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Original Research Article

Magnetic resonance imaging predictors of outcome after surgical intervention for cervical spondylotic myelopathy

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ABSTRACT

Background: Cervical spondylotic myelopathy (CSM) is a commonly seen spinal cord disease. There are no well-defined indications and optimal timing for surgical intervention. Therefore, defining predictors for outcome after surgical intervention will have great advantage in taking decisions for interventions.
Methods: A consecutive series of all patients having signs and symptoms of cervical spondylotic myelopathy admitted to Department of Neurosurgery, Medical College, Thiruvananthapuram who underwent decompressive surgery with or without stabilization in one year were studied. Pre-operative magnetic resonance imaging (MRI) findings were correlated with post-operative surgical outcomes (Nurick grade) after 3 months of follow up. The pattern of spinal cord signal intensity was classified as: group A (MRI N/N) - no SI T1WI or T2WI, group B (MRI N/Hi) - no SI T1WI and high SI on T2WI and, group C (MRI Lo/Hi) - low SI T1WI and high SI on T2WI. CSM clinical outcomes were evaluated using Nurick grading system, which was used pre- and post-operatively (pre op and post op).
Results: Post operatively improvement was seen in 75% of group A and 61.35 % of group B patients, but among group C only 25% patient improved according to Nurick grading pre op and post op.
Conclusions: Patients with high intramedullary signal intensity on T2WI may experience a good surgical outcome. A less favorable surgical outcome is predicted by the presence of low intramedullary signal on T1WI.

Keywords: MRI, MRI A (N/N), MRI B (N/Hi), MRI C (Lo/Hi), Cervical spondylotic myelopathy

INTRODUCTION

Surgical intervention as treatment of cervical spondylotic myelopathy (CSM) is one of the commonest procedures in neurosurgery worldwide. Primary objective of surgery is to decompress spinal cord and improve its circulation by expanding spinal canal while secondary objective of surgery is to stabilize segments whose movements can lead to damage to spinal cord and prevention of further spine deformity. Surgical option will depend on level and degree of spondylotic changes, stability of spine, patient ailments and surgical expertise.[1] Both anterior or posterior approaches can be used for spinal cord decompression surgery. Natural history of CSM is varied and new techniques and methods are continuously evolving, so it becomes important to know reliable predictors to decide timing of surgical intervention in order to achieve maximum functional outcome.

Magnetic resonance imaging (MRI) has become very useful due to its ability to detect extent of spinal cord compression, to measure spinal canal diameters, to detect bony degenerative changes, to delineate suspected lesions of soft tissue around vertebral column in all planes and to reflect pathological changes within cord itself. Additionally, MRI is non-invasive and without risk of radiation exposure.[2] Thus, it is helpful in diagnosis as well as preoperative planning of patients with suspected CSM

but the importance of MRI as a predictor of functional outcome after surgery is still variable. Correlation of MRI features and outcome is not clearly defined yet and also there is need to build a predictive model of functional outcomes after surgery that would combine clinical and MRI features together.

This type of predictive model based on MRI would be useful to identify subset of patients who are most likely to have clinical improvement after surgery. This model would also allow individualized decisions regarding various types of interventions for different age group of CSM patients. This model could also guide application of such strategies in high-risk groups and would potentially optimize functional outcome of surgeries done in CSM patients. The overall objective of this study is to develop a predictive model of functional outcome based on spinal cord signal intensity changes in preoperative MRI in patients with CSM undergoing surgical treatment.

METHODS

A consecutive series of all patients with functional disability secondary to cervical degenerative myelopathy and radiculopathy underwent surgery for decompression of the spinal cord with or without spinal stabilization from April 2017 till March 2018 were studied. The study was done after getting clearance from the institutional review board and the ethics committee.

Study design

The design of the study was a prospective cohort study.

Study setting

The study was conducted in the Department of Neurosurgery, Government Medical College, Thiruvananthapuram.

A diagnosis of CSM required radiological confirmation (MRI) and at least one or more "upper motor neuron" findings (spasticity, hyper-reflexia, clonus and positive Babinski sign).

Inclusion criteria

All patients who were diagnosed with degenerative cervical myelopathy and radiculopathy and did not improve inspite of appropriate conservative management and progressed to functional disability, involvement of sub-axial cervical spine, age >30 years and <80 years were included.

Exclusion criteria

Patients, otherwise meeting the inclusion criteria, were ineligible in case of any of the following criteria: myelopathy secondary to medical causes (e.g. vascular, connective tissue disorder and infection), traumatic myelopathy, congenital myelopathy, previous history of cervical spine surgery, psychiatric disorders, definite diagnosis not established and hemodynamically, medically unstable patients.

