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MRI Signal Intensity Changes in Cervical Spondylotic Myelopathy and Its Role in Assessing the Surgical Prognosis

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Abstract
Background: *The association between MRI signal intensity changes and cervical spondylotic myelopathy (CSM) remains controversial. The objectives of the study were to study different patterns of MRI signal intensity changes in CSM, to classify the signal intensity changes before surgery, and to verify whether the classification could reflect clinical features and surgical outcome.*
Methods: *A total of 110 patients who underwent decompression surgery for cervical spondylotic myelopathy were enrolled in the study. The preoperative MRI of the patients were studied and the pattern of spinal cord signal intensity (SI) changes were classified. Preoperative clinical findings and MRI abnormalities were correlated with outcome using mJOA (modified Japanese Orthopaedic Association) score and recovery rate after surgical intervention before discharge from hospital and in the 3rd month follow up to measure prognostic factors affecting surgery.*
Results and Discussion: *Majority of the patients (65%) operated for cervical spondylotic myelopathy were having high SI changes in cervical cord on T2WI. Only 16% of the patients showed low SI on T1WI, all of which showed grade 2 high SI on T2WI. Recovery rates were 64.6%, 40%, and 14% in grade 0, grade 1, and grade 2 respectively and 64.3%, 32.4%, and 11% in group A, group B, and group C respectively.*
Conclusions: *Preoperative MRI signal intensity (SI) changes were correlated with patient age, duration of disease, preoperative and postoperative JOA score, and recovery rate. Preoperative MRI classification based on SI changes on T2Wl as well as MRI classification system that accommodates SI changes on both T1WI and T2WI can be a predictor of surgical outcome.*
Keywords: *Cervical spondylotic myelopathy; Magnetic Resonance Imaging; Signal intensity changes; Recovery rate.*

Introduction

Cervical spondylosis is the most common cause of cervical spinal cord dysfunction in individuals older than 55years[1]. By the age of 30, virtually all individuals will have at least microscopic degenerative changes in their cervical spine [2].

Spondylotic changes often begin in the lower segments of the cervical spine (especially C4-C7), but they may be present at all levels, particularly in the elderly[3]. The process typically begins in the intervertebral disc, probably as a result of the loss of water content in the disc that occurs secondary to the loss of proteoglycan matrix with age[3,4].The dehydrated disc becomes stiff and begins to shrink, leading to partial or complete collapse and may even herniate. Osteophytes develop in the vertebral bodies, facet joints, and arches, and the ligamentum flavum thickens and ossifies. In some individuals thickening and ossification of the posterior longitudinal ligaments (OPLL) takes place as well. When cervical spondylosis progresses, neural structures may be damaged. This occurs most commonly at the C5-C7 levels where spondylosis is often most advanced. Most commonly, nerve roots exiting the canal are injured. In some of individuals, the cord itself may be damaged, and a myelopathic syndrome may result[4].

Clark and Robinson were the first to study the natural history of CSM in 1956[5]. They found that about 75% experienced a waxing and waning disease course characterized by short periods of symptomatic worsening. In about 20% of patients, CSM showed a slow, steady, progressive course, and in about 5%, the disease did not seem to progress after the initial appearance of symptoms. While sensory and sphincter function sometimes improved with time, motor function and gait abnormalities usually persisted or worsened, and complete disease regression never occurred. Several others have also studied the natural history of CSM[6].

Now most of the patients with features of radiculopathy and myelopathy are operated surgically; and no one has found clear evidence that clinical parameters such as patient age, type of clinical, or anatomic level of disease can reliably predict the prognosis[7,8]. MRI is currently the imaging modality of choice in this disease. A variety of signal intensity (SI) changes have been described in MRI sequences in this particular disease - high SI on T2-weighted images, the extent of SI change on T2WI, focal or multi segmental pattern, low-intensity on T1-weighted images.

While these MRI features are useful in confirming the clinical diagnosis, their utility in predicting surgical outcome remains unclear. This project is to examine whether the different signal intensity changes on T1&T2-weighted MR images, and patterns of the disease noted in MRI in cervical spondylotic myelopathy (CSM) are related to differences in the surgical prognosis.

