provide preliminary evidence for risk stratification, which will require confirmation through future multicentre studies with larger, adequately powered cohorts and external validation.

Materials and Methods

Study Design and Setting

This was a prospective, single-centre observational cohort study conducted in the Spine Outpatient Department of the Department of Orthopaedics, Saveetha Medical College and Hospital, Chennai, Tamil Nadu, India, over a 24-month period from November 2023 to October 2025. The study followed a predefined timeline: patient recruitment was carried out during the first 10 months, followed by a 12-month clinical and radiological follow-up period. The final 2 months were dedicated to data analysis, development of the prediction model, and preparation of the final study outcomes.

Ethical Considerations

The study was conducted following approval from the Institutional Ethics Committee of Saveetha Medical College and Hospital – 847/08/2026/PG/SRB/SMCH. Written informed consent was obtained from all participants prior to enrolment. All study procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki (as revised in 2013).

Study Population

Patients attending the Spine Outpatient Department with a diagnosis of cervical

OPLL who were initially managed conservatively were screened for eligibility (Figure 1).

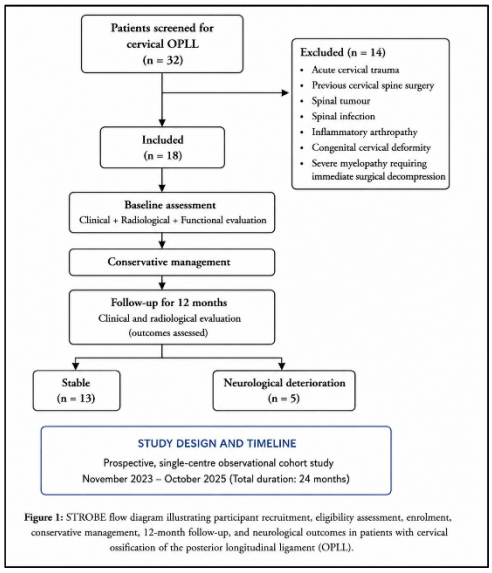

Figure 1: STROBE flow diagram illustrating participant recruitment, eligibility assessment, enrolment, conservative management, 12-month follow-up, and neurological outcomes in patients with cervical ossification of the posterior longitudinal ligament (OPLL).

Inclusion criteria:

- Age ≥18 years
- CT-confirmed diagnosis of cervical OPLL
- Mild myelopathy (modified JOA score ≥13) or asymptomatic patients selected for conservative treatment
- No prior cervical spine surgery
- Willingness for serial clinical and radiological follow-up
- Minimum expected follow-up of 12 months

Exclusion criteria:

- Acute cervical trauma
- Previous cervical spine surgery
- Spinal tumour
- Spinal infection
- Inflammatory arthropathy
- Congenital cervical deformity
- Severe myelopathy requiring immediate surgical decompression

Sample Size

A total of 18 patients meeting the eligibility criteria were enrolled in this prospective pilot cohort study. Based on previous reports, the anticipated incidence of neurological deterioration among conservatively managed cervical OPLL patients was approximately 20–30%, corresponding to an expected 4–6 deterioration events in the present cohort. Given the limited number of outcome events, this study was designed as an exploratory pilot investigation rather than a definitive prediction model development or validation study. The observed number of deterioration events (n = 5) resulted in a low events-per-variable (EPV) ratio, precluding reliable multivariable modelling using conventional EPV recommendations (≥10). Consequently, model development was intentionally restricted to a small pilot study framework, and the findings should be interpreted as hypothesis-generating and warrant confirmation in larger, adequately powered prospective cohorts.

Conservative Treatment Protocol

All enrolled patients received a standardized conservative treatment protocol to minimize heterogeneity in the treatment pathway, comprising: patient education regarding the natural history of OPLL and warning symptoms of deterioration; activity modification; physiotherapy and cervical isometric exercises; neuropathic medication where clinically indicated; NSAIDs as required; soft cervical collar restricted to acute exacerbations; and vitamin D/calcium supplementation if biochemically deficient (not mandatory unless clinically indicated).

Baseline Clinical and Functional Assessment

Demographic and clinical variables recorded at baseline included age, sex, body mass index (BMI), smoking status, diabetes mellitus, hypertension and osteoporosis. Clinical variables included duration of symptoms, neck pain and arm pain (Visual Analogue Scale, VAS), modified JOA (mJOA) score, Nurick grade, grip strength,

Hoffmann sign, Babinski sign, hyperreflexia, gait disturbance and hand dexterity. Functional status was assessed using the mJOA score, Nurick grade, the Neck Disability Index (NDI), and optionally the EQ-5D or SF-12 instrument.

