Original Research Article

COMPARATIVE STUDY OF MULTIDETECTOR CT AND 3 TESLA MRI IN ACUTE TRAUMATIC SPINAL INJURIES

Kishore R[1], Indira N[2]

[1]*Post Graduate in MD Radiodiagnosis, East Point College of Medical Sciences & Research Centre (EPCMSRC), India.*
[2]*Professor, Department of Radiodiagnosis, EPCMSRC, India.*

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Corresponding Author:
Dr. Kishore R,
Post Graduate in MD Radiodiagnosis, East Point College of Medical Sciences & Research Centre (EPCMSRC), India.
Email: Indira@gmail.com

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ABSTRACT

Background: Acute traumatic spinal injuries require rapid and accurate imaging for diagnosis and management. Multidetector Computed Tomography (MDCT) remains the first-line modality owing to its speed and excellent depiction of bony structures. However, 3 Tesla Magnetic Resonance Imaging (3T MRI) offers superior soft-tissue contrast and detailed visualization of ligamentous structures, intervertebral discs, and spinal cord pathology.
Objectives: • To evaluate the spectrum of bony, soft-tissue, and spinal cord injuries in acute spinal trauma using MDCT and 3T MRI.
• To compare the diagnostic sensitivity of MDCT and 3T MRI in detecting osseous, ligamentous, and spinal cord abnormalities.
Materials and Methods: A prospective hospital-based study was conducted on 46 patients presenting with acute spinal trauma within 48 hours. All patients underwent MDCT followed by 3T MRI. Imaging findings were assessed for vertebral fractures, subluxation, ligamentous disruption, intervertebral disc injury, epidural collections, and spinal cord pathology. Diagnostic sensitivity and concordance between modalities were analyzed statistically.
Results: MDCT demonstrated higher sensitivity for osseous injuries, detecting vertebral fractures in 89.1% of cases compared to 78.3% on MRI. In contrast, 3T MRI was significantly superior in identifying ligamentous injuries (23.9% vs 13.0%; $p < 0.05$) and spinal cord pathologies including edema and hemorrhage, neither of which were reliably detected on MDCT. MRI also showed greater accuracy in identifying disc abnormalities and epidural hematomas.
Conclusion: MDCT remains indispensable for rapid evaluation of bony spinal trauma, while 3T MRI is essential for comprehensive soft-tissue and spinal cord assessment. A combined MDCT–MRI approach maximizes diagnostic accuracy and optimizes clinical decision-making in acute spinal trauma.
Keywords: Spinal trauma; MDCT; 3 Tesla MRI; vertebral fractures; spinal cord injury; ligamentous injury; diagnostic sensitivity.

INTRODUCTION

Acute traumatic spinal injuries constitute a major cause of morbidity, long-term disability, and socioeconomic burden worldwide. Rapid and accurate evaluation is essential to prevent secondary neurological deterioration and to guide appropriate management decisions. The spine comprises complex osseous, ligamentous, and neural structures, and trauma can impact one or multiple components, making precise imaging a critical part of early assessment.[1]

Multidetector Computed Tomography (MDCT) has become the primary imaging modality in acute trauma settings owing to its rapid acquisition, wide availability, and superior depiction of bony anatomy. It is highly sensitive for detecting vertebral fractures, alignment abnormalities, canal compromise, and posterior element involvement. As a result, MDCT is often used as the first-line screening tool in most emergency trauma protocols.[2,3]

However, MDCT has inherent limitations in evaluating soft-tissue components such as the posterior ligamentous complex, intervertebral discs, spinal cord, and epidural space. Magnetic Resonance Imaging (MRI), particularly high-field 3 Tesla MRI, provides excellent soft-tissue contrast and allows comprehensive assessment of ligamentous injury, paraspinal soft-tissue trauma, epidural hematoma, spinal cord edema, contusion, and hemorrhage. These findings play a crucial role in determining spinal stability and predicting neurological outcomes.[4,5]

