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Evaluation Of Mri In The Assessment Of Epidural Hematoma, Spinal Cord Transection And Soft Tissues Injury In Spinal Trauma

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Abstract

Introduction: Spinal trauma can cause spinal cord injury (SCI) leading to severe neurological deficits, requiring early diagnosis. MRI is the gold standard for assessing spinal cord and soft tissue injuries, though its use is limited by availability and lack of standard protocols.

Objective: To assess the diagnostic effectiveness of MRI in detecting epidural hematoma, spinal cord transection, and soft tissue injuries in spinal trauma patients.

Methodology: A descriptive cross-sectional study was conducted at DHQ Gujranwala over 4 months with a sample of 60 patients selected through non-probability sampling. Data were analyzed using SPSS 24.0 and Excel 2016. Descriptive statistics frequencies, percentages, mean ± SD were applied, while Chi-square and t-tests assessed associations, with $p < 0.05$ considered significant.

Results: Out of 60 cases, males were 53.3%, with most injuries from non-specific causes (71.7%) and lumbar involvement (55.0%). Pain (60%) was significantly linked to injury level ($p = 0.002$), and paralysis (21.7%) was associated with key MRI findings ($p \leq 0.020$). Mode of injury correlated with major abnormalities ($p < 0.05$). MRI showed high specificity for epidural hematoma (94.3%) and cord transection (90.6%), but low sensitivity for soft tissue injury (20.0%).

Conclusion: MRI is a highly specific and reliable imaging tool in spinal trauma, particularly effective for ruling out epidural hematoma and correlating with neurological deficits such as paralysis. Overall, it plays a key role in accurate diagnosis, management, and outcome prediction, while age and gender are not significant predictors of spinal cord injury.

Introduction

Spinal cord injury (SCI) is a clinical condition in which a complete or incomplete lesion of the spinal cord induces a total or partial interruption of the bidirectional communication between the body and the brain, with the consequence that no somatosensory input from the body periphery below the lesion level (e.g., sensations of touch, pressure, the sense of limb position) is sent to the brain (de-afferentation) and no motor commands from the motor cortices can reach the muscles controlling the body parts below-the-lesion level, ultimately leading to paresis or paralysis (de-efferentation). The extent of deprivation depends on the lesion level[1]

Vertebral fractures have a variety of etiologies including trauma, osteoporosis or neoplasm. An osteoporotic compression fracture has high prevalence among postmenopausal women and occurs less frequently in similar aged men. The young population is frequently involved in road accident, and incidence of fall from height. Spinal injury present in various severity & prognosis varying from asymptomatic condition to neurological deficit. Radiological imaging has important role in the management of spinal cord[2].

Spinal trauma is a common and potentially life-altering condition, particularly when it results in spinal cord injury (SCI). The global incidence of acute SCI is estimated at approximately 750 cases per million annually, with a significant impact on younger individuals and their families due to long-term disability and socio-economic burden[3]. Evidence-based acute management focuses on early intervention strategies such as spinal immobilization, prevention of hypotension and hypoxia, and timely surgical decompression to optimize neurological outcomes[4].

According to the **National Spinal Cord Injury Statistical Center,** approximately **12,500 new SCI cases** occur annually in North America. Over **90% of these injuries are traumatic,** commonly caused by motor vehicle accidents, falls, violence, and sports-related incidents. The condition shows a **male predominance** with a male-to-female ratio of about **2:1,** and it occurs more frequently in adults than in children[5]. Demographically, **men are most affected during early and late adulthood** (third and eighth decades), whereas **women show higher risk during adolescence (15–19 years)** and later adulthood (seventh decade). The **age distribution is bimodal,** with incidence peaks among young adults and individuals over 60 years of age[6]. Notably, **older adults tend to experience poorer outcomes,** as their injuries are often linked to age-related degeneration and falls.

A complete transection model of SCI is relatively easy to reproduce. However, this model is less relevant to human SCI as a complete transection of the spinal cord rarely happens. While they do not represent clinical reality of SCI, transection models are specifically suitable for studying axonal regeneration or developing biomaterial scaffolds to bridge the gap between proximal and distal stamps of the severed spinal cord. Due to complete disconnection from higher motor centers, this model is also suitable for studying the role of propriospinal motor and sensory circuits in recovery of locomotion following SCI. Partial transection models including hemi-section, unilateral transection and dorsal column lesions are other variants of transection models. Partial transection models are valuable for investigation of nerve grafting, plasticity and where a comparison between injured and non-injured pathways is needed in the same animal. However, these models lead to a less severe injury and higher magnitude of spontaneous recovery rendering them less suitable for development and evaluation of new therapies[7].

