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Original Article

Clinical and Imaging Correlation of CT and MRI Findings with Neurological Status in Traumatic Cervical Spine Injuries: A Retrospective Study

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Abstract

Objective: To evaluate and correlate computed tomography and magnetic resonance imaging findings with neurological status in patients with traumatic cervical spine injuries. ***Design:*** Retrospective observational study. ***Subjects/Patients:*** Sixty-five patients with acute cervical spine trauma presenting to a tertiary care center were included. ***Methods:*** Computed tomography was performed in all patients to assess fracture morphology, vertebral alignment, and spinal canal compromise. Magnetic resonance imaging was performed in patients with neurological deficits or inconclusive computed tomography findings to evaluate spinal cord signal abnormalities and discoligamentous complex injury. Neurological status was assessed using the American Spinal Injury Association impairment scale. Statistical association between imaging findings and neurological status was analyzed using the chi-square test. ***Results:*** Subaxial cervical spine injuries were the most common injury pattern. Compression fractures, facet dislocations, and burst fractures were frequently identified. Magnetic resonance imaging demonstrated spinal cord edema and intramedullary hemorrhage in a subset of patients. Spinal cord injury without radiographic abnormality was identified in a small number of cases. A statistically significant association was observed between spinal cord signal abnormalities and neurological impairment. ***Conclusion:*** Computed tomography is essential for rapid assessment of osseous injuries in cervical spine trauma, while magnetic resonance imaging provides important prognostic information by identifying spinal cord and ligamentous abnormalities. Combined use of both modalities improves diagnostic evaluation and neurological prognostication.

Keywords: ***Cervical Vertebrae; Computed tomography; Magnetic Resonance Imaging; Prognosis; Spinal Cord Injuries; X-Ray.***

Introduction

Traumatic cervical spine injuries represent a significant cause of morbidity and long-term neurological disability worldwide, particularly in regions with a high incidence of road traffic accidents. Early and accurate imaging assessment is critical for identifying unstable injuries, determining the extent of spinal cord involvement, and guiding timely management to prevent secondary neurological deterioration [1].

Computed tomography (CT) is widely accepted as the first-line imaging modality in acute cervical spine trauma because of its high sensitivity for detecting fractures, malalignment, and spinal canal compromise [2]. Classification systems integrating imaging findings with neurological status have been developed to standardize injury assessment and assist in treatment decision-making, particularly for subaxial cervical spine injuries [3].

Magnetic resonance imaging (MRI) plays a complementary and indispensable role by providing detailed evaluation of the spinal cord, intervertebral discs, ligaments, and other soft tissues that are not adequately assessed on CT. MRI is especially valuable in identifying cord edema, intramedullary hemorrhage, and discoligamentous complex injuries, which have been shown to correlate with neurological impairment and prognosis [4].

A distinct subgroup of patients presents with neurological deficits despite normal radiographs and CT findings, a condition commonly referred to as spinal cord injury without radiographic abnormality. In such cases, MRI is essential for detecting subtle cord signal changes and guiding clinical management [5]. Current trauma guidelines emphasize the judicious use of CT and MRI to ensure comprehensive evaluation of cervical spine injuries and to optimize patient outcomes [6].

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Despite advances in imaging techniques, the relative contributions of CT and MRI in correlating injury patterns with neurological status continue to be an area of active clinical interest. This study aims to evaluate the spectrum of CT and MRI findings in traumatic cervical spine injuries and to correlate MRI-detected spinal cord abnormalities with neurological status at presentation.

Primary Objectives

1. To evaluate computed tomography and magnetic resonance imaging findings in patients with traumatic cervical spine injuries.
2. To correlate magnetic resonance imaging–detected spinal cord signal abnormalities with neurological status using the American Spinal Injury Association (ASIA) impairment scale.

Secondary Objectives

1. To assess fracture morphology and discoligamentous complex injury.
2. To identify and characterize cases of spinal cord injury without radiographic abnormality.
3. To evaluate the role of combined CT and MRI assessment in guiding clinical management.

Methods

This retrospective observational study was conducted in the Department of Radiology at a tertiary care center and included patients presenting with acute cervical spine trauma between October 2023 and April 2025. The study population consisted of 65 patients who underwent CT evaluation of the cervical spine during the study period.

Patients were identified through the radiology information system, and relevant clinical and imaging data were retrieved from electronic medical records. Inclusion and exclusion criteria applied for patient selection are summarized in Table I. All imaging and clinical data were anonymized prior to analysis.

Table I: Inclusion and Exclusion Criteria for Patient Selection

Inclusion Criteria	Exclusion Criteria
Acute cervical spine trauma confirmed on computed tomography	Penetrating cervical spine injuries
Age ≥ 18 years	Prior cervical spine surgery
Complete clinical records including ASIA impairment scale assessment	Congenital cervical spine anomalies
Magnetic resonance imaging available when clinically indicated	Poor-quality imaging precluding adequate evaluation
Patients presenting within the defined study period	Associated polytrauma with incomplete cervical spine imaging

Abbreviations: ASIA: American Spinal Injury Association.

CT imaging was performed in all patients using a multidetector CT scanner with axial acquisition and sagittal and coronal multiplanar reconstructions. CT assessment included evaluation of vertebral alignment, fracture morphology, spinal canal compromise, and facet joint integrity.

MRI was selectively performed in patients with neurological deficits on clinical examination or in cases where CT findings were equivocal. MRI protocols included T1-weighted, T2-weighted, short tau inversion recovery, and gradient-echo sequences. Particular attention was given to spinal cord signal abnormalities and integrity of the discoligamentous complex.

