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Surgical Outcomes of Cervical Spondylotic Myelopathy: A Prospective Study

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Abstract

Aims and Objective: Cervical spondylotic myelopathy (CSM) has become a prevalent cause of spinal cord dysfunction among the aging population worldwide. Although great strides have been made in spine surgery in past decades, the optimal timing and surgical strategy to treat CSM have remained controversial. In this article the authors aimed to analyse the current trends in studies of CSM and to summarize the recent advances of surgical techniques in its treatment.

Materials and Methods: To prospectively assess and compare the pre- and post-operative clinical and functional status of patients with CSM using the modified Japanese Orthopaedic Association (mJOA) scores and the modified Myelopathy Disability Index (mMDI) scores at baseline, 3, 6- and 12-monthspost-surgery. The following factors were evaluated: age at presentation; gender; cigarette smoking; duration of symptoms; presence of T2WI cord signal cord abnormality on MRI. We also assessed recovery / progression of individual aspects of the mJOA: upper limb; lower limb; sensation and sphincters in both groups. Severity of CSM was assessed as mild if baseline mJOA score was ≥ 12 and moderate-severe if baseline mJOA score was < 12.

Results: Surgery was associated with significant improvement in clinical recovery as assessed by mJOA scores at 3, 6 and 12 months post-operatively. Upper limb function improved after surgery as assessed by the upper limb component of the mJOA score at 3, 6 and 12 months. Lower limb function also improved significantly as assessed by the lower limb recovery scores at 3, 6 and 12 months. Sensation and sphincter function did not improve after surgery. There was significant functional recovery as assessed by mMDI scores at 3, 6 and 12 months after surgery.

Conclusions: Patients with CSM benefit from surgical decompression regardless of baseline severity, with significant clinical and functional improvement noted at least 12 months post-operatively. Upper and lower limb function improves significantly, but sensation and sphincter function do not recover. The occurrence of intra-operative complications results in a worse outcome and this negative effect is still seen 12 months post-operatively. Patients who are managed non-operatively do not show significant improvement and 42% have some clinical deterioration at 12 months. The surgical management of CSM is evolving continuously toward early and anterior approaches. More prospective investigations on the optimal timing and choices of surgery are therefore needed.

Keywords: Cervical spondylotic myelopathy; Modified Japanese Orthopaedic Association; Modified Myelopathy Disability Index.

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Introduction

Cervical spondylotic myelopathy (CSM) is defined as a series of signs and symptoms that result in anatomical and physiological changes in the vertebral column, leading to spinal cord compression. The clinical symptoms are characterized by progressive deterioration of the spinal cord functions. Besides the signs and symptoms, for confirmation of the diagnosis, the patient must present spinal cord compression, proven by computed tomography, MRI or myelography, as well as radiographic evidence of spondylotic damage to the spinal cord.[1,2] In most cases, the natural progression occurs in bursts of exacerbation of symptoms followed by periods of stability. The clinical symptoms rarely improve; however, there have been reports of cases in which this period of stability was not present, and the patient's condition declined continuously and slowly. On the other hand, in a small number of cases, the progression may be acute and rapid.[3,4] The cause of CSM is not well-defined, but it is known that changes in the bones, ligaments and discs act as a trigger for progressive spinal cord degeneration, which leads to direct compression (dynamic or static), often associated with circulatory damage. Nearly all individuals, at around thirty years of age, present microscopic degeneration of the intervertebral discs.[5] In fact, it is believed that the whole process of spondylotic changes begins with disc dehydration, which is related to loss of proteoglycans, elasticity and disc material[6-8] as well as other biochemical changes involving the keratin and chondroitin sulfate.[2,9-11] These biomechanical changes in the discs result in reduced disc space, and this, together with the fact that the disc dehydration tends to herniate, leads to changes such as bone neoformation in the vertebral bodies, usually subsequently, causing anterior spinal cord compression.[7] Hypertrophy and calcification of the Yellow ligament occur[8], contributing to posterolateral spinal cord compression[7], but this mainly occurs with the posterior longitudinal ligament, exacerbating this compression. This ossified ligament becomes a thickened mass, which may be present at one level only, either in intermittent or continuous form, and in more severe cases, ossification of the dura mater also occurs, which can lead to the formation of fistulas of cerebrospinal fluid. Alongside this process, there is also facet joint hypertrophy and arthrosis of the intervertebral and zygapophysial joints, resulting in stenosis of the vertebral canal.[2]