Spontaneous spinal epidural hematoma (SSEH) is a relatively uncommon but potentially devastating disorder first described in 1869 by Jackson. Its estimated incidence is 0.1 in 100,000 per year[8]. Patients generally present with sudden onset acute back or neck pain, followed by progressive motor, sensory symptoms, or sphincter dysfunction, which ultimately leads to complete/incomplete motor deficit caused by spinal cord/nerve root compression or cauda equina. Once the diagnosis is suspected, early surgical intervention should be considered[9]. Although there is no consensus on the ideal timing for surgery, most authors consider that surgery performed within 12 hours after the onset of symptoms is associated with better outcomes. There is some risk factors were reported for the occurrence of SSEH, including older ages, obesity, history of hypertension, alcohol consuming, smoking, abnormal blood coagulation, multilevel surgery, revision surgery and low serum calcium level[10,11].

In the past, radiography (plain radiograph) was the initial imaging modality in evaluation of spinal trauma. However, radiography has limited sensitivity (30%–60%)

for the detection of bony and ligamentous injuries in patients for whom there is a high suspicion of spinal injury[12].

METHODOLOGY:

This descriptive cross-sectional study was conducted at DHQ Hospital Gujranwala over four months with a sample size of 60 patients selected through non-probability sampling. The study included patients with acute spinal trauma who underwent MRI for suspected spinal cord, epidural, or soft tissue injuries. Clinical data such as pain, motor weakness, sensory deficits, and paralysis were recorded using a structured proforma. MRI was performed using 1.5T or 3T scanners with standard spinal trauma protocols including T1, T2, STIR, and GRE sequences. Data were analyzed using SPSS 24.0 and Microsoft Excel 2016. Descriptive statistics, Chi-square tests, and t-tests were applied, with $p < 0.05$ considered statistically significant. Results were presented through tables, charts, and graphs.

RESULTS:

Out of 61 participants, 60 were valid cases, including 32 males (53.3%) and 28 females (46.7%). Most injuries were caused by other/non-specific causes (43, 71.7%), followed by road traffic accidents (9, 15.0%) and falls (8, 13.3%). Lumbar spine injuries were most common (33, 55.0%), followed by cervical (25, 41.7%) and thoracic injuries (2, 3.3%). Pain was present in 36 patients (60%) and showed a significant association with injury level ($p = 0.002$). Radiculopathy was absent in most patients (44, 73.3%) and was significantly associated with fracture type ($p = 0.001$). Paralysis was observed in 13 patients (21.7%) and showed significant associations with disc bulge ($p = 0.020$), epidural hematoma ($p = 0.007$), cord hemorrhage ($p = 0.007$), and disc degeneration ($p = 0.007$), while no significant association was found with cord compression ($p = 0.859$) or soft tissue injury ($p = 0.552$). Sensory loss was present in 12 patients (20%) and showed no significant association with disc bulge ($p = 0.137$), cord compression ($p = 0.605$), epidural hematoma ($p = 0.435$), cord hemorrhage ($p = 0.796$), disc degeneration ($p = 0.598$), or soft tissue injury ($p = 0.405$). Mode of injury was significantly associated with cord compression ($p = 0.048$), epidural hematoma ($p = 0.001$), and cord hemorrhage ($p = 0.004$). No significant association was found between injury level and soft tissue injury ($p = 0.492$) or spinal cord transection ($p = 0.613$). Age showed significant associations with pain ($p = 0.010$), paralysis ($p = 0.002$), and mode of injury ($p = 0.001$), while no significant age difference was found between genders ($p = 0.195$). Logistic regression analysis showed that age ($p = 0.837$) and gender ($p = 0.700$) were not significant predictors of spinal cord injury, with low explanatory power (Nagelkerke $R^2 = 0.002–0.006$). MRI demonstrated high diagnostic performance for epidural hematoma with 94.3% specificity, 60.0% sensitivity, and 91.4% accuracy. For spinal cord transection, MRI showed 90.6% specificity, 40.0% sensitivity, and 86.2% accuracy. Soft tissue injury showed lower diagnostic performance with 69.8% specificity, 20.0% sensitivity, and 65.5% accuracy.

