Original Article

Prediction of surgical outcome in compressive cervical myelopathy: A novel clinicoradiological prognostic score

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Abstract

Context: Preoperative severity of myelopathy, age, and duration of symptoms have been shown to be highly predictive of the outcome in compressive cervical myelopathy (CCM). The role of radiological parameters is still controversial. **Aims:** Define the prognostic factors in CCM and formulate a prognostic score to predict the outcome following surgery in CCM. **Settings and Design:** Retrospective. **Materials and Methods:** This study included 78 consecutive patients with CCM treated surgically. The modified Japanese Orthopaedic Association (mJOA) scale was used to quantify severity of myelopathy at admission and at 12-month follow-up. The outcome was defined as "good" if the patient had mJOA score ≥16 and "poor" if the score was <16. Age, sex, duration of symptoms, comorbidities, intrinsic hand muscle wasting (IHMW), diagnosis, surgical technique, Torg ratio, instability on dynamic radiographs, and magnetic resonance imaging (MRI) signal intensity changes were assessed. **Statistics:** Statistical Package for the Social Sciences (SPSS) (version 20.0) was used for statistical analysis. The association was assessed amongst variables using logistic regression analysis. Parameters having a statistically significant correlation with the outcome were included in formulating a prognostic score. **Results:** Severity of myelopathy, IHMW, age, duration, diabetes, and instability on radiographs were predictive of the outcome with a P value <0.01. Genders, diagnosis, surgical procedure, Torg ratio, and intensity changes on MRI were not significantly related to the outcome. A 8-point scoring system was devised incorporating the significant clinicoradiological parameters, and it was found that nearly all patients (97.82%) with a score below 5 had good outcome and all patients (100%) with a score above 5 had poor outcome. The outcome is difficult to predict with a score of 5. **Conclusions:** Clinical parameters are better predictors of the outcome as compared to radiological findings, following surgery in CCM. A simple scoring system based on clinicoradiological parameters is suggested in this paper to predict the outcome following surgery in cases of CCM.

Key words: Compressive cervical myelopathy (CCM), predictors of the outcome, score, surgical outcome

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INTRODUCTION

Compressive cervical myelopathy (CCM) is a common cause of spinal cord dysfunction worldwide. It encompasses a wide variety of etiologies, the most common being spondylotic myelopathy. The other causes include disc herniation, congenital stenosis, PLL hypertrophy and ossification, ligamentum flavum thickening, and ossification. Emerging evidences suggest that patients improve after surgical decompression; however, the clinical and radiological parameters that predict the outcome are still uncertain.[1]

The aim of the study is to try and identify parameters, which may help in predicting the outcome after surgical decompression. Though it has been suggested that magnetic resonance imaging (MRI) can predict the level of functional recovery, the evidence is not very strong.[2-5] Moreover, as it has been seen with lumbar spine, the degree of cervical cord compression may not correlate with neurological status of the patients. We tried to evaluate preoperative clinical signs and symptoms of the patients and correlated them with the functional outcomes of the patient after surgery.

MATERIALS AND METHODS

A total of 78 patients with CCM who underwent surgery from Jan 2008 to June 2013 were retrospectively reviewed. The patients with CCM who were operated (decompression with/without instrumented fusion) in our institute were included. Only patients with a minimum 12-month follow-up were included in the study. CCM was defined as a constellation of symptoms (numb clumsy hand, gait impairment, paraesthesia, and bowel/bladder impairment) and signs (motor and sensory deficit, atrophy of hand intrinsics, hyperreflexia, Hoffman sign, upgoing plantar, lower limb spasticity, and broad/unsteady gait) supported by radiological findings. The patients with asymptomatic cord compression, pure radiculopathy, previous cervical spine surgery, rheumatoid arthritis, ankylosing spondylitis were excluded from the study.