In the Guidelines for the Surgical Management of Cervical Degenerative Disease, published in August 2009 in the Journal of Neurosurgery, Spine, Mummaneni et al.[12] looked at cervical surgical techniques for the treatment of cervical spondylotic myelopathy. They concluded that there are a variety of techniques, which may be used in the surgical treatment of CSM. These include anterior or posterior approaches to the cervical spine. Anterior approaches include Anterior Cervical Discectomy and Fusion (ACDF) and Anterior Cervical Corpectomy and Fusion (ACCF). Posterior techniques include laminoplasty, laminectomy and laminectomy with fusion. The anterior approach is favoured for CSM, particularly if the cord compression is primarily ventral, is localised to a single interspace or up to three interspaces, or there is associated kyphotic deformity requiring anterior cervical spinal realignment, reconstruction, internal fixation, and fusion. The posterior approach is used if the primary spinal cord compression is dorsal, or if more than 3 interspaces require decompression.

Several outcome measures are available to assess CSM. Both the mJOA and MDI scores were found to be valid and reliable measures for assessing CSM.[13] The JOA Score assesses 4 key areas: upper limb motor function (scored from 0 to 5); lower limb motor function (scored from 0 to 7); sensory abnormalities (scored from 0 to 3) and sphincter disturbances (scored from 0 to 3). Part of the original Japanese Orthopaedic Association scoring system as described by Hirabayashi et al.,[14] looked at the ability to feed oneself with chopsticks to assess upper limb motor function. This ability is culturally appropriate for the Japanese population, but is not widely applicable to other populations. Thus, the JOA was modified by Benzel et al.,[15] to enable it to be used in populations that do not use chopsticks routinely. The score ranges from 0 (worst function) to 18 (normal function).

In view of this, in this study we attempted to prospectively assess and compare the pre- and post-operative clinical status of patients with cervical spondylotic myelopathy (CSM), using the modified Japanese Orthopaedic Association (mJOA) scores at baseline, 3, 6- and 12- months post-surgery.

Materials and Methods

Subjects: Patients were recruited and selected with CSM and possible spinal cord disorders are referred to Neurosurgery or Neurology clinics to the Departments of Neurosurgery and Neurology of Andhra Medical College. Once the patient was diagnosed for cervical spondylotic myelopathy and also the patient met the eligibility and recruitment criteria of this study, such patients were briefed and requested to participate in the study.

Sample Size: This was a descriptive study, so no formula was needed to calculate the sample size, approximately 30 patients were planned to enrolled in both the groups. The key factor was whether the sample group was representative of the population being studied. Since consecutive patients in whom a diagnosis of CSM was made were recruited over a period of 2 years, the sample size was solely dependent on the rate of patients presenting with CSM. The length of sampling was fixed at 2 years, due to time constraints. Significant loss to follow-up was not expected, as participant follow-up is part of routine patient management.

All participants underwent assessment by a neurologist at baseline and were graded according to the mJOA scale as mild CSM (mJOA score ≥ 12) or moderate-severe CSM (mJOA score < 12). In keeping with current practice in the Department of Neurosurgery, of Andhra Medical College. All patients in whom a diagnosis of CSM was made, were offered surgical decompression, regardless of severity of CSM. In particular, participants with moderate-severe CSM were strongly encouraged to undergo surgery.