Combined imaging with MDCT and MRI provides maximal diagnostic information in acute spinal trauma. MDCT rapidly identifies life-threatening bony injuries, whereas MRI reveals occult ligamentous and neural injuries that directly influence treatment planning. Despite their established roles, comparative data on their diagnostic performance—particularly with modern 3T MRI systems—remain essential for optimizing clinical pathways.[6,7,8]

The present study evaluates and compares MDCT and 3T MRI in the assessment of acute spinal trauma, focusing on the spectrum of osseous, soft-tissue, and spinal cord abnormalities, as well as the diagnostic sensitivity of each modality.[9]

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, hospital-based observational study conducted in the Department of Radiodiagnosis at East Point College of Medical Sciences & Research Centre (EPCMSRC). The study period included all patients presenting with acute spinal trauma within 48 hours of injury.

Sample Size:

A total of **46 patients** were included based on inclusion and exclusion criteria.

Inclusion Criteria

- Patients presenting with acute spinal trauma within 48 hours
- Age ≥ 18 years
- Patients stable enough to undergo both MDCT and 3T MRI
- Consent provided by patient or attendant

Exclusion Criteria

- Penetrating spinal trauma
- Prior spinal surgery
- Polytrauma patients who were hemodynamically unstable for MRI
- Patients with MRI contraindications (pacemakers, metallic implants, claustrophobia)

Imaging Protocol

MDCT Protocol

- Scanner: 16-slice GE Revolution MDCT
- Coverage: Occiput to sacrum
- Slice thickness: 5 mm with 1.25 mm reconstructions
- Sagittal and coronal reformats
- Evaluation for:
  - Vertebral fractures
  - Alignment abnormalities
  - Canal compromise
  - Posterior element fractures

3T MRI Protocol

- Scanner: 3 Tesla Philips Achieva
- Sequences performed:
  - Sagittal T1-weighted
  - Sagittal T2-weighted
  - Sagittal STIR
  - Axial T2-weighted
  - GRE/SWI sequences for hemorrhage
- Evaluation for:
  - Ligamentous integrity
  - Spinal cord edema
  - Spinal cord hemorrhage
  - Intervertebral disc injuries
  - Epidural hematoma
  - Paraspinal soft-tissue injuries

Data Collection and Image Analysis

- Images were interpreted independently.
- Radiological findings were compared between MDCT and MRI for:
  - Osseous injuries
  - Ligamentous injury
  - Disc injury
  - Cord edema/hemorrhage
  - Epidural collection

Statistical Analysis

- Sensitivity and specificity were calculated using the other modality as reference standard.
- Cohen's kappa test assessed agreement between MDCT and MRI.
- p-value < 0.05 was considered statistically significant.

RESULTS

A total of 46 patients with acute traumatic spinal injuries were included in the study. The mean age of the study population was 43.02 years, with a median age of 41.5 years, and the age range extended from 21 to 70 years. The most frequently affected age group was 41–50 years (26.1%), followed by 51–60 years (23.9%) and 31–40 years (21.7%), indicating that spinal trauma occurred predominantly in middle-aged adults.

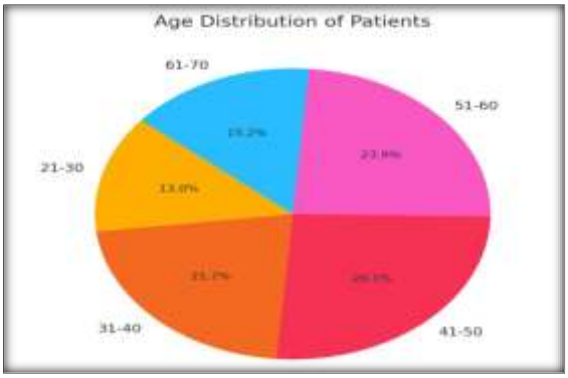

Figure 1: Age Distribution of Patients with Acute Spinal Trauma

There was a male predominance in the study, with 28 males (60.9%) and 18 females (39.1%), reflecting a higher exposure of men to high-energy trauma.

