Predicting the minimum clinically important difference in patients undergoing surgery for the treatment of degenerative cervical myelopathy

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OBJECTIVE The minimum clinically important difference (MCID) is defined as the minimum change in a measurement that a patient would identify as beneficial. Before undergoing surgery, patients are likely to inquire about the ultimate goals of the operation and of their chances of experiencing meaningful improvements. The objective of this study was to define significant predictors of achieving an MCID on the modified Japanese Orthopaedic Association (mJOA) scale at 2 years following surgery for the treatment of degenerative cervical myelopathy (DCM).

METHODS Seven hundred fifty-seven patients were prospectively enrolled in either the AOSpine North America or International study at 26 global sites. Fourteen patients had a perfect preoperative mJOA score of 18 and were excluded from this analysis (n = 743). Data were collected for each participating subject, including demographic information, symptomatology, medical history, causative pathology, and functional impairment. Univariate log-binominal regression analyses were conducted to evaluate the association between preoperative clinical factors and achieving an MCID on the mJOA scale. Modified Poisson regression using robust error variances was used to create the final multivariate model and compute the relative risk for each predictor.

RESULTS The sample consisted of 463 men (62.31%) and 280 women (37.69%), with an average age of 56.48 ± 11.85 years. At 2 years following surgery, patients exhibited a mean change in functional status of 2.71 ± 2.89 points on the mJOA scale. Of the 687 patients with available follow-up data, 481 (70.01%) exhibited meaningful gains on the mJOA scale, whereas 206 (29.98%) failed to achieve an MCID. Based on univariate analysis, significant predictors of achieving the MCID on the mJOA scale were younger age; female sex; shorter duration of symptoms; nonsmoking status; a lower comorbidity score and absence of cardiovascular disease; and absence of upgoing plantar responses, lower-limb spasticity, and broad-based unstable gait. The final model included age (relative risk [RR] 0.924, $p < 0.0001$), smoking status (RR 0.837, $p = 0.0043$), broad-based unstable gait (RR 0.869, $p = 0.0036$), and duration of symptoms (RR 0.943, $p = 0.0003$).

CONCLUSIONS In this large multinational prospective cohort, 70% of patients treated surgically for DCM exhibited a meaningful functional gain on the mJOA scale. The key predictors of achieving an MCID on the mJOA scale were younger age, shorter duration of symptoms, nonsmoking status, and lack of significant gait impairment.

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KEY WORDS degenerative cervical myelopathy; cervical spondylotic myelopathy; minimum clinically important difference; MCID; outcome prediction; surgical outcomes

DEGENERATIVE cervical myelopathy (DCM) is a progressive degenerative spine condition and is the most common cause of spinal cord dysfunction in adults worldwide.⁷ DCM is an umbrella term that encompasses all forms of degenerative changes to the cervi-

cal spine, including spondylosis, hypertrophy or ossification of the spinal ligaments, disc herniation, and subluxation.^{17,26} DCM results in progressive compression of the spinal cord and can manifest as an array of neurological signs and symptoms, such as hyperreflexia, atrophy of in-

ABBREVIATIONS DCM = degenerative cervical myelopathy; MCID = minimum clinically important difference; mJOA = modified Japanese Orthopaedic Association.

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trinsic hand muscles, and gait dysfunction.²⁹ Patients with DCM may have substantial functional impairment, significantly reduced quality of life, and be unable to perform certain activities of daily living.

Surgery is typically recommended as the preferred management strategy for patients with clinical and imaging evidence of DCM.^{5,8} In general, surgical decompression of the cervical spine is effective at halting neurological deterioration, relieving certain symptoms, and improving functional status and quality of life. The minimum clinically important difference (MCID) is defined as the minimum change in a measurement that a patient would identify as beneficial.^{3,19,20} Based on two recent prospective studies, patients, on average, exhibited a 2.40- to 2.88-point gain on the modified Japanese Orthopaedic Association (mJOA) scale following surgery, an improvement exceeding the overall MCID for this metric (2 points).^{2,5,8,28}

The MCID of the mJOA scale, however, varies based on preoperative myelopathy severity: 1 point for mild myelopathy (mJOA ≥ 15), 2 points for moderate myelopathy (mJOA score of 12–14), and 3 points for severe disease (mJOA score < 12).²⁸ Before undergoing surgery, patients are likely to inquire about the ultimate goals of the operation and of their chances of experiencing meaningful improvements in functional status. Although several high-quality prognostic studies exist in the literature, no study has examined important predictors of achieving an MCID on the mJOA scale. This knowledge is critically important to patients and is essential to appropriately manage their expectations regarding the outcomes of surgery, increase satisfaction, and provide decision-making support to surgeons.

