



An Evidence-Based Stepwise Surgical Approach to Cervical Spondylotic Myelopathy: A Narrative Review of the Current Literature

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Key words

- Anterior cervical discectomy
- Cervical kyphosis
- Cervical spondylotic myelopathy
- Conservative care
- Posterior cervical fusion
- Stenosis
- Stepwise approach
- Straightened spine
- Surgery

Abbreviations and Acronyms

ACDF: Anterior cervical discectomy and fusion
CSF: Cerebrospinal fluid
CSM: Cervical spondylotic myelopathy
DCI: Dynamic cervical implant
EMG: Electromyography
MEP: Motor evoked potential
MRI: Magnetic resonance imaging
NDI: Neck disability index
PCORI: Patient Centered Outcomes Research Institute
QOL: Quality of life
SAS: Subarachnoid space
SEP: Sensory evoked potential

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INTRODUCTION

Cervical spondylotic myelopathy (CSM) is the most common progressive degenerative disease of the spine in the geriatric population, leading to a high social and economic burden.¹⁻³ The radiologic evidence of CSM is reported in more than 50% of middle-aged patients, whereas only 10% of patients have clinical cord or root compression.⁴ CSM is defined as a part of a spectrum of cervical spine degeneration ranging from neck pain to radiculopathy or myelopathy. CSM is a complex neurosurgical entity that requires

■ **OBJECTIVE:** Cervical spondylotic myelopathy (CSM) is the most common progressive degenerative disease of the spine in the geriatric population. The aim of the current review is to provide an evidence-based stepwise surgical approach to CSM according to the recent literature.

■ **METHODS:** We searched for evidence regarding the surgical approach to CSM in medical databases with articles dated from 1985 to 2016.

■ **RESULTS:** In patients with effective cervical lordosis (fewer than 3 levels of ventral disease), anterior cervical discectomy and fusion (ACDF) or arthroplasty is preferred. Patients with more than 3 levels of compression are generally treated by laminoplasty, especially with preserved lordotic curvature. In patients with straightened spine who have less than 3 involved levels, ACDF with a plate is recommended, whereas patients with more than 3 involved levels with instability should undergo posterior decompression and fusion. In young patients who have a stable cervical spine, laminoplasty is recommended and in old patients with ankylosed spine, only laminectomy should be performed. Patients with mild cervical kyphosis (kyphotic angle $\leq 10^\circ$) should be managed in the same way as patients with straightened spine. However, in severe kyphosis, cervical traction is recommended. If the kyphosis is reducible, further posterior decompression and fusion is adequate. In patients with irreducible kyphosis, if the number of involved levels is less than 2, ACDF is adequate, but if it is more than 2 levels, anterior cervical corpectomy and fusion should be performed using cervical magnetic resonance imaging for evaluation of the patency of the subarachnoid space (SAS). With patent SAS, only posterior fusion is adequate, whereas in closed SAS, posterior decompression with posterior fusion is required. These approaches are based on the most recent evidence.

■ **CONCLUSIONS:** This article provides a stepwise evidence-based surgical approach for the management and treatment of patients with CSM.

various operative and nonoperative managements.^{5,7} Previous systematic review has shown that low levels of evidence support the role of nonoperative management in mild CSM. In those with moderate to severe CSM, nonoperative management is prohibited⁷ because this option has been shown to have outcomes inferior to those of surgery.⁸ Given the unpredictably progressive nature of cervical myelopathy, the indications for nonoperative management are ostensibly limited.^{7,8} Based on results from a systematic review, approximately 20%–60% of patients with symptomatic and radiologic features of CSM deteriorate over time if not

treated surgically.⁹ Therefore, surgery remains the mainstay of treatment in patients with CSM. In the past decade, our understanding of the biomechanics of the spine has improved along with advances in spinal instrumentation and this has led to significant changes in the surgical management of CSM. Preservation or improvement of neurologic function, correction of sagittal or coronal deformity, and maintaining cervical spine stability are the main aims of surgical intervention. The choice of surgical intervention in CSM mainly depends on clinical condition and the surgeon's choice. The choice of operative procedure should take into

consideration the individual patient's clinical and radiologic characteristics, age, comorbidities, lifestyle (eg, smoking), procedure-specific risks, and the experience and comfort level of the surgeon with various surgical procedures. Studies, including the AOSpine International multicenter prospective study, have also shown that most spine surgeons prefer the anterior approach in 51%–60% of cases, the posterior approach in about 35% of cases, and a combined approach in the remainder.^{10,11} The anterior approach appears to be more suitable when the diseases of the anterior involve only 1 or 2 vertebral body levels, whereas if more than 2 levels are involved, a posterior approach is generally used clinically.¹² A systematic review of the literature showed that, for both effectiveness and safety, there was no clear advantage to either an anterior surgical approach or a posterior surgical approach when treating patients with multilevel CSM, but the overall strength of the evidence was low.¹³ There is no consensus among experts about the best way to perform the surgery to ease CSM. Recently, some researchers have conducted the PCORI (Patient Centered Outcomes Research Institute) study into CSM to find the best surgical method, but their findings have not yet been published.¹⁴ Although it is generally agreed that surgical intervention positively affects the prognosis of CSM, the decision algorithm for the selection of the most appropriate surgical technique is complex. Several studies have addressed the issue extensively,^{6,8,15-17} but none of them provided a stepwise practical approach for surgical management of CSM. The aim of the current review is to provide an evidence-based stepwise surgical approach to CSM according to the recent literature.