Preoperative assessment
- Demographic profile: Age, sex.
- Diagnosis: Spondylotic myelopathy/congenital stenosis/posterior longitudinal ligament (PLL) hypertrophy and ossification/ligamentum flavum thickening and ossification.
- Comorbidities: Diabetes, hypothyroidism, etc.
- Duration of symptoms in months.
- Functional status: Calculated using Benzel's modified Japanese Orthopaedic Association (mJOA) score.
- Bowel/bladder involvement: Yes or No.
- Radiological assessment.
  - Torg–Pavlov ratio on lateral cervical spine x-ray.
  - Instability on flexion and extension x-ray of cervical spine.
  - Intensity changes on T2 weighted (T2W) MRI images: Hyperintense signal changes within the cord were noted by a spine surgeon and lead surgeon in all the cases (2nd author).

Assessments at follow-up
The 12-month time frame was chosen because it represents a typical time period of optimum recovery from myelopathy:
- Only patients with a minimum follow-up of 1 year were included.
- Functional status evaluated using Benzel's mJOA score.
- Outcome evaluation: The functional outcome was divided into two categories based on mJOA score at latest follow-up.[6]
  - mJOA score ≥16: good outcome.
  - mJOA score <16: poor outcome.

Statistical analysis and formulation of clinicoradiological score
Statistical Package for the Social Sciences (SPSS) Statistics (version 20.0) (SPSS-Inc., Chicago, IL) was used for statistical analysis. Descriptive statistics were calculated for all variables with distributions assessed for normality. Association was assessed amongst variables using logistic regression analysis. Variables that showed significance at $P < 0.05$ were considered statistically significant. The variables, which showed a statistically significant correlation to the outcome, were included in making the prognostic score.

RESULTS

The study included 15 females and 63 males. Table 1 presents demographic and diagnostic characteristics of the patients. The mean mJOA score improved from 11.44 ± 3.03 to 14.79 ± 3.02 at 12 months. The anterior approach (discectomy/corpectomy with anterior cervical plating and fusion) was done in 41 patients and posterior approach (laminectomy and fusion) was done in 37 patients. Of these 37 patients, lateral mass fixation was done in 7 patients.

Intraoperative complication in the form of CSF leakage was seen in one patient who underwent corpectomy and anterior cervical plating. The leak stopped spontaneously without the need for addition surgery. One patient who underwent laminectomy had transient C5 paresis, which recovered spontaneously.

We had two long-term complications. One patient had delayed esophageal perforation 15 months following the surgery that was managed by implant removal and feeding by nasogastric tube for 6 weeks. The esophageal perforation healed at 6 weeks. One patient has implant failure in the form of backing out of the anterior cervical plate. Implant removal was done for the same.

Correlation of demographic, clinical, and radiological parameters to the outcome
The association between demographic, clinical, and radiological parameters to the outcome following surgery was assessed using logistic regression analysis. The results are shown in Table 2.

Formulation of prognostic score
After correlation of demographic, clinical, and radiological parameters to the functional outcome, it was found that only

Table 1: Characteristics of patients included in the series

Characteristics	Number of patients (%)
Total	78
Mean duration of symptoms	8.21 months
Duration	
<12 months	48 (62%)
≥12 months	30 (38%)
Sex	
Male	63 (81%)
Female	15 (19%)
Severity of myelopathy (Mean mJOA score)	11.44±3.03
Severity	
Mild (Per op mJOA ≥15)	7 (9%)
Moderate (Pre op mJOA 12 - 14)	40 (51%)
Severe (Pre op mJOA < 12)	31 (40%)
Etiology	
Cervical spondylotic myelopathy (CSM)	57 (58%)
Single level	11
Two Level	27
≥Three Level	19
Ossified posterior longitudinal ligament (OPLL)	19 (24%)
Single level	1
Two Level	3
≥Three Level	15
Congenital stenosis (All were ≥ 3 level)	2 (3%)
Type of surgery	
Anterior	41 (53%)
Posterior	37 (47%)

one of the radiological parameters (Instability) was statistically related to the outcome with a *P* value <0.05. Gender of the patient, approach to surgery (anterior or posterior), number of levels involved, and diagnosis had no statistically significant effect on the outcome following surgery.