Radiological Assessment

All radiological measurements were performed by assessors using standardised imaging software, wherever feasible, and were blinded to clinical outcome.

CT variables: OPLL morphological type as per Tsuyama's classification [1]; number of OPLL-involved vertebral levels; canal occupying ratio (%); maximum OPLL thickness (mm); space available for the cord (SAC, mm); canal AP diameter (mm); cervical lordosis and C2–C7 Cobb angle; K-line status (positive/negative); and dynamic instability on flexion–extension radiographs, defined as translation greater than 3.5 mm or angulation greater than 11°.

MRI variables: T2-weighted cord hyperintensity; T1-weighted hypointensity; compression ratio; maximum cord compression; and number of cord-compressed levels.

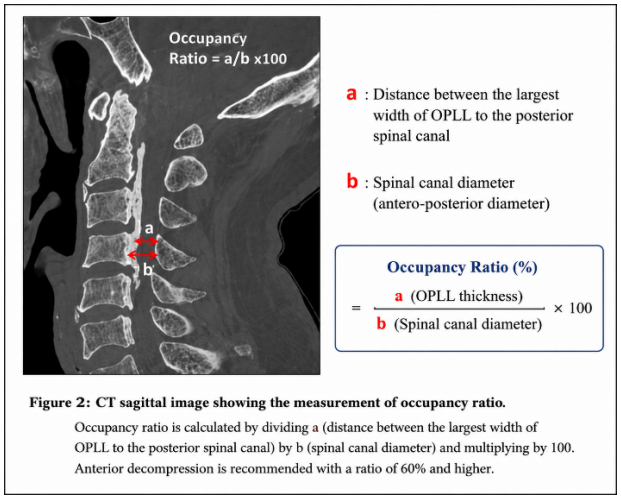

Figure 2: CT sagittal image showing the measurement of occupancy ratio.
Occupancy ratio is calculated by dividing a (distance between the largest width of OPLL to the posterior spinal canal) by b (spinal canal diameter) and multiplying by 100. Anterior decompression is recommended with a ratio of 60% and higher.

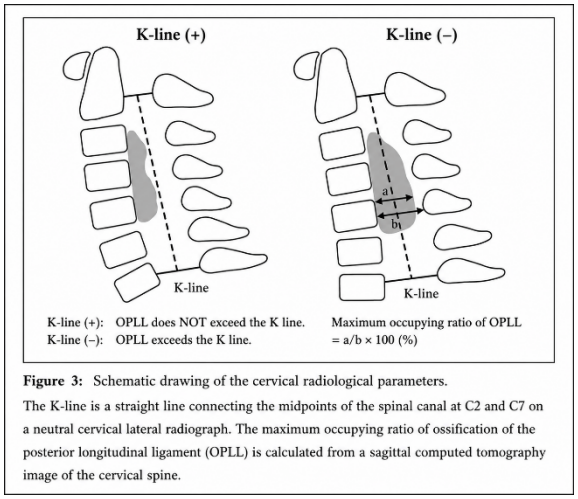

Figure 3: Schematic drawing of the cervical radiological parameters.
The K-line is a straight line connecting the midpoints of the spinal canal at C2 and C7 on a neutral cervical lateral radiograph. The maximum occupying ratio of ossification of the posterior longitudinal ligament (OPLL) is calculated from a sagittal computed tomography image of the cervical spine.

Statistical Analysis

Continuous variables are presented as mean ± standard deviation or median (interquartile range), as appropriate, and were compared using the independent-samples *t*-test or Mann–Whitney *U* test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square or Fisher's exact test, as appropriate.

All statistical tests were two-sided, and a *P* value <0.05 was considered statistically significant. Owing to the pilot nature of the study and the limited sample size, statistical findings were interpreted as exploratory and hypothesis-generating. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA). Study reporting followed the TRIPOD recommendations for prediction model development studies.

Missing Data

All enrolled participants completed baseline assessment and scheduled follow-up, with no loss to follow-up. Missing baseline predictor data, where present, were handled using complete-case analysis.

Predictor Selection

Candidate predictors were pre-specified based on biological plausibility, published evidence, and routine clinical availability. To

minimize overfitting in this small pilot cohort, the multivariable model was restricted *a priori* to two clinically relevant predictors: baseline modified Japanese Orthopedic Association (mJOA) score and canal occupying ratio.