The objective of this study was to define significant predictors of achieving an MCID on the mJOA scale at 2 years following surgery for the treatment of DCM.

Methods

Patients

Seven hundred fifty-seven patients were prospectively enrolled in either the AOSpine North America ($n = 278$) or International ($n = 479$) study at 26 global sites. Centers were asked to participate if they were either high-volume private practices or academic institutions and if they had experience conducting prospective clinical research. Investigators were neurosurgeons or orthopedic spine surgeons. Ethical approval was obtained from each site's institutional review board.

The inclusion criteria for both studies were identical: 1) age 18 years or older; 2) symptomatic DCM with at least one clinical sign of myelopathy; 3) imaging evidence of cervical cord compression; and 4) no previous cervical spine surgery. Patients were excluded if they were asymptomatic or had a diagnosis of active infection, neoplastic disease, rheumatoid arthritis, ankylosing spondylitis, or concomitant symptomatic lumbar stenosis. Verbal and written informed consent was obtained from each participant.

Surgical Intervention

All patients underwent surgical decompression of the cervical spine. The attending surgeon decided what ap-

proach to use, the number of levels to operate on, and whether to use fusion or instrumentation. Patients were either treated anteriorly, posteriorly, or with a 2-stage anterior-posterior surgery. Anterior techniques included discectomy and/or corpectomy with fusion. Patients operated on posteriorly underwent either laminectomy with or without fusion or laminoplasty.

Data Collection

Extensive data were collected for each participant, including demographic information, symptomatology, medical history, causative pathology and surgical summary. Each patient was clinically examined at baseline and at 6-, 12-, and 24-month intervals following surgery. Functional impairment was measured using the mJOA and Nurick scales, disability was evaluated using the Neck Disability Index, and quality of life was assessed using the SF-36 version 2.

The primary outcome measure for this study was the mJOA score. The mJOA scale is an investigator-administered DCM-specific index that separately addresses motor function of the upper and lower extremities, sensory function of the upper extremities, and sphincter function. A score of 18 indicates normal function, whereas a lower score reflects more severe neurological impairment. Kopjar et al.,¹³ in 2015, evaluated the psychometric properties of this scale and reported that it is composed of two dimensions, has moderate internal consistency, is responsive to change, and demonstrates both convergent and divergent validity. The reliability of the mJOA scale has not been established; however, the inter- and intrarater reliabilities of the JOA scale are high.

External Monitoring

External research monitors performed onsite evaluations to ensure that the data were accurate, reliable, and complete and that the study was conducted in compliance with the protocol. All data were transcribed into an electronic data capture system and were processed at the AOSpine clinical research network data management center.

Statistical Analysis

Continuous variables were described using means, standard deviations, and ranges. Categorical variables were summarized using frequencies and percentages.

A last-observation-carry-forward approach was used to impute missing data at 24 months. Change in mJOA score was calculated by subtracting a patient's preoperative score from his/her 24-month follow-up score. An "optimal" outcome was defined as a change in mJOA score greater than or equal to the MCID of this scale. For patients with severe myelopathy (mJOA score < 12), the MCID is 3 points; for those with moderate disease (mJOA score of 12–14), the MCID is 2 points; and for those with mild disease (mJOA score ≥ 15), the MCID is 1 point. A "suboptimal" outcome was classified as a change in mJOA score that was less than the MCID, no change in status, or functional deterioration.

Univariate log-binomial regression analyses were conducted to evaluate the association between several pre-

operative factors and surgical outcomes. Variables that yielded a p value < 0.20 in univariate analysis were further examined in a multivariate analysis. Variables that were considered clinically relevant but had a p value > 0.2 were also assessed in multivariate analyses. Multicollinearity was evaluated by calculating tolerance. Modified Poisson regression using robust error variances was used to create the final multivariate model and compute the relative risk for each predictor.

Results

Patients

Four hundred one participants (52.97%) were enrolled at sites in North America (278 from North American study, 123 from International study), 150 (19.82%) in Asia Pacific, 126 (16.64%) in Europe, and 80 (10.57%) in Latin America. Of these 757 participants, 14 were excluded from this analysis because they scored the maximum preoperative mJOA score of 18. Table 1 summarizes enrollment by site.

