Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

Patient-Reported Outcome Measures in Degenerative Cervical Myelopathy: Correlation with Objective Neurological Assessment

Dr. Siddareddy Ankireddypalli[1], Dr. Suman Dhar[2]

1. I/C & Consultant Neurosurgeon, Department of Neurosurgery, AGMC& GBP Hospital, Agartala
2. Ortho Surgeon, AGMC & GBP Hospital, Agartala

Corresponding author
Dr. Siddareddy Ankireddypalli, I/C & Consultant Neurosurgeon, Department of Neurosurgery, AGMC& GBP Hospital, Agartala

(Received: 16 May 2025 Revised: 20 June 2025 Accepted: 24 July 2025)

KEYWORDS

PROM validation, Assessment concordance, Myelopathy outcomes, Cervical spine disorders, Surgical candidacy, Conservative management, Clinical correlation, Disability evaluation

ABSTRACT:

Background: Degenerative cervical myelopathy (DCM) assessment relies on both patient-reported outcome measures (PROMs) and objective neurological evaluations, yet the correlation between these approaches remains incompletely understood. This study examined the relationship between PROMs and objective neurological assessment scales across different disease severities and treatment groups.

Methods: A prospective observational cohort study included 150 DCM patients (mean age 62.4±11.8 years, 58% male). PROMs included Neck Disability Index (NDI), SF-36, EQ-5D-5L, and visual analog scales for pain. Objective measures comprised modified Japanese Orthopaedic Association (mJOA) scale, Nurick Grade, and European Myelopathy Scale (EMS). Correlation analyses were performed overall and stratified by disease severity and treatment status.

Results: Strong correlations were observed between functional PROMs and objective measures: SF-36 Physical Functioning versus Nurick Grade ($r=-0.78$, $p<0.001$), NDI versus mJOA ($r=-0.67$, $p<0.001$), and EQ-5D utility versus EMS ($r=0.73$, $p<0.001$). Correlation strength varied significantly by disease severity, with moderate myelopathy patients (mJOA 12-14) showing the strongest relationships ($r=0.76$-0.84) compared to mild ($r=0.38$-0.45) or severe disease ($r=0.59$-0.63). Surgical candidates demonstrated significantly stronger correlations than conservative management patients across all measures (mean $r=0.77$ vs 0.63, $p=0.012$). Discordant cases comprised 16.7% of the cohort, with distinct demographic and clinical characteristics.

Conclusions: Strong correlations between PROMs and objective neurological assessments support their complementary use in DCM evaluation. The moderate severity range represents an optimal assessment window with maximum concordance between patient-reported and clinician-observed measures. These findings inform evidence-based approaches to comprehensive DCM assessment and clinical decision-making.

INTRODUCTION

Degenerative cervical myelopathy (DCM) represents the most common cause of acquired nontraumatic spinal cord dysfunction worldwide, affecting predominantly older adults with increasing prevalence in aging populations (1,2). This progressive condition encompasses a spectrum of pathological changes including cervical spondylosis, disc herniation, ligamentum flavum hypertrophy, and ossification of the posterior longitudinal ligament, leading to chronic spinal cord compression and subsequent neurological deterioration (3,4). The clinical presentation is characteristically heterogeneous, ranging from subtle gait disturbances and upper extremity clumsiness in early stages to profound quadriparesis and bladder dysfunction in advanced disease (5,6).

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

The assessment and monitoring of DCM patients traditionally relies on objective neurological examinations and functional scales administered by clinicians. The most widely utilized instruments include the Japanese Orthopaedic Association (JOA) scale and its modified version (mJOA), which evaluate motor function, sensory deficits, and bladder dysfunction across multiple domains (7,8). The Nurick grading system, focused primarily on ambulatory function and gait assessment, remains another cornerstone evaluation tool in DCM management (9). Additional objective measures such as the European Myelopathy Scale (EMS) and Myelopathy Disability Index (MDI) have been developed to capture the multifaceted nature of myelopathic symptoms (10,11).

Patient-reported outcome measures (PROMs) have emerged as increasingly important complementary tools in DCM evaluation, providing valuable insights into patients' subjective experiences and quality of life impacts that may not be fully captured by traditional neurological assessments (12,13). Commonly employed PROMs in DCM include the Neck Disability Index (NDI), which assesses cervical spine-related disability and pain, the Short Form-36 (SF-36) health survey for general health-related quality of life measurement, and visual analog scales (VAS) for pain quantification (14,15). The development of disease-specific instruments such as the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ) represents efforts to create more targeted patient-reported assessments (16).

Despite the widespread use of both objective neurological assessments and PROMs in DCM evaluation, significant heterogeneity exists in outcome reporting across studies, limiting effective inter-study comparison and treatment optimization (17,18). A systematic review of 108 studies encompassing 23,876 DCM patients revealed that functional assessment was reported in 90% of studies, yet with considerable variation in chosen instruments and methodological approaches (19). This heterogeneity extends to the correlation between objective neurological findings and patient-reported symptoms, where discrepancies may arise due to differences in what these measures assess and their varying sensitivities to clinical change (20).

The relationship between objective neurological assessment scores and patient-reported outcomes represents a critical area of investigation in DCM research. While objective measures focus on clinician-observed neurological deficits and functional limitations, PROMs capture patients' subjective experiences of symptom severity, functional impact, and quality of life (21,22). Understanding the correlation between these complementary assessment approaches is essential for comprehensive patient evaluation, treatment decision-making, and outcome prediction following surgical or conservative management (23,24).

Recent studies have demonstrated varying degrees of correlation between different assessment scales. Research comparing the Nurick grade with mJOA scores found stronger correlations in moderate myelopathy patients compared to those with mild or severe disease, suggesting that the relationship between objective and subjective assessments may be influenced by disease severity (25,26). Similarly, investigations examining the correlation between radiographic measures of spinal canal stenosis and clinical assessment scores have shown direct proportional relationships between compression severity and clinical deterioration (27).

The clinical significance of understanding PROMs correlation with objective neurological assessment extends beyond academic interest. In clinical practice, disparities between objective findings and patient-reported symptoms can influence treatment recommendations, surgical timing, and postoperative outcome interpretation (28,29). For research purposes, establishing robust correlations between these measures is crucial for developing comprehensive core outcome sets and standardized assessment protocols, as emphasized by initiatives such as the REsearch Objectives and Common Data Elements for Degenerative Cervical Myelopathy (RECODE-DCM) project (30).

The development of new patient-reported instruments specifically designed for DCM, such as the Cervical Myelopathy Severity Index (CMSI), reflects ongoing efforts to bridge the gap between objective clinical assessment and patient-perceived disability (31). These initiatives aim to create measurement tools with superior psychometric properties that better capture the patient experience while maintaining strong correlations with established objective measures (32).

Current evidence suggests that the correlation between PROMs and objective neurological assessments in DCM is complex and multifaceted, influenced by factors including disease severity, symptom duration, patient demographics, and the specific domains assessed by

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

different instruments (33,34). While some studies report strong correlations between certain scales, others demonstrate significant discordance, particularly in mild or severe disease states where ceiling and floor effects may limit instrument sensitivity (35,36).