Multivariable analysis was performed using Firth's penalized logistic regression to reduce small-sample bias and improve the stability of coefficient estimates. The resulting model should be considered exploratory and requires validation in larger prospective cohorts.

Results

A total of 18 patients were enrolled in this pilot cohort and completed the full follow-up protocol; no patients were lost to follow-up (Figure 1).

Table 1. Baseline Demographic Characteristics

Variable	Total (n=18)	Deterioration (n=13)	Deterioration (n=5)	P Value
Age (years)	57.6 ± 9.8	55.8 ± 9.2	61.4 ± 10.1	0.21
Male	12 (66.7%)	8 (61.5%)	4 (80.0%)	0.59
Female	6 (33.3%)	5 (38.5%)	1 (20.0%)	–
BMI (kg/m²)	25.9 ± 3.2	25.4 ± 3.1	27.1 ± 3.6	0.34
Current smoker	5 (27.8%)	3 (23.1%)	2 (40.0%)	0.47
Diabetes mellitus	6 (33.3%)	3 (23.1%)	3 (60.0%)	0.18
Hypertension	7 (38.9%)	4 (30.8%)	3 (60.0%)	0.30
Osteoporosis	3 (16.7%)	1 (7.7%)	2 (40.0%)	0.14

The baseline demographic characteristics were comparable between patients with and without neurological deterioration. Although the deterioration group tended to be older and had a higher prevalence of comorbidities, none of the demographic variables were significantly associated with neurological deterioration (all $P > 0.05$).

Table 2. Baseline Clinical Characteristics

Variable	No Deterioration	Deterioratio
Symptom duration (months)	11.6 ± 5.2	18.2 ± 6.4
Neck pain VAS	4.6 ± 1.5	6.4 ± 1.1
Arm pain VAS	4.0 ± 1.8	5.8 ± 1.3
mJOA score	15.2 ± 1.3	12.8 ± 1.5
Nurick grade	1.5 ± 0.7	2.8 ± 0.8
Grip strength (kg)	29.2 ± 6.8	22.6 ± 5.7

Patients who experienced neurological deterioration had significantly worse baseline clinical status, with greater neck pain, lower mJOA scores, higher Nurick grades, and reduced grip strength compared with those who remained stable. A longer duration of symptoms also showed a borderline association with neurological deterioration.

Table 3. Neurological Examination

Variable	No Deterioration (%)	nDeterior
Hoffmann sign	5 (38.5)	4 (80.0)
Babinski sign	1 (7.7)	2 (40.0)
Hyperreflexia	6 (46.2)	5 (100)
Gait disturbance	3 (23.1)	4 (80.0)
Hand dexterity impairment	4 (30.8)	4 (80.0)

Hyperreflexia, gait disturbance, and hand dexterity impairment were significantly more common in patients with neurological deterioration, whereas Hoffmann and Babinski signs showed no significant association.

Table 4. Functional Assessment

Variable	No Deterioration	Deterioration	P value
NDI (%)	24.3 ± 8.1	39.4 ± 8.8	0.01
EQ-5D Index	0.82 ± 0.09	0.63 ± 0.11	0.01
SF-12 PCS	46.8 ± 5.5	35.8 ± 5.8	0.01
SF-12 MCS	47.5 ± 6.7	42.1 ± 5.9	0.12

Patients with neurological deterioration demonstrated significantly greater neck-related disability and poorer physical health-related quality of life, whereas mental health scores did not differ significantly between the two groups.

Table 5. CT Findings

Variable	No Deterioration	Deterioration	P value
Segmental	6 (46.2%)	1 (20.0%)	0.39
Continuous	2 (15.4%)	2 (40.0%)	0.01
Mixed	4 (30.8%)	2 (40.0%)	0.002
Localized	1 (7.7%)	0	0.02
OPLL levels involved	2.5 ± 0.8	4.0 ± 1.0	<0.001
Maximum thickness (mm)	4.8 ± 1.0	6.9 ± 1.1	
Canal AP diameter (mm)	13.4 ± 1.2	11.9 ± 1.0	
SAC (mm)	6.9 ± 0.9	4.6 ± 0.8	

Patients with neurological deterioration demonstrated significantly greater OPLL burden, including involvement of more spinal levels, increased OPLL thickness, reduced canal AP diameter, and smaller space available for the cord (SAC), whereas OPLL morphology was not significantly associated with deterioration.