Neurological status at presentation was assessed using the American Spinal Injury Association impairment scale, and patients were categorized into grades A through E based on motor and sensory function. Clinical records were reviewed to document management strategies and early neurological outcomes.

Statistical analysis was performed using the chi-square test to evaluate the association between MRI findings and neurological status. A p value of less than 0.05 was considered statistically significant.

The study was conducted in accordance with institutional ethical guidelines. Approval for retrospective analysis of anonymized patient data was obtained from the Institutional Ethics Committee, with a waiver of informed consent due to the retrospective nature of the study.

Results

A total of 65 patients with acute cervical spine trauma were included in the study. The cohort comprised 46 males (70.8%) and 19 females (29.2%), with a mean age of 38.4 years (SD 12.7). Subaxial cervical spine levels (C3–C7) were involved in 48 patients (73.8%), while upper cervical spine levels (C1–C2) were affected in 17 patients (26.2%).

Computed Tomography Findings

Computed tomography demonstrated a wide spectrum of osseous cervical spine injuries. Compression fractures were the most frequent injury pattern, followed by facet dislocations, burst fractures, and teardrop fractures. Significant spinal canal compromise exceeding 30% was identified in a subset of patients. The distribution of CT findings and injury morphology is summarized in Table II.

Upper cervical spine injuries included various atlas fracture patterns, such as isolated anterior or posterior arch fractures, combined anterior and posterior arch fractures consistent with Jefferson fractures, and fractures extending into the lateral masses (**Figure 1**). Odontoid fractures predominantly involved the base of the dens with extension into the body of the axis (**Figure 2**). Fractures of the C2 vertebral body with associated anterior subluxation, indicating unstable axis injuries, were also observed (**Figure 3**). Traumatic spondylolisthesis of the axis (Hangman's fracture) was identified in patients with hyperextension mechanisms of injury (**Figure 4**).

Subaxial cervical spine injuries were common and included compression fractures, burst fractures, and combined vertebral body and posterior element injuries (**Figures 5 and 6**). Facet joint injuries were frequently encountered, including bilateral locked facet dislocations producing the characteristic inverted hamburger sign on axial CT images (**Figure 7**). Posterior element fractures involving the spinous processes and laminae were also noted, including isolated Clay-shoveler's fractures of the C7 spinous process (**Figures 8 and 9**).

Magnetic Resonance Imaging Findings

Magnetic resonance imaging was performed in 31 patients (47.7%). Spinal cord edema was the most frequent MRI abnormality, followed by intramedullary hemorrhage. Discoligamentous complex injury was identified in a substantial proportion of patients, and spinal cord injury without radiographic abnormality was diagnosed in a small subset. The distribution of MRI findings is summarized in Table III.

MRI demonstrated severe cervical spine instability in selected cases, including anterior dislocation of C5 over C6 with complete spinal cord transection and disruption of the discoligamentous complex (**Figure 10**). Subaxial cervical spine subluxation with locked facet joints resulted in spinal canal compromise and spinal cord compression, most commonly at the C4–C5 level (**Figures 11 and 12**).

MRI was particularly valuable in identifying cases of spinal cord injury without radiographic abnormality. These patients demonstrated focal spinal cord signal changes, including cord edema with or without intramedullary hemorrhage, despite the absence of cervical vertebral fractures on CT (**Figure 13**).

Neurological Status and Correlation with MRI Findings

Neurological assessment using the American Spinal Injury Association impairment scale revealed a spectrum of deficits ranging from complete neurological injury to normal neurological status. The distribution of ASIA grades is summarized in Table IV.

Patients with intramedullary hemorrhage predominantly presented with severe neurological deficits (ASIA grades A or B), whereas patients with isolated spinal cord edema most commonly demonstrated incomplete neurological deficits (ASIA grades C or D). Chi-square analysis demonstrated a statistically significant association between MRI-detected spinal cord signal abnormalities and ASIA impairment grade ($\chi^2 = 16.42$, df = 4, $p = 0.002$), with a moderate effect size ($\varphi = 0.53$).

Management Outcomes

Surgical intervention was performed in 28 patients (43.1%), most commonly in those with facet dislocations, significant discoligamentous complex disruption, intramedullary hemorrhage, or unstable vertebral translation. Conservative management was undertaken in 37 patients (56.9%). All patients diagnosed with spinal cord injury without radiographic abnormality were managed conservatively and demonstrated favorable neurological outcomes during early follow-up.

Table II: Distribution of Computed Tomography Findings and Injury Morphology

CT Finding	n	%
Compression fracture	21	32.3
Facet dislocation	14	21.5
Burst fracture	10	15.4
Teardrop fracture	6	9.2
Spinal canal compromise >30%	12	18.5
Subaxial level involvement (C3–C7)	48	73.8
Upper cervical involvement (C1–C2)	17	26.2

Abbreviations: CT: Computed tomography; C1–C2: Upper cervical spine; C3–C7: Subaxial cervical spine.

Table III: Magnetic Resonance Imaging Findings

MRI Finding	n	% (Total cohort)	% (MRI subgroup)
Spinal cord edema	18	27.7	58.1
Intramedullary hemorrhage	10	15.4	32.3
Discoligamentous complex injury	22	33.8	71.0
Spinal cord injury without radiographic abnormality	3	4.6	9.7

Abbreviations: MRI: Magnetic resonance imaging; DLC: Discoligamentous complex; SCIWORA: Spinal cord injury without radiographic abnormality.