Our cohort consisted of 463 (62.31%) men and 280 (37.69%) women, with an average age of 56.48 ± 11.85 years (range 21–87 years). Patients presented with a wide array of neurological signs and symptoms, including hyperreflexia (77.90%), corticospinal distribution motor deficits (62.80%), numb hands (89.49%), weakness (82.88%), and gait impairment (76.55%). The average baseline mJOA score was 12.52 ± 2.74 (range 3–17 points), with 193 presenting with mild myelopathy (mJOA score of 15–17), 296 with moderate disease (mJOA score of 12–14), and 254 with severe disease (mJOA score < 12). Four hundred fifty-nine patients (61.78%) suffered from comorbidities, with the most common being cardiovascular (44.95%), endocrine (18.17%), and gastrointestinal (16.15%) disorders. With respect to causative pathology, 77.25% of patients displayed evidence of spondylosis, 71.74% of disc herniation, and 24.23% of a hypertrophied ligamentum flavum. A smaller percentage of patients presented with ossification of the posterior longitudinal ligament (21.13%) and subluxation (5.79%).

All 743 patients underwent surgical decompression of their cervical spine: 436 (58.68%) were treated anteriorly, 284 (38.22%) posteriorly, and 23 (3.10%) underwent a 2-stage anterior-posterior surgery. The mean number of decompressed segments was 3.74 ± 1.27 (range 1–7 levels), and the mean operative duration was 180.70 ± 80.03 minutes (range 45–575 minutes). Table 2 displays a complete summary of the demographics and surgical characteristics of patients enrolled in the International and North American studies.

24-Month Follow-Up

Five hundred fifty (74.02%) of the 743 patients attended their 2-year follow-up visit and were evaluated for improvements in functional status (mean mJOA score 15.34 ± 2.64 , range 7–18). Following imputation, mJOA data were available for 687 participants (92.46%) (mean mJOA score 15.26 ± 2.77 , range 2–18). The mean change in functional status was 2.71 ± 2.89 points (range –10 to 14) on the mJOA scale. One hundred twenty-four patients (68.89%) with mild myelopathy, 201 (72.04%) with mod-

TABLE 1. Participating centers and respective enrolled patients

Site	No. of Enrolled Patients (%)
Medical University of Ancona	9 (1.21)
Emory University	50 (6.73)
Johns Hopkins University	4 (0.54)
New England Baptist Hospital	13 (1.75)
Brigham and Women's Hospital	2 (0.27)
Canisius Wilhelmina Hospital	41 (5.52)
Hospital San Juan de Dios	4 (0.54)
Medical University of Catania	40 (5.38)
Southwestern Hospital	39 (5.25)
University of Virginia	17 (2.29)
Beaumont Hospital	4 (0.54)
Indiana Spine Group	5 (0.67)
Ege University	29 (3.90)
Kansas University Medical Center	79 (10.63)
Chubu Rosai Hospital	19 (2.56)
All India Institute of Medicine	57 (7.67)
Okayama University	7 (0.94)
University of São Paulo	56 (7.54)
Thomas Jefferson University	29 (3.90)
Mayo Clinic	1 (0.13)
Tan Tock Seng Hospital	19 (2.56)
University of Utah	18 (2.42)
Hospital Santa Marcelina	17 (2.29)
Teikyo University Chiba Medical Center	7 (0.94)
Spine Education and Research Institute	4 (0.54)
Toronto Western Hospital	173 (23.28)

erate myelopathy and 156 (68.42%) with severe disease exhibited clinically meaningful changes in functional status and achieved the MCID of the mJOA score (mild ≥ 1 point, moderate ≥ 2 points, and severe ≥ 3 points). In total, 481 (70.01%) of the 687 patients had an “optimal” surgical outcome, whereas 206 (29.98%) failed to improve by greater than or equal to the MCID. Of these 206 patients, 75 (10.92% of the 687 participants) exhibited an improvement less than the MCID, 54 (7.86%) stayed the same, and 77 (11.21%) deteriorated.

Univariate Analysis

Based on univariate analysis, the significant predictors of achieving the MCID on the mJOA scale were younger age (relative risk [RR] 0.918, $p < 0.0001$); female sex (RR 0.881, $p = 0.010$); shorter duration of symptoms (RR 0.938, $p = 0.0001$); nonsmoking status (RR 0.869, $p = 0.025$); a lower morbidity score (RR 0.966, $p = 0.035$) and absence of comorbidities; and absence of upgoing plantar responses (RR 0.885, $p = 0.028$), lower-limb spasticity (RR 0.856, $p = 0.0025$), and broad-based unstable gait (RR 0.847, $p = 0.0007$). The associations between this outcome and gastrointestinal disorders, endocrine comorbidities, and hyperreflexia yielded p values < 0.20 and these variables were evaluated in multivariate analysis (Table 3).