Data collection

Data collected after patient got admitted for surgery in Neurosurgery ward, Government Medical College, Thiruvananthapuram. Follow up data collected in Neurosurgery outpatient department (OPD).

Data analysis

Categorical variables were summarized as frequencies and percentages; and continuous variables as means and standard deviation. Categorical variable was compared using Pearson chi-square test for independent proportions and student's t-test was used to compare continuous variables.

Pre-operative clinical findings and MRI abnormalities on T1 (T1WI) and T2 (T2WI) images were correlated with outcomes (Nurick grade) following surgical intervention. The pattern of spinal cord signal intensity was classified as: group A (MRI N/N) - no intramedullary signal intensity abnormality on T1WI or T2WI; group B (MRI N/Hi) - no intramedullary signal intensity abnormality on T1WI and high intramedullary signal intensity on T2WI and; group C (MRI Lo/Hi) - low intensity intramedullary signal abnormality on T1WI and high intensity intramedullary signal abnormality on T2WI. All the patients had received appropriate conservative management before undergoing surgical intervention.

CSM clinical outcomes were evaluated using Nurick grading system and pre-operative and post-operative grades compared.

Nurick grade

Grade 0- root signs and symptoms with no evidence of cord involvement, grade 1- signs of cord involvement with normal gait, grade 2- mild gait involvement but able to be employed, grade 3- gait abnormality prevents employment but ambulant without support, grade 4- able to ambulate with assistance, and grade 5- chair-bound or bedridden.[3]

RESULTS

In this study, we evaluated total of 30 patients (22 males, 8 females) in the analysis. Age ranging from 43 years to 77 years and mean age being 59.53 years. 24 patients (80%) were lying in age group of 50 to 70 years.

All patients were followed up after 3 months of surgery. Among the study population there were 22 males (73.3%) and 8 females (26.7%) (Table 1).

Table 1: Distribution according to age.

Age in years	Frequency	Percentage
≤50	4	13.3
51-60	11	36.7
61-70	13	43.3
>71	2	6.7
Total	30	100.0

In this study, the average duration of symptoms was ranging from 4 months to 4 years with average of 11 months (Table 2).

Table 2: Distribution according to duration of symptom.

Duration of symptoms (in years)	Frequency	Percentage
≤1	26	86.7
>1	4	13.3
Total	30	100.0

All patients were divided according to the preoperative MRI into 3 groups: group A (MRI N/N, 11 patients), group B (MRI N/Hi, 15 patients) and group C (MRI Lo/Hi, 4 patients) (Table 3).

Table 3: Distribution into groups according to MRI signal intensities.

Groups	Frequency	Percentage
A (MRI N/N)	11	36.7
B (MRI N/Hi)	15	50.0
C (MRI Lo/Hi)	4	13.3
Total	30	100

In this study, 18 patients were treated by anterior approach (60%) and 12 patients were treated by posterior approach (40%). Among group A, 8 patients (72.72%) while among group B, 9 patients (60%) were treated by anterior decompressive procedures. Anterior decompressive procedures were used more frequently in patients with focal pathology and group A/B MRI changes. 3 patients (75%) in group C were treated by posterior decompression as they were having multilevel pathology (Table 4).

Table 4: Distribution according to procedure among groups.

Group	Anterior procedure	Posterior procedure
	N (%)	**N (%)**
A	8 (72.72)	3 (27.28)
B	9 (60)	6 (40)
C	1 (25)	3 (75)

In this study, pre-operatively 50% patients belonged to grade 2 Nurick and 16.7% in grade 1. While post-operatively number of patients in Nurick grade 1 and 2 were 46.7% and 36.7% respectively (Table 5).

Table 5: Comparison of pre-op and post-op status of patients according to Nurick grade.

Nurick grade	Pre-op		Post-op	
	N	**%**	**N**	**%**
Grade 1	5	16.7	14	46.7
Grade 2	15	50.0	11	36.7
Grade 3	7	23.3	3	10.0
Grade 4	2	6.7	1	3.3
Grade 5	1	3.3	1	3.3
Total	30	100.0	30	100.0

P<0.001.

This table indicates that all 5 patients with preoperative Nurick grade 1 remained in Nurick grade 1 in post-operative period. 9 patients who were having Nurick grade 2 pre-op improved to grade 1 postop while 6 patients in grade 2 remained in same grade postop. 5 patients with Nurick pre-op grade 3 improved to grade 2 postop while 2 patients remained in grade 3 postop. 1 patient having Nurick grade 4 pre-op improved to grade 3 post-ops while 1 patient remained in grade 4. Only 1 patient having Nurick grade 5 pre-op remained in grade 5 post-op without improvement (Table 6).