Table IV: Neurological Status According to ASIA Impairment Scale

ASIA Grade	n	%
ASIA A	9	13.8
ASIA B	7	10.8
ASIA C	14	21.5
ASIA D	20	30.8
ASIA E	15	23.1

Abbreviations: ASIA: American Spinal Injury Association.

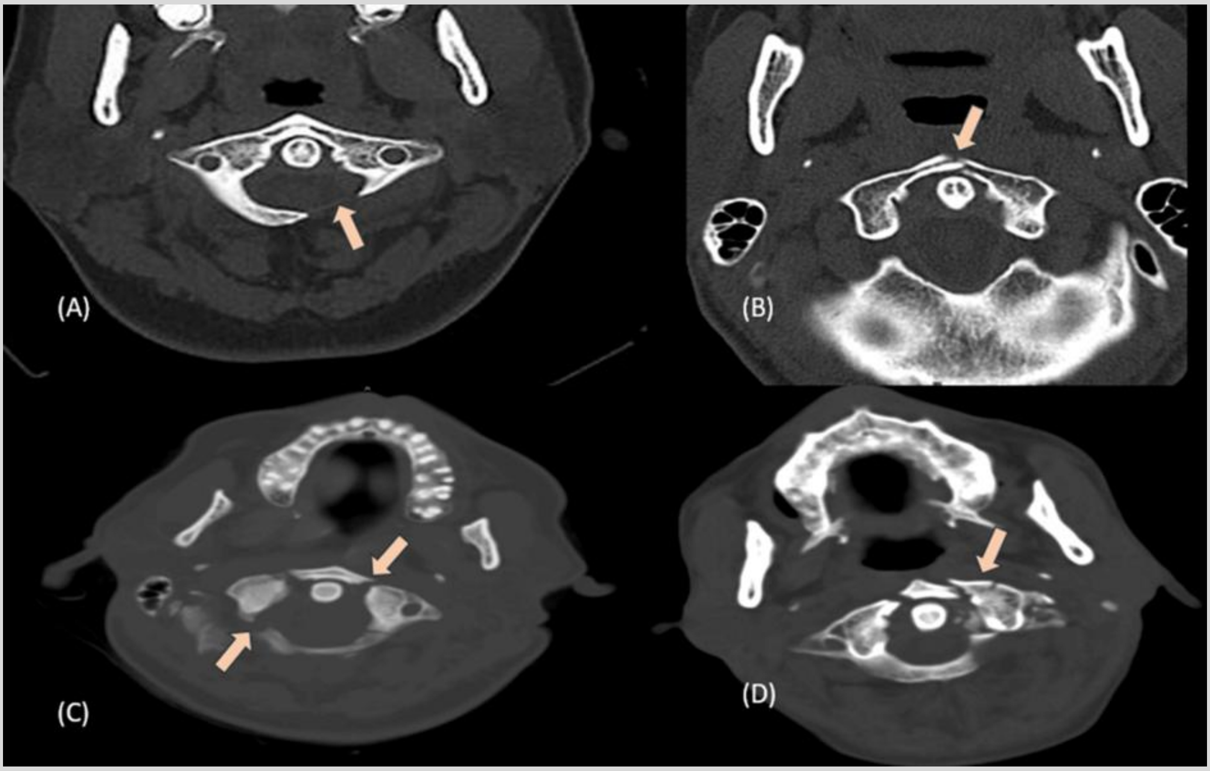

Fig. 1: Axial computed tomography images of the atlas demonstrating different fracture patterns.

(A) Posterior arch fracture of the atlas (arrow).
(B) Anterior arch fracture of the atlas (arrow).
(C) Fracture involving both anterior and posterior arches consistent with a Jefferson fracture (arrows).
(D) Fracture involving the anterior arch with extension into the lateral mass of the atlas (arrow).

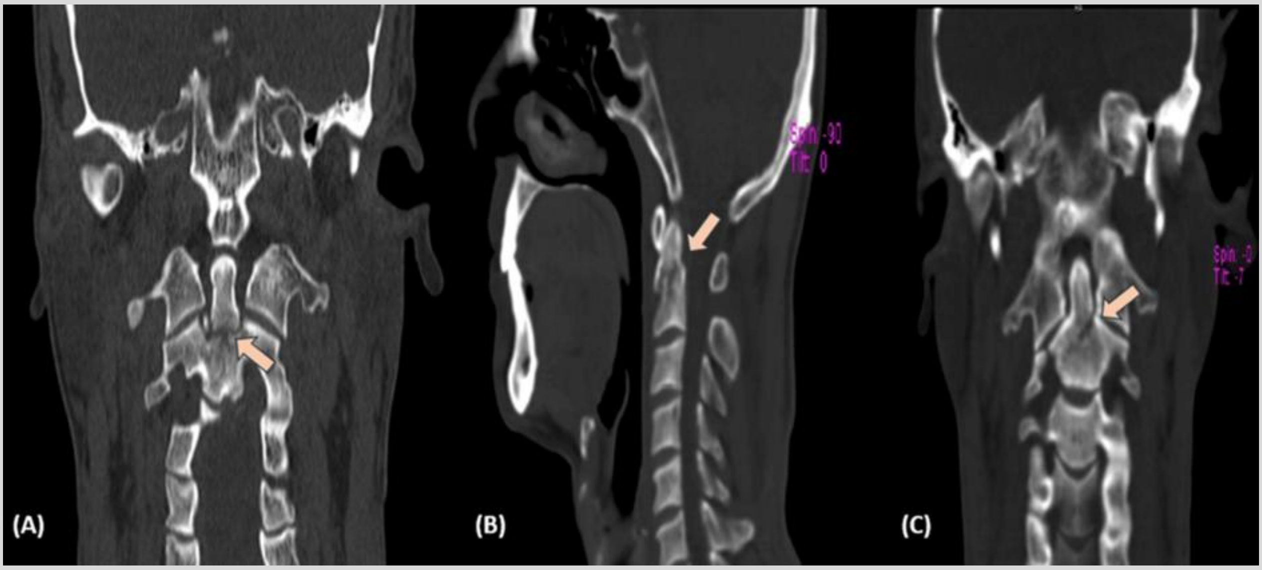

Fig. 2: Computed tomography images demonstrating odontoid fractures.