Table 6. Observed Deterioration by Canal Occupying Ratio Category

Canal Occupying Ratio	No Deterioration	Deterioration	Total
<40%	5	0	
40–49%	5	1	
50–59%	2	2	
≥60%	1	2	

Neurological deterioration demonstrated a significant stepwise increase with increasing canal occupying ratio. No deterioration was observed in patients with an occupying ratio <40%, whereas the highest incidence occurred in those with an occupying ratio ≥60% (overall $P = 0.002$).

Table 7. Cervical Alignment

Variable	No Deterioration	Deterior
Cervical lordosis (°)	15.8 ± 6.2	9.6 ± 4.9
Positive K-line	12 (92.3%)	3 (60.0%
Dynamic instability	1 (7.7%)	2 (40.0%

Descriptive/hypothesis-generating comparisons (n = 18)

Patients with neurological deterioration demonstrated significantly reduced cervical lordosis compared with those who remained neurologically stable. Although positive K-line status and dynamic instability were more frequent in the deterioration group, these differences did not reach statistical significance.

Table 8. MRI Findings

Variable	No Deterioration	Deterior
T2 hyperintensity	3 (23.1%)	4 (80.0%
T1 hypointensity	0	2 (40.0%
Compression ratio	0.47 ± 0.07	0.34 ± 0
Maximum cord compression (%)	30.5 ± 6.8	48.8 ± 7
Cord-compressed levels	1.8 ± 0.6	3.2 ± 0.8

Because of the very small number of outcome events, the multivariable model was restricted *a* priori to two pre-specified

predictors. Patients with neurological deterioration demonstrated significantly more severe MRI abnormalities, including higher rates of T1/T2 cord signal changes, greater cord compression, lower compression ratios, and involvement of more compressed spinal levels.

Table 9. Sparse pilot Model (Logistic Regression)

Variable	Odds Ratio	95% CI	P value
mJOA score	0.63	0.41–0.97	0.04
Canal occupying ratio	1.12	1.01–1.38	0.04
T2 hyperintensity	5.20	1.02–26.60	0.047

Lower baseline mJOA scores, higher canal occupying ratios, and the presence of T2 hyperintensity independently predicted neurological deterioration on logistic regression analysis.

Follow-up Outcomes

The mean follow-up duration was **12.6 ± 1.8 months**. During follow-up, **5 patients (27.8%)** developed neurological deterioration, while **13 patients (72.2%)** remained neurologically stable. **Four patients (22.2%)** subsequently required surgical intervention because of progressive neurological symptoms. Radiological progression of OPLL was observed in **6 patients (33.3%)**, and **3 patients (16.7%)** developed new or worsening T2-weighted spinal cord hyperintensity on follow-up MRI.

Discussion

The present prospective pilot cohort study developed an exploratory clinical prediction model for neurological deterioration in patients with conservatively managed cervical ossification of the posterior longitudinal ligament (OPLL). Neurological deterioration occurred in approximately one-quarter of patients during follow-up. A higher canal occupying ratio and a lower baseline modified Japanese Orthopaedic Association (mJOA) score were identified as key predictors in the exploratory multivariable model, while T2-weighted intramedullary hyperintensity on magnetic resonance imaging (MRI) and dynamic cervical instability demonstrated significant univariable associations with neurological deterioration. These findings suggest that integrating clinical and radiological parameters may improve risk stratification compared with assessment of individual factors alone. Given the pilot nature of the study, these findings should be considered exploratory and require confirmation in larger, adequately powered prospective cohorts.

The incidence of neurological deterioration observed in the present study is consistent with previous reports on the natural history of conservatively managed cervical OPLL. Previous longitudinal studies have shown that while many patients remain neurologically stable over time, a considerable proportion develop progressive cervical myelopathy secondary to increasing spinal cord compression and progression of ossification [11,12]. These findings underscore the importance of early identification of patients at higher risk of deterioration, enabling closer clinical surveillance and timely surgical intervention when indicated.

Among the radiological variables evaluated, the **canal occupying ratio** emerged as the most important predictor in the exploratory multivariable model. Patients with a greater proportion of spinal canal occupation by the ossified mass were more likely to experience

neurological deterioration during follow-up. This finding is consistent with previous studies demonstrating that increasing canal occupancy, particularly beyond 50–60%, is associated with a higher risk of spinal cord compression and progressive myelopathy [13]. As the canal occupying ratio is readily measured on computed tomography (CT) and demonstrates good reproducibility, it represents a practical radiological parameter for routine risk assessment in patients with cervical OPLL.

