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Original Research Article

Role of magnetic resonance imaging in spinal cord evaluation in traumatic spinal injuries

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ABSTRACT:

Background: Spinal cord injuries have a significant impact on individual's quality of life. It can be evaluated using MRI. MRI plays a crucial role in assessing ligamentous injuries, spinal cord injuries and soft tissue injuries. MRI imaging appearance of the spine also predicts outcomes after trauma. Most of the previous studies are based on the same. Few studies, like the present study, correlate vertebral and ligamentous injuries with spinal cord findings. This study aimed to evaluate the role of MRI in spinal cord evaluation in various osseous and ligamentous spinal injuries.

Methodology: In this prospective study, a total of 66 patients of all ages with a history of trauma and involvement of the spine were taken as per inclusion-exclusion criteria. On MRI, various spinal cord injuries were evaluated in traumatic vertebral and ligamentous injuries of the spine.

Results: In our study, cord abnormalities are found in 36 (55%) of patients and vertebral abnormalities are found in 56 (85%) of patients. The most common finding in the spinal cord was spinal cord oedema in 35(53%) cases. The results of our study have shown that spinal cord injuries are significantly associated in patients with posterior element fracture, facet joint dislocation, ALL tear, PLL tear and posterior ligament complex tear. Also, in patients having more than one fracture, significant bony and ligamentous injuries are more commonly associated with spinal cord injuries.

Conclusion: It can be concluded that if an X-Ray of a traumatic spinal injury patient shows posterior element fracture, multiple bony fractures and facet joint dislocation, there is a high likelihood of spinal cord injury in them.

KEYWORDS: Magnetic Resonance Imaging, Spinal cord injuries, Spinal trauma.

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1. INTRODUCTION-

Spinal cord injuries have a significant impact on an individual's quality of life. It can be evaluated using Magnetic Resonance Imaging (MRI). Early diagnosis of traumatic lesions of the spine helps in their early management and improves the prognosis. The correlation between lesion length and clinical neurological outcome can be demonstrated in the acute phase of cervical trauma [1,2]. In fact, it is recommended that the initial MR imaging be performed between 24 and 72 hours after injury [3].

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MRI plays a crucial role in assessing ligamentous injuries, spinal cord injuries and soft tissue injuries [4]. MRI imaging appearance of the spine also predicts outcome after trauma [5].

Spinal cord findings in trauma include cord oedema, cord compression and cord hematoma. In the present study, these findings are evaluated in patients with vertebral fractures and ligamentous injuries. Most of the studies show the association between radiological findings and clinical outcome. Few studies have been conducted to show the correlation between spinal cord findings with osseous and ligamentous injuries. Hence, we have conducted a study on the same. In 2016, Yogesh Kumar and Daichi Hayashi et al. conducted a study in which they determined that MRI is more sensitive than other imaging modalities for diagnosing soft tissue and spinal cord injuries. Despite the fact that CT is deemed adequate for determining stable versus unstable spinal injuries, MRI can provide additional assistance due to its superior ability to diagnose ligamentous injuries compared to CT. By demonstrating hemorrhagic and non-hemorrhagic cord injuries, MRI can also aid in prognosis prediction [4].

Normal cord on the base MRI predicts an outstanding outcome. Significant differences were observed in cord haemorrhage, cord transfer, and cord compression between patients with complete, fragmentary, and spine trauma without SCI [6]. There is a significant correlation between MRI findings and ASIA scores at various times following SCI [7].

In a study conducted in 2018, Bukke Ravin Naik et al. found that MRI can depict alterations in the injured spine and cord. The presence of cord oedema and a normal cord was associated with a favourable neurological outcome. In comparison to cord oedema and a normal cord, the neurological recovery of patients with cord contusion was unsatisfactory. Complete spinal cord injury and poor neurological rehabilitation were associated with cord transaction and haemorrhage [8].