TABLE 2. Patient baseline demographic information on 743 patients with degenerative cervical myelopathy enrolled in either the AOSpine North America or International study*

Variable	Total Sample
Baseline severity score (mJOA)	12.52 ± 2.74 (3–17)
Mild (mJOA ≥15)	193 (25.98%)
Moderate (mJOA = 12–14)	296 (39.84%)
Severe (mJOA <12)	254 (34.19%)
Age (yrs)	56.48 ± 11.85 (21–87)
Gender (%)	463 (62.31%) M
Duration of symptoms, mos (n = 743)	26.79 ± 39.25 (0.25–432)
<3 mos	118 (15.88%)
≥3 mos, <6 mos	113 (15.21%)
≥6 mos, <12 mos	162 (21.80%)
≥12 mos, <24 mos	152 (20.46%)
≥24 mos	198 (26.65%)
Smoking status (%)	199 (26.78%)
Comorbidities (%)	459 (61.78%)
Comorbidity score	1.45 ± 1.82 (0–13)
Cardiovascular	334 (44.95%)
Respiratory	80 (10.77%)
Gastrointestinal	120 (16.15%)
Renal	22 (2.96%)
Endocrine	135 (18.17%)
Psychiatric	103 (13.86%)
Rheumatological	38 (5.11%)
Neurological	47 (6.33%)
Diagnosis	
Spondylosis	574 (77.25%)
Disc herniation	533 (71.74%)
OPLL	157 (21.13%)
HLF	180 (24.23%)
Subluxation	43 (5.79%)
Symptoms (n = 742)	
Numb hands	664 (89.49%)
Clumsy hands	556 (74.93%)
Impaired gait	568 (76.55%)
Bilateral arm paresthesia	422 (56.87%)
L'Hermite's phenomena	198 (26.68%)
General weakness	615 (82.88%)
Signs (n = 742)	
Corticospinal motor deficits	466 (62.80%)
Atrophy of intrinsic hand muscles	268 (36.12%)
Hyperreflexia	578 (77.90%)
Positive Hoffman's sign	465 (62.67%)
Upgoing plantar responses	266 (35.85%)
Lower-limb spasticity	353 (47.57%)
Broad-based unstable gait	442 (59.57%)

HLF = hypertrophy of the ligamentum flavum; OPLL = ossification of the posterior longitudinal ligament.

* Continuous variables are described using means ± standard deviations and ranges. Baseline categorical variables are summarized as percentages.

Multivariate Analysis

The final model consisted of 4 statistically significant and clinically relevant predictors: age (RR [by decade] 0.924, 95% CI 0.889–0.960, $p < 0.0001$), smoking sta-

TABLE 3. Univariate analyses evaluating the association between various clinical predictors and achieving an MCID on the mJOA scale at 2 years following surgery

Predictor	Relative Risk	95% CI	p Value
Baseline severity score (mJOA)	0.991	0.973–1.009	0.335
Age (by decade)	0.918	0.881–0.955	<0.0001
Gender (ref = female)	0.881	0.800–0.970	0.010
Duration of symptoms	0.938	0.907–0.969	0.0001
Smoking status (ref = no)	0.869	0.768–0.982	0.025
Comorbidities (ref = absence)	0.948	0.859–1.046	0.285
Comorbidity score*	0.966	0.935–0.998	0.035
Cardiovascular	0.894	0.808–0.989	0.029
Respiratory	0.918	0.767–1.097	0.345
Gastrointestinal	1.118	0.996–1.255	0.060
Renal	1.095	0.837–1.432	0.508
Endocrine	0.879	0.760–1.016	0.080
Psychiatric	1.058	0.929–1.206	0.397
Rheumatological	0.867	0.665–1.130	0.291
Neurological	0.972	0.790–1.197	0.790
Symptoms (ref = absence)			
Numb hands	1.073	0.899–1.280	0.435
Clumsy hands	0.997	0.890–1.116	0.958
Impaired gait	0.913	0.821–1.014	0.090
Bilateral arm paresthesia	1.032	0.934–1.141	0.531
L'Hermite's phenomena	0.985	0.880–1.102	0.790
General weakness	0.952	0.842–1.077	0.438
Signs (ref = absence)			
Corticospinal motor deficits	0.955	0.865–1.055	0.367
Atrophy of intrinsic hand muscles	0.992	0.896–1.100	0.885
Hyperreflexia	0.917	0.823–1.023	0.120
Positive Hoffman's sign	1.010	0.912–1.119	0.845
Upgoing plantar responses	0.885	0.794–0.987	0.028
Lower-limb spasticity	0.856	0.774–0.947	0.0025
Broad-based unstable gait	0.847	0.770–0.932	0.0007

Ref = reference.

