

Editorial

Surgical management of cervical degenerative disease: the evidence related to indications, impact, and outcome

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In this special edition of *Journal of Neurosurgery: Spine*, a series of systematic reviews sponsored by the Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons/Congress of Neurological Surgeons is presented. This collection of comprehensive reviews summarizes the medical evidence related to the surgical management of cervical degenerative disc disease. Several of the key conclusions are discussed in this introduction to the issue:

- There is Class II evidence to suggest that the clinical condition remains stable when observed over a 3-year period in patients with mild-to-moderate cervical spondylotic myelopathy (CSM) and age younger than 75 years.
- There is consistent Class III evidence that the duration of symptoms, and possibly advancing age, negatively affect outcome in patients with CSM.
- There is Class II evidence that somatosensory evoked potentials have prognostic value in patients with CSM. There is Class I evidence to show that electromyographic abnormalities (as well as the presence of radiculopathy) are predictive of the development of myelopathy in minimally symptomatic patients with cervical stenosis and spinal cord compression.
- The presence of a low signal on T1-weighted images, high signal on T2-weighted images, and the presence of cord atrophy on preoperative MR images are indicators of a poor outcome in CSM.
- There is Class III evidence to show that anterior or posterior surgical approaches that effectively decompress the cervical canal promote short-term improvements in outcome. However, there appears to be a risk of late kyphosis in patients who undergo laminectomy or anterior cervical discectomy alone compared with patients in whom decompression is combined with fusion.
- The use of BMP-2 is discouraged for anterior cervical spine surgery based on evidence suggesting that the risks outweigh any potential benefits.

Finally, in patients with symptomatic cervical radiculopathy, arthroplasty achieves outcomes that are equivalent to anterior cervical decompression and fusion, although evidence for superiority is lacking.

Further prospective longitudinal data are required to better define the role and timing of surgical intervention in CSM and to determine the appropriate use of cervical arthroplasty in the management of symptomatic cervical degenerative disc disease. (DOI: 10.3171/2009.5.SPINE09210)

KEY WORDS • cervical degenerative disease • introduction • evidence

CERVICAL degenerative disease is the most common cause of acquired disability in patients over the age of 50.^{1,10} In spite of this, there is a lack of firm evidence regarding the surgical options and prognostic factors associated with its management.³ In this issue of the *Journal of Neurosurgery: Spine*, a consensus group representing the Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and Congress of Neurological Surgeons has addressed this vital knowledge gap, and has critically

Abbreviations used in this paper: ACD = anterior cervical discectomy; ACDF = anterior cervical discectomy with fusion; CSM = cervical spondylotic myelopathy; EMG = electromyography; mJOA = modified Japanese Orthopaedic Association.

summarized and synthesized the current evidence related to the natural history, indications for treatment, management options, and the optimal ways to assess clinical and radiological outcomes. Using evidence-based approaches with meticulous systematic literature reviews, the following 17 articles synthesize the current understanding related to cervical degenerative disc disease. In this editorial, we summarize and comment on some of the key points addressed in these systematic reviews. We focus in particular on the indications for and outcomes of surgery in patients with cervical myelopathy and radiculopathy, as well as the key techniques for assessing outcomes related to cervical degenerative disc disease, and factors associated with prognosis.

Cervical Spondylotic Myelopathy

Cervical spondylotic myelopathy is the most common cause of spinal cord dysfunction in adults. The lack of clear guidelines on the indications and timing of surgery in patients with CSM is mainly related to the lack of large, prospective studies using consistent, validated outcome measures. This lack of Class I and II evidence is further compounded by the inherent heterogeneity of this patient population. A current effort by AOSpine North America is seeking to address this knowledge gap with regard to the management of CSM. The results of this prospective, multicenter study in 300 patients are expected to be available in the next year.⁴

The natural history of CSM is effectively summarized in this issue by Matz et al.¹² It appears that there is Class II (and possibly Class I) evidence to guide treatment options in patients with mild CSM (defined as a score of ≥ 12 on the mJOA scale). There is evidence to suggest that the clinical condition remains stable when observed over a 3-year period in this group of patients younger than 75 years of age.⁷ However, it bears noting that patients with apparently mild myelopathy may in fact harbor considerable functional impairment, and that clinical stability may not be equivalent to a good clinical outcome. Hence, authors of future studies may need to use complementary outcome measures including the Short Form-36 and Neck Disability Index. Moreover, the definition of mild myelopathy is itself a subject of some debate. For example, in the AOSpine North America study, mild CSM is defined more strictly as a myelopathic deficit associated with an mJOA scale score ≥ 15 and it is noteworthy that surgical decompression may be associated with improved clinical outcomes in this subgroup of patients.