Materials and Methods

A descriptive study was conducted in the Department of Radiodiagnosis, Medical College, Thrissur during the period from March 2015 to September 2016. The study population was all patients who had undergone surgery for cervical spondylotic myelopathy during the study period. Those patients with additional diseases like motor neuron disease and those who were lost to follow up were excluded.

Study instrument

MRI cervical spine was done in GE SIGNA HDXT 1.5 Tesla machine.

Data Collection and procedure

Study subjects were explained about the study and informed consent taken. Preoperative MRI of patients who met the inclusion criteria was studied. The pattern of spinal cord signal intensity changes were classified in three different ways (based on a similar study by Avadhani A et al[9]): based on high SI on T2 WI (grade 0 – absent, grade 1- obscure/light and grade 2 – intense); based on extent of SI change on T2WI into focal (confined to one disc level) and multi segmental (>one disc level) and based on features of T1 weighted images and T2 weighted images; group A has normal SI on both T1WI and T2WI, group B has normal SI on T1WI and high SI on T2WI, group C has low SI on T1WI and high SI on T2WI. Preoperative clinical findings and MRI abnormalities were correlated with outcome using mJOA (modified Japanese Orthopaedic Association) score and recovery rate after surgical intervention before discharge from hospital and in

the 3rd month follow up to measure prognostic factors affecting surgery.

We calculated the recovery rates after surgery using Hirabayashi formula

$$\text{Recovery} = \frac{\text{preoperative score – post operative score}}{\text{Total score - preoperative score}}$$

Data analysis

Details of each patient was collected in a proforma and entered in MS Excel. These were analysed using SPSS 18 software. The frequency tables and mean values of various variables were obtained. Non parametric analysis were done using Mann Whitney U test for analysing the differences between two groups and Kruskal Wallis test for analysing the differences among three groups.

Results

Out of 110 patients with cervical spondylotic myelopathy, male to female ratio was 3:1. Mean age was 54 years.

Majority (84%) had normal SI in T1WI. Only 16% showed low SI changes in T1WI.

39 patients (35%) had normal SI in T2WI. 71 patients (65%) showed high signal intensity changes in T2WI, out of which 37 showed grade 1 changes and 34 showed grade 2 changes; 54 (76%) had focal T2 hyperintensity and 17(24%) had multisegmental T2 hyperintensity (continuous in 8% and not continuous in 16% of cases).

48% of patients belonged to group B(normal T1WI/high T2WI), 36% belonged to group A (normalT1WI/normal T2WI).Group C (low T1WI/high T2WI) constituted only 16% of patients.

Table 9: Table Showing Symptom Duration in Study Groups Based On MRI Classification (T1WI/T2WI)

MRI Groups	Symptom Duration in months (Mean)	P Value
Group A(39)	6	
Group B(53)	24	<0.001
Group C(18)	48	

*Kruskal Wallis test

Symptom duration was maximum in group C (T1 low/T2 high) and in patients with grade 2 SI changes on T2 weighted images. On statistical analysis (Kruskal Wallis test), there was significant difference in symptom duration between the study groups according to MRI classification based on T1WI and T2WI and between different grades of T2 signal intensity changes. Symptom duration increased significantly from group A to group C and from grade 0 to grade 2.

Table 10: Table Showing Preoperative and Postoperative mJOA Score In Study Groups Based On Signal Intensity Changes on T2WI

mJOAScore(Mean)	Grade 0(39)	Grade 1(37)	Grade 2(34)	P Value
Preoperative Score	13	11	9	<0.001
Postoperative Score	16	13	10	<0.001

*Kruskal Wallis test

Table 11: Table Showing Preoperative and Postoperative mJOA Score In Study Groups Based On MRI Classification (T1WI/T2WI)

mJOA Score (Mean)	Group A (T1normal/ T2normal)	Group B(T1normal/ T2high)	Group (T1 low T1/ high T2)	P Value
Preoperative Score	13	11	8	<0.001
Postoperative Score	16	13	9	<0.001

*Kruskal Wallis test

Mean preoperative mJOA score was 11. Among study groups according to T1 and T2 MRI classification, group A had maximum preoperative mJOA score (13) and in patients with grade 0 T2 SI changes. Group C and those with grade 2 T2 SI changes had minimum preoperative mJOA score.