Table 6: Comparison of pre-op and post-op status of patients according to Nurick grade.

Nurick grade		Post-operative					Total
		1	**2**	**3**	**4**	**5**	
Pre-operative	1	5	0	0	0	0	5
	2	9	6	0	0	0	15
	3	0	5	2	0	0	7
	4	0	0	1	1	0	2
	5	0	0	0	0	1	1
Total		14	11	3	1	1	30

Among group A patients, 3 patients were having pre op Nurick grade 1 which remained same in postop also, as further improvement cannot be quantified according to Nurick grade.

Among group A patients, 6 patients (75%) have improved postoperatively when compared according to Nurick grading.

Among group B patients, 2 patients were having Nurick grade 1 preoperatively, which remained same in post op period. 8 patients (61.53%) have improved postoperatively.

Among group C patients, only 1 patient (25%) have improved and majority (75%) remained in same grade as per Nurick grading.

Improvement was seen in 75% of group A and 61.53% of group B patients. But among group C only 25% have improved postoperatively. Although there is large difference in improvement rate of group C patients, statistical insignificance may be due to smaller number of patients in group C (Table 7).

Table 7: Comparison of groups according to outcome on the basis of change in Nurick grade.

Change in Nurick grade	Groups						Total	
	A		B		C			
	N	%	N	%	N	%	N	%
Same status	2	25	5	38.5	3	75	10	40
Improved	6	75	8	61.5	1	25	15	60
Total	8	100	13	100	4	100	25	100

χ^2=2.804, df=2, P=0.246.

DISCUSSION

In our study when outcome was evaluated by Nurick grading pre-op and post-op, improvement seen in groups A, B and C was 75%, 61.5% and 25% respectively. When compared with a similar study by Alafifi et al improvement seen in groups A, B and C was 73.3%, 56.52% and 10% respectively.[4] Both the studies are showing similar results. In both studies improvement in group C was very poor i.e. 25% and 10% only respectively.

In another study by Chikhale et al on comparison of outcome scores at 1 year after surgery, there was a significant correlation between patients with no signal intensity changes and those with signal intensity changes where the former group fared better.[5] According to Avadhani et al MRI signal changes that accommodates both T1WI and T2WI is more predictive of surgical outcome than those that include T2W SI changes alone.[6] MRI indicators of poorer outcome include the presence of low T1 signal, focal increased T2 signal and segmentation of T2 signal changes according to Arvin et al.[7] Mehalic et al found that those patients who improved clinically has less T2WI SI postoperatively than who didn't improved clinically which are having same or increased T2WI SI postoperatively.[8] Yukawa et al found that patients with increased SI on T2WI had longer duration of illness and carries poorer prognosis.[9] Suri et al found that decreased SI on T1WI along with increased SI on T2WI has got a very poor prognosis as compared to patients with increased SI on T2WI only.[10] Morio et al also found that decreased SI on T1- WI MRI carried a poor prognosis and that increased SI on T2-weighted MRI could be due to a broad spectrum of pathologic changes, and that T2-weighted abnormalities alone did not help to predict surgical outcomes.[11]

Ohshio et al studied correlation between the MRI findings and histopathology of diseased spinal cord.[12] They found that MRI (N/Hi) was associated with edema, gliosis and slight loss of nerve cells in gray matter while MRI (Lo/Hi) was associated with necrosis, myelomalacia and spongiform changes in gray matter. A systematic review by Mummaneni et al showed that multilevel T2 hyperintensity, T1 focal hypointensity combined with T2 focal hyperintensity convey a poor prognosis.[13] In a meta-analysis by Chen et al it was found that the surgical outcomes were poorer in the patients with both T2 intramedullary signal changes and T1 intramedullary signal changes compared with those without intramedullary signal changes.[14]

CONCLUSION

From this study, it can be concluded that preoperative normal signal intensity in T1WI and high signal intensity on T2WI of intramedullary spinal cord has a better surgical outcome than that of the low signal intensity on T1WI with high signal intensity on T2WI. High signal intensity changes on T2WI were nonspecific and may represent reversible causes such as venous edema, ischemia, inflammation or gliosis due to disturbed local venous circulation induced by chronic spinal cord compression. Patients with low signal intensity on T1WI with high signal intensity on T2WI have poor surgical outcome suggesting that these changes may be due to irreversible causes like necrosis, spongiform changes and secondary syrinx formation.

There are some limitations in this study. This study is conducted for a short period with short follow up which may have possibility of data bias. Study for long period with follow up for more duration will give a greater number of sample size and better follow up data to be analyzed. But we were able to throw a light of MRI signal intensity as predictors for outcome. We would suggest a large randomized control trial with this methodology to reach more reliable evidences.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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