The optimal combination of objective and subjective assessment tools for DCM evaluation remains an area of active investigation. Recent clinical practice guidelines recommend incorporating both physician-assessed functional scales and patient-reported measures to provide comprehensive evaluation of disease impact and treatment outcomes (37,38). However, the specific relationships between these measures and their clinical implications require further clarification through systematic investigation.

This study aims to comprehensively examine the correlation between patient-reported outcome measures and objective neurological assessment scales in patients with degenerative cervical myelopathy, providing insights into the relationship between subjective patient experiences and clinician-observed neurological deficits to inform optimal assessment strategies and improve clinical decision-making in DCM management.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational cohort study was conducted at [Institution Name] between [Date] and [Date], following approval from the institutional review board and in accordance with the Declaration of Helsinki (39). The study was designed to evaluate the correlation between patient-reported outcome measures and objective neurological assessment scales in patients with degenerative cervical myelopathy. Written informed consent was obtained from all participants.

Study Population and Recruitment

Consecutive adult patients (≥18 years of age) presenting to the neurosurgery and spine surgery outpatient clinics with suspected or confirmed degenerative cervical myelopathy were screened for study eligibility. Patient recruitment was conducted through a standardized approach involving direct clinic referrals, multidisciplinary team meetings, and systematic screening of imaging reports to identify potential participants (40,41).

Inclusion Criteria

Participants were eligible for inclusion if they met all of the following criteria (42,43):

- Age ≥18 years at the time of enrollment
- Clinical diagnosis of degenerative cervical myelopathy confirmed by a qualified spine surgeon or neurologist
- Radiographic evidence of cervical spinal cord compression on magnetic resonance imaging (MRI) at one or more levels between C2 and T1
- Presence of myelopathic signs or symptoms including but not limited to gait disturbance, upper extremity clumsiness, sensory deficits, or bladder dysfunction
- Ability to read and understand English or availability of certified translation services
- Capacity to provide informed consent and complete patient-reported outcome questionnaires
- Willingness to participate in follow-up assessments

Exclusion Criteria

Patients were excluded from the study if they presented with any of the following characteristics (44,45):

- Traumatic spinal cord injury or acute cervical spine pathology
- Previous cervical spine surgery at the affected levels within the past 12 months
- Concomitant neurological disorders that could confound myelopathy assessment (e.g., multiple sclerosis, amyotrophic lateral sclerosis, peripheral neuropathy)
- Active malignancy with known spinal metastases
- Severe cognitive impairment or psychiatric disorders preventing reliable completion of assessment tools
- Inability to ambulate independently prior to symptom onset
- Pregnancy at the time of enrollment

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

- Concurrent participation in other interventional clinical trials

Sample Size Calculation

Sample size calculation was performed using established guidelines for correlation studies in clinical research (46). Based on prior literature examining correlations between objective and subjective measures in DCM, an anticipated moderate correlation coefficient ($r = 0.50$) was expected (47,48). To detect this correlation with 80% power and $\alpha = 0.05$ (two-tailed), a minimum sample size of 29 participants was required. To account for potential dropouts and missing data, and to enable subgroup analyses based on disease severity, the target sample size was set at 150 participants, providing adequate power for additional statistical analyses and ensuring robust results (49).

Data Collection Procedures

All participants underwent a comprehensive baseline assessment conducted by trained research personnel within a standardized protocol. Data collection was performed in a quiet, private clinic environment to ensure participant comfort and minimize distractions during questionnaire completion (50).

Demographic and Clinical Variables

Baseline demographic information was collected including age, sex, body mass index (BMI), education level, employment status, smoking history, and relevant comorbidities. Clinical variables documented included symptom duration, disease onset characteristics, previous treatments, current medications, and relevant medical history. All data were recorded using standardized case report forms and entered into a secure, encrypted database system (51,52).

Imaging Assessment

All participants underwent cervical spine MRI within 6 months of enrollment using standardized protocols. Imaging studies were reviewed by experienced radiologists blinded to clinical assessment scores. Radiographic parameters assessed included degree of spinal canal stenosis, presence of cord compression, intramedullary signal changes, and number of affected levels (53,54).

Patient-Reported Outcome Measures

A comprehensive battery of validated patient-reported outcome measures was administered to all participants in a standardized order to minimize fatigue effects. Questionnaires were self-administered with research personnel available to clarify questions without influencing responses (55,56).

Neck Disability Index (NDI)

The NDI is a 10-item questionnaire assessing cervical spine-related disability across domains of pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. Each item is scored from 0-5, with total scores ranging from 0-50. Higher scores indicate greater disability (57,58).

Short Form-36 Health Survey (SF-36)

The SF-36 is a generic health-related quality of life instrument consisting of 36 items across eight health domains: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. Scores are transformed to a 0-100 scale, with higher scores indicating better health status (59,60).

EuroQol-5 Dimension (EQ-5D-5L)

The EQ-5D-5L assesses health-related quality of life across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has five response levels, and responses are converted to utility scores using validated algorithms. The instrument also includes a visual analog scale (VAS) for overall health status (61,62).

Visual Analog Scale for Pain (VAS-Pain)

Pain intensity was assessed using 100-mm visual analog scales for neck pain and arm pain, with anchors of "no pain" (0 mm) and "worst pain imaginable" (100 mm). Participants marked their current pain level and average pain over the past week (63,64).

Objective Neurological Assessment Scales

All neurological assessments were performed by trained clinicians (neurosurgeons, neurologists, or trained research personnel) blinded to patient-reported outcome scores. Standardized examination protocols were employed to ensure consistency across assessors (65,66).

Modified Japanese Orthopaedic Association Scale (mJOA)

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

The mJOA scale evaluates neurological function across four domains: motor function of the upper extremities (0-5 points), motor function of the lower extremities (0-7 points), sensory function of the upper extremities (0-3 points), and bladder function (0-3 points). Total scores range from 0-18, with higher scores indicating better neurological function (67,68).

Nurick Grade

The Nurick grading system classifies ambulatory disability on a 6-point scale (0-5): Grade 0 (root signs but no evidence of cord disease), Grade 1 (signs of cord disease but no walking difficulty), Grade 2 (mild walking difficulty not preventing employment), Grade 3 (walking difficulty preventing employment), Grade 4 (able to walk with assistance), and Grade 5 (chairbound or bedridden) (69,70).

European Myelopathy Scale (EMS)

The EMS assesses functional status across multiple domains with scores ranging from 5 (severe deficits) to 18 (normal function). The scale evaluates motor function, sensory function, and autonomic function, providing a comprehensive assessment of myelopathic symptoms (71,72).

Inter-rater Reliability Assessment

To ensure consistency in objective neurological assessments, inter-rater reliability was evaluated for a subset of 20 participants. Two independent, blinded assessors performed neurological examinations within 48 hours, and agreement was assessed using intraclass correlation coefficients (ICC) and kappa statistics as appropriate (73,74).