(A) Coronal image showing a fracture through the base of the dens consistent with a type II odontoid fracture (arrow).
(B) Sagittal image demonstrating extension of the fracture into the body of the axis (arrow).
(C) Coronal image further delineating the fracture line involving the odontoid process and vertebral body (arrow).

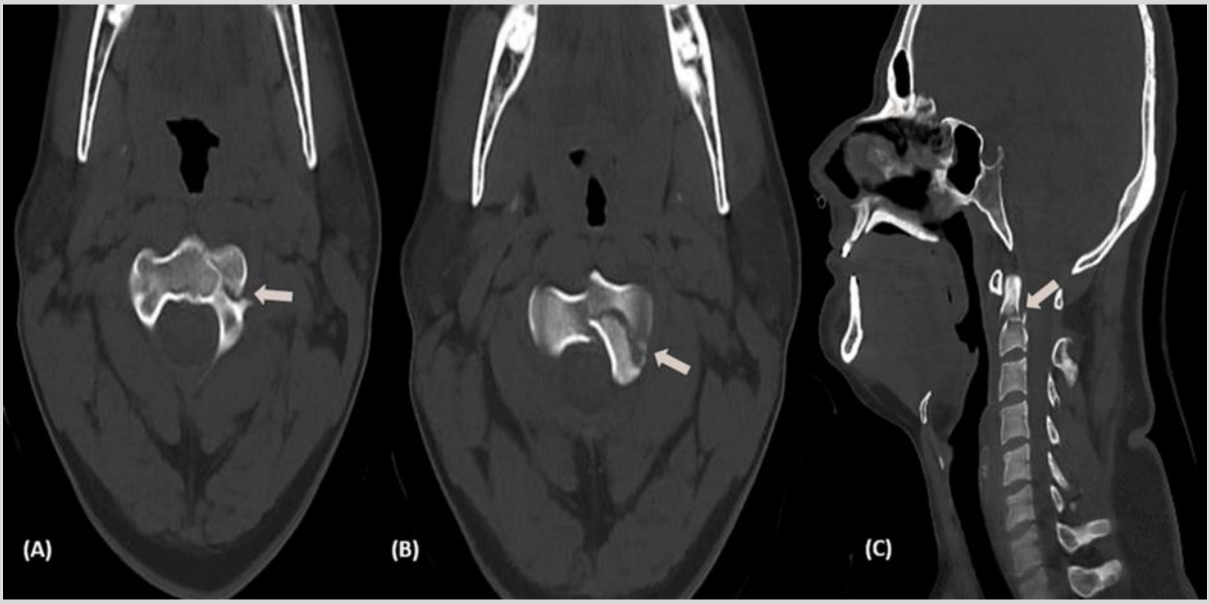

Fig. 3: Computed tomography images of the axis demonstrating an unstable C2 vertebral body fracture.

(A, B) Axial images showing a fracture involving the left side of the C2 vertebral body with displaced fragments (arrows).
(C) Sagittal image demonstrating subtle anterior subluxation at the odontoid base (arrow).