Participants with mild CSM who preferred non-operative management were given this option, as objectively measurable deterioration in function is rarely seen acutely in this group of patients. Non-operative management included cervical bracing with a hard collar, referral for physiotherapy and simple analgesia as needed.

Those participants who agreed to operative management (the surgical group) underwent surgical decompression by the neurosurgeons. These participants were then followed up at 3, 6 and 12 months post-operatively where the neurologists assessed mJOA and mMDI scores. A few participants also had follow-up scores at 24 months, however a minimum of 12 months follow up was obtained in all participants.

Participants who were offered, but declined operative management and participants who were deemed unfit for surgery (the non-surgical group) were also followed up at 3, 6 and 12 months where the neurologists assessed mJOA and mMDI scores. At any point during follow-up, the participants who declined surgery had the option to accept operative management and cross-over into the surgical group. A few participants in the non-operative group also had follow up scores at 24 months. However, a minimum of 12 months follow-up was obtained in all participants.

Both groups were assessed at baseline, and followed up at 3, 6, 12 (and in some 24) months using the mJOA and mMDI scores. Direct comparisons between the surgical and non-surgical groups was not thought to be possible, as we anticipated that the latter group would probably comprise those patients with mild CSM (single level disease with mild symptoms) who declined surgery, or patients with severe multi-level CSM in a poor clinical condition in whom the risk-benefit ratio would not justify major surgery. However, when doing the statistical analysis, the groups did not differ significantly, so comparison between the two groups was performed.

Statistical analysis: Data analysis was done by using SPSS Package version.Simple proportions, mean, standard deviation and Chi-square test was used. Chi-squaretest was used to find out the association between two groups. P value of less than 0.05is considered as statistically significant.

Result

Patient presented with onset of the pathological symptoms with degenerative processes of the spine, and progressively decreasing sensitivity and movements. Evolved to surgical treatment with placement of graft and prosthesis in the left anterolateral region of C4. Initially the lesion affected sensitivity, muscle strength, and range of movement (ROM) of the upper limbs, which subsequently progressed to include the lower limbs.

When comparing the above demographics between the surgical and non-surgical groups, the only statistically significant difference was age with a mean age of in the surgical and in the non-surgical group (p = 0.0127) (Table 1).

In the surgical group, those patients who had longer duration of symptoms, had a better outcome at 6 months. This effect was no longer evident at 12 months. In the non-surgical group, the duration of symptoms at time of presentation had no effect on outcome at 3, 6 or 12 months (Table 2).

Comparison of recovery / progression rates and actual mJOA and mMDI scores between the surgical and non-surgical groups did not show any significant differences in outcome between the two groups (Table 3).

Table 1: Showing the age, gender, smoking status, duration of symptoms, presence of T2WI cord signal abnormality on MRI, number of levels operated or affected and severity of CSM at baseline in the surgical and nonsurgical groups.

Characteristics		Surgical group (n=17)	Percentage	Non-surgical group (n=13)	Percentage
Age (in years)	Mean	56.8		64.2	
	Range	28-74		43-85	
Gender	Males	12	70.5	10	76.9
	Females	05	29.5	03	23.1
Smoking status	Smokers	08	47.05	09	69.23
	Non-smokers	09	52.09	04	30.07
Duration of symptoms	Average (months)	14		11	
	Range (months)	2-28		2-23	
T2WI cord signal abnormality on pre-op MRI	Yes	14	82.35	10	76.9
	No	03	17.65	03	23.1
Number of levels affected/ operated	1 Level	6	35.29	4	30.76
	2 Levels	6	35.29	6	46.15
	3 Levels	3	17.64	2	15.38
	4 Levels	2	11.76	1	7.69
Severity of CSM at baseline	Mild (mJOA≥12)	11	64.70	10	76.9
	Moderate-Severe (mJOA<12)	06	35.29	03	23.1

Table 2: Shows the effect of duration of symptoms on recovery / progression rates by mJOA at 3, 6 and 12 months in the surgical and non-surgical groups.