Table 4.1 & Fig.4.1
Frequency Distribution of Clinical History:

Variable	**Category**	**Frequency (n=60)**	**Percentage (%)**
Gender	Male	32	53.3
	Female	28	46.7
Mode of Injury	RTA	9	15.0
	Fall	8	13.3

	Other	43	71.7
Level of Injury	Cervical	25	41.7
	Thoracic	2	3.3
	Lumbar	33	55.0
Pain	Present	36	60.0
Radiculopathy	Present (all types)	16	26.7
Numbness	Present	16	26.7
Paralysis	Present	13	21.7
Sensory Loss	Present	12	20.0

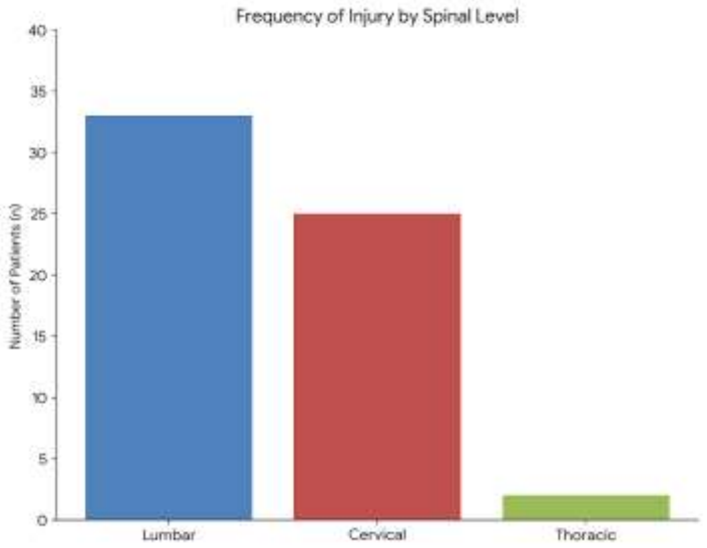
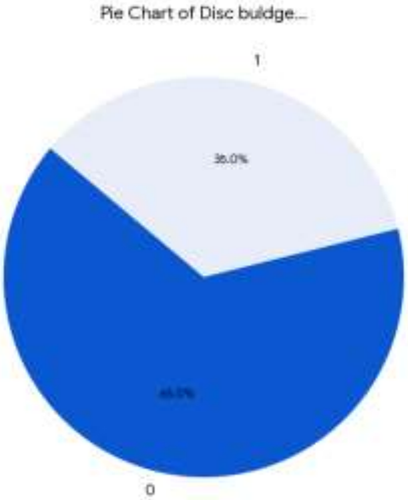
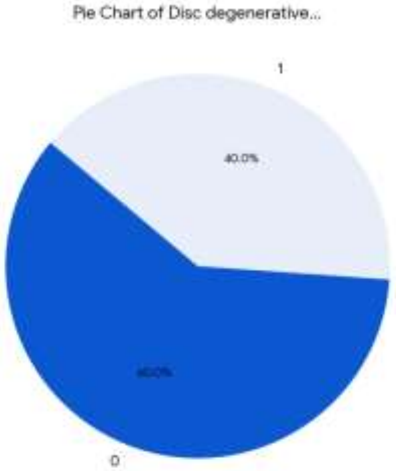
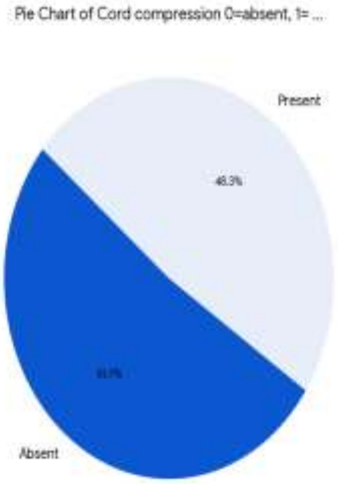


Table 4.2 & Fig.4.2
Frequency Distribution MRI Finding:

Variable	Category	Frequency (n=60)	Percentage (%)
Disc Bulge	Present	21	35.0
Disc Degeneration	Present	24	40.0
Cord Compression	Present	29	48.3
Spinal Cord Injury	Present	5	8.6
Cord Hemorrhage	Present	4	6.7
Cord Edema	Present	13	21.7
Soft Tissue Injury	Present	19	31.7







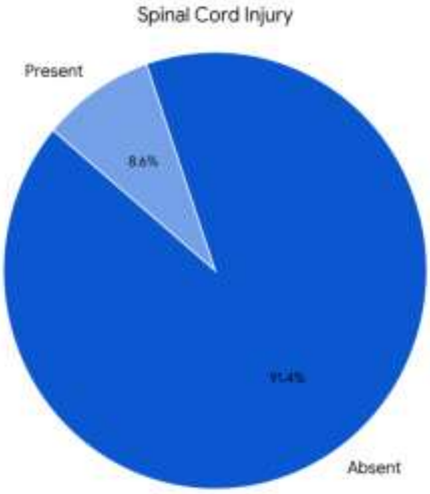


Table 4.3 & Fig.4.3

Mode of Injury * Epidural Hematoma					
		Epidural Hematoma			Total
		Absent	Anterior	Posterior	
Mode of Injury	RTA	6	1	2	9
	Fall	6	2	0	8
	other	42	1	0	43
Total		54	4	2	60

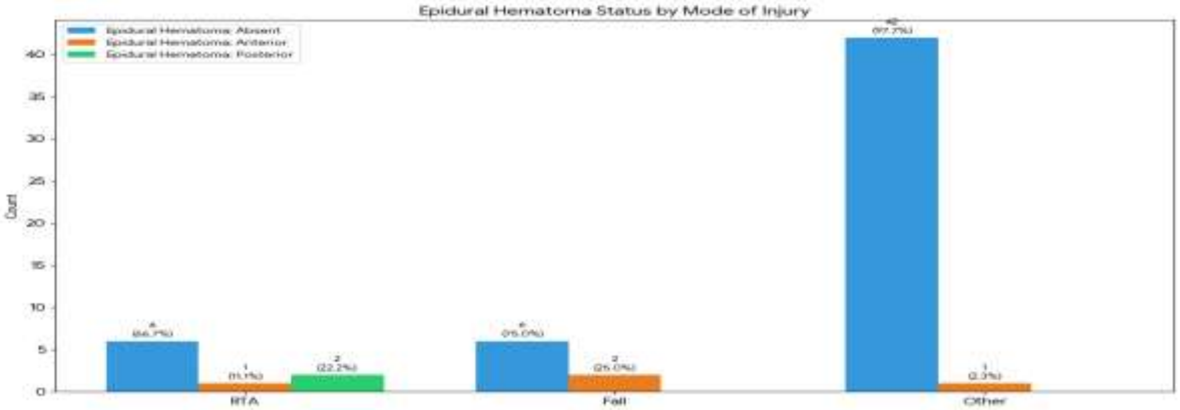


Table 4.4 & Fig.4.4

Radiculopathy * Type of Fracture

		Type of Fracture				Total
		Absent	Compress	Brust	Dislocate	
Radiculopathy	Absent	40	0	0	4	44
	Right	5	2	0	0	7
	Left	3	1	0	1	5
	Bilateral	3	0	1	0	4
Total		51	3	1	5	60