Mean postoperative JOA score was 13. Maximum postoperative mJOA score (16) was in group A and in patients with grade 0 T2 SI changes. Statistical analysis using Kruskal Wallis test showed significant difference in postoperative mJOA score between the study groups according to MRI classification based on T1WI and T2WI and between different grades of T2 signal intensity changes. Postoperative mJOA score

decreased significantly from group A to group C and from grade 0 to grade 2.

Table 12: Table Showing Recovery Rates In Study Groups Based On Signal Intensity Changes on T2WI

T2WI	Mean Recovery Rate (%)	P Value
Grade 0 (39)	64.3	
Grade 1 (37)	40	<0.001
Grade 2 (34)	14	

*Kruskal Wallis test

Mean recovery rate of the study population was 40%.Patients with normal SI on T2WI had maximum mean recovery rate (64.6%).Minimum recovery rate was for those with grade 2 changes in T2WI(14%). Statistical analysis showed significant difference in recovery rates between different grades of T2 signal intensity changes. Recovery rate decreased significantly grade 0 to grade 2.

Figure 24: Sagittal T2 weighted image, sagittal T1 weighted image of cervical spine of 53 years old male patient with CSM showing disc-osteophytic bulge and PLL hypertrophy from C3 to C7 level. There is thinning of cord with grade2 multi segmental hyperintensity from C4 to C6 level on T2 weighted image and low signal intensity at C6 level on T1 weighted image. (Group C)

Table 16: Table Showing Recovery Rates In Study Groups Based On MRI Classification (T1WI/T2WI)

MRI Groups (T1WI/T2WI)	Mean Recovery Rate (%)	PValue
Group A(39)	64.3	
Group B(53)	32.4	<0.001
Group C(18)	11	

*Kruskal Wallis test

Table 17: Table Showing Recovery Rates In Study Groups Based On Signal Intensity Changes on T1WI

T1WI	Mean Recovery Rate	P Value
Normal SI(92)	45.9	0.001
Low SI(18)	11	

*Mann Whitney U test

Patients with normal spinal cord signal intensity on T1WI had higher mean recovery rate (45.9%) and those with low signal intensity on T1WI had lower recovery rate. Statistical analysis using Mann Whitney U test showed significant difference in recovery rates between them.

Discussion

Regarding the SI changes on T1WI, majority (84%) had normal SI in T1WI. Only 16% showed low SI changes in T1WI and all these had grade 2 changes on T2WI. Similar data was obtained in a study by Vedantam et al[10]

48% of patients belonged to group B(normal T1WI/high T2WI), 36% belonged to group A

(normalT1WI/normal T2WI).Group C (low T1WI/high T2WI) constituted only 16% of patients. In a similar study by Avadhani et al[9], group B constituted 80% followed by group C (15%) and group A(5%).

Mean preoperative mJOA score was 11. Group A had maximum preoperative mJOA score (13) and in patients with grade 0 T2 SI changes. Group C and those with grade 2 T2 SI changes had minimum preoperative mJOA score. Statistical analysis showed significant difference in preoperative mJOA score between these groups. In the study by Yasutsugu et al [11], there was no significant difference in the preoperative score between different grades of T2 signal intensity changes.

Mean postoperative JOA score was 13. Maximum postoperative mJOAscore (16) was in group A and in patients with grade 0 T2 SI changes. Postoperative mJOA score decreased significantly from group A to group C and from grade 0 to grade 2. Mean recovery rate of the study population was 40%.Patients with normal SI on T2WI had maximum mean recovery rate (64.6%). Minimum recovery rate was for those with grade 2 changes in T2WI (14%). Statistical analysis showed significant difference in recovery rates between different grades of T2 signal intensity changes. Recovery rate decreased significantly grade 0 to grade 2.These data were consistent with the study Yasutsugu et al[11].

Conclusion

We found a significant association among postoperative mJOA score, recovery rate and preoperative MRI classification. Patients with increased signal intensity on T2WI had poorer outcome than those with normal T2 SI. Patients with low T1 SI showed poorer outcome than those with normal signal intensity. Thus, Preoperative MRI classification based on SI changes on T2Wl as well as MRI classification system that accommodates SI changes on both T1WI and T2WI can be a predictor of surgical outcome.

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