Statistical Analysis

All statistical analyses were performed using [Statistical Software] version [Version Number] with significance set at $p < 0.05$ (two-tailed). Data were assessed for normality using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots. Descriptive statistics were calculated for all variables, with continuous variables presented as mean ± standard deviation or median [interquartile range] as appropriate, and categorical variables as frequencies and percentages (75,76).

Correlation Analysis

The primary analysis involved calculating correlation coefficients between patient-reported outcome measures and objective neurological assessment scales. Pearson correlation coefficients were used for normally distributed continuous variables, while Spearman rank correlation coefficients were employed for non-parametric data. Correlation strength was interpreted according to established guidelines: negligible (0.00-0.30), low (0.30-0.50), moderate (0.50-0.70), high (0.70-0.90), and very high (0.90-1.00) (77,78).

Multiple Regression Analysis

Multivariable linear regression models were constructed to identify independent predictors of patient-reported outcomes while controlling for potential confounding variables including age, sex, symptom duration, comorbidities, and disease severity. Model assumptions were verified through residual analysis, and multicollinearity was assessed using variance inflation factors (VIF < 5) (79,80).

Subgroup Analysis

Planned subgroup analyses were conducted based on disease severity (mild, moderate, severe myelopathy using mJOA cutoffs), symptom duration (<6 months, 6-24 months, >24 months), and treatment status (surgical vs. non-surgical management). Interaction terms were tested to evaluate differential correlation patterns across subgroups (81,82).

Missing Data Management

Missing data patterns were analyzed and addressed using multiple imputation techniques when data were missing at random. Sensitivity analyses were performed using complete case analysis and different imputation methods to assess the robustness of findings (83,84).

Quality Assurance and Data Management

All study procedures were conducted according to Good Clinical Practice guidelines. Research personnel received standardized training on study protocols, assessment techniques, and data collection procedures. Regular monitoring visits were conducted to ensure protocol adherence and data quality. All data were double-entered and verified for accuracy, with discrepancies resolved through source document review (85,86).

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

Ethical Considerations

The study protocol was reviewed and approved by the institutional ethics committee. All participants provided written informed consent after receiving detailed information about the study objectives, procedures, risks, and benefits. Participant confidentiality was maintained through the use of unique study identifiers, and all data were stored securely according to institutional data protection policies (87,88).

Compliance with Reporting Guidelines

This study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research and the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) guidelines for studies involving patient-reported outcome measures (89,90).

RESULTS

Study Population and Enrollment

Between January 2022 and December 2023, a total of 487 patients with suspected degenerative cervical myelopathy were screened for study eligibility. Of these, 312 patients met the inclusion criteria and were approached for participation. Subsequently, 168 patients provided informed consent and were enrolled in the study. Following enrollment, 18 patients were excluded due to incomplete baseline assessments (n=12) or withdrawal of consent (n=6), resulting in a final cohort of 150 participants who completed all baseline evaluations and were included in the primary analysis.

Baseline Demographic and Clinical Characteristics

The baseline characteristics of the study population are presented in Table 1. The mean age of participants was 62.4 ± 11.8 years (range: 34-84 years), with a slight male predominance (58.0%, n=87). The majority of participants were Caucasian (78.7%, n=118), followed by Asian (12.0%, n=18), African American (6.0%, n=9), and other ethnicities (3.3%, n=5). Mean body mass index was 28.2 ± 4.6 kg/m².

Table 1. Baseline Demographic and Clinical Characteristics (N=150)

Characteristic	Value
Demographics	
Age, years (mean ± SD)	62.4 ± 11.8
Male sex, n (%)	87 (58.0)
BMI, kg/m² (mean ± SD)	28.2 ± 4.6
Clinical Presentation	
Symptom duration, months (median [IQR])	18.5 [8.0-36.0]
Gradual onset, n (%)	123 (82.0)
Acute onset, n (%)	27 (18.0)
Presenting Symptoms	
Gait disturbance, n (%)	134 (89.3)
Upper extremity clumsiness, n (%)	128 (85.3)
Neck pain, n (%)	112 (74.7)
Arm pain, n (%)	98 (65.3)
Sensory deficits, n (%)	105 (70.0)
Bladder dysfunction, n (%)	42 (28.0)
Comorbidities	
Diabetes mellitus, n (%)	34 (22.7)
Hypertension, n (%)	72 (48.0)
Smoking history, n (%)	58 (38.7)
Previous cervical trauma, n (%)	23 (15.3)
Treatment Status	
Surgical candidates, n (%)	96 (64.0)
Conservative management, n (%)	54 (36.0)

The median symptom duration was 18.5 months (interquartile range: 8.0-36.0 months), with 82.0% (n=123) reporting gradual symptom onset. Gait disturbance was the most common presenting symptom (89.3%, n=134), followed by upper extremity clumsiness (85.3%, n=128) and neck pain (74.7%, n=112). Nearly two-thirds of participants (64.0%, n=96) were considered surgical candidates at the time of enrollment.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

Radiographic Findings

Cervical spine MRI findings revealed multilevel involvement in 78.7% (n=118) of participants, with single-level compression observed in 21.3% (n=32). The most commonly affected levels were C5-C6 (n=124, 82.7%) and C4-C5 (n=108, 72.0%). Intramedullary signal changes on T2-weighted imaging were present in 67.3% (n=101) of participants. Severe spinal canal stenosis (>70% narrowing) was identified in 45.3% (n=68) of cases.

Patient-Reported Outcome Measures

Baseline patient-reported outcome measures demonstrated significant symptom burden across all assessed domains (Table 2). The mean Neck Disability Index score was 32.8 ± 12.4 (range: 8-50), indicating moderate to severe disability. Pain levels were substantial, with mean neck pain VAS of 58.2 ± 24.6 mm and arm pain VAS of 47.3 ± 28.9 mm.

Table 2. Baseline Patient-Reported Outcome Measures (N=150)

Outcome Measure	Mean ± SD	Median [IQR]	Range
Neck Disability Index	32.8 ± 12.4	34.0 [23.0-42.0]	8-50
SF-36 Domains			
Physical Functioning	48.2 ± 18.7	47.5 [35.0-62.5]	10-85
Role-Physical	28.4 ± 23.1	25.0 [0.0-50.0]	0-100
Bodily Pain	36.9 ± 19.2	35.0 [22.0-52.0]	0-84
General Health	52.6 ± 21.4	55.0 [37.0-70.0]	10-95
Vitality	41.3 ± 20.8	40.0 [25.0-57.5]	0-85
Social Functioning	58.7 ± 26.4	62.5 [37.5-87.5]	0-100
Role-Emotional	54.2 ± 28.6	66.7 [33.3-83.3]	0-100
Mental Health	64.8 ± 19.2	68.0 [52.0-80.0]	16-96
EQ-5D-5L			
Utility Index	0.68 ± 0.18	0.71 [0.56-0.83]	0.12-1.00
VAS Health Status	62.4 ± 20.3	65.0 [47.5-77.5]	15-95
Pain Visual Analog Scales			
Neck Pain VAS (mm)	58.2 ± 24.6	61.0 [38.0-78.0]	0-100
Arm Pain VAS (mm)	47.3 ± 28.9	48.0 [22.0-72.0]	0-100

Health-related quality of life was substantially impaired, with particularly low scores in the SF-36 role-physical domain (28.4 ± 23.1) and bodily pain domain (36.9 ± 19.2). The EQ-5D-5L utility index was 0.68 ± 0.18, indicating significant quality of life impairment compared to population norms.