RR / PR	Surgical group (n=17)		Non-surgical group (n=13)	
	Result	p value	Result	p value
At 3 months	No difference	p = 0.0759	No difference	p = 0.5360
At 6 months	Better recovery in those with longer duration	p = 0.0221	No difference	p = 0.5834
At 12 months	No difference	p = 2569	No difference	p = 0.8845

RR = Recovery Rate, PR = Progression Rate

Table 3: Comparison of actual mJOA and mMDI scores between recovery / progression rates in the surgical and non-surgical groups.

Parameter	Results	p Value
mJOA at 3 months	No difference between groups	0.2135
mJOA at 6 months	No difference between groups	0.4586
mJOA at 12 months	Non-surgical group had better scores	0.4123
UL recovery at 3 months	No difference between groups	0.3268
UL recovery at 6 months	No difference between groups	0.3369
UL recovery at 12 months	No difference between groups	0.4571
LL recovery at 3 months	No difference between groups	0.5231
LL recovery at 6 months	Non-surgical group had better scores	0.5521
LL recovery at 12 months	No difference between groups	0.6031
Sensation at 3 months	No difference between groups	0.6011
Sensation at 6 months	No difference between groups	0.7423
Sensation at 12 months	No difference between groups	0.2318
Sphincters at 3 months	No difference between groups	0.2238
Sphincters at 6 months	No difference between groups	0.3361
Sphincters at 12 months	No difference between groups	0.3265
mMDI at 3 months	No difference between groups	0.4569
mMDI at 6 months	Non-surgical group had better scores	0.2013
mMDI at 12 months	No difference between groups	0.3022

Discussion

When the study was planned, we anticipated that direct comparisons between the surgical and non-surgical groups would not be possible as we expected the latter group to consist of patients with either mild CSM who refuse surgery as their disease does not significantly impact their lifestyle; or patients with severe debilitating CSM who are bed-bound in whom we thought surgery would not be of benefit to the patient. There is only one patient with moderate-severe CSM who was offered surgery but declined. The aim is to assess outcomes in the surgical group after surgical decompression and follow up the non-surgical group in order to obtain an idea of the natural history in our patients. However, when comparing the surgical and non-surgical groups, we find that the only statistically significant difference is age, with the non-surgical group having a mean age 7.1 years older than the surgical group.

Most of the reports on CSM indicated a decline in patients' neurological status, including hand dexterity, gait disturbance, and sphincter functions. However, the patterns of deterioration could vary, from a rapid onset of symptoms followed by long periods of remission, to a slow and gradual decline or a stepwise decline. The speed of the decline could depend on the related pathologies, the cause of onset, timing of the diagnoses, and simply the duration of observation.

The negative effect of smoking on clinical recovery after surgery for cervical myelopathy has been documented.[16] This is presumed to be on the basis of an increased rate of pseudoarthrosis in smokers. While this effect is seen after posterolateral lumbar spine grafting, the same effect has not been conclusively proven in the cervical spine.

Findings in our study show that patients who have T2-signal change on baseline MRI have significantly higher probability of having moderate-severe as opposed to mild CSM. This however has no effect on outcome, as there is no difference in recovery / progression rates in those patients who have, vs. those who do not have, signal change. This is true for both the surgical and non-surgical groups. Findings in our study show that patients who have T2WI cord signal abnormality on baseline

MRI have significantly higher probability of having moderate-severe as opposed to mild CSM. This however has no effect on outcome, as there is no difference in recovery / progression rates in those patients who have, vs. those who do not have, signal change. This is true for both the surgical and nonsurgical groups.

