ORIGINAL ARTICLE

Role of magnetic resonance imaging in spinal cord injury: A cross-sectional study

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Objective: This study investigates the correlation between magnetic resonance imaging (MRI) findings and clinical outcomes in spinal trauma patients. **Background:** Traumatic spinal cord injuries can result in devastating and long-lasting consequences, making accurate diagnosis and prognosis crucial for effective treatment. MRI plays a key role in assessing the severity and extent of spinal cord damage. **Materials and Methods:** This study evaluated MRI findings in spinal trauma patients within 15 days of injury, correlating them with clinical profiles and neurological outcomes. A comprehensive database of MR features was established, and the prognostic value of MRI was assessed. **Results:** The study identified distinct MRI patterns in spinal trauma patients, including hemorrhages, edema, and cord ischemia. The majority of patients were male (68.63%) and between 31 and 40 years old (29.41%). Edema and hemorrhage were the most common lesions, followed by no significant change, cord transection, and cord ischemia. Only 15.69% of patients showed neurological improvement, while 84.31% exhibited no improvement. The study also found a high prevalence of soft-tissue changes, including paravertebral muscle edema and posterior longitudinal ligament sprain/tear. **Conclusion:** Despite treatment, many patients showed no neurological improvement, underscoring the severity and complexity of spinal cord injuries. The findings highlight MRI's crucial role in diagnosis and prognosis, contributing to the understanding of spinal cord injuries' management and the correlation between MRI findings and patient outcomes.

KEY WORDS: Magnetic resonance imaging, neurological outcomes, spinal cord injury, spinal trauma

INTRODUCTION

A traumatic spinal cord injury (tSCI) occurs when external forces damage neuronal components within the spinal canal, leading to motor and/or sensory function loss. This can result from falls, car accidents, or other forces and may involve the cauda equine and conus medullaris. Approximately 70% of spinal trauma patients experience spinal cord involvement, leading to potential lifelong complications.[1] Comprehensive evaluation, including radiological investigations like magnetic resonance imaging (MRI), is crucial for diagnosis and treatment planning.[2] MRI is particularly useful for diagnosing soft-tissue injuries, detecting bone fractures, and evaluating spinal cord microstructure using techniques like diffusion tensor imaging (DTI).[3]

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A spinal cord injury can be diagnosed using a variety of MRI techniques. Some of these techniques include as follows: For the purpose of diagnosing spinal cord injuries, multi-parametric MRI techniques such as chemical exchange saturation transfer, DTI, quantitative magnetization transfer, and functional MRI (fMRI) are reliant on blood oxygenation levels. FMRI (BOLD) MRI can be utilized.[4]

The use of flexion/extension radiography, computed tomography (CT), and MRI is all complementing modalities that are utilized in the examination of spinal trauma.[5] In the clinical diagnosis of spinal injuries, common diagnostic tools include magnetic resonance spectroscopy, dynamic contrast-enhanced MRI, and diffusion-weighted MRI (DWI).[6] MRI biomarkers known as DWI and perfusion-weighted imaging of spinal cord blood flow can provide information about axonal injury and perfusion abnormalities in spinal cord injuries.[7] MRI techniques can offer precise indicators of the structural integrity of tissue in tSCI and non-traumatic spinal cord injuries, like degenerative cervical myelopathy.[8]

Early detection and monitoring with MRI enables medical professionals to take prompt action, tailor treatment plans, and deliver optimal care, ultimately enhancing patients' quality of life.[9,10] This study aimed to advance the understanding and management of spinal trauma cases by establishing a comprehensive database of MRI features associated with spinal cord injuries. By evaluating MRI findings in patients within 15 days of trauma, this research created a valuable resource for medical practitioners to identify and describe specific MRI features of spinal cord injuries.

In addition, the purpose of the work was to estimate the prognostic value of MR imaging, which was critical for forecasting the outcomes of patient care and promptly organizing the most appropriate interventions. Furthermore, the research aims to fill the slit in joining imaging and patient outcomes by correlating MRI findings with clinical profiles and neurological outcomes. As a result, it has provided crucial insights that can inform treatment decisions and improved the overall quality of care for individuals who are suffering from spinal trauma. Hence, the present study aimed to evaluate diverse MRI observations in a patient with spinal trauma performed within 15 days after trauma.

MATERIALS AND METHODS

A cross-sectional study was conducted at the Department of Radiodiagnosis, Rohilkhand Medical College and Hospital, Bareilly, after receiving approval from the Board of Studies and Ethical Committee. The study aimed to evaluate MRI findings in spinal trauma and their correlation with clinical and neurological outcomes. Using a stratified random sampling method, a diverse and comprehensive sample of 51.9 patients with spinal trauma was obtained, allowing for an in-depth analysis of MRI findings across different patient groups.