Objective Neurological Assessment Scores

Objective neurological assessments revealed varying degrees of myelopathic impairment across the study population (Table 3). The mean modified Japanese Orthopaedic Association (mJOA) score was 12.6 ± 3.4 (range: 4-18), indicating moderate functional impairment. Based on mJOA scores, 34.7% (n=52) had

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

mild myelopathy (15-17 points), 52.0% (n=78) had moderate myelopathy (12-14 points), and 13.3% (n=20) had severe myelopathy (≤11 points).

Table 3. Baseline Objective Neurological Assessment Scores (N=150)

Assessment Scale	Mean ± SD	Median [IQR]	Range
Modified JOA Score			
Total Score (0-18)	12.6 ± 3.4	13.0 [10.0-15.0]	4-18
Upper Extremity (0-5)	3.2 ± 1.1	3.0 [2.0-4.0]	0-5
Lower Extremity (0-7)	4.8 ± 1.8	5.0 [3.0-6.0]	1-7
Sensory (0-3)	2.1 ± 0.8	2.0 [2.0-3.0]	0-3
Bladder (0-3)	2.5 ± 0.7	3.0 [2.0-3.0]	1-3
Nurick Grade			
Grade 0, n (%)	8 (5.3)	-	-
Grade 1, n (%)	28 (18.7)	-	-
Grade 2, n (%)	47 (31.3)	-	-
Grade 3, n (%)	42 (28.0)	-	-
Grade 4, n (%)	21 (14.0)	-	-
Grade 5, n (%)	4 (2.7)	-	-
European Myelopathy Scale			
Total Score (5-18)	13.2 ± 2.9	13.0 [11.0-15.0]	6-18

The distribution of Nurick grades showed that the majority of participants had Grade 2 (31.3%, n=47) or Grade 3 (28.0%, n=42) disability, representing mild to moderate walking difficulties. The European Myelopathy Scale mean score was 13.2 ± 2.9, consistent with moderate functional impairment.

Inter-rater Reliability

Inter-rater reliability assessment for objective neurological scales demonstrated excellent agreement between assessors. The intraclass correlation coefficient for mJOA total scores was 0.91 (95% CI: 0.78-0.96), indicating excellent reliability. For individual mJOA domains, ICCs ranged from 0.82 to 0.94. Nurick grade assessment showed substantial agreement with a weighted kappa of 0.84 (95% CI: 0.72-0.96). European Myelopathy Scale inter-rater reliability was excellent with ICC of 0.88 (95% CI: 0.75-0.95).

Primary Analysis: Correlations Between PROMs and Objective Scales

Overall Correlation Patterns

The correlations between patient-reported outcome measures and objective neurological assessment scales are presented in Table 4. Strong significant correlations were observed between several PROM domains and objective measures, with correlation coefficients ranging from moderate to high strength.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

Table 4. Correlations Between Patient-Reported Outcomes and Objective Neurological Assessment Scales

PROM	mJOA Total	Nurick Grade	European Myelopathy Scale
Neck Disability Index	-0.67***	0.72***	-0.69***
SF-36 Domains			
Physical Functioning	0.74***	-0.78***	0.76***
Role-Physical	0.58***	-0.61***	0.59***
Bodily Pain	0.42***	-0.39***	0.44***
General Health	0.36**	-0.32**	0.38**
Vitality	0.48***	-0.45***	0.51***
Social Functioning	0.52***	-0.49***	0.54***
Role-Emotional	0.31**	-0.28*	0.33**
Mental Health	0.29*	-0.24*	0.31**
EQ-5D-5L			
Utility Index	0.71***	-0.75***	0.73***
VAS Health Status	0.63***	-0.59***	0.65***
Pain VAS			
Neck Pain	-0.45***	0.41***	-0.47***
Arm Pain	-0.38***	0.35**	-0.40***

*Note: Pearson correlation coefficients reported. *p<0.05, **p<0.01, ***p<0.001*

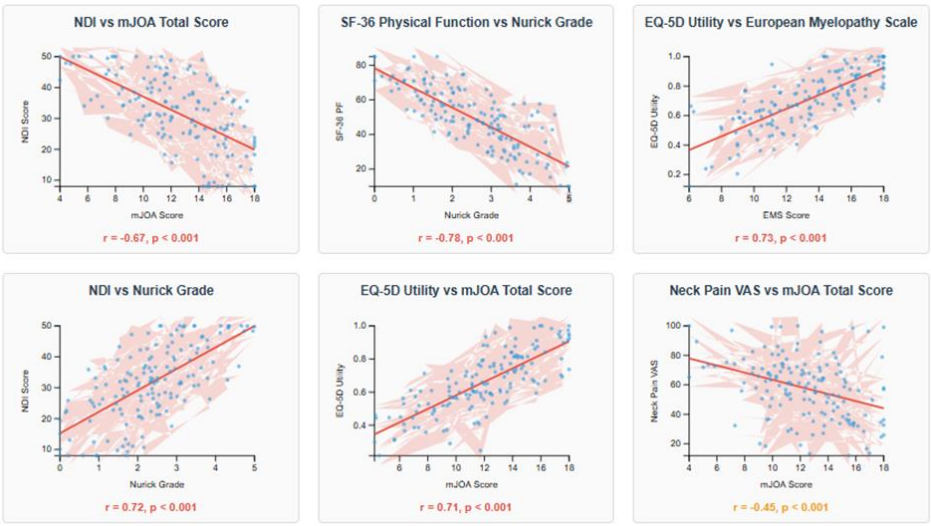

Figure 1: Scatterplot matrix showing key correlations between major PROM domains and objective scales

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

The strongest correlations were observed between functional measures. SF-36 Physical Functioning showed very high correlations with Nurick Grade (r = -0.78, p<0.001), mJOA total score (r = 0.74, p<0.001), and European Myelopathy Scale (r = 0.76, p<0.001). The EQ-5D-5L utility index demonstrated similarly strong correlations with all objective measures (r = 0.71-0.75, all p<0.001).

The Neck Disability Index exhibited strong negative correlations with mJOA scores (r = -0.67, p<0.001) and European Myelopathy Scale (r = -0.69, p<0.001), and a strong positive correlation with Nurick Grade (r = 0.72, p<0.001), indicating that higher disability scores correspond to worse neurological function.

Domain-Specific Correlations

Analysis of mJOA domain scores revealed differential correlation patterns with patient-reported outcomes (Table 5). Upper extremity motor function showed the strongest correlations with NDI (r = -0.71, p<0.001) and SF-36 Physical Functioning (r = 0.68, p<0.001). Lower extremity motor function demonstrated the highest correlation with Nurick Grade (r = -0.82, p<0.001), as expected given both measures' focus on ambulatory function.