Diffusion Tensor Imaging (DTI), with its quantitative indices, is a useful instrument for evaluating the white matter integrity of the spinal cord. Fractional anisotropy and apparent diffusion coefficient values are considerably reduced at the level of injury, with fractional anisotropy being more sensitive and accurate in detecting abnormalities at the site of injury. DTI is therefore indicated as a routine investigation in spinal trauma in addition to standard MRI sequences [9].

Cong Xing et al. conducted a study on a rat model and found that the lesion area of the spinal cord finding is significantly related to behavior outcomes and is a better indicator for damage assessment compared with other parameters in sagittal T2-weighted MRI (T2WI) [10].

R Martinez Perez et al. conducted a study in which they observed that Anterior longitudinal Ligament (ALL) and Posterior longitudinal ligament (PLL) had a positive correlation with the severity of the spinal cord injury. Still, only ligamentum flavum demonstrated a statistically significant association with lesion length. As ligamentous injury detected by MRI is not a dynamic finding, it is therefore valuable for predicting neurologic outcomes in patients whose MRI examination was delayed [11].

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The aim of the present study is to study the characteristic MR imaging findings in various traumatic lesions of the spine and to study the association of spinal cord findings with bony and ligamentous injuries.

2. MATERIAL AND METHODS-

The study was a prospective study conducted on 66 patients in the Department of Radiodiagnosis, G.R.M.C. Gwalior. The study was approved by the ethical committee of Gajra Raja Medical College, M. P., and IEC approval certificate number is 136/IEC-GRMC/2020. Patients of all ages with a history of trauma and likely involvement of the spine will be considered for the study. After clinical evaluation, once a patient is satisfied with the inclusion and exclusion criteria for the study, he or she will be taken for an MRI examination of the affected region of the spine.

Inclusion criteria were patients undergoing an MRI of the spine for various traumatic etiologies with clinically suspected spinal involvement. Exclusion criteria were patients not giving consent, claustrophobic patients, and patients with the metallic implant, cardiac pacemakers, cochlear implant and metallic foreign body. MRI was done using Phillips Ingenia 1.5 Tesla dStream with surface coil wherever necessary. The data is taken from MRI spine studies of 66 patients performed between December 2020 to May 2022.

Statistical analysis-

Mean, and standard deviation was calculated for quantitative data. Frequency and percentage were calculated to show the distribution of qualitative data. Chi-square tests were applied to see an association between variables. For the expected cell count of less than 5, the fisher exact test was applied. p values were calculated at 5% level of significance. Data was entered into Microsoft excel software, and statistical analysis was done with IBM SPSS 22 software.

3. RESULTS-

Observations are made on the basis of clinical history and MRI findings of the patient. Maximum patients (23) were in the age group of 19 to 30 years(35%) followed by 31 to 40 years (26%) and minimum in the age more than 60 years (4.5%). Forty-four were males (67%) and 22 were females (33%). Twenty-eight patients came for MRI examination within three days of trauma, 11 came four to seven days after trauma, 23 came 7-30 days after trauma, and 4 came more than 30 days after trauma. Seventeen patients have a cervical spine injury, 19 have a dorsal spine injury, 23 have lumbar spine injury, and seven have an injury in multiple spinal segments. Various spinal cord findings on MRI in spinal trauma and their frequency is shown in Table 1. The most common finding in the spinal cord was spinal cord oedema in 35(53%) cases. The association of spinal cord findings with various traumatic bony and ligamentous spinal injuries is shown in Table 2. The frequency of individual spinal cord finding in various bony and ligamentous spinal injuries is shown in Table 3. A few combined injuries, like both posterior element fracture and posterior ligament complex tear, have also been added in these tables and spinal cord findings are discussed in them. Various vertebral injuries, ligamentous injuries and combined injuries are enlisted, and their association with various spinal cord findings are studied in the present study.