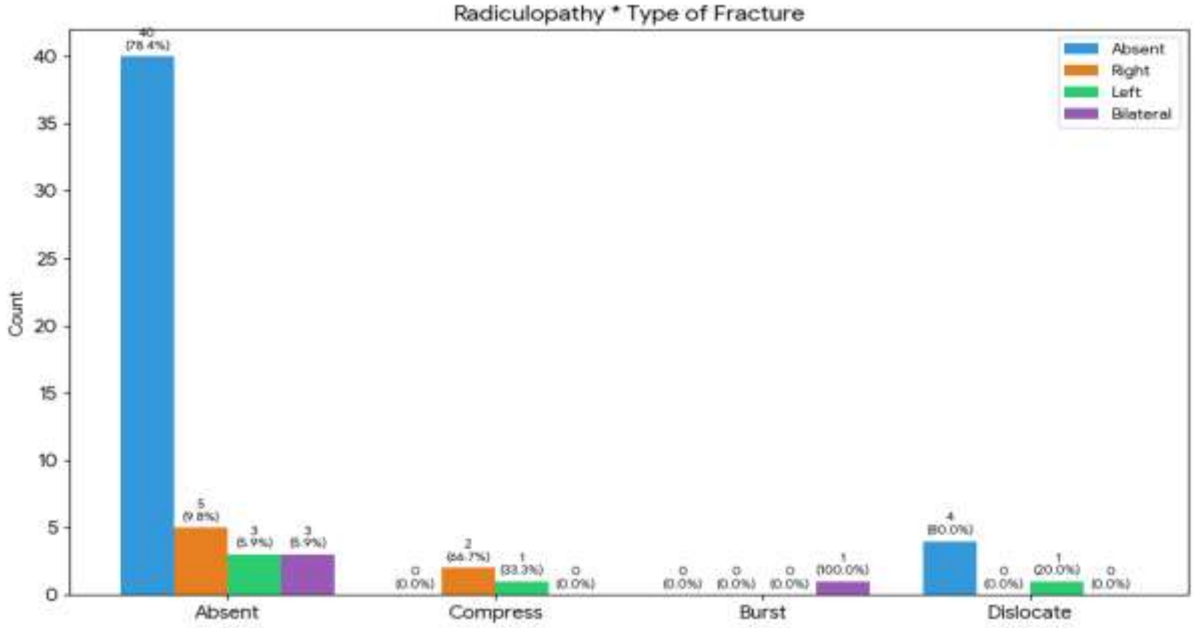


Table 4.5 & Fig.4.5

Paralysis * Cord Compression

		Cord Compression		Total
		Absent	Present	
Paralysis	Absent	24	23	47
	Present	7	6	13
Total		31	29	60

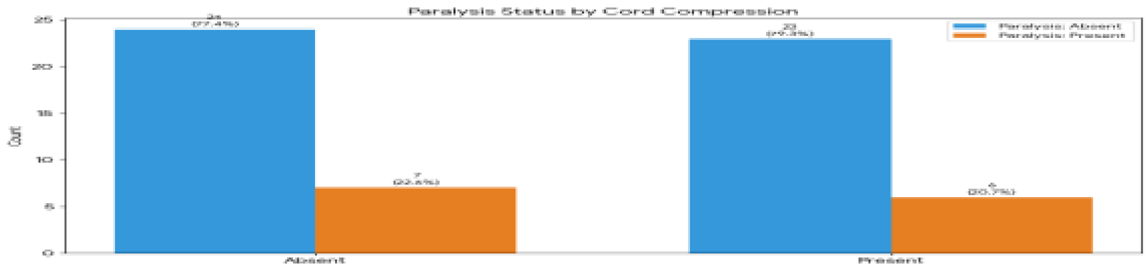


Table 4.6 & Fig.4.6

Paralysis * Epidural Hematoma					
		Epidural Hematoma			Total
		Absent	Anterior	Posterior	
Paralysis	Absent	45	2	0	47
	Present	9	2	2	13
Total		54	4	2	60