In a complementary article, Holly et al.⁶ efficiently summarized our current knowledge of the clinical prognostic indicators of surgical outcomes in CSM. There is consistent Class III evidence that the duration of symptoms, and possibly advancing age, negatively affect outcome. In a separate paper, Holly and colleagues further described the functional outcome assessments used in the setting of CSM. Multidomain measures such as the Myelopathy Disability Index, mJOA (or JOA), the Short Form-36, and quantitative gait analysis were found to be valid, reliable, and responsive in patients with CSM. There is clearly a need for further validation of outcome measures used in CSM, as the gold standard has yet to be defined. Another commonly used approach is assessment of patient satisfaction scores, which remain an important indicator of patient ultimate outcome; however, measuring patient satisfaction in a standardized fashion also remains a challenge.

Predictive Value of Electrophysiology and Imaging in CSM

The use of electrophysiological assessments and radiological studies to guide prognosis and outcome is an emerging area of interest. Holly et al.,⁶ in their excellent summary of the clinical prognostic indicators of surgical outcomes in CSM, showed that there is Class II evidence

that somatosensory evoked potentials, and in particular recordings obtained following stimulation of the median nerve, have prognostic power. The use of EMGs has not been convincingly shown to be predictive of recovery in either myelopathy or radiculopathy, and there is conflicting Class III evidence regarding its predictive power (see the article by Mummaneni et al.¹⁵ in this issue). However, EMG or clinical evidence of nerve root impairment (that is, symptomatic radiculopathy) have been shown to be predictive of developing myelopathy in otherwise asymptomatic patients (mJOA scale Score 18) with cervical stenosis and cord compression. This finding, summarized by Matz et al.¹² in their article on the natural history of CSM, is based on Class I evidence showing the predictive power of electrophysiological assessments in the development of myelopathy.²

There is controversy and a lack of consensus related to the clinical value of intraoperative evoked potential monitoring in the surgical management of CSM, as summarized by Resnick et al.¹⁶ in this issue of *JNS: Spine*. In particular, the lack of specificity in the recordings and the lack of clarity as to whether electrophysiological changes influence a clear change in the surgical approach or plan makes many studies of intraoperative monitoring in patients with cervical spine disorders difficult to interpret. However, in one of the largest recent series, 1055 consecutive patients underwent cervical spine surgery with multimodality neurophysiological intraoperative monitoring with EMG, somatosensory evoked potentials, and the selective use of muscle evoked potentials. This strategy was reported to be helpful in predicting and possibly preventing neurological injury.⁹ It is acknowledged, however, that there is no Class I evidence to support the value of electrophysiological studies in improving outcome.

There has been a surge of recent studies examining various radiological factors, in particular MR imaging, as indicators of function and outcome. The authors of earlier studies using less powerful magnets lacked the resolution required for the assessment of cord signal changes. Mummaneni et al.¹⁵ looked at preoperative patient selection by MR imaging and CT (and EMG) and tackled the question: do these tests predict surgical outcome? There appears to be a consensus that the presence of a low signal on preoperative T1-weighted images, multisegment and focal high signal on T2-weighted images, and the presence of cord atrophy on MR images are indicators of a poor outcome. These changes occur late in the evolution of CSM, and the challenge remains to find indicators that have prognostic power in patients with mild myelopathy or in those with cervical stenosis and minimal clinical symptoms.

