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Dr. Bharat MP
Associate Professor,
Department of Radiodiagnosis,
Subbaiah Institute of Medical
Sciences, Shimoga, Karnataka,
India

Dr. Deepak KS
Associate Professor,
Department of Radiodiagnosis,
Subbaiah Institute of Medical
Sciences, Shimoga, Karnataka,
India

Dr. Dhruva R
Assistant Professor,
Department of Radiodiagnosis,
Subbaiah Institute of Medical
Sciences, Shimoga, Karnataka,
India

Cervical spondylotic myelopathy: Association of MRI changes and outcome predictors after surgical intervention

Dr. Bharat MP, Dr. Deepak KS and Dr. Dhruva R

Abstract
Introduction: Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction in older individuals. Controversy remains in terms of the optimal timing and indications for surgical intervention. In this context, it would be of benefit to define clinical and magnetic resonance imaging (MRI) predictors of outcome after intervention for CSM.
Material and Methods: This was a prospective and observational study conducted in the Department of Radio diagnosis, Subbaiah Institute of Medical Sciences, Shimoga. 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 January 2020 to September 2020 were studied. 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).
Result: Among group A patients, 7 patients (77.7%) have improved postoperatively when compared according to Nurick grading. 9 patients (60%) have improved postoperatively. Among group C patients, only 2 patient (33.3%) have improved and majority (66.6%) remained in same grade as per Nurick grading.
Conclusions: MR techniques play an indispensable role in the management of CSM patients and have evolved primarily from a diagnostic modality to a method that can potentially predict patient outcome following surgical intervention. Functional MRI can help to assess the neurological functional recovery after decompression surgery for CSM

Keywords: Cervical spondylotic myelopathy, Magnetic resonance imaging, Nurick grading

Introduction

Magnetic resonance imaging (MRI) plays an essential role in the management of patients with cervical spondylotic myelopathy (CSM). There have been many advances in MR technology over the past few years and the resolution and image quality have improved greatly. With these improvements, the application of MRI in CSM has progressed in parallel. [1] The novel MR techniques not only offer a diagnostic modality, but also can be used to predict neurological outcome and response to intervention [2].

In addition to conventional MRI, recent application of novel techniques in CSM, such as diffusion tensor imaging (DTI), MR spectroscopy (MRS) and functional MR imaging (fMRI), further highlights the potential influence of MR technology on the disease process [3]. By providing pertinent information about the spinal cord microstructure and metabolism, and assessing the neurological function after surgery, these novel techniques provide increased sensitivity to diagnosis of spinal cord injury, especially the cellular injury that ubiquitously occurs during CSM pathogenesis [4].

Myelopathy can also be seen in younger patients when central disc herniations compress the spinal cord. Most typically, however, there are osteophytic changes and ligament thickening that make the canal stenotic. The close association between the presence of spinal stenosis and the occurrence of cervical myelopathy has led to the assumption that stenosis is the most important pathophysiological factor in the disease [5]. Nevertheless, this concept is incapable of explaining the spectrum of the disease, particularly myelopathy without stenosis. Spinal stenosis is often accompanied by instability. The spondylotic restriction of the spinal canal results in release and shear forces on the spinal cord. These pathological factors lead to diffuse and focal axonal damage [6].

Corresponding Author:
Dr. Deepak KS
Associate Professor,
Department of Radiodiagnosis,
Subbaiah Institute of Medical
Sciences, Shimoga, Karnataka,
India

Although surgical decompression has been the treatment of choice for cervical compressive myelopathy, conservative treatment is an alternative therapeutic option for mild cervical myelopathy [7-11].

This article attempts to investigate the application of MR technology to the management of CSM patients and discusses recent and future advances in both conventional and novel MR techniques.

Material and Methods

Study design: This was a prospective and observational study.

Study place: Conducted in the Department of Radio diagnosis, Subbaiah Institute of Medical Sciences, Shimoga.

Duration of the study: January 2020 to September 2020 were studied.

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

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 age >30 years and <80 years either gender 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.

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.

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 [12].

Statistical analysis: Data compiled in the excel sheet and analysis in the SPSS 20th version software.

Results

In our study, we evaluated total of 40 patients age ranging from <45 years to >66 years and mean age being 57.32 years. Maximum number of patients 18 (45%) were lying in age group of 56 to 65 years and least more than 66 years 5% were all patients were followed up after 3 months of surgery (Table 1).

Table 1: Distribution according to age.

Age in years	Number of patients	Percentage
<45	6	15
46-55	14	35
56-65	18	45
>66	2	5
Total	40	100

Table 2: Distribution according to Sex.

Age in years	Number of patients	Percentage
Male	27	67.5
Female	13	32.5
Total	40	100

Among the study population there were 27 males (67.5%) and 13 females (32.5%) in table 2.

Table 3: Distribution according to duration of symptom.

Duration of Symptoms (years)	Number of patients	Percentage
<1	33	82.5
>1	7	17.5
Total	40	100

In table 3, in this study, duration of symptoms < 1 year was 82.5% and >1 year was 17.5%.

Table 4: Distribution into groups according to MRI signal intensities.

Groups	Number of patients	Percentage
A (MRI N/N)	16	40
B (MRI N/Hi)	19	47.5
C (MRI Lo/Hi)	5	12.5
Total	40	100

In table 4, all patients were divided according to the preoperative MRI into 3 groups: group A (MRI N/N, 16 patients), group B (MRI N/Hi, 19 patients) and group C (MRI Lo/Hi, 5 patients)

Table 5: Distribution according to procedure among groups.