It was found that, six clinical parameters statistically correlated to the outcome following a decompressive surgery. These are age, duration of symptoms, presence or absence of diabetes mellitus, preoperative mJOA score, bowel bladder involvement, and wasting of intrinsic muscles of hand. Incorporating all these parameters, the clinicoradiological scoring system was devised as shown in Table 3. Bowel bladder involvement was not included in formulating the clinicoradiological score as mJOA score incorporates sphincter function as a part of scoring system.

Correlation of clinicoradiological score to the outcome

The score devised [as shown in Table 3] was calculated for each patient. The score was then correlated to the outcome following surgery. The results of the same are tabulated in Table 4.

DISCUSSION

The primary findings of this study were that a lower preoperative mJOA score (greater severity), wasting of intrinsic muscles of hand, longer duration of symptoms, old age, and presence of diabetes mellitus were all associated with a decreased probability of a successful outcome. Of the three radiological parameters studied, only presence of instability showed a statistically significant association with the outcome. This study highlights the fact that the clinical parameters are more important in predicting the outcome after a decompressive surgery for CCM rather than radiological findings.

Numerous studies have already proven that the preoperative severity of myelopathy adjudged by mJOA (or JOA) score is the best and most important predictor of the surgical outcome.[1,6-8] Our study also showed this and we found that mJOA score ≤ 12 had the most statistically significant correlation with poor outcome with 77% (24 out of 31) while 100% (7 out of 7) patients with mild myelopathy (mJOA score ≥15) had good recovery.

Intrinsic hand muscle wasting forms an important component of patient evaluation. It represents not only the severity, but also the chronicity of compression of spinal cord. In our study, the mean preoperative mJOA score of 32 patients who had wasting was 8.97 ± 2.99 as compared to the mean of 13.17 ± 1.44 of the remaining 46 patients without wasting. Moreover, six patients had intrinsic muscle wasting but a preoperative mJOA score of >12 owing to minimal gait abnormality with preserved sensation and no bowel/bladder involvement. All of these six patients did not have good outcome (postoperative mJOA score was <16). Thus, intrinsic hand muscle wasting is an individual predictor of the outcome.

Studies have shown that longer duration of symptoms have a negative impact on the outcome after surgery.[1,6,7,9] The rationale behind this is that chronic, long-standing compression of the spinal cord may lead to irreversible damage due to demyelination and necrosis of the gray matter. In our study, duration of 12 months was the cutoff below which, 75% (36 of 48) of the patients had good outcome and above it 60% (18 of 30) had poor outcome.

In a survey of members from AOSpine International, 65 years of age was found to be the cutoff above/below which the outcome was affected.[10] In our study, we found this cutoff to be 60 years. In the same survey, most surgeons chose diabetes as the most important comorbidity affecting surgical outcome.[10] Even in our study, these parameters were found to have a statistically significant (*P* < 0.001) correlation with the outcome.

The clinicoradiological score we propose has a maximum score of 8 and minimum score of 1. Nearly all (45 out of 46, 97.82%) patients with a score of below 5 had good outcome and 100% (23 out of 23) patients with a score above 5 had poor outcome. The outcome is difficult to predict with a score of 5 as 67% (6 of 9) with a score of 5 had poor outcome and the remaining 33% (3 of 9) had good outcome. Thus, a

Table 2: Logistic regression analysis evaluating the association between demographics, clinical parameters, radiological parameters and outcome