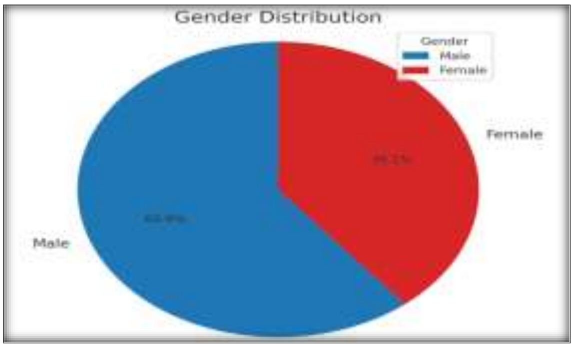

Figure 2: Gender distribution of patients showing male predominance (60.9%) compared to females (39.1%).

Road traffic accidents represented the most common mechanism of injury, accounting for 41.3% of cases, followed by falls (34.8%), sports-related trauma (15.2%), and other causes (8.7%), highlighting the high-energy nature of spinal trauma in this population. The thoracic spine was the most frequently involved region (39.1%), followed by the cervical spine (26.1%), lumbar spine (21.7%), and multilevel involvement (13.0%).

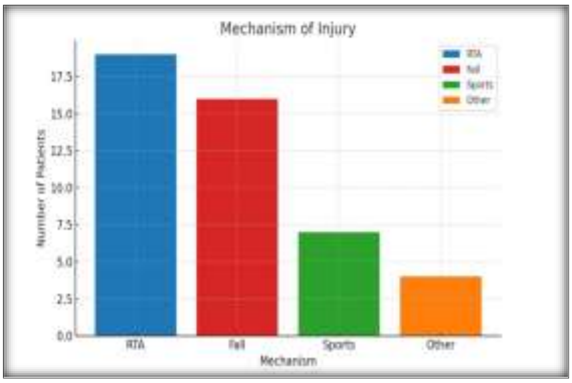

Figure 3: Mechanism of injury among study subjects showing road traffic accidents as the most common cause (41.3%), followed by falls (34.8%), sports injuries (15.2%), and other mechanisms (8.7%).

MDCT detected osseous injuries in 89.13% of patients compared to 78.26% detected by MRI, reaffirming the superior sensitivity12 of MDCT for evaluating bony trauma. MDCT identified vertebral body fractures in 50%, posterior element involvement in 34.8%, dislocations in 30.4%, and intervertebral disc injury in 17.4% of patients. MRI detected vertebral fractures in 39.1%, posterior element injuries in 28.3%, dislocations in 23.9%, and disc injuries in 21.7%, demonstrating its broader assessment of adjacent soft-tissue structures.

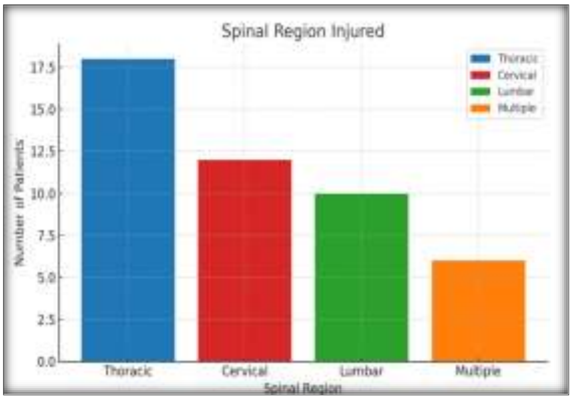

Figure 4: Spinal region involvement in acute trauma showing thoracic spine as most frequently affected (39.1%), followed by cervical (26.1%), lumbar (21.7%), and multiple-level injuries (13.0%).

Ligamentous injuries were detected in 13% of patients on MDCT, whereas MRI identified ligament disruption in 23.9%, a statistically significant difference ($p < 0.05$). MRI detected more injuries involving the posterior longitudinal ligament (9 cases), paraspinal soft tissues (9 cases), anterior longitudinal ligament (4 cases), and ligamentum flavum (3 cases). MDCT failed to detect any ligamentum flavum injury. These findings reaffirm the superior soft-tissue resolution of MRI in evaluating ligamentous stability.