The study included patients with a history of spinal cord injury who were clinically suspected to have spinal injury within 15 days, as well as both male and female patients of all age groups. In addition, patients referred to the Radiology Department of Rohilkhand Medical College and Hospital, Bareilly, for MRI whole spine investigation were also included in the study. However, patients with a previous history of spinal cord disease, those with a documented history of claustrophobia, and individuals with cardiac pacemakers or metallic foreign bodies in place were excluded from the study. MRI machine of 1.5 Tesla Magnetom Sempra Siemens machine was used.

Before MRI scans, patients underwent comprehensive screening for ferromagnetic objects and were positioned correctly with minimal movement. The scan protocol included in the study:

- Scanogram of the spine
- Axial T2- and T1-weighted rapid coronal STIR images
- Sagittal images with 3.0-mm thickness and 0.5-mm slice gap
- T2-weighted images with fat suppression
- Axial images using fast spin echo with optimized technical specifications (Figure 1)

The goal was to evaluate spinal cord hemorrhage and acquire high-quality images while minimizing susceptibility effects.

Clinical Assessment

The patient underwent a comprehensive evaluation based on the American Spinal Injury Association protocols,[11] which assess motor and sensory abilities according to the International Standards for Neurological and Functional Classification of Spinal Cord Injury Patients. The evaluation assigns Grades from A to E, with A indicating complete loss of motor and sensory function in the sacral segments, B indicating incomplete loss with retained sensory function, C indicating incomplete loss

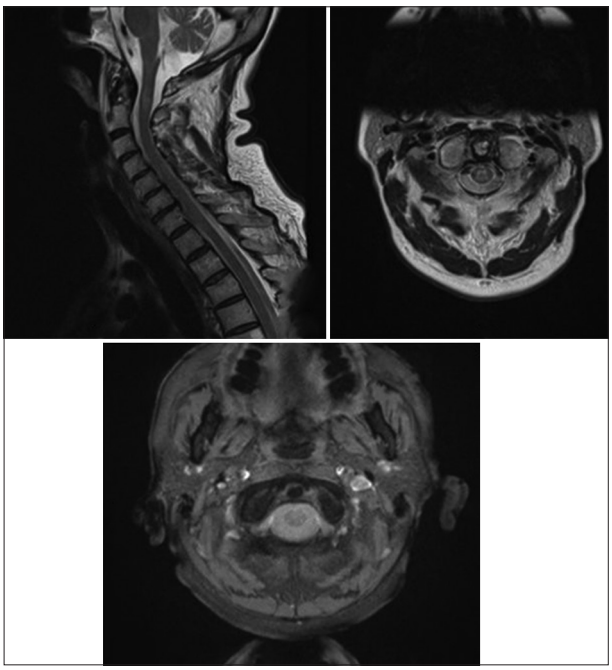

Figure 1: Patient presented with a history of fall from bike complaining of neck pain and quadriparesis. (a) Sagittal T2-weighted image showing ill-defined hyperintensities involving the cervical cord. (b) Axial T2-weighted image showing hyperintensities involving the central aspect of cervical cord. (c) Corresponding axial gradient T2* image showing no evidence of blooming – suggesting no evidence of hemorrhages. Above MRI findings in associated with clinical history suggest a diagnosis of acute spinal cord edema

with limited motor function, D indicating incomplete loss with preserved motor function, and E indicating normal motor and sensory function. This grading system helps determine the severity and extent of spinal cord injury.

Statistical Analysis

The data were first imported into a Microsoft Excel spreadsheet and then analyzed using SPSS statistical software, version 25.0. To compare the mean values of two distinct groups, the student t-test was utilized, and differences in the frequency between these groups were examined using the Chi-square test. A $P < 0.05$ was considered to denote statistical significance.

RESULTS

The sample population of 51 individuals with spinal cord injury is primarily composed of younger to middle-aged adults, with the largest proportion (29.41%) falling within the 31–40-year age group, followed by the 21–30-year age bracket (25.49%). The majority of the sample (73.53%) is under the age of 50, with smaller proportions in the older age groups [Table 1]. The MRI scans of 51 patients with spinal cord injuries revealed the following lesion distribution: Edema cord (35.29%, $n = 18$) and hemorrhage (29.41%, $n = 15$) were the most common, followed by no significant change (21.57%, $n = 11$), cord transection (9.80%, $n = 5$), and cord ischemia (3.92%, $n = 2$) [Tables 2-4]. Table 5 shows that only 15.69% ($n = 8$) of patients with spinal cord injury improved neurologically, while 84.31% ($n = 43$) did not. Improvement rates varied by clinical profile: Edema (5.88%, $n = 3$) and cord hemorrhage (5.88%, $n = 3$) showed some improvement, while cord ischemia (0%, $n = 2$) and cord transection (0%, $n = 5$) showed no improvement. The majority of patients across all profiles did not exhibit neurological improvement.