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Table 1- Evaluation of spinal cord findings on MRI in spinal trauma

Spinal cord findings	Number	Percentage
Cord oedema/ contusion	35	53%
Cord hemorrhage	1	1.5%
Cord compression	17	25%
Epidural hematoma	2	3%
No findings in cord	31	47%

Table 2: Association of spinal cord findings with various traumatic bony and ligamentous spinal injuries

Bone and ligamentous injuries	Cases with spinal cord findings	Cases without spinal cord findings	Total	Chi square	p value
Vertebral body fracture	31	22	53	3.221	0.073
Posterior element fracture	19	4	23	12.40	.0005*
Posterior ligament complex tear	9	0	9	9.230	0.002*
PLL tear	14	1	15	12.65	0.0003*
ALL tear	9	2	11	4.392	0.036*
Facet joint dislocation	7	0	7	6.936	0.008*
Vertebral body and posterior element fracture	17	4	21	9.641	0.002*
Facet joint dislocation and posterior element fracture	5	0	5	4.792	0.029*
Posterior ligament complex tear and posterior element fracture	7	1	8	4.342	0.037*

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Table 3: Comparative evaluation of various bony and ligamentous spinal injuries with various spinal cord findings.

Bone and ligamentous injuries	Spinal cord oedema	Cord compression	Cord hemorrhage	Epidural hematoma	No findings in cord
Vertebral body fracture	31	14	1	1	22
Posterior element fracture	19	15	0	2	4
Posterior ligament complex tear	9	7	0	0	0
PLL tear	14	9	1	0	1
ALL tear	9	5	0	0	2
Facet joint dislocation	7	7	0	0	0
Vertebral body and posterior element fracture	17	14	0	1	4
Facet joint dislocation and Posterior element fracture	5	5	0	0	0
Posterior ligament complex tear and Posterior element fracture	7	6	0	0	1

4. DISCUSSION-

With the increasing availability of new technology, the standard of care for imaging the spine of trauma patients is continuously evolving. Prior to the advent of multidetector helical computed tomography (CT), imaging the spine was less precise and time-consuming. MRI plays a significant role in the imaging algorithm as well. Being a noninvasive technique with high specificity and sensitivity, MRI should be performed whenever a spinal cord lesion is suspected, and it is more sensitive than any other modality in assessing soft tissue and spinal cord injuries.

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In the current study, cord abnormalities is found in 36 (55%) of patients and vertebral abnormalities are found in 56 (85%) of patients. These results are comparable to the study of Kulkarni et al. who revealed the presence of cord abnormalities in 70% of patients and skeletal abnormalities in 78% of patients[12].

In the current investigation, oedema of the spinal cord was the most common finding, seen in 35 cases. Bleeding or haemorrhage in the spinal cord was observed in one case (Figure 1), cord compression in seventeen cases, and epidural hematoma in two cases. In the study by Gupta R. et al., oedema was the most frequently observed MRI pattern, observed in 26% of the subjects, while haemorrhage was observed in 16% of the subjects[13]. In 2011, Parashari et al. found that among 62 patients with SCI, 41.5% had spinal cord oedema without bleeding, 33% had spinal cord hemorrhaging, 5% had epidural hematoma, and 26% had a normal spinal cord. The neurological injury and prognosis of spinal cord oedema and haemorrhage patients were exacerbated[14].

In the current study significant association of posterior element fracture with spinal cord oedema was found. Posterior element fracture is found to have a significant association with facet joint dislocation and posterior ligament complex tear too. These injuries, in turn, lead to antero and retro-listhesis of one vertebra over another, which causes spinal cord oedema and compression.

In the current study, it was found that out of 53 cases diagnosed with vertebral body fracture, 21 were also diagnosed to have posterior element fracture. This fracture is classified as a two-column injury, calling it unstable and requiring surgical stabilization. Figure 2 shows a case with vertebral body and posterior element fracture with spinal cord compression due to posterosuperior dislocation of fractured bony fragment. In the current study, it was found that out of 53 cases with vertebral body fracture, four cases also show posterior element fracture, facet joint dislocation and posterior ligament complex tear. This pattern is similar to that seen in flexion distraction injuries. Flexion/distraction injuries may be either purely osseous or an association of osseous and ligamentous injuries, with purely ligamentous injuries being uncommon[15-17]. Significant association of these combined osseous and ligamentous injuries is found with spinal cord findings in the present study. More than one vertebral body fracture was seen in five cases in the present study, and all of these cases were associated with spinal cord findings.