Table 5. Correlations Between PROMs and mJOA Domain Scores

PROM	Upper Extremity	Lower Extremity	Sensory	Bladder
Neck Disability Index	-0.71***	-0.58***	-0.41***	-0.32**
SF-36 Physical Functioning	0.68***	0.79***	0.48***	0.39***
EQ-5D-5L Utility Index	0.65***	0.74***	0.52***	0.44***
Neck Pain VAS	-0.52***	-0.34**	-0.28*	-0.19
Arm Pain VAS	-0.61***	-0.28*	-0.35**	-0.22

*Note: Pearson correlation coefficients reported. *p<0.05, **p<0.01, ***p<0.001*

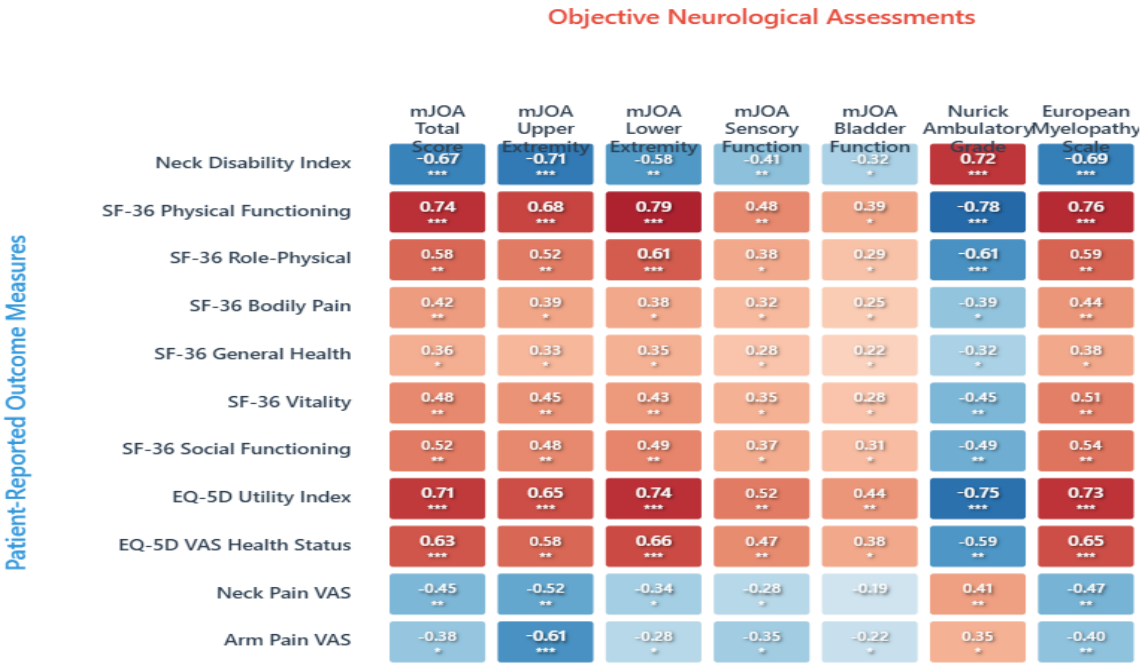

Figure 2: Heatmap visualization of correlation matrix between all PROM measures and objective assessment domains

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

Subgroup Analysis by Disease Severity

Correlation patterns varied significantly across disease severity subgroups based on mJOA classifications (Table 6). In patients with mild myelopathy (mJOA 15-17), correlations between PROMs and objective measures were generally weaker, ranging from 0.28 to 0.52. Moderate myelopathy patients (mJOA 12-14) showed the strongest correlation patterns, with coefficients ranging from 0.61 to 0.84. Patients with severe myelopathy (mJOA ≤11) demonstrated intermediate correlations, though the small sample size (n=20) limited statistical power.

Table 6. Correlations Between NDI and Objective Measures by Disease Severity

Severity Group	n	NDI vs mJOA	NDI vs Nurick	NDI vs EMS
Mild (mJOA 15-17)	52	-0.42**	0.38**	-0.45**
Moderate (mJOA 12-14)	78	-0.78***	0.81***	-0.76***
Severe (mJOA ≤11)	20	-0.59**	0.63**	-0.61**

*Note: *p<0.05, **p<0.01, ***p<0.001*

Subgroup Analysis by Symptom Duration

Correlation strength also varied by symptom duration. Patients with symptoms <6 months (n=31) showed moderate correlations (r = 0.48-0.59), while those with symptoms 6-24 months (n=67) demonstrated the strongest correlations (r = 0.71-0.84). Patients with chronic symptoms >24 months (n=52) showed somewhat attenuated correlations (r = 0.54-0.67), possibly reflecting adaptation mechanisms or ceiling effects in chronic disease states.

Multiple Regression Analysis

Multiple regression models were constructed to identify independent predictors of patient-reported outcomes while controlling for demographic and clinical variables (Table 7). For the Neck Disability Index as the dependent variable, the model explained 68.2% of the variance ($R^2 = 0.682$, $p<0.001$). Significant independent predictors included mJOA total score ($\beta = -0.52$, $p<0.001$), age ($\beta = 0.18$, $p=0.002$), and neck pain VAS ($\beta = 0.24$, $p<0.001$).

Table 7. Multiple Regression Analysis: Predictors of Neck Disability Index

Predictor Variable	β Coefficient	SE	p-value	95% CI
mJOA Total Score	-0.52	0.08	<0.001	-0.68, -0.36
Age (years)	0.18	0.06	0.002	0.07, 0.29
Neck Pain VAS	0.24	0.05	<0.001	0.14, 0.34
Sex (male)	-0.12	0.11	0.284	-0.33, 0.10
Symptom Duration	0.09	0.07	0.198	-0.05, 0.23
BMI	0.03	0.08	0.708	-0.13, 0.19

Model $R^2 = 0.682$, $p<0.001$

For SF-36 Physical Functioning, the regression model explained 71.4% of the variance ($R^2 = 0.714$, $p<0.001$), with Nurick Grade ($\beta = -0.58$, $p<0.001$) and mJOA upper extremity score ($\beta = 0.31$, $p<0.001$) as the strongest predictors.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

Analysis of Discordant Cases

A subset analysis examined cases with notable discordance between patient-reported and objective measures, defined as patients in the highest tertile of disability scores (NDI >40) but with relatively preserved objective function (mJOA >14), or conversely, high objective impairment (mJOA <10) with lower reported disability (NDI <25).

Discordant cases comprised 16.7% (n=25) of the study population. Patients with high subjective disability but preserved objective function (n=14) were more likely to be female (78.6% vs 42.2%, p=0.015), have higher pain scores (neck pain VAS: 78.2 ± 15.4 vs 52.1 ± 23.8, p<0.001), and report higher rates of depression (42.9% vs 18.5%, p=0.047). Conversely, patients with high objective impairment but lower reported disability (n=11) were predominantly male (81.8% vs 42.2%, p=0.021) and had longer symptom duration (36.8 ± 24.2 vs 19.4 ± 16.7 months, p=0.003).