However, when analysing the literature, a recent systematic review concluded that there is controversy in the literature regarding the ability of MRI to predict surgical outcome .[17,18] Some studies have found that T2WI cord signal hyperintensity MRI is not a prognostic factor after surgery and that this finding on MRI indicates reversible changes on MRI such as oedema and ischaemia. T1 weighted image cord signal hypointensity however, is more suggestive of chronic, irreversible changes such as necrosis, syrinx formation or cavitation and these may be associated with a worse prognosis after surgery. There are five reported relevant studies, but the evidence for this is low.[15] In addition, the number of levels where T2- signal change is evident, the height of signal intensity on T2, the ratio of T2-T1 signal change, the ratio of T2 normal signal-to-high signal areas and the transverse area of the spinal canal dimensions at the affected level are MRI factors, which have all been considered, to predict outcome in patients undergoing surgery for CSM. The level of evidence to support any MRI finding as a predictor of outcome after surgery is low at best.

Duration of symptoms at time of presentation is obtained from the history taken when the patient is first assessed. This is taken as the time at which the patient first noted symptoms referable to the cervical myelopathy. These include, but are not limited to: limb stiffness, limb weakness, limb pain, altered limb sensation, diminished manual dexterity, and altered gait. Symptoms referable to cervical spondylosis (neck stiffness, neck pain) were not used as the sole markers of onset of symptoms.

This is contrary to findings in literature where patients with longer duration of symptoms do worse than patients who present earlier.[13,15,17-19] Most studies focus on the 12-month period as the clinically relevant threshold.[15] The findings in our study may indicate a more indolent or insidious course in those patients who have longer duration of symptoms. Because their symptoms progress slowly, they seek medical attention later as they presumably have a milder form of disease.

In the surgical group, there is statistically significant improvement in overall clinical and functional recovery as assessed by mJOA and mMDI scores. This improvement is noted at 3, 6 and 12 months after surgery. When assessing individual components of the mJOA score, upper limb and lower limb recovery both improve from 3 months with further improvement at 6 and 12 months after surgery. Sensation and sphincter function do not show any significant improvement after surgery. This is useful information when counselling patients prior to decompressive surgery for CSM because we can advise that patients can expect improvement in upper and lower limb function but sensation and sphincter function do not improve.

Cheung et al.[20] showed similar results with upper limb recovery being the best followed by lower limb and poor recovery of sphincters. However, they found that recovery reached statistical significance at 3 months and plateaued at 6 months. We find continued recovery at 12 months post-surgery. Fehlings et al.[21] in their recent prospective multi-centre study on the efficacy and safety of surgical decompression in patients with CSM, conclude that surgical decompression is associated with improvement in functional, disability-related, and quality-of-life outcomes at one year of follow-up for all disease severity categories.

The findings are reflective of our patient population and are a more useful guide when counselling patients with CSM regarding expected outcomes after surgery and natural history of the disease. This has to, however, be individualised as other factors such as age, duration of symptoms, severity of CSM, number of levels affected and presence of signal change on baseline MRI also have to be considered.

Conclusions

Surgery is associated with statistically significant improvement in clinical recovery as assessed by mJOA scores at 3, 6 and 12 months post-operatively. The pattern of recovery that can be expected is predictable in that upper limb and lower limb function show statistically significant recovery as assessed by the upper and lower limb components of the mJOA scores respectively. Sensation and sphincter function do not recover after surgical decompression in patients with CSM. There is statistically significant functional recovery after surgical decompression in patients with CSM as assessed by mMDI scores at 3, 6 and 12 months after surgery.

When assessing factors that can predict outcome: age, gender, smoking status and duration of symptoms have no effect on outcome. The presence of T2WI cord signal abnormality on baseline MRI is associated with statistically significant probability of having moderate-severe CSM at presentation, but this in itself, does not confer a worse outcome.

Limitations: The sample size is small with only 13 patients in the non-surgical group. A number of potential patients are excluded from the study because pre-operative mJOA and mMDI scores were not performed. The natural history of these patients cannot be fully elucidated. Furthermore, direct comparisons between the surgical and non-surgical groups are not beneficial.

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