In the current study, it was found that there is a significant association between ALL and PLL tears with spinal cord oedema. Figure 3 shows a case of PLL and interspinous ligament (posterior ligament complex) tear with spinal cord oedema. A significant association between facet joint dislocation and spinal cord compression was also found. Of five patients with both facet joint dislocation and posterior element fracture, all are associated with spinal cord findings. Spinal cord compression by facet joint dislocation is due to anterolisthesis and retrolisthesis of the superior vertebra over inferior vertebra. Zhang et al. found that unilateral cervical facet dislocations account for 5% of cervical spine injuries and are frequently accompanied by posterior fractures, ligamentous avulsions, and annulus fibrosis ruptures, which can result in instability, neurologic deficits, and severe disability[18].

The current study found a significant association between posterior ligament complex tear and spinal cord compression. Partial transaction of the cord was seen in one patient only, so we included it in cord compression. The present study shows more spinal cord findings in

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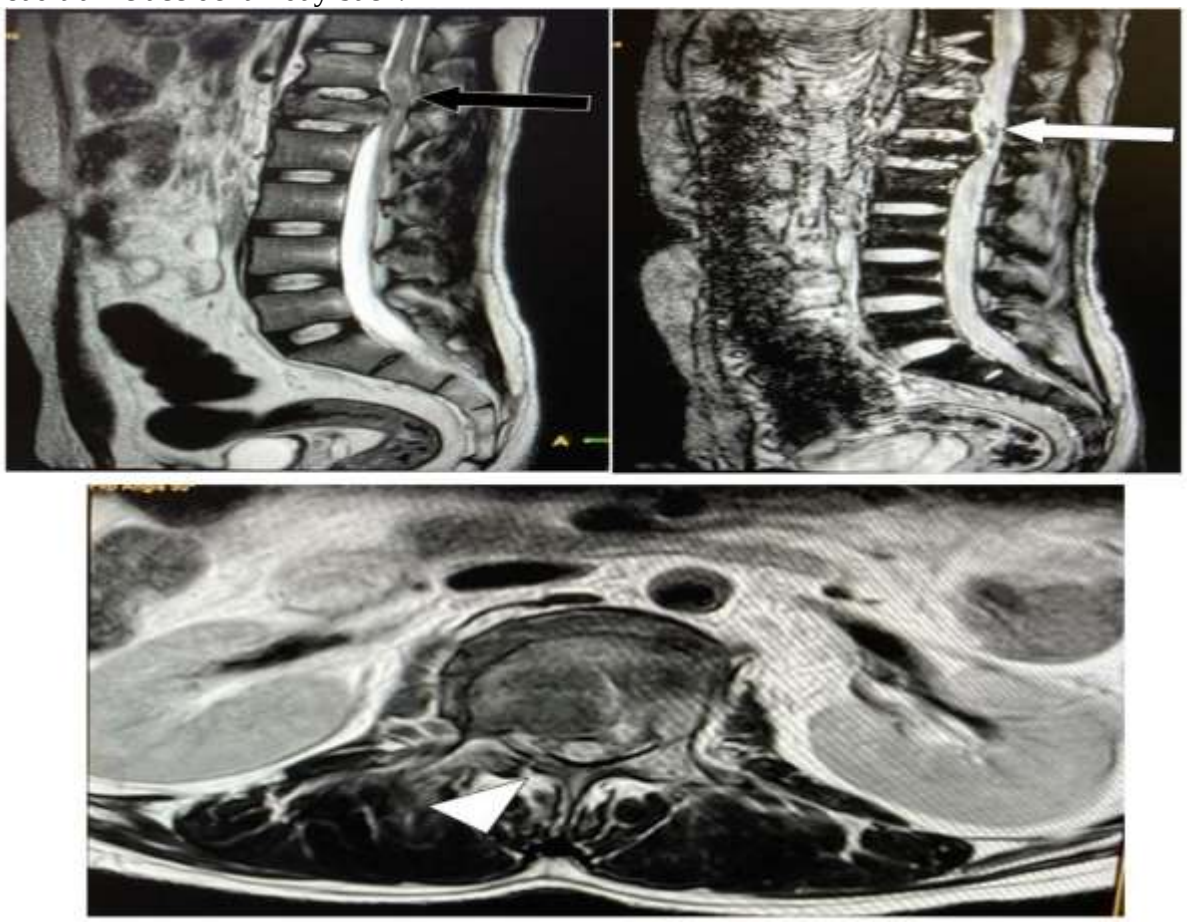
patients with both posterior ligament complex tear and posterior element fracture. In a sequential paradigm of injuries to the posterior ligamentous complex, facet diastasis and interspinous ligament oedema occur first and may be present in stable injuries. In potentially unstable injuries, the supraspinous ligament and then the ligamentum flavum can rupture. Vertebral displacement corresponds to complete ruptures of the posterior ligamentous complex and fracture or dislocation of the facet joints[19].