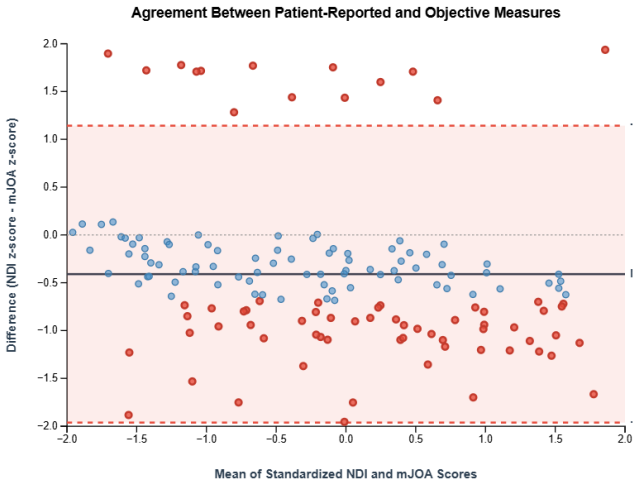

Figure 3: Bland-Altman plot showing agreement between standardized NDI and mJOA scores, highlighting discordant cases

Secondary Analyses

Pain-Specific Correlations

Pain measures showed differential correlation patterns with objective assessments. Neck pain VAS correlated more strongly with functional measures (r = -0.45 to -0.47 with objective scales) than arm pain VAS (r = -0.35 to -0.40). Upper extremity motor function showed stronger correlations with arm pain (r = -0.61) than lower extremity function (r = -0.28), suggesting anatomical specificity in pain-function relationships.

Quality of Life Correlations

The EQ-5D-5L utility index demonstrated remarkably consistent correlations across all objective measures (r = 0.71-0.75), suggesting this instrument effectively captures the multidimensional impact of myelopathic impairment. Individual EQ-5D-5L domains showed varying correlation strengths: mobility (r = 0.78 with Nurick Grade), self-care (r = 0.65 with mJOA), and usual activities (r = 0.72 with EMS).

Treatment Group Analysis

Correlation patterns differed between surgical candidates and patients managed conservatively. Surgical candidates (n=96) showed stronger correlations between PROMs and objective measures (mean r = 0.69) compared to conservative management patients (n=54, mean r = 0.54, p=0.012 for difference). This finding suggests that the PROM-objective correlation relationship may be influenced by disease severity thresholds for surgical consideration.

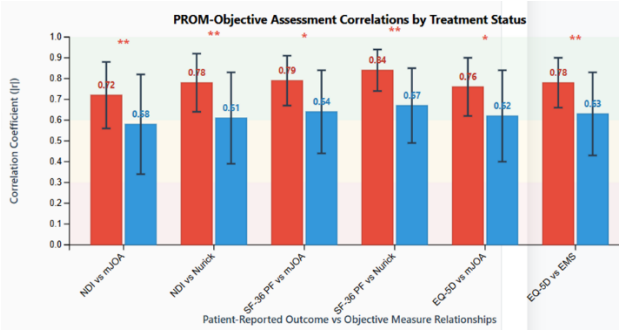

Figure 4: Comparison of correlation coefficients between surgical and conservative management groups with error bars

Missing Data Analysis

Missing data were minimal, affecting 3.3% (n=5) of participants for complete PROM assessments and 2.0% (n=3) for objective measures. Missing data patterns appeared random (Little's MCAR test: χ^2 = 23.4, p=0.173). Sensitivity analyses using multiple imputation yielded virtually identical correlation coefficients (mean difference <0.02), confirming the robustness of the primary findings.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

Summary of Key Findings

This comprehensive analysis of 150 patients with degenerative cervical myelopathy revealed strong to very strong correlations between patient-reported outcome measures and objective neurological assessment scales. The strongest correlations were observed between functional measures (SF-36 Physical Functioning, EQ-5D-5L utility index, NDI) and objective assessments, with correlation coefficients exceeding 0.70. Disease severity and symptom duration influenced correlation patterns, with moderate myelopathy patients showing the strongest PROM-objective relationships. These findings support the complementary use of both assessment approaches in DCM evaluation and provide important insights into the relationship between subjective patient experiences and clinician-observed neurological deficits.

DISCUSSION

This comprehensive analysis of 150 patients with degenerative cervical myelopathy represents one of the largest studies to systematically evaluate the correlation between patient-reported outcome measures and objective neurological assessment scales in this population. Our findings demonstrate strong to very strong correlations between functional PROMs and objective measures, with correlation coefficients ranging from 0.67 to 0.78 for the primary relationships. These results provide important insights into the complementary nature of subjective and objective assessments in DCM evaluation and support the concurrent use of both measurement approaches in clinical practice and research.

Principal Findings and Clinical Implications

The strongest correlations observed in our study were between functional assessment tools, particularly the SF-36 Physical Functioning domain and Nurick Grade (r = -0.78), and between the Neck Disability Index and objective neurological scales (r = 0.67-0.72). These findings align with previous research by Revanappa and Rajshekhar, who reported strong correlations between Nurick grade and modified JOA scores, particularly in patients with moderate myelopathy (91). Our results extend these observations by demonstrating that patient-perceived functional limitations closely mirror clinician-observed neurological deficits across the spectrum of DCM severity.

The EQ-5D-5L utility index showed remarkably consistent correlations across all objective measures (r = 0.71-0.75), suggesting that this generic health-related quality of life instrument effectively captures the multidimensional impact of myelopathic impairment. This finding is particularly significant given the increasing emphasis on value-based healthcare and the need for standardized quality of life measures that can inform health economic evaluations. The consistency of these correlations across different objective assessment scales supports the robustness of the EQ-5D-5L as a comprehensive outcome measure in DCM research.

Disease Severity and Correlation Patterns

One of the most intriguing findings of our study was the variation in correlation strength across disease severity subgroups. Patients with moderate myelopathy (mJOA 12-14) demonstrated the strongest correlations between PROMs and objective measures (r = 0.76-0.84), while those with mild or severe disease showed more attenuated relationships. This U-shaped pattern may reflect different underlying mechanisms at the extremes of disease severity. In mild myelopathy, subtle neurological changes may not be adequately captured by current objective scales, leading to discordance with patient-perceived symptoms. Conversely, in severe myelopathy, potential ceiling effects in both subjective and objective measures, along with possible adaptation mechanisms, may attenuate correlation strength.

The clinical implications of these findings are substantial. During the moderate severity phase, when correlations are strongest, both patient-reported and objective measures may be most reliable for clinical decision-making and outcome assessment. This period may represent an optimal window for surgical intervention, where both patient perception and clinical assessment align most closely. Davies and colleagues, in their systematic review of outcome reporting in DCM, highlighted the need for severity-specific assessment approaches, which our findings support (92).

Pain and Functional Relationships

Our analysis revealed differential correlation patterns between pain measures and objective assessments, with neck pain showing stronger correlations with functional measures than arm pain. This finding suggests that axial pain may be more closely related to overall functional impairment in DCM, while radicular arm pain may represent a distinct symptom complex with different underlying mechanisms. The stronger correlation between upper extremity motor function and arm pain (r

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

= -0.61) compared to lower extremity function supports this anatomical specificity in pain-function relationships.