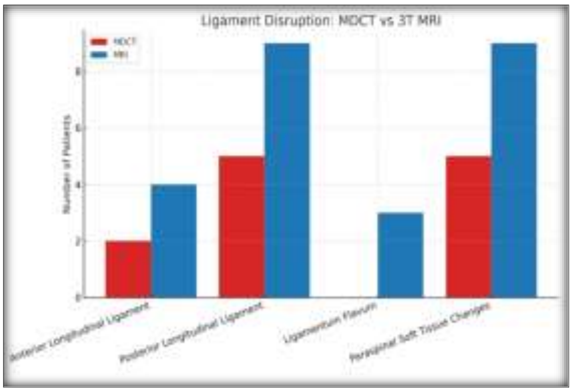

Figure 5: Comparison of ligamentous injury detection by MDCT and 3T MRI showing MRI superiority, particularly for posterior longitudinal ligament and ligamentum flavum involvement.

Spinal cord abnormalities were seen in 21.7% of patients on MDCT and 26.09% on MRI. MRI further differentiated cord pathology into cord edema (8 cases), cord hemorrhage (3 cases), and combined edema with hemorrhage (3 cases), none of which were identifiable on MDCT. Cord compression was visualized in 9 cases on MDCT and 11 cases on MRI.

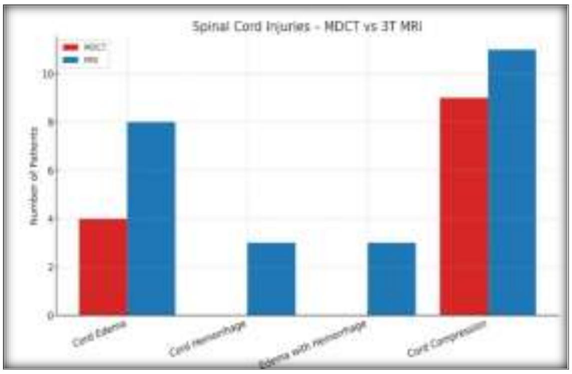

Figure 6: Comparison of spinal cord injuries detected by MDCT and 3T MRI showing MRI superiority for detecting cord edema, hemorrhage, and combined edema-with-hemorrhage patterns.

Epidural collections were detected in 13% of patients using MDCT, compared to 17.39% using MRI. MRI characterized epidural hematomas more accurately due to its enhanced ability to delineate soft-tissue contrast.

Multiple concurrent injuries were common in this study. While 5 patients showed no additional injuries, 14 patients had one associated injury, 18 patients had two concurrent injuries, and 9 patients presented with three different types of injuries, emphasizing the multifocal complexity of spinal trauma.

A strong correlation was observed between ASIA neurological grading and spinal cord involvement. All patients with ASIA A and ASIA B deficits demonstrated MRI-proven cord injury, whereas none of the neurologically normal patients exhibited cord abnormalities, indicating a strong clinico-radiological association.

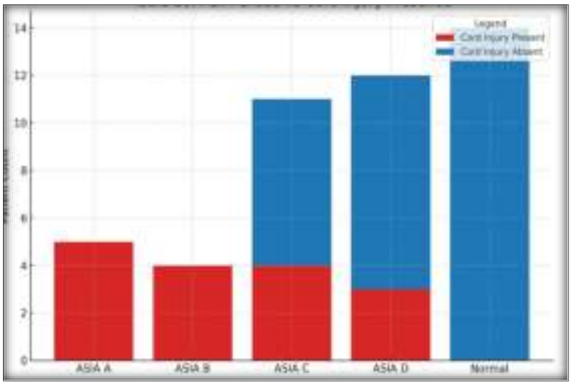

Figure 7: Correlation of ASIA Grade with Cord Injury

Stacked bar graph correlating ASIA neurological grades with presence or absence of cord injury, showing highest cord injury rates in ASIA A and B categories.

Using MDCT as the reference standard, the sensitivity and specificity of MRI for detecting osseous injuries were 87.8% and 100%, respectively. When MRI was considered the gold standard for soft-tissue injuries, MDCT demonstrated high specificity (100%) but variable sensitivity:

- 54.5% for ligamentous injuries
- 83.3% for spinal cord injuries
- 75% for epidural collections

Cohen's kappa analysis showed perfect agreement ($\kappa = 1.0$) between MDCT and MRI for vertebral fractures and spinal cord injury detection, fair agreement ($\kappa = 0.36$) for ligamentous injury, and substantial agreement ($\kappa = 0.83$) for epidural collections. This underscores MRI's diagnostic advantage in soft-tissue and intramedullary assessments.