The timing of the magnetic resonance imaging is the first limitation of our investigation. Clinical instability caused by cervical trauma can hinder the reliability of MR imaging in the initial hours. Bozzo et al. concluded that MR imaging should be performed immediately after SCI for improved prognosis[20]. During the initial days, transferring critical or unstable patients from the intensive care unit to the MRI room poses an unacceptable risk, particularly for trauma patients. The duration of edoema in T2-weighted images after trauma depends on when MR imaging was conducted[21]. Correct identification and diagnosis of ligament rupture may be the second limitation of our investigation. When compared to intraoperative findings in ligament rupture, T2-weighted images have demonstrated moderate to high sensitivity with low specificity[22,23]. Thirdly, this study consisted of a limited group of spinal trauma patients for whom an MRI spine was recommended and who came to our department for MRI. In the majority of cases, MR imaging is not necessary for minor spinal injuries with a lesser degree of the lesion.

Figure 1: A 35-year-old male presents with weakness in bilateral lower limbs followed by road traffic accident 1 day back.



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(A)Sagittal T2 w image shows fracture of L1 vertebra with hyperintensity in the spinal cord at this level (black arrow). (B) The sagittal GRE image shows foci of blooming in the spinal cord suggestive of spinal cord haemorrhage (white arrow). (C) Axial T2 w image shows fracture of posterior elements (arrowhead) and vertebral body causing compression of the spinal canal.

Figure 2. A 17-year-old female presents with a history of fall from a height one day back, followed by weakness in both lower limbs.

(A) Sagittal T2 w image shows fracture of L2 vertebral body and posterior element with posterosuperior dislocation of fractured bone fragment causing spinal canal stenosis (arrowhead) and compression over conus and proximal cauda equina nerve roots. Tear of the anterior longitudinal ligament (white arrow) and posterior longitudinal ligament were noted at this level. (B) Axial T2 w image showing spinal canal stenosis and compression of bilateral exiting nerve roots at this level (black arrow).

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Figure 3: A 18-year-old female presents with weakness in bilateral lower limbs followed by a fall from height 2 days back.

(A) Sagittal T2 w and (B) Sagittal STIR image showing fracture of L3 and l2 vertebral body with a widened distance between posterior elements of L1 and L2 vertebra, soft tissue oedema, posterior longitudinal ligament tear and interspinous ligament tear (white arrow). There is buckling of ALL and PLL. T2/STIR hyperintensity noted in conus (arrowhead), likely oedema.

4. CONCLUSION-

Spinal cord injuries are very commonly seen in traumatic spinal injuries, which affects the prognosis. The results of our study have shown that spinal cord injuries are significantly associated in patients with posterior element fracture, facet joint dislocation, ALL tear, PLL tear and posterior ligament complex tear. Also, patients having more than one fracture, and significant bony and ligamentous injuries are more commonly associated with spinal cord injuries. It can be concluded that if an X-Ray of a traumatic spinal injury patient shows posterior element fracture, multiple bony fractures and facet joint dislocation, there is a high likelihood of spinal cord injury in them. Hence, they should be further imaged with MRI to evaluate the spinal cord.

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