The distribution of soft-tissue changes in 51 patients with spinal cord injuries revealed that paravertebral muscle edema was the most prevalent, observed in 37.25% ($n = 19$) of cases. Posterior longitudinal ligament sprains and tears followed, occurring in 17.65% ($n = 9$) and 11.76% ($n = 6$) of patients, respectively. Epidural hematomas and anterior longitudinal ligament (ALL) tears were each found in 5.88% ($n = 3$) of cases, while epidural collections, ALL sprains, paravertebral muscle hemorrhage, and fluid collection in surrounding tissues were each identified in 3.92% ($n = 2$) of patients. Paraspinal muscle edema was the least common, occurring in only 1.96% ($n = 1$) of cases [Table 6].

Table 1: Describing the study groups as per age

Age	*n*	%
<20 years	4	7.84
21–30 years	13	25.49
31–40 years	15	29.41
41–50 years	9	17.65
51–60 years	6	11.76
61–70 years	2	3.92
71–80 years	2	3.92
Total	51	100.0

Table 2: Describing the study groups as per spinal cord lesion on MRI

Spinal cord lesion on MRI	*n*	%
Edema	18	35.29
Cord hemorrhage	15	29.41%
Cord ischemia	2	3.92
Cord transection	5	9.80
No change	11	21.57
Total	51	100.0

DISCUSSION

In this study, we systematically evaluated the MRI findings in patients with spinal trauma admitted in the Department of Radiodiagnosis, Rohilkhand Medical College and Hospital, Bareilly.

The data reveals that the largest proportion of the sample falls within the 31–40-year age group, accounting for 29.41% of the total. This is closely followed by the 21–30 years age bracket, which constitutes 25.49% of the population. In Andreoli *et al.*,[12] it was found that most patients with spinal cord injuries were in the age group of 40–60 years, and the majority of them had only hemorrhage on MRI. Another study by Shimada and Tokioka[13] focused on neck pain and found that reduced vertebral height, disk height, and disk bulge were common MRI findings in this age group. Ahuja and Fehlings[14] conducted a study on and found that MRI was an excellent modality for imaging acute spinal trauma, with significant differences observed in cord hemorrhage, compression among patients with complete, incomplete, and no spinal cord injury. Therefore, age plays a role in determining the specific MRI findings in patients with spinal trauma.

In our study, the most prevalent lesions identified were edema cord (35.29%, $n = 18$) and hemorrhage (29.41%, $n = 15$), followed by cord transection (9.80%, $n = 5$) and cord ischemia (3.92%, $n = 2$). The prevalence of these lesions varies depending on the specific condition, such as spinal cord hemorrhage, cavernous malformations, and ischemia. MRI can provide valuable information on the characteristics of these lesions, aiding in early.

In our study, 15.69% of patients initially presented with complete motor and sensory loss (AIS grade A), decreasing to 11.76% at discharge, indicating some recovery. Conversely, AIS Grade C injuries increased from 1.96% to 5.88% at discharge. Cord hemorrhage on MRI correlated with severe neurological impairment, and patients with complete injuries had a higher frequency of intramedullary hemorrhage. The study found that lesion length, compression, and hemorrhage predicted poor neurological outcomes. Most patients had severe injuries (AIS

Table 3: Describing the study groups as per AIS grading with cord hemorrhage and cord edema

AIS grading	Cord hemorrhage				Cord edema			
	Patients at admission		Patients at discharge		Patients at admission		Patients at discharge	
	n	%	*n*	%	*n*	%	*n*	%
A	8	15.69	7	13.73	7	13.73	5	9.80
B	6	11.76	2	3.92	2	3.92	1	1.96
C	1	1.96	2	3.92	2	3.92	1	1.96
D	0	0.00	7	13.73	7	13.73	11	21.57
E	0	0.00	0	0.00	0	0.00	0	0.00
Total	15	29.41%	18	35.29	18	35.29	18	35.29

Table 4: Describing the study groups as per AIS grading with cord transection and cord ischemia