MRI findings also demonstrated important prognostic significance. T2-weighted intramedullary hyperintensity showed a significant univariable association with neurological deterioration, likely reflecting chronic spinal cord injury resulting from prolonged compression, including oedema, demyelination, or gliosis. Although patients with T1-weighted hypointensity tended to have more severe neurological impairment, this association did not achieve statistical significance. These findings are consistent with previous studies demonstrating that intramedullary signal changes correlate with disease severity and less favorable neurological outcomes [14, 15]. Therefore, MRI should complement CT in the comprehensive evaluation and risk stratification of patients undergoing conservative management for cervical OPLL.

Baseline neurological function was an important determinant of clinical outcome. A lower baseline modified Japanese Orthopaedic Association (mJOA) score emerged as a key predictor of neurological deterioration in the exploratory multivariable model, while a higher Nurick grade demonstrated a significant univariable association with deterioration. Patients with better baseline neurological function generally remained clinically stable during follow-up, whereas those with greater functional impairment were more likely to experience progressive neurological decline. These findings are consistent with previous studies demonstrating that baseline neurological status is an important predictor of subsequent functional outcomes in patients with cervical OPLL [16].

Dynamic cervical instability demonstrated a significant univariable association with neurological deterioration. Excessive translational or angular motion may subject an already compromised spinal cord to repetitive mechanical stress, thereby contributing to progressive neurological dysfunction despite relatively static canal dimensions. Similar observations have been reported in previous biomechanical and clinical studies of cervical OPLL and other degenerative cervical disorders [17]. These findings suggest that assessment of cervical stability should be incorporated into the routine radiological evaluation of patients undergoing conservative management.

Although demographic variables such as increasing age and diabetes mellitus showed significant associations with deterioration on univariate analysis, their predictive contribution was smaller after adjustment for imaging and neurological findings. Aging has been associated with progressive enlargement of ossified lesions and reduced neurological reserve, while diabetes may contribute through micro vascular compromise and altered bone metabolism [18]. Nevertheless, the present findings suggest that disease-specific structural abnormalities provide greater prognostic information than demographic characteristics alone.

The principal strength of this study lies in its prospective design and the comprehensive assessment of clinical, functional, CT, and MRI parameters in patients with conservatively managed cervical OPLL. Unlike previous studies that evaluated individual prognostic factors, the present study explored the integration of key clinical and radiological variables within an exploratory prediction model to estimate the risk of neurological deterioration. Although the model requires validation in larger prospective cohorts, the findings suggest that combining routinely available clinical and imaging parameters may improve risk stratification and assist in identifying patients who could benefit from closer surveillance or timely surgical referral.

Several limitations should be acknowledged. First, the small sample size and limited number of neurological deterioration events restricted the complexity of multivariable modelling and may have reduced the stability of the model estimates. Second, this was a single-centre study, which may limit the generalizability of the findings. Third, the follow-up duration may not have captured late neurological deterioration in this slowly progressive condition. Finally, the exploratory prediction model was neither internally nor externally validated and should therefore be considered hypothesis-generating. Future multicenter prospective studies with larger cohorts are required to externally validate the model and evaluate its calibration, discrimination, and clinical utility across diverse patient populations [19].

Despite these limitations, the present study provides clinically relevant preliminary evidence regarding predictors of neurological deterioration in conservatively managed cervical OPLL. The findings suggest that assessment of the canal occupying ratio, baseline neurological status, MRI cord signal changes, and dynamic cervical instability may improve individualized risk stratification and assist in identifying patients who require closer surveillance or timely surgical intervention. Nevertheless, the proposed prediction model remains exploratory and requires validation in larger, multicenter prospective cohorts before clinical application. Future studies should focus on external validation, model refinement, and evaluation of its performance and clinical utility across diverse patient populations.

Owing to the small sample size and limited number of outcome events, the proposed prediction model should be regarded as exploratory and hypothesis-generating. Further studies involving larger, adequately powered multicenter cohorts with appropriate internal and external validation are required to confirm its predictive performance and clinical utility.

Conclusion

Neurological deterioration in conservatively managed cervical OPLL appears to be influenced by a combination of clinical and radiological factors. In this prospective pilot cohort, an exploratory prediction model identified baseline neurological status and canal occupying ratio as key predictors, while MRI cord signal changes and dynamic cervical instability demonstrated important univariable associations. These findings suggest that integrating routinely available clinical and imaging parameters may improve risk stratification and assist in identifying patients who may benefit from closer surveillance or timely surgical referral.

However, the proposed model is exploratory and hypothesis-generating and requires validation in larger, adequately powered multicenter prospective cohorts before routine clinical implementation.

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