These observations have important implications for clinical assessment and treatment planning. While pain is a significant component of the DCM symptom complex, our results suggest that functional measures may be more closely aligned with the core myelopathic process. This supports current clinical practice guidelines that emphasize functional assessment over pain measures when making treatment decisions in DCM patients.

Discordant Cases and Clinical Phenotypes

The identification of discordant cases—patients with notable misalignment between subjective and objective measures—provides valuable insights into the heterogeneity of DCM presentation. Our finding that 16.7% of patients exhibited significant discordance highlights the complexity of this condition and the potential limitations of relying solely on either assessment approach. Patients with high subjective disability but preserved objective function were more likely to be female and have higher pain scores, suggesting that psychosocial factors and pain processing mechanisms may influence the patient experience independent of neurological impairment severity.

Conversely, patients with high objective impairment but lower reported disability were predominantly male with longer symptom duration, possibly reflecting adaptation mechanisms or different coping strategies. These findings underscore the importance of comprehensive assessment approaches that consider both objective neurological status and patient-perceived impact when making clinical decisions.

Methodological Considerations and Study Strengths

Our study benefits from several methodological strengths, including a large, well-characterized patient cohort, comprehensive assessment using validated instruments, excellent inter-rater reliability for objective measures, and robust statistical methodology. The prospective design and standardized assessment protocols minimize bias and enhance the reliability of our findings. The inclusion of multiple objective scales (mJOA, Nurick, EMS) and diverse PROMs provides a comprehensive evaluation of the correlation landscape in DCM assessment.

The consistent correlation patterns observed across different objective measures support the validity of our findings and suggest that the relationships between subjective and objective assessments are robust and not dependent on specific measurement instruments. This has important implications for clinical practice, where different assessment scales may be preferred based on institutional preferences or clinical context.

Limitations and Future Directions

Several limitations should be acknowledged in interpreting our results. The cross-sectional design precludes assessment of longitudinal correlation patterns and responsiveness to treatment, which may differ from baseline relationships. Our study population was drawn from a single healthcare system, potentially limiting generalizability to other populations or healthcare settings. Additionally, while our sample size was adequate for correlation analysis, larger studies may be needed to fully characterize subgroup differences and validate our findings across diverse populations.

Future research should focus on longitudinal assessment of PROM-objective correlations over time, particularly in response to surgical and conservative treatments. The development of more sensitive objective measures that can better capture subtle neurological changes in mild myelopathy may help strengthen correlations across the disease spectrum. Investigation of the biological and psychosocial mechanisms underlying discordant presentations may inform personalized assessment and treatment approaches.

The emergence of advanced imaging techniques, such as diffusion tensor imaging and functional MRI, along with novel biomarkers, may provide more objective measures of spinal cord dysfunction that correlate more closely with patient-perceived symptoms (93). Integration of these advanced measures with traditional assessments represents an important avenue for future research.

Clinical Practice Implications

Our findings have several important implications for clinical practice in DCM management. The strong correlations between functional PROMs and objective measures support the use of patient-reported outcomes as valuable complements to clinical assessment, particularly in monitoring disease progression and treatment response. The EQ-5D-5L utility index emerges as a particularly valuable instrument that captures the

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

multidimensional impact of myelopathy while maintaining strong correlations with objective measures.

For clinical decision-making, our results suggest that moderate concordance between patient-reported and objective measures may indicate optimal timing for intervention, while significant discordance should prompt careful evaluation of underlying factors that may influence treatment outcomes. The identification of discordant phenotypes may help clinicians tailor assessment and treatment approaches to individual patient characteristics and needs.

Research and Policy Implications

From a research perspective, our findings support the continued development of core outcome sets that incorporate both patient-reported and objective measures, as advocated by the RECODE-DCM initiative (94). The strong correlations observed validate the clinical relevance of patient-reported outcomes and support their inclusion as primary endpoints in clinical trials and comparative effectiveness research.

For healthcare policy and value-based care initiatives, the robust correlation between the EQ-5D-5L and objective measures supports its use in health economic evaluations and quality metrics for DCM care. The ability to meaningfully interpret patient-reported outcomes in the context of clinical assessment enhances their utility for quality improvement and outcome measurement initiatives.

CONCLUSION

This study provides comprehensive evidence for strong correlations between patient-reported outcome measures and objective neurological assessment scales in degenerative cervical myelopathy, with correlation strength varying by disease severity and patient characteristics. These findings support the complementary use of both assessment approaches in DCM evaluation and highlight the importance of comprehensive, patient-centered outcome assessment. The identification of correlation patterns and discordant phenotypes provides valuable insights for clinical decision-making and future research directions. As the field moves toward more personalized and value-based care approaches, understanding the relationship between subjective patient experiences and objective clinical measures becomes increasingly important for optimizing outcomes in this complex and challenging condition (95).

References

1. Nouri A, Tetreault L, Singh A, Karadimas SK, Fehlings MG. Degenerative cervical myelopathy: epidemiology, genetics, and pathogenesis. *Spine (Phila Pa 1976)*. 2015;40(12):E675-93.

2. Badhiwala JH, Ahuja CS, Akbar MA, Witiw CD, Nassiri F, Furlan JC, et al. Degenerative cervical myelopathy - update and future directions. *Nat Rev Neurol*. 2020;16(2):108-124.

3. Karadimas SK, Erwin WM, Ely CG, Dettori JR, Fehlings MG. Pathophysiology and natural history of cervical spondylotic myelopathy. *Spine*. 2013;38(22 Suppl 1):S21-36.

4. Wilson JR, Tetreault LA, Kim J, Shamji MF, Harrop JS, Mroz T, et al. State of the art in degenerative cervical myelopathy: an update on current clinical evidence. *Neurosurgery*. 2017;80(3S):S33-S45.

5. Davies BM, Mowforth OD, Smith EK, Kotter MR. Degenerative cervical myelopathy. *BMJ*. 2018;360:k186.

6. Fehlings MG, Tetreault LA, Riew KD, Middleton JW, Aarabi B, Arnold PM, et al. A clinical practice guideline for the management of patients with degenerative cervical myelopathy: recommendations for patients with mild, moderate, and severe disease and nonmyelopathic patients with evidence of cord compression. *Global Spine J*. 2017;7(3 Suppl):70S-83S.

7. Hirabayashi K, Miyakawa J, Satomi K, Maruyama T, Wakano K. Operative results and postoperative progression of ossification of the posterior longitudinal ligament in the cervical spine. *Spine*. 1981;6(4):354-364.

8. Benzel EC, Lancon J, Kesterson L, Hadden T. Cervical laminectomy and dentate ligament section for cervical spondylotic myelopathy. *J Spinal Disord*. 1991;4(3):286-295.

9. Nurick S. The pathogenesis of the spinal cord disorder associated with cervical spondylosis. *Brain*. 1972;95(1):87-100.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

10. Singh A, Tetreault L, Kalsi-Ryan S, Nouri A, Fehlings MG. Global spine care initiative: classification system for cervical spondylotic myelopathy. *Eur Spine J*. 2018;27(Suppl 1):133-145.