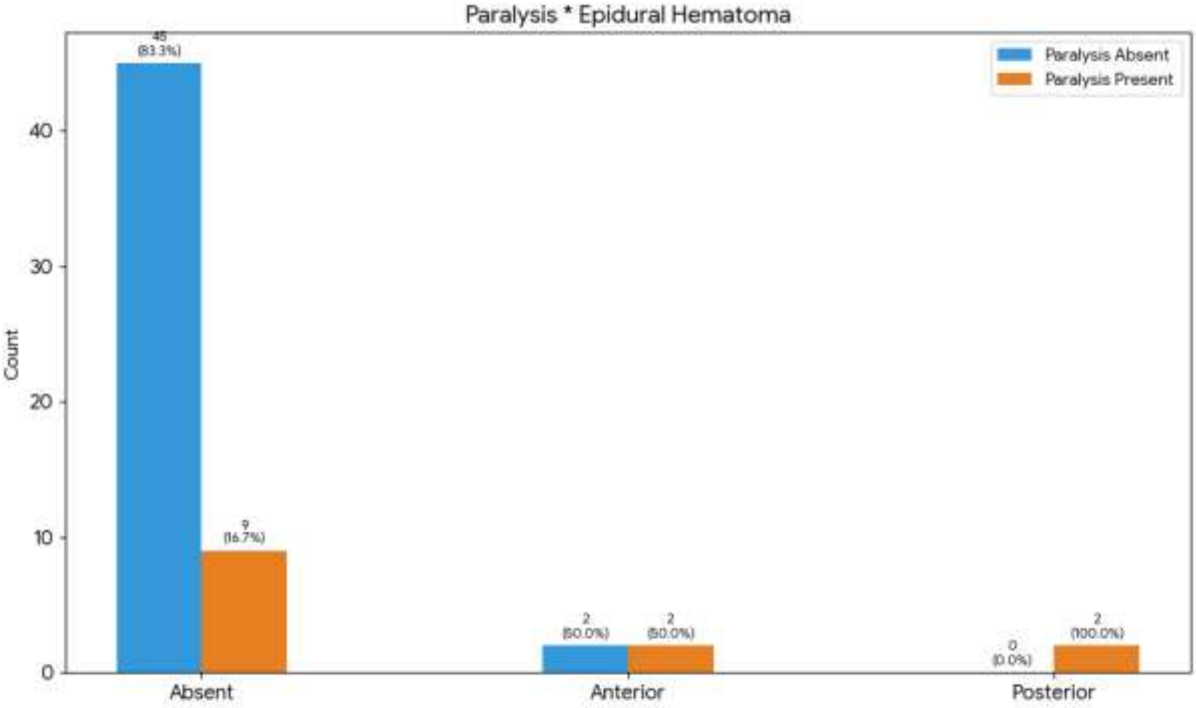
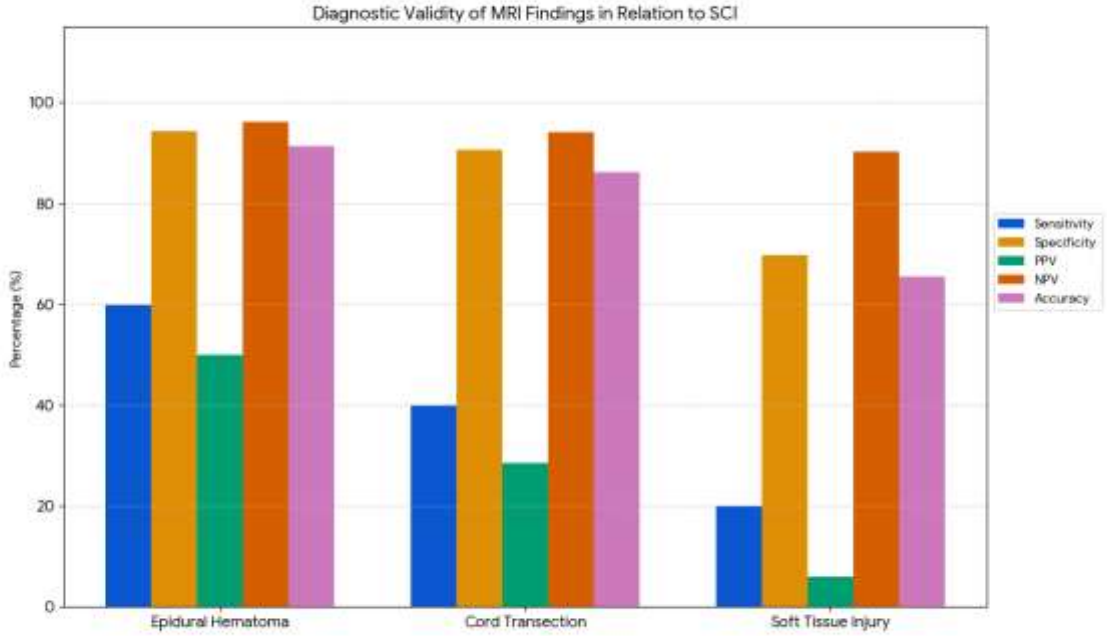


Table 4.7 & Fig.4.7
Diagnostic Validity of MRI Findings in Relation to Spinal Cord Injury (n=60)

MRI Finding	**Sensitivity (%)**	**Specificity (%)**	**Positive Predictive Value (%)**	**Negative Predictive Value (%)**	**Accuracy (%)**
Epidural Hematoma	60.0%	94.3%	50.0%	96.2%	91.4%
Cord Transection	40.0%	90.6%	28.6%	94.1%	86.2%
Soft Tissue Injury	20.0%	69.8%	5.9%	90.2%	65.5%



