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Managing the Complex Patient with Degenerative Cervical Myelopathy: How to Handle the Aging Spine, the Obese Patient, and Individuals with Medical Comorbidities.

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Title

Managing the Complex Patient with Degenerative Cervical Myelopathy: How to Handle the Aging Spine, the Obese Patient, and Individuals with Medical Comorbidities

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Keywords

Degenerative cervical myelopathy; Co-morbidities; Functional outcome; Perioperative complication

Key Points

- Surgery is an effective treatment for DCM.
- Age is correlated with functional outcomes and the risk of perioperative morbidity following surgery for DCM, but it is a non-modifiable risk factor.
- Cardiovascular co-morbidity, diabetes, and obesity are all associated with reduced functional improvement following surgery for DCM.
- Many co-morbidities can increase the risk of perioperative complication.

Synopsis

Degenerative cervical myelopathy (DCM) is the most common cause of non-traumatic spinal cord injury worldwide. Even relatively mild impairment in functional scores can significantly impact daily activities. Surgery is an effective treatment for DCM, but outcomes are dependent on more than technique and preoperative neurologic deficits.

Introduction

Degenerative cervical myelopathy (DCM) encompasses multiple degenerative conditions including cervical spondylotic myelopathy (CSM), ossification of the posterior longitudinal ligament (OPLL), ossification of the ligamentum flavum (OLF), and degenerative disc disease.[1] Forms of degenerative myelopathy are the most common cause of non-traumatic spinal cord injury in the aging population.[2,3] While the natural history of DCM is unclear,[4] Fehlings and Arvin documented an important clinical observation that even clinically stable, mild myelopathy can be associated with significant functional limitations.[5] Prospective data from AO North American and International cohorts of patients with cervical myelopathy have demonstrated that surgery provides a significant functional benefit, significantly improves quality of life, and is cost-effective.[6–8] Age, medical comorbidities, and smoking status are associated with functional outcomes following surgery.[9–11] Achieving a positive outcome relies on understanding how these factors influence patient selection, surgical decision making, and functional improvement.

Age

Approximately 90% of patients over age 65 will have some evidence of cervical spondylosis on imaging studies.[12] However, the existence of degenerative changes or spinal cord compression on imaging does not necessarily correlate with symptoms of myelopathy.[13,14] Degenerative changes will continue to progress over time[15] and may result in the development of functional deficits. Bednarik, et al. prospectively followed asymptomatic patients with cervical spondylosis and observed the development of myelopathy in more than 22% of patients within a median follow-up time of 44 months.[14] Thus, as the average age of the general population and life expectancy both increase, it is likely that the number of people with degenerative cervical myelopathy will also climb.

Prospectively collected data has shown that surgery provides a significant clinical benefit for patients with cervical myelopathy,[6,7,16] but how does age impact outcomes? Data from the international arm of the AOSpine CSM study found preoperative modified Japanese Orthopedic Association (mJOA) scores were significantly lower and preoperative Nurick scores were significantly higher in elderly patients (aged 65 or older) when compared with the younger cohort.[10] Post-operatively, elderly and non-elderly patients were found to have a significant improvement in Nurick and mJOA scores following surgery, however younger patients still had significantly higher mJOA and lower Nurick scores (**Table 1**).[10] Tetreault et al. used combined data from the AOSpine CSM-International and CSM-North American studies to construct prediction models for the minimum clinically important difference (MCID) in mJOA score after surgery for cervical myelopathy; MCID was defined as a 1 point improvement for mild, 2 points for moderate, and 3 points for severe myelopathy.[17] Younger age was found to be a significant predictor of achieving the MCID on post-operative mJOA score; for every 10-year increase in age, a patient was 8-9% less likely to achieve the MCID.[9,11] A separate prospective study by Machino et al. also concluded that patient age of 65 or older was a significant risk factor for lower preoperative and postoperative JOA score and lower JOA recovery rate.[16,18]