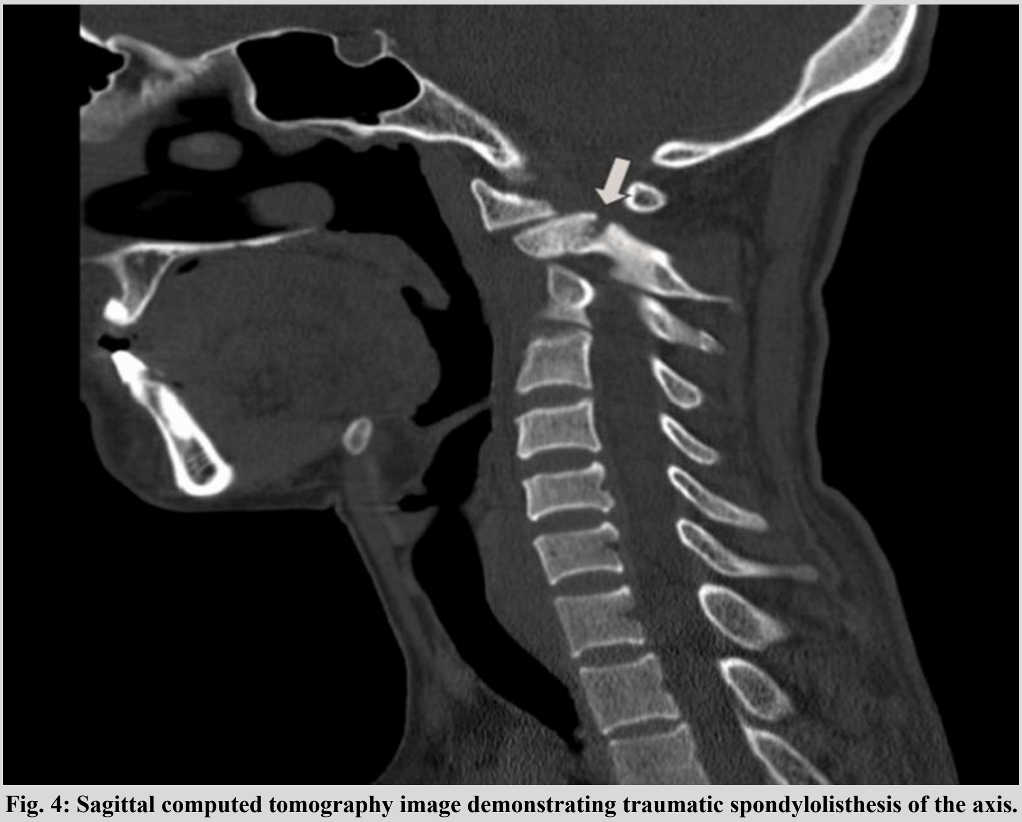

Fig. 4: Sagittal computed tomography image demonstrating traumatic spondylolisthesis of the axis.

Bilateral fractures through the pars interarticularis of C2 with anterior displacement over C3 are seen, consistent with a Hangman's fracture (arrow).

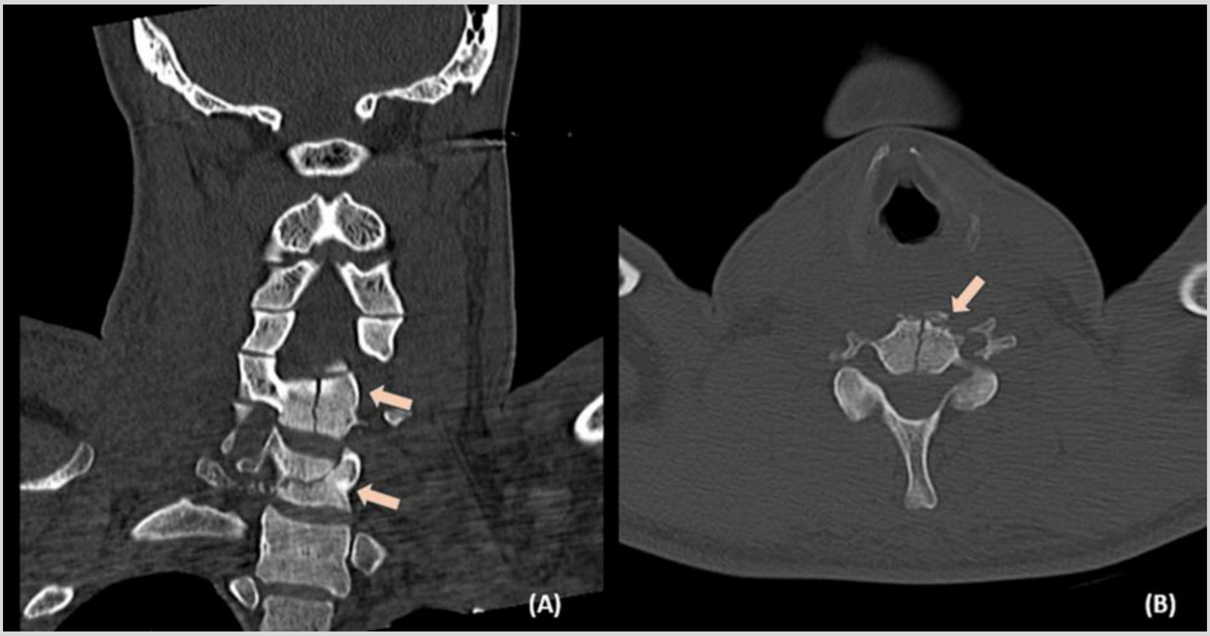

Fig. 5: Computed tomography images demonstrating subaxial cervical spine fractures.

(A) Coronal image showing a compression fracture of C5 and a burst fracture of C6 (arrows).
(B) Axial image demonstrating a compression fracture of the C5 vertebral body (arrow).

