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Association between MRI intensity change in the spinal cord on T1 and T2 images and myelopathic severity in patients with cervical spondylotic diseases

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ABSTRACT

Background: Cervical Spondylotic Myelopathy (CSM) is a prevalent degenerative spinal condition characterized by spinal cord compression. The accurate diagnosis and timely treatment of CSM are challenging due to its gradual progression. The aim of this study is to identify the association between signal intensity changes in the spinal cord on T1- and T2-weighted MRI images and motor myelopathic severity in patients with cervical spondylotic disease (CSD).

Methods: This study was a cross-sectional descriptive type of study. It included 30 patients. The study was carried out in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University, Dhaka.

Results: The mean±SD age of the patients was 44.83±11.87 years, Out, 13 (43.33%) were aged 40 years or younger, while 17 (56.67%) were older than 40 years. The data showed that no patients were classified as Nurick grade 0 or 1. Five patients (16.67%) were graded as 2, while the majority of patients, sixteen patients were (53.33%) into grade 3, the majority of patients in this study. Eight patients (26.67%) were classified as grade 4, and one patient (3.33%) had the most severe grade of 5. Notably, hyper-intense T2 signal changes were observed in 21 patients, predominantly in those with Nurick grades 3 and 4. No patients showed only T1 signal changes. The p-value of 0.2 indicates insignificant association between MRI signal changes and Nurick grading severity.

Conclusion: In conclusion, this study reveals that there was no significant association between T2 signal intensity changes on spinal cord MRI and motor myelopathy severity in cervical spondylotic disease patients.

Keywords: CSD, Nurick Grades, Myelopathy, MRI.

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1. INTRODUCTION

In neurosurgical practice, cervical spondylosis is frequently treated, a common condition involving the degeneration of bones and discs in the neck. Patients typically exhibit localised cervical symptoms, radiculopathy, and possibly myelopathy, in terms of Cervical spondylotic disease (CSD) and Cervical spondylotic myelopathy (CSM). Cervical spondylotic myelopathy (CSM) is a degenerative spinal condition that affects the cervical canal, resulting in compression of the spinal cord or the anterior spinal artery (1). This degeneration process is often initiated by disc deterioration, leading to instability in the posterior joints, osteophyte formation, and hypertrophy of the ligamentum flavum, which collectively contribute to the stenosis of the cervical canal. (2). The natural history of CSM indicates that while 20% of patients experience slow deterioration, 5% remain static, and 75% exhibit new symptoms and signs over time (3). CSM predominantly affects males around the age of 50, particularly those with a history of chronic occupational neck trauma. (4) The advancements in neuroradiologic imaging techniques have contributed significantly to the identification and understanding of CSM as a clinical entity. Among various imaging modalities, magnetic resonance imaging (MRI) has emerged as the preferred method, owing to its pathophysiologic specificity and the ability to perform repeated studies without adverse effects on patients' health. (5) Sagittal MRI views provide a clear visualization of cord compression at the level of the disc space, while hyperintensity within the cord on T1 & T2 weighted images may be indicative of cord damage and could correlate with the severity of myelopathy and patient outcomes (6). Increased signal intensity (ISI) changes within the cervical cord on T2-weighted MRI images have been categorised into three types: Type 0 (no change), Type 1 (faint, fuzzy changes), and Type 2 (intense, sharp changes). This classification is based on the sharpness of the margins and the degree of hyperintensity observed in intramedullary changes. Type 1 changes are characterised by dull or light intramedullary signal changes with unclear margins, whereas Type 2 changes exhibit brilliant or intense signal changes with well-defined margins (7). The primary objective of this study is to explore the association between signal intensity changes in the spinal cord on MRI and motor myelopathic severity in patients with CSD. By investigating this relation, the study aims to enhance the understanding of CSD pathophysiology and improve the accuracy of diagnosis, prognosis, and treatment planning for patients affected by this condition. In this study, preoperative Nurick grading was done to assess the myelopathic severity and establishment of the relationship of MRI image findings.

2. METHODS

This was a Cross-sectional descriptive study. Held on the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University (currently, Bangladesh Medical University), Shahbagh, Dhaka. This study was conducted from July 2021 to March 2024. Purposive sampling collection data was done from 30 individuals for more accuracy.

Inclusion criteria

Adult patients diagnosed with cervical spondylotic myelopathy (CSM) based on clinical examination and radiological findings, both Male& female. Patients who have undergone T1- and T2-weighted MRI imaging of the cervical spine. Patients with varying degrees of motor myelopathic severity to ensure a diverse range of disease severity in the sample.

Exclusion criteria

Patients with a history of spinal surgery, trauma, subluxation or infection affecting the cervical spine, which may confound the relation between MRI signal intensity changes and motor myelopathic severity in CSD.

Data collection procedure

This study was conducted in the Department of Neurosurgery, Bangabandhu Sheikh Mujib Medical University (currently, Bangladesh Medical University). All patients were included after primary screening with inclusion and exclusion criteria. History, neurological examination and evaluation of the MRI of the cervical spine of all patients would be done.