EPIDEMIOLOGY

CSM is considered to be the most common degenerative disease of the spinal column in patients older than 55 years.^{3,4} Age and comorbid conditions, such as hypertension, lung disease, diabetes, and obesity, as predictors of adverse surgical events are also important factors in choosing an appropriate surgical approach.¹⁸ Boakye et al.¹⁸ showed that in patients with CSM undergoing anterior cervical discectomy and fusion (ACDF), age is the most important indicator of the outcome. It is clearly shown that the degree of cervical lordosis increases with

age and the increase in the lordosis is significantly higher in women compared with men (-25 ± 16 vs. -22 ± 13 , respectively).¹⁹ Although the disease is common and associated with high socioeconomic burden, a recent meta-analysis¹ reported that the literature did not include any article reporting incidence or prevalence of CSM. According to this study,¹ the annual incidence of CSM was 1.6 per 100,000 inhabitants based on the number of patients who underwent the operation and those who were screened in outpatient clinics. The reported mean age was 62.1 ± 10.6 years (range, 34.5–80.9 years) with a male predominance (52.5%).¹ According to some studies,^{20,21} the prevalence of CSM accounts for 10%–15% of cervical spondylosis. A national cohort study in Taiwan⁴ reported that the overall incidence of CSM-related hospitalization is 4.04 per 100,000 person-years. Men and older patients had a higher incidence of CSM.⁴ This study reported that the incidence of spinal cord injury in those with CSM is 12.33 per 1000 person-years,⁴ which is extremely high compared with the general population (0.13 per 1000 person-years).²² Another recent study in England³ also reported a male/female ratio of approximately 2.7:1, with an average age of 63.8 years at diagnosis. Multilevel disease was seen in most patients, with C5–C6 being the most commonly affected level. In Rochester, the average annual age-adjusted incidence rates per 100,000 populations were 83.2 for the total, 107.3 for males, and 63.5 for females. The age-specific annual incidence rate per 100,000 population reached a peak of 202.9 for the age-group 50–54 years.²³ The prevalence of CSM in Italy was also reported to be 3.5 per 1000 inhabitants, which increased to a peak at age 50–59 years, and decreased thereafter. The age-specific prevalence was consistently higher in women, contrary to other reports.²⁴

PATHOPHYSIOLOGY AND NATURAL COURSE

CSM is considered to be the result of both static and dynamic mechanical factors that compress the cord, resulting in myelopathy.²⁵ Static mechanical factors refer to structural abnormalities and degenerative spondylosis changes of the cervical spinal column such as osteophyte and spur formations, ossification of the posterior longitudinal

ligament, ligamentum flavum hypertrophy, and kyphosis and subluxation of the cervical spine, which result in physical narrowing of the spinal canal or direct compression of the cervical spinal cord.^{17,26,27} Dynamic mechanical factors refer to diseases associated with cervical motion (flexion and extension). Dynamic factors result from static factors that have previously narrowed the cervical canal. Flexion and extension of the stenotic cervical canal lead to compression of the spinal cord toward the osteophytes and hypertrophied ligamentum flavum, respectively.²⁸ These continuous and chronic microtraumas along with ischemia lead to myelopathy.

Although several studies have investigated the natural history of untreated CSM, the subject still remains unclear.^{9,29-31} A recent meta-analysis of the literature showed that 20%–60% of patients would deteriorate neurologically over time without surgical intervention (moderate strength of evidence).⁹ This study also indicated that there is low strength of evidence indicating that the area of circumferential compression is associated with deteriorating neurologic symptoms.⁹ According to the results of several studies that evaluated the outcome of nonoperative management of CSM,²⁹⁻³¹ it can be concluded that even in patients with mild CSM, surgery should be recommended. Even patients with mild CSM show a progressive course, especially those who are older than 65 years. This is because chronic compression of the spinal cord results in progressive neural cell loss after apoptosis, neuroinflammation, and vascular disruption.^{30,32} Those with mild CSM should be consulted regarding the natural course of the disease and surgery should be recommended.

NEUROPHYSIOLOGIC FINDINGS

CSM has a variable course and different possible treatment strategies. To choose the best treatment strategy, patients with CSM must be evaluated with neuroimaging and neurophysiology.^{33,34} The neurophysiologic evaluation often includes electromyography (EMG), electro-neurography, and evoked potentials.^{33,35} EMG performed with needle electrodes is the oldest method for diagnosing nerve root compression and anterior horn cell syndromes and is claimed to have no false-

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