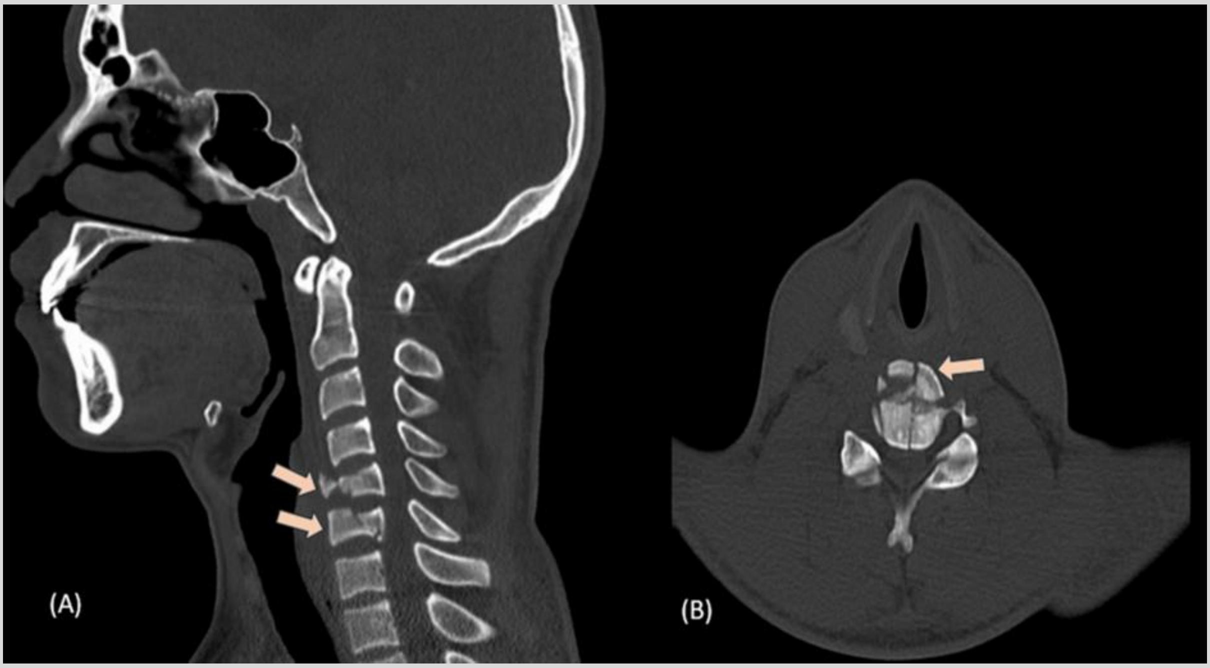

Fig. 6: Computed tomography images demonstrating combined subaxial cervical spine injuries.

(A) Sagittal image showing a fracture of the C5 vertebral body with anteriorly displaced fragment and widening of the interspinous distance (arrows).
(B) Axial image demonstrating an associated burst fracture of the C6 vertebral body (arrow).

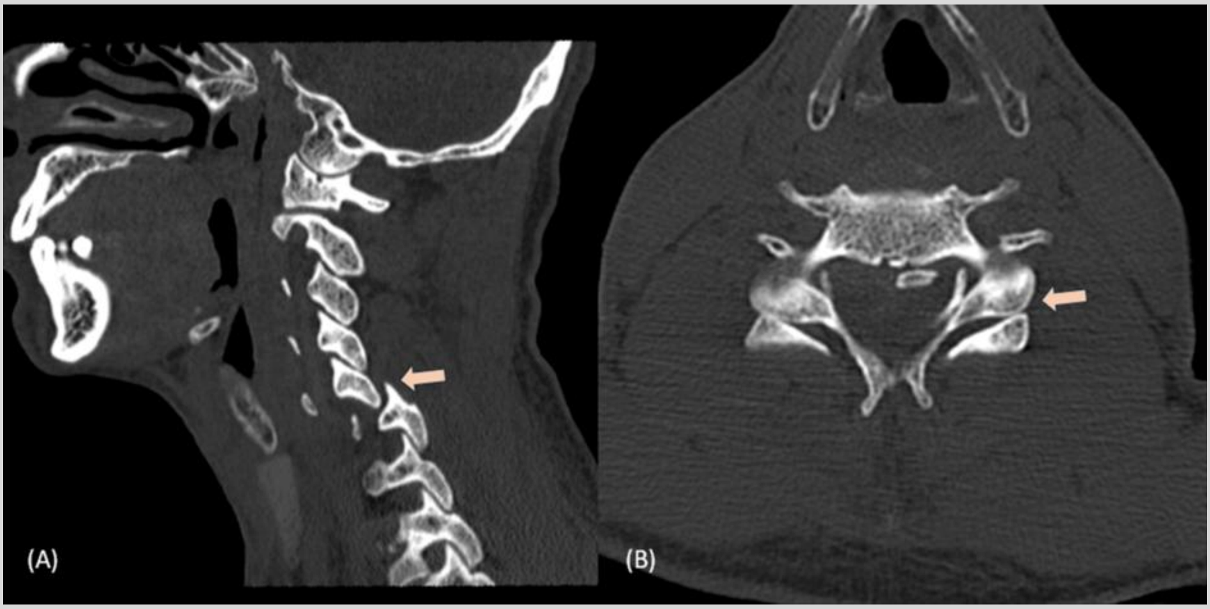

Fig. 7: Computed tomography images demonstrating bilateral facet dislocation.

(A) Sagittal image showing anterior dislocation and interlocking of the C6 facets over C7 (arrow).
(B) Axial image demonstrating the bilateral "inverted hamburger" sign, confirming locked facets (arrow).

Fig. 8: Computed tomography images demonstrating posterior element fractures of the cervical spine.

(A) Sagittal image showing fractures of the spinous processes of C4, C5, and C6.
(B) Axial image demonstrating a fracture of the right lamina of C4 (arrow).

Fig. 9: Sagittal computed tomography image demonstrating a fracture of the C7 spinous process, consistent with a Clay-shoveler's fracture (arrow).