* Comorbidity score comprises both number and severity of comorbidities.

tus (RR [ref = nonsmoker] 0.837, 95% CI 0.741–0.946, $p = 0.0043$), broad-based unstable gait (RR [ref = absent] 0.869, 95% CI 0.791–0.955, $p = 0.0036$), and duration of symptoms (RR 0.943, 95% CI 0.913–0.974, $p = 0.0003$).

Based on relative risks, the probability of achieving a score greater than or equal to the MCID on the mJOA scale 1) decreases by approximately 6% when a patient has an increased duration of symptoms (i.e., moves from the ≤ 3-month to the 3 to 6-month group); 2) decreases by approximately 8% for every decade increase in age; 3) decreases by 13% when a patient presents with gait impairment (vs no impairment); and 4) decreases by 16% when a patient smokes (Table 4). To better interpret the impact of age on outcomes, Table 5 presents, by decade, the percentage of patients who achieved the MCID on the mJOA scale versus those who experienced a decline in function.

TABLE 4. Multivariate analyses evaluating the association between various clinical predictors and achieving an MCID on the mJOA scale at 2 years following surgery

Predictor	Relative Risk	95% CI	p Value
Smoking status (ref = nonsmoker)	0.837	0.741–0.946	0.0043
Age (by decade)	0.924	0.889–0.960	<0.0001
Broad-based unstable gait (ref = absence)	0.869	0.791–0.955	0.0036
Duration of symptoms	0.943	0.913–0.974	0.0003

Discussion

This study aimed to identify important predictors of achieving an MCID in functional status following surgery for the treatment of DCM. Based on our results, we found that patients are more likely to exhibit a clinically important improvement if they are younger, do not smoke, have a shorter duration of symptoms, and do not present with a broad-based unstable gait. These factors have previously been identified as important predictors of outcomes, but this is the first study to use a severity-dependent MCID as the dependent variable.

The objectives of surgery are, first, to halt the progression of myelopathy and, second, to improve neurological impairment, functional disability, and quality of life.⁸ In our study, 610 patients (88.79%) either stayed the same or improved, while 77 patients (11.21%) deteriorated based on mJOA scale scores. The MCID is a metric that describes a change in status that a patient would define as meaningful. For the mJOA scale, the MCID varies based on severity: patients with more severe myelopathy must make larger gains than those with mild disease to consider their improvement as important. Our model can be used to predict which patients are likely to achieve meaningful improvements in impairment. This information is valuable to the patient and should be used to discuss the probable outcome of the surgery and to appropriately manage expectations. These expectations are closely linked to patient satisfaction, which is of increasing importance in performance-based health care systems.²⁷

Older patients are less likely to attain an “optimal” outcome on the mJOA scale. Older patients, however, are more severely impaired and therefore require a larger improvement to achieve an MCID. In a study by Nakashima et al., age was identified as an independent predictor of improvement on the mJOA scale, after controlling for baseline severity score, comorbidities, and surgical factors.¹⁶ Elderly patients may not be able to translate neurological improvements to functional recovery as well as younger patients; however, despite this, the elderly do achieve similar improvements in disability and quality of life as evaluated by the Neck Disability Index and SF-36 Physical and Mental Component scores. Along with more severe degenerative changes, the elderly may experience age-related alterations to the composition of their spinal cord.⁶ Advancing age is significantly correlated with a decreased density of small myelinated fibers in the cortico-

TABLE 5. Impact of age on achieving an MCID on the mJOA scale 2 years after surgery*

Age Decade (yrs)	No. of Patients (%)	
	Achieved the MCID on the mJOA Scale	Experienced Decline in the mJOA Score
20–29 (n = 7)	7 (100.00)	0 (0.00)
30–39 (n = 45)	39 (86.67)	2 (4.44)
40–49 (n = 137)	97 (70.80)	17 (12.41)
50–59 (n = 222)	162 (72.97)	24 (10.81)
60–69 (n = 176)	122 (69.32)	18 (10.23)
70–79 (n = 84)	46 (54.76)	16 (19.05)
80–89 (n = 16)	8 (50.00)	0 (0.00)