Parameter	Number	Outcome		P value	Relative risk	95% CI
		Good	Poor			
Age < 60	38	29 (76.5%)	9 (23.5%)	0.009	2.21	1.16-4.21
Age ≥ 60	40	19 (47.5%)	21 (52.5%)			
Male	63	40 (63.5%)	23 (36.5%)	0.467	0.78	0.41-1.47
Female	15	8 (53.33%)	7 (46.67%)			
Duration < 12 months	48	36 (75%)	12 (25%)	0.002	2.4	1.35-4.24
Duration ≥ 12 months	30	12 (40%)	18 (60%)			
Diabetics	27	7 (25.92%)	20 (74.08%)	< 0.001	3.77	2.07-6.87
Non Diabetics	51	41 (80.39%)	10 (19.61%)			
Severity Of Myelopathy						
Mild myelopathy (mJOA ≥ 15)	7	7 (100%)	0			
Moderate myelopathy (mJOA 12-14)	40	34 (85%)	6 (15%)	< 0.001	NA	NA
Severe myelopathy (mJOA <12)	31	7 (22.58%)	24 (77.41%)			
Hand wasting present	32	4 (12.5%)	28 (87.5%)	< 0.001	20.12	5.15-78.55
Hand wasting absent	46	44 (95.65%)	2 (4.35%)			
Torg pavlov ratio < 0.8	57	31 (54.38%)	26 (45.62%)	0.124	0.41	0.16-1.05
Torg rpavlov atio > 0.8	21	17 (81%)	4 (19%)			
Instability present	16	4 (25%)	12 (75%)	0.001	2.58	1.59-4.17
Instability absent	62	44 (71%)	18 (29%)			
MRI : No Intensity changes	33	24 (72.72%)	9 (27.28%)	0.082	1.71	0.90-3.24
MRI : Intensity changes present	45	24 (53.33%)	21 (46.67%)			
Number of Levels						
Single Level	12	7	5			
Two Level	30	21	9	0.471	NA	NA
Multilevel (≥3)	36	20	16			
Type of Surgery						
Anterior	41	25	16	0.914	1.03	0.58-1.81
Posterior	37	23	14			

Table 3: Clinico-radiological prognostic score

Parameter		Points
Severity of myelopathy	mJOA Score	
Mild	≥15	1
Moderate	12-14	2
Severe	<12	3

	Yes (Points)	No (Points)
Intrinsic hand muscle wasting	1	0
Diabetes mellitus	1	0
Age ≥ 60 years	1	0 (Age < 60)
Duration of symptoms ≥12 months	1	0 (Duration < 12 months)
Instability on dynamic X rays	1	0

Table 4: Correlation of clinical score of patients and outcome following surgery

Score	Number	Outcome	
		Good	Poor
1	1	1 (100%)	0
2	11	11 (100%)	0
3	24	24 (100%)	0
4	10	9 (90%)	1 (10%)
5	9	3 (33.33%)	6 (66.67%)
6	9	0	9 (100%)
7	12	0	12 (100%)
8	2	0	2 (100%)

The presence of instability, which is detected on dynamic radiographs, has been shown to be significantly associated with poor outcome. This is probably due to the fact that untreated instability leads to repeated micromovement of the vertebral column that may cause irreversible changes in the spinal cord. Our study emphasizes the importance of getting dynamic radiographs done of every patient as the presence of instability

score of less than 5 may be considered as a predictor of good outcome and a score of more than 5 may be considered as a predictor of poor outcome while at a score of 5 the outcome is indeterminate.

not only is an indication for instrumented fusion, but it also has a role in predicting prognosis.

The role of MRI findings as a prognostic indicator is still controversial with report both in favor and against it.[2-5] Though it has been suggested that transverse area of cord and type 2 signal intensity changes on MRI (hypointense on T1W and hyperintense on T2W images) are also helpful in predicting the outcome, these facilities may not be available at every center as high-quality MRI images are needed for the same.[1] A simple clinicoradiological prognostic score will be helpful in such situation to give the patients an idea regarding functional recovery following surgery.

The limitation of the study is that it is a retrospective analysis of patients operated by a single surgeon in a single tertiary-care hospital. A prospective multicentric study would help in validation of the prognostic score. A relatively smaller sample size is another limitation of the study. Due to suboptimal quality of few MRIs, we could not calculate transverse area of cord in every patient, which is one of the MRI parameters we would have liked to assess.

CONCLUSION

Clinical parameters are better predictors of the outcome as compared to radiological findings, following surgery in case of CCM. Preoperative severity of myelopathy, wasting of intrinsic muscles of hand, longer duration of symptoms, old age, presence of diabetes mellitus, and instability on radiographs were all associated with a decreased probability of a successful outcome. A simple scoring system based on clinicoradiological parameters is suggested in this paper to predict the outcome following surgery in cases of CCM.

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Conflicts of interest
All the authors state that we have no conflict of interests.

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