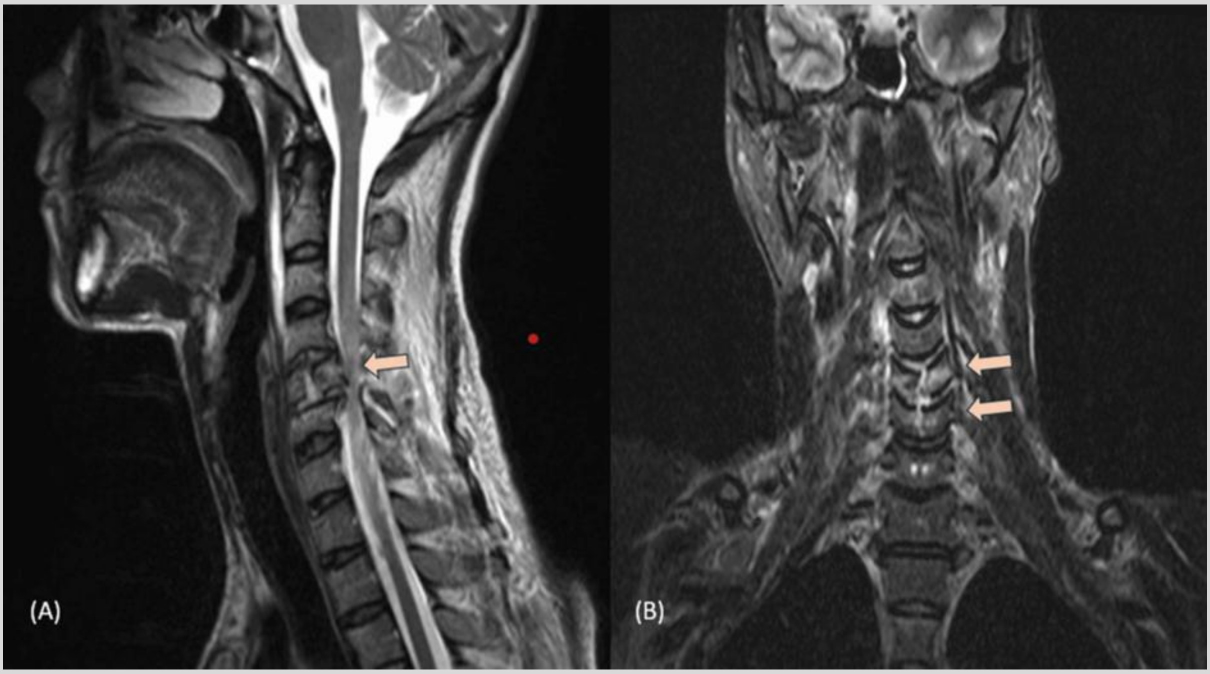

Fig. 10: Magnetic resonance images demonstrating severe cervical spine instability.

(A) Sagittal T2-weighted image showing anterior dislocation of C5 over C6 with complete spinal cord transection (arrow).
(B) Coronal image demonstrating disruption of the discoligamentous complex at the same level (arrows).

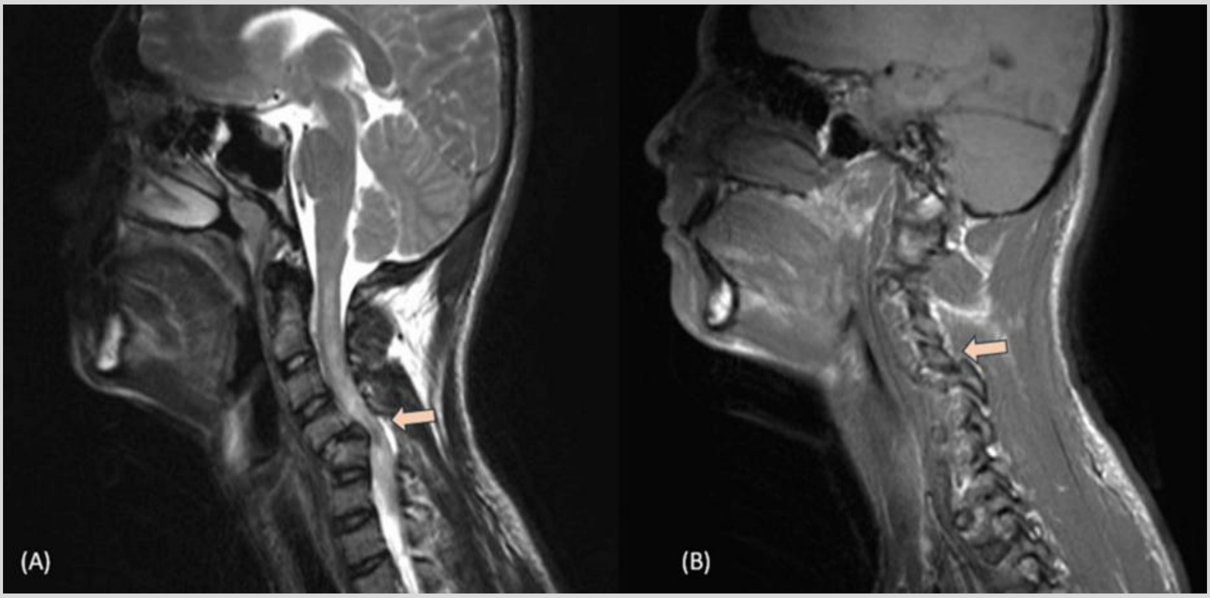

Fig. 11: Magnetic resonance images demonstrating subaxial cervical spine instability with spinal cord compression.

(A) Sagittal T2-weighted image showing anterior subluxation of C4 over C5 with spinal cord compression (arrow).
(B) Sagittal T1-weighted image demonstrating corresponding vertebral malalignment and locked facet joints (arrow).