* mJOA data were available for 687 patients after imputation. A decline in status was defined as a negative change in mJOA score between baseline and 2 years postoperatively.

spinal tract and a reduced number of alpha and gamma motor neurons and small neurons in the intermediate zone of the ventral horn.^{24,25} Other potential explanations for the association between age and outcome include the following: 1) mJOA scoring may be affected by other aspects of the natural aging process, including hip and knee osteoarthritis, sarcopenia, and lumbar canal stenosis; and 2) the elderly have reduced physiological reserves and may be less tolerant of surgery.¹⁶ Throughout the literature, although less effective, surgery still halts disease progression in elderly patients and, in some cases, results in significant improvements in functional status and quality of life. Surgeons should therefore not discriminate on the basis of age but use this information to appropriately manage their patients' expectations. Future studies are required to determine if there is a cut-off age above which the risks of surgery outweigh the benefits.

Patients who smoke are also less likely to achieve an MCID on the mJOA scale. In preclinical studies, tobacco smoking has been associated with increased intervertebral disc degeneration, decreased bone mineral density and reduced microstructural integrity of cerebral white matter.^{9,11,31} Furthermore, nicotine treatment results in stenosis of and a decrease in the number of vascular bulbs, enlargement of vascular endothelial cells, and reduced blood flow.¹¹ Smoking may therefore amplify the hypoxic conduction caused by cord compression, reinforce oxidative stress, aggravate edema, and increase the permeability of the blood–spinal cord barrier.⁴ In addition, nicotine may worsen the severity of ischemia-reperfusion injury following decompression of the spinal cord, as demonstrated in models of myocardial infarction, brain injury, and necrotizing enterocolitis.^{15,21,30} In clinical studies, smoking has been shown to be associated with poor wound and bone healing and increased rates of pseudarthrosis and non-union.^{10,14} Decreased recovery in smokers is therefore likely due to a combination of vascular changes, impaired bone remodeling, and increased risk of complications. Future research is required to evaluate whether smoking cessation improves outcomes.

A longer duration of symptoms and impaired gait may

indicate more severe degenerative changes, cord compression, and histological damage. Some DCM patients, however, remain neurologically stable and relatively mild for extended periods of time, whereas others deteriorate rapidly.²⁶ The duration of symptoms is likely to have a greater impact on outcomes in patients with progression of myelopathy; in these cases, a substantial delay of surgery may prevent optimal outcomes. It is therefore necessary to diagnose myelopathy at an early stage in the disease course and to identify patients at a high risk of progression. Important predictors of neurological deterioration include the following: 1) circumferential cord compression shown on axial MRI;²² 2) an “angular-edged” spinal cord, defined as an acute angled or lateral corner at one or both sides;²³ 3) greater range of preoperative neck and head motion;¹ 4) lower segmental lordotic angle and greater percentage of vertebral slip;¹⁸ and 5) segmental instability and reduced diameter of the CSF column.¹² These patients with progressive myelopathy should be recommended surgery and counseled as to the risks of delaying intervention.

Limitations

This large prospective study represents the first analysis of important predictors of a severity-dependent MCID. This study has certain limitations: 1) the follow-up rate at 24 months was only 74.02%; however, we accounted for missing data using a last-value-carry-forward imputation technique and were able to obtain mJOA scores for 92.46% of the sample; and 2) the reliability of the mJOA and other predictor variables such as duration of symptoms is unknown.

Conclusions

In this large multinational prospective cohort, 70% of patients treated surgically for DCM exhibited a meaningful functional gain on the mJOA scale. The key predictors of achieving an MCID on the mJOA scale were younger age, shorter duration of symptoms, nonsmoking status, and lack of significant gait impairment.

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Author Contributions

Conception and design: Fehlings. Acquisition of data: Fehlings, Kopjar, Arnold. Analysis and interpretation of data: Fehlings, Tetreault, Wilson, Kotter, Nouri, Kopjar, Arnold. Drafting the article: all authors. Critically revising the article: Fehlings, Tetreault, Wilson, Kotter, Côté, Kopjar, Arnold. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Fehlings. Statistical analysis: Kopjar. Study supervision: Fehlings.

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