Groups	Anterior procedure		Posterior procedure	
	Number of patients	Percentage	Number of patients	Percentage
A	9	56.2	4	10
B	11	57.8	7	17.5
C	2	40	4	80

In this study, 21 patients were treated by anterior approach (55%) and 15 patients were treated by posterior approach (37.5%). Among group a only 9 patients (56.2%), while among group B there was 11 patients (57.8%) were treated by anterior de-compressive procedures. Anterior de-compressive procedures were used more frequently in patients with focal pathology and group A/B MRI changes. 4 patients (80%) in group C were treated by posterior decompression as they were having multilevel pathology (Table 5).

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

Nurick grade	Pre-operative		Post-operative	
	Number of patients	Percentage	Number of patients	Percentage
Grade 1	7	17.5	17	42.5
Grade 2	19	47.5	13	32.5
Grade 3	9	22.5	7	17.5
Grade 4	3	7.5	2	5
Grade 5	2	5	1	2.5
Total	40	100	40	100

In this study, pre-operatively 47.5% patients belonged to grade 2 Nurick and 17.5% in grade 1. While postoperatively number of patients in Nurick grade 1 and 2 were 42.5% and 32.5% respectively (Table 6).

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

Change in Nurick grade	Groups						Total	
	No. of patients	%	No. of patients	%	No. of patients	%	No. of patients	%
Same status	2	22.2	6	40.0	4	66.6	12	40.0
Improved	7	77.7	9	60.0	2	33.3	18	60.0
Total	9	100	15	100	6	100	30	100

Among group A patients, 7 patients (77.7%) have improved postoperatively when compared according to Nurick grading. 9 patients (60%) have improved postoperatively. Among group C patients, only 2 patient (33.3%) have improved and majority (66.6%) remained in same grade as per Nurick grading. 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).

Discussion

Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction. It is the result of static or dynamic repeated compression of the spinal cord. The diagnosis of CSM is based on specific symptoms, physical signs, and imaging findings. Neck pain, arm pain, limited motion of neck, diminished function of hands (clumsiness or difficulty with buttoning buttons, using keys, or changes in hand writing), wasting of the intrinsic muscles, spasticity, walking difficulty which can be tested by "heel-to-toe tandem walking," "heelwalking," or "toe-walking." Myelopathic signs can be defined as hyperreflexia (grade 3 or 4) or provocative signs (clonus [>3 beats], Babinski's sign, Hoffmann sign, inverted brachioradialis reflex) [13].

In our investigation when result was assessed by Nurick evaluating pre-operative and post-operative, progress found in groups A, B and C was 77.7%, 60.5% and 33.3% respectively. When contrasted and a comparable with Nagata K *et al.* progress found in groups A, B and C was 73.3%, 56.52% and 10% respectively [14]. Both the authors are indicating comparative outcomes. In the two investigations progress in group C was extremely poor for example 25% and 10% just respectively. According to Chikhale *et al.*, contrast result scores at 1 year after surgical procedure, there was a significant correlation between patients with no signal intensity changes and those with signal force changes where the previous group fared better [15]. As per Avadhani *et al.* MRI signal changes that accommodates both T1WI and T2WI is more predictive of surgical outcome results than those that in-clucde T2W SI changes alone [16].

The MRI indicators inferior outcome consist of presence of low T1 signal, focal increased T2 signal and segmentation of T2 signal changes as per Arvin *et al.* [17] According to Mehalic *et al.* found that those patients who better-quality clinically has less T2WI SI postoperatively than who did not improved clinically which are having same or increased T2WI SI postoperatively [18]. According to Yukawa *et al.* found that patients with increased SI on T2WI had got very poor prognosis [19]. As per Suri *et al.* revealed that decreased SI on T1WI alongside increased SI on T2WI has an extremely poor as contrasted with patients with increased SI on T2WI only [20] in addition, Morio *et al.* stated that decreased SI on T1-WI MRI carried a poor prongnosis and that increased SI on T2-weighted MRI could be because of a wide range of pathologic changes, and T2-weighted anomalies alone did not help to predict surgical outcomes [21].

Furthermore, Ohshio *et al.* compared between MRI results and histopathology of diseased spinal cord [22]. They revealed that MRI (N/Hi) was related with gliosis, edema and slight loss of nerve cells in gray matter although MRI (Lo/Hi) was related with myelomalacia, necrosis, and spongiform changes in gray matter. Previous study by Mummaneni *et al.* indicated that multilevel T2 hyperintensity, T1 focal hypointensity combined with T2 focal hyperintensity revealed poor prognosis [23]. In a metaanalysis by Chen *et al.* it was discovered that the surgical outcomes were poorer in the patients with both T2 intramedullary signal changes and T1 intramedullary signal changes contrasted and those without intramedullary signal changes [24].

Limitations in this study: This study is conducted for a short period of time with less follow up which may have probability of data bias. Study for significant result, long period of time with better follow up data, more number of sample size to be analyzed. However, we had the option to toss a light of MRI signal force as indicators for result. We would recommend an enormous randomized control preliminary with this methodology to reach more reliable evidences.

Conclusion

MR techniques play an indispensable role in the management of CSM patients and have evolved primarily from a diagnostic modality to a method that can potentially

predict patient outcome following surgical intervention. MRI have further enhanced our knowledge about the pathogenic mechanism in CSM by providing detailed information regarding the spinal cord microstructure that reflect patient-specific pathogenesis and can be used to predict neurological outcome and response to intervention. In addition, MRI can help to assess the neurological functional recovery after decompression surgery in CSM. Generally speaking, these MR techniques and others may play an expanded role in the management of CSM patients in the future.

Author's Contribution
Dr Bharat M.P: Study design, Literature survey, data analysis, paper writing.
Dr K S Deepak: Study design, paper writing, and Literature survey.
Dr Nandan Kumar LD: Paper writing, statistical part.

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