Data from larger retrospective articles concurs with the findings from the prospective AOSpine and Machino studies.[19,20] A meta-analysis from Madhavan et al. looked at more than 2,800 patients from 18 different studies, calculated the average age for elderly and non-elderly patients, and compared preoperative and post-operative outcomes. Average age for elderly patients was 74, non-elderly average age was 55, and the authors concluded that elderly patients had significantly lower preoperative and post-operative JOA scores compared with non-elderly, leading to a significantly lower recovery rate.[19] A systematic review by Tetreault et al. identified 36 articles that examined the impact of age on surgical outcome and then categorized them as 'Excellent,' 'Good,' or 'Poor' using a modified version of the SIGN scoring system.[20] Sixteen articles were identified as 'Excellent' and collectively suggested that age may be a predictor of outcome using JOA, mJOA, or Nurick scores.[20] However, when 'Good' and even 'Poor' articles were included in their assessment, age was not found to be a significant predictor of outcome.[20]

In addition to functional outcomes, there are also significant age-related differences in surgical approach. Sixty-five percent of younger patients (age <65) in the AOSpine CSM-International study had anterior surgery while 59% of elderly patients (age ≥ 65) had posterior surgery.[10] Of the elderly patients treated anteriorly, a significantly higher percentage had a combined discectomy and corpectomy when compared with younger patients (28% vs 13%).[10] Elderly patients also had more levels decompressed than younger patients, most likely a result of the increasing degenerative changes that accumulate with age thus explaining the bias towards posterior surgery.[10,15] Age-related differences in functional outcomes remained significant after controlling for differences in surgical approach.[10]

While the evidence supports a significant interaction between age and functional improvement after surgery for DCM, it is also important to consider the impact of age on post-operative recovery and the rate of surgical complication. Older patients have been found to have significantly longer hospital stays,[10,19,21] but similar operative time and less blood loss.[10,18,19] Data regarding the relationship between age and complication rate is mixed. Results from the AOSpine CSM-International study and Machino's cohort did not find any significant difference in perioperative complication rate with regards to age.[10,18,22] Madhavan's meta-analysis made similar conclusions except that older patients had a higher rate of perioperative delirium.[19] However, a retrospective review of more than 54,000 patients from the Nationwide Inpatient Sample (NIS) who underwent surgery for cervical myelopathy found that patients over age 65 had a significantly higher risk for perioperative complications including cardiac, respiratory, gastrointestinal, and wound healing.[21,23]

Age is a non-modifiable risk factor; it's impact on functional recovery and perioperative complication should be an important part of any preoperative consultation, but it cannot be adjusted. Although age is a fixed predictor, it has also been shown to correlate with the incidence and severity of preoperative co-morbidities.[10,18,21] Increasing co-morbid score has been shown to be a negative predictor for achieving the MCID in functional scores[9] and the presence of some co-morbidities increases the risk of perioperative complication following surgery for cervical myelopathy (**Tables 2 and 3**).[22] Identifying and optimizing modifiable co-morbidities should be a priority in the preoperative setting in order to maximize outcomes.

Medical comorbidities

Cardiovascular

Cardiovascular comorbidity was the most common comorbidity among enrollees in the combined cohorts of the prospective AOSpine CSM study, occurring in 45% of patients.[9] Specific comorbidities included: history of myocardial infarct, congestive heart failure, arrhythmia, hypertension, and peripheral vascular disease.[22] Functional outcomes analysis found cardiovascular comorbidity to be a significant predictor for not obtaining the MCID following surgery.[9,11] Maeno, et al. retrospectively reviewed their patients with cervical myelopathy who had undergone laminoplasty and also found that patients with hypertension had significantly lower preoperative and postoperative JOA scores, leading to a lower recovery rate.[24]

A retrospective analysis of patients with symptomatic cervical stenosis looked at the correlation between hypertension, MRI findings, and functional scores.[25] All patients with a diagnosis of hypertension, either controlled or uncontrolled, were significantly more likely to have increased signal intensity (ISI) on sagittal T2-weighted MRI when compared with non-hypertensive patients and the ISI surface area was significantly larger in hypertensive patients than non-hypertensive.[25] When looking at controlled versus uncontrolled hypertensive patients, the surface area of ISI in uncontrolled hypertensive patients was significantly larger than those with adequately controlled blood pressure; maximal canal stenosis was equivalent between all groups.[25] The presence of signal changes in the spinal cord were found to correlate with worse mJOA and Nurick scores independent of the surface area of ISI.[25]