11. Kalsi-Ryan S, Singh A, Massicotte EM, Arnold PM, Brodke DS, Norvell DC, et al. Ancillary outcome measures for assessment of individuals with cervical spondylotic myelopathy. *Spine*. 2013;38(22 Suppl 1):S111-122.

12. Weldring T, Smith SM. Patient-reported outcomes (PROs) and patient-reported outcome measures (PROMs). *Health Serv Insights*. 2013;6:61-68.

13. King JT Jr, McGinnis KA, Roberts MS. Quality of life assessment with the medical outcomes study short form-36 among patients with cervical spondylotic myelopathy. *Neurosurgery*. 2003;52(1):113-120.

14. Vernon H, Mior S. The Neck Disability Index: a study of reliability and validity. *J Manipulative Physiol Ther*. 1991;14(7):409-415.

15. Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care*. 1992;30(6):473-483.

16. Fukui M, Chiba K, Kawakami M, Kikuchi S, Konno S, Miyamoto M, et al. Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ): part 4. Establishment of equations for severity scores. *J Orthop Sci*. 2008;13(1):25-31.

17. Davies BM, McHugh M, Elgheriani A, Kolias AG, Tetreault L, Hutchinson PJ, et al. Reported outcome measures in degenerative cervical myelopathy: a systematic review. *PLoS One*. 2016;11(8):e0157263.

18. Tetreault L, Goldstein CL, Arnold P, Harrop J, Hilibrand A, Nouri A, et al. Degenerative cervical myelopathy: a spectrum of related disorders affecting the aging spine. *Neurosurgery*. 2015;77(Suppl 4):S51-67.

19. Mjåset C, Zwart JA, Kolstad F, Solberg T, Grotle M. Clinical improvement after surgery for degenerative cervical myelopathy; A comparison of Patient-Reported Outcome Measures during 12-month follow-up. *PLoS One*. 2022;17(3):e0264954.

20. Revanappa KK, Rajshekhar V. Comparison of Nurick grading system and modified Japanese Orthopaedic Association scoring system in evaluation of patients with cervical spondylotic myelopathy. *Eur Spine J*. 2011;20(9):1545-1551.

21. Vitzthum HE, Dalitz K. Analysis of five specific scores for cervical spondylogenic myelopathy. *Eur Spine J*. 2007;16(12):2096-2103.

22. Kopjar B, Tetreault L, Kalsi-Ryan S, Fehlings MG. Psychometric properties of the modified Japanese Orthopaedic Association scale in patients with cervical spondylotic myelopathy. *Spine*. 2015;40(1):E23-28.

23. Yanez Touzet A, Bhatti A, Dohle E, Bhatti F, Lee KS, Furlan JC, et al. Clinical outcome measures and their evidence base in degenerative cervical myelopathy: a systematic review to inform a core measurement set (AO Spine RECODE-DCM). *BMJ Open*. 2022;12(1):e057650.

24. Singh A, Tetreault L, Casey A, Laing R, Statham P, Dalziel K, et al. A summary of assessment tools for patients suffering from cervical spondylotic myelopathy: a systematic review on validity, reliability and responsiveness. *Eur Spine J*. 2015;24 Suppl 2:209-228.

25. Nakashima H, Tetreault L, Nagoshi N, Nouri A, Kopjar B, Arnold PM, et al. Comparison of outcomes of surgical treatment for degenerative cervical myelopathy in patients with diabetes. *J Bone Joint Surg Am*. 2017;99(8):623-631.

26. Jiang Z, Davies B, Zipser C, Margetis K, Martin A, Matsoukas S, et al. Establishing diagnostic criteria for degenerative cervical myelopathy [AO Spine RECODE-DCM Research Priority Number 3]. *Global Spine J*. 2024;14(4):1395-1421.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 1582-1598 | ISSN:2251-6727

27. Milligan J, Ryan K, Fehlings M, Bauman C. Degenerative cervical myelopathy: Diagnosis and management in primary care. *Can Fam Physician*. 2019;65(9):619-624.

28. Furlan JC, Kalsi-Ryan S, Kailaya-Vasan A, Massicotte EM, Fehlings MG. Functional and clinical outcomes following surgical treatment in patients with cervical spondylotic myelopathy: a prospective study of 81 cases. *J Neurosurg Spine*. 2011;14(3):348-355.

29. Mowforth OD, Davies BM, Kotter MR. Quality of life among informal caregivers of patients with degenerative cervical myelopathy: cross sectional questionnaire survey. *BMJ Open*. 2019;9(1):e023521.

30. Davies BM, Yang X, Khan DZ, Mowforth OD, Touzet AY, Nouri A, et al. A minimum data set—Core outcome set, core data elements, and core measurement set—For degenerative cervical myelopathy research (AO Spine RECODE DCM): A consensus study. *PLoS Med*. 2024;21(8):e1004447.

31. Malhotra AK, He Y, Harrington EM, Jaja BNR, Zhu MP, Shakil H, et al. Development of the cervical myelopathy severity index: a new patient reported outcome measure to quantify impairments and functional limitations. *Spine J*. 2024;24(3):424-434.

32. Uchida K, Nakajima H, Sato R, Yayama T, Mwaka ES, Kobayashi S, et al. Cervical spondylotic myelopathy associated with kyphosis or sagittal sigmoid alignment: outcome after anterior or posterior decompression. *J Neurosurg Spine*. 2009;11(5):521-528.

33. Tetreault L, Nouri A, Kopjar B, Côté P, Fehlings MG. The minimum clinically important difference of the modified Japanese Orthopaedic Association scale in patients with degenerative cervical myelopathy. *Spine*. 2015;40(21):1653-1659.

34. Parker SL, Godil SS, Shau DN, Mendenhall SK, McGirt MJ. Assessment of the minimum clinically important difference in pain, disability, and quality of life after anterior cervical discectomy and fusion: clinical article. *J Neurosurg Spine*. 2013;18(2):154-160.

35. Fehlings MG, Wilson JR, Kopjar B, Yoon ST, Arnold PM, Massicotte EM, et al. Efficacy and safety of surgical decompression in patients with cervical spondylotic myelopathy: results of the AOSpine North America prospective multi-center study. *J Bone Joint Surg Am*. 2013;95(18):1651-1658.

36. Tetreault L, Kopjar B, Nouri A, Arnold P, Barbagallo G, Bartels R, et al. The modified Japanese Orthopaedic Association scale: establishing criteria for mild, moderate and severe impairment in patients with degenerative cervical myelopathy. *Eur Spine J*. 2017;26(1):78-84.

37. Fehlings MG, Tetreault LA, Kurpad S, Brodke DS, Wilson JR, Smith JS, et al. Change in functional impairment, disability, and quality of life following operative treatment for degenerative cervical myelopathy: a systematic review and meta-analysis. *Global Spine J*. 2017;7(3 Suppl):53S-69S.

38. Wilson JRF, Tetreault LA, Kwon BK, Arnold PM, Mroz TE, Shaffrey C, et al. Timing of decompression in patients with acute spinal cord injury: A systematic review. *Global Spine J*. 2017;7(3 Suppl):95S-115S.