DISSCUSSION:

The present study is largely consistent with Puranik et al. (2021) confirming MRI as a highly effective, non-invasive tool for evaluating spinal trauma, with both studies showing male predominance. However, differences exist in injury patterns: Puranik et al. reported blunt trauma with predominant cervical spine involvement, while the present study found non-specific causes (71.7%) and lumbar spine involvement (55.0%) to be more common. Both studies identified important MRI findings, including spinal cord and soft tissue injuries; additionally, the present study highlighted epidural hematoma, cord hemorrhage, disc bulge, and disc degeneration, which were significantly associated with neurological deficits such as paralysis ($p \leq 0.020$). The weaker association with sensory loss and soft tissue injury in the present study indicates variability in clinical correlations based on injury severity and population differences[13].

The present study aligns with Singh et al. (2022) in demonstrating the diagnostic importance of MRI in spinal trauma, with both studies showing slight male predominance and strong correlation between MRI findings and clinical features. While Singh et al. reported a higher frequency of vertebral injuries, particularly compression fractures (71%), the present study identified the lumbar spine as the most commonly affected region (55.0%). Both studies confirmed that MRI findings are closely associated with clinical manifestations such as pain and motor deficits. Additionally, the present study found a significant association between paralysis and MRI findings ($p \leq 0.020$), whereas sensory loss showed no significant relationship, reflecting variability in clinical presentation. Overall, both studies support MRI as a reliable tool for evaluating spinal injuries and predicting neurological outcomes[14].

The present study shows strong agreement with Jain et al. (2023) regarding the importance of MRI in spinal trauma diagnosis. Both studies highlight MRI’s effectiveness in detecting spinal cord and vertebral injuries and its value in clinical management. Jain et al. reported higher rates of vertebral and ligamentous injuries, while the present study found significant MRI findings like epidural hematoma, cord hemorrhage, disc bulge, and disc degeneration associated with paralysis ($p \leq 0.020$). However, differences were noted in specific predictors of injury. Overall, both studies confirm MRI as an essential tool in spinal trauma assessment[15].

CONCLUSIONS:

This study concludes that MRI is a highly specific and essential tool for assessing spinal trauma, especially in detecting structural abnormalities linked to neurological deficits. Although its sensitivity for epidural hematoma is moderate (60.0%), its high specificity (94.3%) and negative predictive value (96.2%). Significant associations were found between paralysis and MRI findings like epidural hematoma, cord hemorrhage, and disc bulge, while no link was observed with cord compression or soft tissue injury. Age and gender were not significant predictors of spinal cord injury, highlighting MRI's key role in diagnosis, management, and outcome prediction.

LIMITATION:

This study has several limitations, including a relatively small sample size 60 cases, which restricts generalizability and limits the ability to capture rare conditions. Low frequencies of certain findings, such as spinal cord injury and transection, led to class imbalance and reduced the accuracy of statistical models. Some analyses were also affected by small subgroup sizes, requiring cautious interpretation. Additionally, the study relied on MRI without surgical confirmation or long-term follow-up, and being conducted at a single center may reflect local patterns rather than broader trends.

RECOMMENDATION:

Future research should include larger multi-center studies, long-term follow-up, and comparison with surgical findings to further validate MRI accuracy. Standardized MRI protocols are also recommended to improve consistency and reliability in spinal trauma assessment.

Case no 1

A 34-year-old male presented following a hyperextension injury with associated weakness of the upper limbs. Magnetic resonance imaging (MRI) of the cervical spine demonstrated marked spinal canal stenosis from the C3 to C6 levels, resulting in significant compression of the spinal cord. Increased T2-weighted signal intensity within the spinal cord at this level was noted, consistent with cord edema secondary to spinal cord injury. No convincing evidence of intramedullary hemorrhage was identified.

Case no 2

A 30-year-old male presented after a fall onto his face while intoxicated. MRI revealed an acute C5 vertebral body fracture with approximately 4 mm retropulsion into the spinal canal, causing moderate canal narrowing. Bone marrow edema extended into the right C5 lamina, consistent with CT findings. The retropulsed fragment contacted the right hemicord, with high T2 signal and focal blooming on GRE, indicating spinal cord contusion with hemorrhagic components.

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