Patients with cardiovascular comorbidity in the CSM-International study, in addition to worse functional outcomes, were also significantly more likely to have post-operative complications, with hypertension carrying the greatest risk.[22] Retrospective review of more than 54,000 patients from the NIS database found that congestive heart failure (CHF), peripheral vascular disorders, and cardiac valvular disease were also associated with a significantly increased risk of perioperative complication.[23] However hypertension (grouped as complicated and uncomplicated) had no impact on perioperative morbidity, but was associated with a decreased risk of mortality.[23] The authors of this review surmised that a known diagnosis of hypertension lead to better preoperative optimization of patients, yielding the observed mortality benefit.[23]

Cardiovascular co-morbidities have been shown to correlate with perioperative complications and functional outcome following surgery for CSM. While the interaction between hypertension and perioperative morbidity is unclear, hypertension may significantly compound the neurological damage caused by cervical spondylosis. The impact of cardiovascular co-morbidities on outcomes should be discussed with the patient and optimized prior to elective surgery to minimize the risk of perioperative complication and maximize the chances for functional improvement.

Diabetes

The rate of diabetes among patients undergoing surgery for DCM is cited at 9-36%, making it the second most common co-morbidity in this population.[26–30] Although chronic diabetes is known to have neurological sequelae, data regarding preoperative functional scores in diabetic patients with DCM is mixed: retrospective data from a few small studies suggests that diabetic patients do not have significantly worse preoperative JOA[24,27,28,31] or Nurick scores.[32] However, one prospective study found diabetic patients had a significantly higher preoperative Nurick score, but no difference in mJOA[26] while another study observed significantly lower preoperative JOA scores in diabetic patients compared with non-diabetic patients.[29] Regardless of preoperative differences, diabetic patients appear to have a significant improvement in functional scores after surgery.[26–28] Some studies have found total post-operative JOA, mJOA, and Nurick scores to be significantly worse among diabetic versus non-diabetic patients[26,29,32] while others have found significantly less recovery of only lower extremity motor and sensory function based on JOA score.[27,31] Despite these differences, univariate analysis from the AOSpine CSM studies found that endocrine co-morbidities did not significantly impact realization of an MCID on the mJOA scale.[9,11] While individual diagnoses within the endocrine category were not evaluated, diabetes undoubtedly constituted a significant component.

The impact of diabetes on outcomes following surgery for DCM has also been evaluated based on hemoglobin A1c (HbA1c) and serum blood glucose levels. Preoperative HbA1c levels in diabetic patients with DCM ranged from 6.5-8.3%[16,27,31] and were found to negatively correlate with post-operative JOA recovery rate (**Table 4**).[29,31] One retrospective study found higher average perioperative glucose values in diabetic patients negatively correlated with improvement in Nurick score; stratification using an average blood glucose cut-off of 150 mg/dL found significantly improved outcomes for diabetic patients with values below 150.[32] While absolute values make it easier to monitor and adjust perioperative care, two other studies, one prospective and one retrospective, observed no correlation between either fasting blood glucose levels or highest perioperative blood glucose level and JOA recovery rate.[16,31] Duration of diabetes may also be important as one prospective study observed patients who had diabetes for more than 10 years had a lower JOA recovery rate following surgery.[16] Kawaguchi, et al. did not find a similar association, but their conclusion was based on an average duration of diabetes of 6.7 years.[31]

In addition to functional recovery, it is also important to consider how diabetes impacts the perioperative process. Diabetes is not associated with significantly increased length of surgery or greater blood loss when compared with non-diabetic patients.[29,31] While some studies have found no difference in major surgical complication rates between diabetic and non-diabetic patients,[26,27,29,31] larger data sets have suggested that diabetic patients do have a significantly increased risk of perioperative complications including: respiratory complications, cardiac and peripheral vascular complications, dysphagia, dysphonia and an increased transfusion requirement.[22,23,30] Importantly, most studies agree that while diabetic patients may sometimes have delayed superficial wound healing, there was no significant difference in the rate of surgical site infection.[22,30] When comparing well-controlled with poorly-controlled diabetic patients, those with poor control were found to have a significantly higher risk of perioperative mortality, cardiac complication, hematoma formation, infection, and non-routine discharge, but still no difference in the rate of wound complication.[30] Cook's review of the NIS database also found that diabetic patients were more likely to have longer hospital stays and higher hospitalization costs.[30]