DISCUSSION

In this prospective study of 46 patients with acute traumatic spinal injuries, MDCT and 3T MRI demonstrated distinctly different strengths in the evaluation of osseous, ligamentous, soft-tissue, and spinal cord abnormalities, reaffirming the complementary roles of these two imaging modalities in the acute trauma setting.[10]

MDCT showed a significantly higher sensitivity for detecting osseous injuries, identifying fractures in 89.1% of cases compared to 78.3% detected by MRI. The rapid acquisition time and superior spatial resolution of MDCT make it indispensable in emergency triage, especially for unstable or polytrauma patients. The higher detection of vertebral body fractures (50%) and posterior element involvement (34.8%) further highlights its superiority in bony injury assessment.[11]

In contrast, 3T MRI clearly outperformed MDCT in identifying soft-tissue and neural injuries, including ligamentous disruptions and spinal cord pathology, supporting its superior sensitivity for soft-tissue contrast.[12]

One of the most important findings in this study is the clear advantage of MRI in detecting spinal cord edema, contusion, and hemorrhage, lesions that have strong prognostic implications. Consistent with existing literature, these intramedullary signal changes correlated strongly with neurological deficits; all patients with ASIA A and ASIA B grades demonstrated cord injury on MRI, whereas neurologically normal patients had no cord abnormalities. This strong clinico-radiological correlation underscores the indispensable value of MRI in predicting neurological outcomes.[13]

Epidural collections were also more frequently identified on MRI, which provided clearer delineation of hematoma extent and its effect on the thecal sac. This is particularly relevant in patients requiring urgent surgical decompression.[14]

Diagnostic concordance between the two modalities varied by injury type. Perfect agreement ($\kappa = 1.0$) was observed for vertebral body fractures and cord injuries, while only fair agreement ($\kappa = 0.36$) was seen for ligamentous injuries. This reinforces that MDCT alone is insufficient for evaluating soft-tissue stabilizing structures. Substantial agreement ($\kappa = 0.83$) for epidural collections reflects that CT can detect large collections but tends to underestimate small or complex ones.[15]

The study also revealed a high prevalence of multiple concurrent injuries, with more than half of the patients demonstrating two or more types of trauma. This highlights the complex nature of spinal trauma and the need for multimodality imaging in comprehensive evaluation.[16]

Overall, the study findings mirror international observations that MDCT is unmatched for rapid, detailed assessment of bony structures, but MRI is essential for evaluating soft tissue, spinal cord, ligamentous integrity, and epidural pathology.[17] The combined use of both modalities ensures accurate diagnosis, guides appropriate management, and improves neurological prognostication. In acute spinal trauma—where missing a ligamentous or cord injury can have devastating consequences—MRI serves as a vital complementary tool rather than a substitute for CT.

CONCLUSION

In this study comparing Multidetector Computed Tomography (MDCT) and 3 Tesla Magnetic Resonance Imaging (3T MRI) in acute spinal trauma, MDCT proved to be highly sensitive for detecting osseous injuries and vertebral alignment abnormalities, making it indispensable for rapid emergency assessment. However, 3T MRI demonstrated clear superiority in identifying soft-tissue and neural injuries, including ligamentous disruption, spinal cord edema, intramedullary hemorrhage, paraspinal soft-tissue changes, and epidural collections—many of which were not detectable on MDCT. MRI findings also showed strong correlation with neurological status, especially in patients with severe ASIA grades.[18]

Overall, while MDCT remains the first-line modality for initial triage due to its speed and excellent depiction of bony structures, MRI plays an equally critical role by providing comprehensive soft-tissue and spinal cord evaluation. A combined imaging approach ensures maximal diagnostic accuracy and optimal clinical decision-making in patients with acute traumatic spinal injuries.[19]

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