Statistical analysis

Obtained informed consent from eligible CSD patients who met the inclusion and exclusion criteria. Collected demographic information, including age, gender, and occupational history, using a standardised questionnaire or form. Recorded the duration of CSD symptoms for each patient. Performed T1- and T2-weight MRI imaging of the cervical spine for each patient. Evaluated and categorised signal intensity changes in the spinal cord on T1- and T2-weighted MRI images. Assessed motor myelopathic severity using a clinical scale, such as the Nurick Score. Recorded all collected data in a secure and organised database or spreadsheet for later analysis. Statistical analyses were conducted using SPSS Version 26.

3. RESULTS

The present study aimed to investigate the association between signal intensity changes in the spinal cord, as observed on T1- and T2-weighted magnetic resonance imaging (MRI), and the severity of motor myelopathy in patients with cervical spondylotic disease (CSD). Out of the total 30 patients in this study, 13 (43.33%) were aged 40 years or younger, while 17 (56.67%) were older than 40 years (Table 1). The data shows that no patients were classified as Nurick grade 0 or 1. Five patients (16.67%) were graded as 2, while the majority of patients, sixteen patients were (53.33%) into grade 3, the majority of patients in this study. Eight patients (26.67%) were classified as grade 4, and one patient (3.33%) had the most severe grade of 5 (Table 2). The frequencies and percentages of different types of MRI signal changes observed in the spinal cord of the study participants. The signal changes are categorized into four groups: **Isointense:** In this category, neither T1 nor T2 signal intensities are altered. This was observed in 7 cases (23% of the total). **Hypo-intense:** This category refers to cases where only the T1 signal intensity is decreased (hypointense). However, in this dataset, there were no cases (0.00%) with hypo-intense T1 signal changes. **Hyper-intense:** This category represents cases where only the T2 signal intensity is increased (hyperintense). This was the most frequent observation, with 21 cases (70.0% of the total) exhibiting hyperintense T2 signal changes. **Hypo-Hyper-intense:** In this category, both T1 and T2 signal intensities are altered, with T1 being hypointense and T2 being hyperintense. This was observed in 2 cases (6.7% of the total). The table highlights that the majority of the cases (70.0%) showed hyperintense T2 signal changes, suggesting that T2-weighted imaging may be more sensitive in detecting spinal cord abnormalities in patients with cervical spondylotic disease (Table 3).

This table illustrates the association between MRI signal changes and Nurick Grading in 30 patients with cervical spondylotic myelopathy. It categorizes MRI findings into four types: isointensity (no signal change), hypo-intense (T1 changes only), hyper-intense (T2 changes only), and both hypo & hyper-intense (T1 & T2 changes). The distribution of these signal changes is shown across different Nurick grades (0-5). Notably, hyper-intense T2 signal changes were the most common, observed in 21 patients, predominantly in those with Nurick grades 3 and 4. No patients showed only T1 signal changes. The p-value of 0.2, indicates insignificant association between MRI signal changes and Nurick grading severity. This data suggests that T2 signal changes on MRI may be particularly relevant in assessing the severity of cervical spondylotic myelopathy. Fisher's exact test was employed due to the small sample size (n=30) and categorical nature of our data, where both MRI signal changes and Nurick grades were analyzed as categorical variables with cells having expected frequencies less than 5 in the contingency table (Table 4).

Table 1: Distribution of Age (n=30)

Distribution of Age	**N = 30**[1]
Mean ± SD	44.83 ± 11.87
Age Group	[1]n (%)
<=40 Years	13 (43.33%)
>40 Years	17 (56.67%)
Total	30 (100%)

Table 2: Distribution of patients according Nurick Grading

Distribution of Nurick Grading	**N = 30**[1]
Nurick grading *(0 to 5)	n (%)
0	0 (0.0%)
1	0 (0.0%)
2	5 (16.67%)
3	16 (53.33%)
4	8 (26.67%)
5	1 (3.33%)
Total	30 (100%)

Table 3: Frequencies of MRI Signal Changes

MRI Signal Changes	Counts	% of Total
Isointense (no signal intensity change)	7	23.3%
Hypo-intense (only T1 signal changes)	0	0.00%
Hyper-intense (only T2 signal changes)	21	70.0%
Hypo-Hyper-intense (Both T1 & T2 signal changes)	2	6.7%

Table 4: Association of MRI signal changes with Nurick Grading

MRI Signal Changes	Nurick Grading							
	Grade 0	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 5**	**Total**	**[1]P-Value**
Isointensity (no signal intensity change)	0	0	3	4	0	0	7	0.2
Hypo-intense (only T1 signal changes)	0	0	0	0	0	0	0	
Hyper-intense (only T2 signal changes)	0	0	2	11	7	1	21	
Both Hypo & Hyper-intense (Both T1 & T2 signal)	0	0	0	1	1	0	2	
Total	**0**	**0**	**5**	**16**	**8**	**1**	**30**	