Although diabetes does not preclude a patient from gaining meaningful functional recovery following surgery for DCM, it does appear to limit the extent of recovery and is associated with a higher risk of perioperative complication when compared with non-diabetic patients. Patients with a prolonged history of poorly controlled diabetes are the least likely to gain significant functional recovery and the most likely to suffer from perioperative complications. Furthermore, diabetic patients are also more likely to have general cardiovascular co-morbidities,[26] including hypertension,[29] and tend to be older than non-diabetic patients.[10,26] Preparing for positive outcomes in the diabetic patient must go beyond controlling HbA1c and blood glucose to identify other conditions that can impact improvement and recovery.

Psychiatric: Depression and Bipolar

Psychiatric co-morbidity, including depression and bipolar disorder, is observed in 14-25% of patients with DCM.[11,33] Data analyzing the impact of psychiatric co-morbidities on the management of patients with CSM is in limited supply. The AOSpine CSM-International study observed that patients with depression or bipolar had significantly worse preoperative neck disability index (NDI) scores compared with those who did not, but mJOA and Nurick scores were not significantly different.[33] Post-operatively, patients had statistically significant improvement in mJOA, Nurick, and NDI scores and while improvement in mJOA and Nurick scores were similar between patients with depression and those without, changes in NDI were significantly larger in patients without psychiatric disorders.[33] Univariate analysis confirmed that psychiatric co-morbidities were not significantly correlated with achieving a post-operative MCID in mJOA score.[11] Zong, et al. also prospectively looked at the impact of depression in CSM patients.[34] Where the AOSpine study relied on patient reported and clinical review of medical records to diagnose psychiatric co-morbidity, Zong obtained Beck Depression Index (BDI) scores for a group of 511 patients; patients with a BDI score of 10 or higher were considered to have depression. They found that patients with depression had significantly less change in mJOA following surgery, however their final analysis excluded all patients who had recovered from their depression or had subsequently become depressed following surgery.[34]

Evaluation of the impact of psychiatric co-morbidity on functional outcomes is limited by the volume and quality of data. While there does not appear to be an interaction with functional outcome, no study has compared outcomes between well-controlled and poorly controlled patients, or considered the duration of depression in their evaluation. Although data from the AOSpine CSM-International study found that psychiatric co-morbidities were not a predictor for increased risk of perioperative complication,[22] they have been shown to correlate with a higher incidence of cardiovascular disease.[33] Thus preoperative evaluation of the DCM patient with psychiatric co-morbidity should take this into account and include adequate screening and optimization as necessary given the impact of cardiovascular co-morbidity as outlined above.

Body Mass Index (BMI)

Of the more than 700 patients enrolled in the AOSpine CSM-North American and International studies, 25% were found to be obese (BMI>30 kg/m^2), with an additional 36% classified as overweight (BMI>24.99 kg/m^2).[35] At baseline, elevated BMI was correlated with an increased NDI but not associated with mJOA; similar observations were made 1 year after surgery.[35] Categorization of outcomes based on weight class found post-operative NDI was an average of 4.2 points higher in overweight patients and 7.6 points higher in obese patients when compared with normal weight patients; only obese patients exhibited a significant difference in NDI.[35] The likelihood of obese patients achieving the MCID for NDI scores at 1 year was also significantly less than for normal weight patients.[35] A prospective study by Machino et al. utilized JOA scores and also observed that patients with a BMI of 25 kg/m^2 or higher did not have a significantly increased risk for poor functional outcome, but they did not separately evaluate the obese population.[16,29]

Outside of functional improvement, it's also important to consider the impact of body weight on the perioperative process. The average BMI of patients in AOSpine CSM-International study was 25.8, falling into the 'overweight' category; univariate analysis of this population found that despite the elevated BMI, there was no increased risk of perioperative complication.[22] Retrospective review of more than 54,000 patients from the NIS database found that obese patients had a significantly higher risk of perioperative complication, although they also had a lower perioperative mortality.[23]

While BMI may not directly influence functional outcomes, the obese patient's perception of how their daily activities are impacted by DCM is significantly worse than the non-obese patient. Additionally, obesity was shown to significantly increase the risk of perioperative morbidity. Bodyweight may be a modifiable risk factor that, when optimized, can improve patient perceived outcomes and reduce perioperative complications.