Controversies in Surgical Approaches for Symptomatic Cervical Degenerative Disc Disease

Posterior Approaches

There is a lack of Class I or II evidence to support any particular surgical approach in patients with CSM. The consensus, using Class III evidence as a guide, is that all surgical approaches which effectively decompress

the cervical canal are effective with regard to achieving short-term improvements in outcome. These include laminectomy, laminoplasty, laminectomy with arthrodesis, and anterior decompression. Mummaneni et al.¹⁴ critically examined cervical surgical techniques in general for CSM, Ryken and associates¹⁷ looked at the efficacy of laminectomy alone, and Matz et al.¹¹ evaluated the role of laminoplasty in the treatment of CSM. It is evident that at least in the short term, laminectomy alone has an efficacy similar to that of laminoplasty and arthrodesis. However, there appears to be a risk of late kyphosis in a subset of patients who undergo laminectomy alone. Other less destabilizing operations in the cervical spine, such as laminoforaminotomy, are effective in the treatment of radiculopathy associated with spondylosis and disc herniation. These operative options are nicely reviewed in this issue by Heary et al.⁵

Anterior Approaches

Matz and colleagues¹³ concluded that anterior surgery improves radicular symptoms more rapidly than conservative modalities of treatment with possible improvements in clinical function as well. However, there is still no Class I or II evidence supporting the conclusion that surgery is superior in the long-term compared with non-operative management (that is, the use of a cervical collar and/or physiotherapy). The treatment algorithm should thus be patient-driven, and should take into consideration the skills and resources of the treating team. For example, in units where the health care system facilitates the early assessment of patients, or for patients where even short-term disability and time off work is not acceptable, surgical options become more attractive. Also, as summarized by the same authors, the evidence shows that there is no definite superiority of ACD, ACD with fusion or instrumentation, or corpectomy with plating. It is apparent that in Level 1 disease, there is Class II evidence that ACD and ACDF are equally effective in terms of long-term outcome. Mirroring arthrodesis in posterior surgery, ACDF achieves a more rapid reduction in neck pain and radiculopathy, and reduces the risk of kyphosis.

For multiple level anterior decompressions, there is compelling evidence that ACDF is superior to ACD. The addition of plating improves arm pain compared with ACDF alone and reduces the risk of pseudarthrosis, but no convincing evidence is available to suggest that the addition of instrumentation results in improvements in long-term outcome. Regarding the techniques to achieve arthrodesis, the article by Ryken et al.¹⁸ concluded that there appears to be equivalency regarding the use of harvested iliac crest bone, allograft, polyetheretherketone, and titanium in anterior fusion. The presence of readily available technology with very high fusion rates should surely steer us away from the widespread use of iliac bone graft, and its associated problems, in the future.

The use of BMP-2 in the cervical spine is discouraged based on the current evidence suggesting that the risks of this osteobiologic outweigh any potential benefits, especially for anterior approaches. In the event of the development of pseudarthrosis, Kaiser et al.⁸ report that the current evidence weakly supports (Class III) surgical cor-

rection of pseudarthrosis by either anterior and posterior approaches, with a higher rate of fusion seen in the latter group but no definite difference in outcome. Finally, the use of arthroplasty in the management of cervical degenerative disc disease continues to evoke controversy. The balance of the current literature suggests that, in patients with symptomatic cervical radiculopathy, arthroplasty has equivalent effectiveness and outcome compared with ACDF. However, there still is no Class I evidence to support the superiority of cervical artificial disc replacement over ACDF.

Conclusions

Cervical spondylotic myelopathy is a challenging condition. A large number of patients are severely, and in our opinion, unnecessarily disabled by this preventable condition. Several key messages emerge from the excellent systematic reviews in this edition of *JNS: Spine*. It is clear that the duration of symptoms has a negative impact on prognosis in patients with CSM, suggesting that early surgery in myelopathic patients is probably advisable. Furthermore, the method of decompression appears unimportant as long as the presence of kyphosis and the maximal focus of compression are considered. However, there remains a paucity of Class I or II data which assess the role and timing of surgical intervention in patients with CSM. The lack of such prospective, controlled data represents a key knowledge gap which should be addressed by the recent AOSpine North America study to a greater extent. Emerging new technologies in arthrodesis and biological agents are not fully proven but remain areas of intense investigation. Finally, rigorous longitudinal data with long-term follow-up are required to define the role of cervical arthroplasty in the management of symptomatic cervical degenerative disc disease.

Disclosure

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