AIS grading	Cord transection				Cord ischemia			
	Patients at admission		Patients at discharge		Patients at admission		Patients at discharge	
	n	%	*n*	%	*n*	%	*n*	%
A	5	9.80	5	9.80	2	3.92	3	5.88
B	0	0.00	0	0.00	0	0.00	0	0.00
C	0	0.00	0	0.00	0	0.00	0	0.00
D	0	0.00	0	0.00	0	0.00	0	0.00
E	0	0.00	0	0.00	0	0.00	0	0.00
Total	5	9.80	5	9.80	2	3.92	3	5.88

Table 5: Describing the study groups as per neurological outcome

Clinical profile	Improvement		No improvement	
	n	%	*n*	%
Cord hemorrhage	3	5.88	12	23.53
Edema	3	5.88	15	29.41
Cord ischemia	0	0.00	2	3.92
Cord transection	0	0.00	5	9.80
No Change	2	3.92	9	17.65
Total	8	15.69	43	84.31

Table 6: Describing the study groups as per soft-tissue changes

Soft-tissue changes	*n*	%
Epidural hematoma	3	5.88
Epidural collection	2	3.92
ALL sprain	2	3.92
ALL tear	3	5.88
PLL sprain	9	17.65
PLL tear	6	11.76
Paravertebral muscle edema	19	37.25
Paravertebral muscle hemorrhage	3	5.88
Fluid collection	3	5.88
Paraspinal muscle edema	1	1.96
Total	51	100.0

PLL: Posterior longitudinal ligament, ALL: Anterior longitudinal ligament

grade D, 13.73%), and the presence and extent of edema on MRI predicted initial neurological deficits and final outcomes, with patients having edema showing good functional recovery on follow-up.

In the present study, majority of cases who were diagnosed with cord transection and ischemia had poor prognosis and their percentage slightly increased at discharge. Andreoli *et al.*[12] also showed results that were very similar to these. Patients who suffered from ischemia, transection, and hemorrhage had a worse prognosis compared to those who had edema. It was shown by Flanders and Croul[15] that patients who did not have hemorrhages in their spinal cords had significant improvements in their mobility and self-care who did have hemorrhages. A favorable link was found between the rostral limit of edema and the self-care scores, according to their research findings. Having hemorrhage high cervical location was all factors that indicated a poor prognosis. Similar findings were observed in the work of Selden NR, including long length of intra-axial hematoma and cord edema, both of which are associated with a poor neurological outcome.

MRI offers diagnostic insights into bone and soft-tissue damage but does not significantly contribute to the assessment of neurological function, as evidenced by randomized clinical trials led by Shepard and Bracken.[16] Although the trials indicated that the existence of hemorrhage is linked to a poorer prognosis, they did not offer any details on the chances of a patient's recovery. AE the findings of Flanders and Croul were also very similar to those of our study. In the post-operative care of patients, MRI is a very helpful diagnostic tool. Andreoli *et al.*[12] demonstrated

a significant relationship between the appearance of an MRI during the long-term recovery of motor and sensory functions. In patients who are unconscious and unable to undergo motor and sensory neurological evaluation, MRI is an especially helpful diagnostic tool.

Saifuddin[17] confirmed that crucial imaging technology is MRI. Selden NR showed that conducting an urgent MRI following injury can offer precise prognostic details about neurological function. This information can aid in diagnosing and treating situations of prolonged cord compression following vertebral alignment. In essence, our research contributes to the understanding of spinal trauma, particularly MRI findings, demographic factors, lesion prevalence, and prognosis. It underscores the significance of age and gender in spinal trauma presentation and outcomes and highlights the crucial role of MRI in the comprehensive management of such injuries, from diagnosis to prognostication and recovery tracking.

The study, however, is not without its limitations. The sample size of 51 patients, while informative, limits the generalizability of the findings to broader populations. In addition, the study's retrospective nature and the focus on a single medical center may introduce biases or limit the applicability of the findings to other settings or populations. The diversity of spinal injuries and the complexity of their outcomes also suggest that multiple factors, beyond those assessed in this study, may influence recovery and prognosis. Future research should aim to include larger, more diverse populations to enhance the generalizability of the findings. Prospective studies that follow patients from injury through recovery could provide more nuanced insights into the factors that contribute to better or worse outcomes.

CONCLUSION

The prognostic value of MRI features in spinal trauma was assessed, alongside their correlation with clinical profiles and neurological outcomes, and the relationship between AIS grading and clinical profile. Despite various treatments, a significant proportion of patients did not exhibit neurological improvement across different clinical profiles. The findings emphasize the severity and complexity of spinal cord injuries and highlight the critical role of MRI in diagnosing and prognosticating spinal trauma. This study contributes to the understanding of spinal cord injuries' diagnostic and clinical management, offering insights into the correlation between MRI findings and patient outcomes.

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