Tobacco use

Data from the combined AOSpine CSM-North American and International studies found that 27% of enrolled patients were smokers.[36] Although smokers tended to be younger than non-smokers, smokers had significantly less improvement in mJOA and NDI scores 1 year after surgery.[36] A separate, retrospective study observed smokers to have significantly less improvement in Nurick scores and found a significant negative correlation between number of packs smoked per day and post-operative change in Nurick score.[37] Further analysis of the AOSpine cohorts confirmed that smoking status was a significant predictor for achieving an MCID on the mJOA 2 years after surgery and the likelihood of having an MCID decreased by 16% if patient is a smoker.[9] Tobacco use was not found to be associated with a higher rate of perioperative complication.[22]

Smoking is a modifiable risk factor that can significantly impact patient outcomes. The non-smoker has a significantly higher chance of gaining significant functional recovery following surgery. Tobacco use was also found to interact with other co-morbidities that influence outcomes including diabetes and older age; in combination, the chance of poor outcomes is further increased.[28] Smoking cessation should be a preoperative priority in the patient with DCM.

Conclusions

Degenerative cervical myelopathy is the most common cause of non-traumatic spinal cord injury in adults.[3] Surgery has been shown to be a safe treatment option that offers significant functional improvement, is cost-effective, and improves patient quality of life.[6–8,18] However, successful outcomes depend on adequate patient counseling and effective management of modifiable risk factors. While age is a not a modifiable risk factor, older patients are more likely to have medical co-morbidities; taking the time to look for cardiovascular, endocrine, and psychiatric conditions in this population can improve functional recovery and limit perioperative complications. Additionally, weight loss in the obese patient and smoking cessation in the tobacco user can also improve outcomes. Surgery is a valuable therapy for the treatment of DCM, but that value relies on proactively identifying obstacles and minimizing their impact.

Outcome Measure	Younger Patients (<65)	Elderly Patients (≥65)	p Value
Baseline			
mJOA	12.86	11.41	<0.0001
Nurick	3.16	3.75	<0.0001
24-month post-op			
mJOA	15.45	14.08	<0.0001
Nurick	1.64	2.44	<0.0001

Table 1: Preoperative and 24-month post-operative mJOA and Nurick scores compared between elderly and non-elderly patients. Data from Nakashima et al. 2016.[10]

Clinical Predictor	Odds Ratio	95% CI	p Value
Comorbidities	2.03	1.18-3.47	0.01
Number of co-morbidities	1.32	1.11-1.56	0.002
Comorbidity score	1.19	1.05-1.34	0.006
Cardiovascular	1.64	1.01-2.68	0.046
Diabetes	2.83	1.54-5.20	<0.001

Psychiatric	0.17	0.50-2.76	0.72

Table 2: Univariate analysis assessing the relationship between various clinical factors and perioperative complications. Data from Tetreault et al. 2016.[22]

Clinical Predictor	**Relative Risk**	**95% CI**	**p Value**
Age	0.918	0.881-0.955	<0.0001
Comorbidities	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
Endocrine	0.879	0.760-1.016	0.080
Psychiatric	1.058	0.929-1.206	0.397

Table 3: Univariate analyses evaluating the association between various clinical predictors and achieving an MCID on the mJOA scale at 2 years following surgery. Data from Tetreault et al. 2016.[9]

Variable	**Good Outcome**	**Poor Outcome**	**p Value**
Preoperative			
JOA score	10.6	0.7	0.075
HbA1c level (%)	6.8	7.2	0.0165
Post-operative			
JOA score	15.2	11.2	<0.0001

Recovery rate of JOA score	73.8	22.3	<0.0001

Table 4: HbA1c levels are correlated with outcomes following surgery for DCM in diabetic patients; poor outcome defined as recovery rate of less than 50%. Data from Machino et al 2014.[16]

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