[1]Fisher's exact test

4. DISCUSSION

The present study aimed to investigate the association between signal intensity changes observed on T1- and T2-weighted magnetic resonance imaging (MRI) of the spinal cord and the severity of motor myelopathy in patients with cervical spondylotic disease (CSD). The findings of this study contribute to a better understanding of the role of MRI in assessing the severity of myelopathy in CSD patients and provide valuable insights into the underlying pathophysiology of this condition. The present study found no statistically significant association (p=0.2) between MRI signal intensity changes and myelopathic severity as measured by Nurick grading in patients with cervical spondylotic disease (CSD). This finding contrasts with some previous research that suggested stronger correlations between imaging findings and clinical severity (7,8). While our study observed that hyperintense T2 signal changes were the most common finding, present in 70% of cases, the lack of significant association with clinical severity suggests that the relationship between imaging findings and functional impairment may be more complex than previously thought. This complexity aligns with observations by McCormick et al. and Zhao et al. (9) regarding the multifaceted nature of CSM pathophysiology, where clinical manifestations may not directly correspond to imaging findings. The absence of correlation might also reflect the limitations of conventional MRI in capturing the full spectrum of pathological changes, as suggested by Nukala et al. (10), who noted that traditional MRI has relatively low sensitivity (around 65%) for detecting myelopathy changes. Furthermore, this finding supports the perspective offered by Hassan et al. (11) that advanced imaging techniques like diffusion tensor imaging (DTI) might be necessary to detect subtle changes in the spinal cord before they become apparent on conventional MRI sequences. Our findings of predominantly T2 hyperintense signals (70% of cases) without corresponding clinical severity correlation aligns with observations by Peng et al. (12) regarding the complex interplay between static and dynamic compression factors in cervical myelopathy. The presence of both T1 and T2 signal changes in only a small proportion of our cases (6.7%) despite varying degrees of clinical severity challenges the traditional understanding of signal intensity progression in CSM. This finding may be better understood in the context of Zhou et al.'s (13) research on inflammatory processes and neuronal damage in CSM, suggesting that cellular and molecular changes may precede or occur independently of visible MRI signal alterations. The complex inflammatory cascade involving NLRP3-mediated pathways, as described by Liu et al. (14), might explain why some patients with significant clinical symptoms showed minimal MRI changes, while others with notable imaging findings had less severe clinical presentations. As supported by Landi et al.

(15) and Hassan et al. (11), the integration of advanced imaging techniques such as diffusion tensor imaging (DTI) alongside standard T1 and T2 sequences could help capture subtle spinal cord changes that may not be apparent on conventional MRI. This multi-modal imaging approach could potentially bridge the gap between imaging findings and clinical manifestations. Given that MRI signal changes alone did not significantly correlate with clinical severity, we recommend developing a more comprehensive clinical assessment protocol. Future research efforts should prioritize longitudinal studies that track both imaging and clinical changes over time, with particular emphasis on integrating advanced imaging techniques as suggested by Nukala et al. (10). Investigation of molecular and inflammatory markers, as highlighted by Liu et al. (14), could provide additional insights into the pathophysiology of CSM. These studies should aim for larger sample sizes and multi-center collaboration to increase result generalizability. Regular monitoring of both clinical and radiological progression should be standard practice, considering the dynamic nature of CSM pathophysiology described by Petrin & Freedman (16). These recommendations collectively aim to address the complex nature of CSM evaluation and management, acknowledging that while MRI remains an important diagnostic tool, its findings should be interpreted within a broader clinical context. By implementing these recommendations, we can work toward improving patient care through a more comprehensive and nuanced approach to diagnosis, monitoring, and treatment decision-making in CSM. The goal is to develop a more sophisticated understanding of the relationship between imaging findings and clinical manifestations, ultimately leading to better outcomes for patients with cervical spondylotic myelopathy.

5. CONCLUSION

In conclusion, based on our findings, this study suggest that conventional MRI findings alone may not be sufficient for predicting clinical severity, highlighting the need for a more comprehensive approach to patient assessment that combines advanced imaging techniques, detailed clinical examination, and potentially biochemical markers.

Author contributions

- Conception or design of the work; or the acquisition, analysis, or interpretation of data for the work: MATM, KOR, ASMAO, MK, MRA, MH
- Drafting the work or reviewing it critically for important intellectual content: MATM, KOR, MK
- Final approval of the version to be published: MATM
- Accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are investigated and resolved: MATM, MRA

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Conflict of interest

We do not have any conflicts of interest.

Ethical approval

The protocol was approved by Institutional Review Board of Bangabandhu Sheikh Mujib Medical University (currently, Bangladesh Medical University), Dhaka, Bangladesh. Ref no-BSMMU/2023/10190, Date-31/07/2023.

Data availability statement

We confirm that the data supporting the findings of this study will be shared upon reasonable request.

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