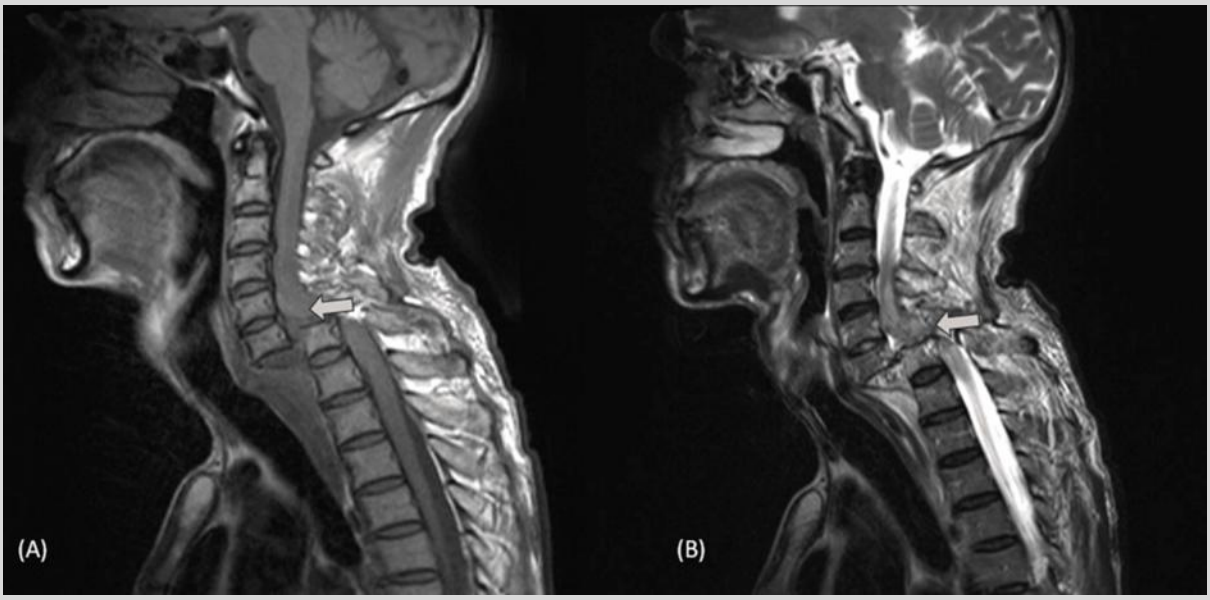

Fig. 12: Magnetic resonance images demonstrating subaxial cervical spine instability.

(A) Sagittal T1-weighted image showing anterior subluxation of C4 over C5 with facet joint locking.
(B) Sagittal T2-weighted image demonstrating compression of the cervical spinal cord at the C4–C5 level.

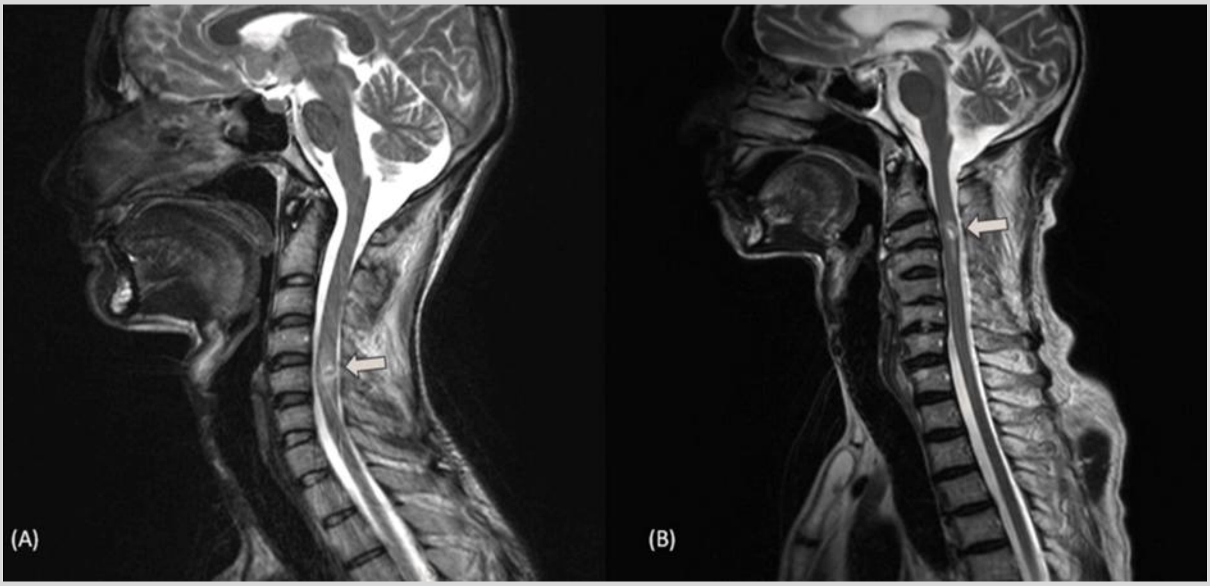

Fig. 13: Magnetic resonance images demonstrating spinal cord injury without radiographic abnormality.

(A) Sagittal T2-weighted image showing focal spinal cord edema at the C5 level in the absence of cervical vertebral injury (arrow).
(B) Sagittal T2-weighted image demonstrating spinal cord edema with intramedullary hemorrhage at the C3 level without osseous injury (arrow).

Conclusion

Computed tomography remains indispensable for rapid characterization of osseous injuries in cervical spine trauma, whereas magnetic resonance imaging provides important prognostic information by identifying spinal cord and ligamentous abnormalities. In this retrospective observational study, MRI-detected spinal cord signal changes showed a significant association with neurological status as assessed by the ASIA impairment scale. Cord edema was more frequently observed in patients with incomplete neurological deficits, while intramedullary hemorrhage was commonly associated with severe neurological impairment. These findings highlight the complementary role of MRI alongside CT in the evaluation and prognostic stratification of traumatic cervical spine injuries.

Declarations

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Conflict of interest

The authors declare that they have no conflicts of interest related to this study.

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Ethical Clearance

This study was conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Ethical approval for this retrospective observational study was obtained from the Institutional Ethics Committee of Apollo institute of medical sciences and research.

The requirement for informed consent was waived due to the retrospective nature of the study and use of anonymized data.

Trial details

Not applicable.

(This study is a retrospective observational study and was not registered as a clinical trial.)

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