RESEARCH PAPER

Evaluation of Spinal Cord Injuries by Magnetic Resonance Imaging in Trauma Patient

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ABSTRACT

Background: Spinal trauma is a major cause of morbidity and long-term disability worldwide, particularly among young and economically productive individuals. Road traffic accidents, falling from height, and routine injuries are the leading causes of spinal injuries, often resulting in vertebral damage and spinal cord involvement. Early and accurate assessment of spinal trauma is critical for timely intervention, prevention of secondary neurological injury, and appropriate treatment planning. Conventional imaging modalities such as radiography and computed tomography are effective in detecting bone injuries but have limitations in evaluating spinal cord, ligamentous, intervertebral disc, and soft tissue injuries. Magnetic Resonance Imaging (MRI), with its superior soft tissue contrast and multiplanar capability, allows direct visualization of the spinal cord, neural elements, and supporting ligamentous structures. MRI plays a crucial role in detecting cord edema, contusion, hemorrhage, ligamentous disruption, and epidural collections, which significantly influence prognosis and clinical management.

Aim and Objectives: The aim of the Study is to evaluate the role of Magnetic Resonance Imaging (MRI) in the assessment of spinal trauma by identifying vertebral, ligamentous, intervertebral disc, spinal cord, and associated soft tissue injuries, and to determine its diagnostic and prognostic significance in patients with spinal injuries.

Objectives:

1. To evaluate vertebral body injuries in patients with spinal trauma using MRI.
2. To assess spinal cord abnormalities such as edema, contusion, and hemorrhage.
3. To identify ligamentous injuries including anterior and posterior longitudinal ligaments, ligamentum flavum, and interspinous ligaments.
4. To evaluate intervertebral disc injuries associated with spinal trauma.

Methodology: A hospital-based observational study was conducted at Shaafi Superspeciality Hospital, Anantnag, Jammu and Kashmir. The study included 60 patients with clinically suspected spinal trauma. All patients underwent MRI examination using a GE HDxT 1.5 Tesla scanner. Standard imaging sequences, including T1-weighted, T2-weighted, STIR, and Gradient Echo images, were obtained in appropriate planes. MRI findings were evaluated for vertebral.

fractures, ligamentous injuries, intervertebral disc abnormalities, spinal cord edema, contusion, hemorrhage, and associated soft tissue injuries. The imaging findings were correlated with clinical and neurological status to assess the diagnostic and prognostic role of MRI in spinal trauma.

Results: Among the 60 patients studied, 42 (70%) were males and 18 (30%) were females, with road traffic accidents accounting for 38 cases (63.3%), followed by falls from height in 17 cases (28.3%). Cervical spine involvement was observed in 26 patients (43.3%), thoracic spine in 18 patients (30%), and lumbar spine in 16 patients (26.7%). Vertebral fractures were detected on MRI in 44 patients (73.3%). Spinal cord abnormalities were identified in 31 patients (51.7%), of which cord edema was seen in 19 cases (31.7%), cord contusion in 8 cases (13.3%), and cord hemorrhage in 4 cases (6.7%). Ligamentous injuries were present in 29 patients (48.3%), while epidural hematoma was noted in 9 patients (15%). MRI findings showed a strong correlation with neurological deficits and played a significant role in assessing injury severity and prognosis.

Conclusion: Magnetic Resonance Imaging plays a pivotal role in the comprehensive evaluation of spinal trauma by accurately depicting vertebral, ligamentous, intervertebral disc, and spinal cord injuries. MRI is particularly valuable in identifying spinal cord edema, contusion, and hemorrhage, which have important prognostic implications. The strong correlation between MRI findings and neurological status underscores its significance in guiding clinical management and treatment planning. MRI should be considered the imaging modality of choice in patients with suspected spinal trauma, especially in those presenting with neurological deficits.

Keywords: Spinal Trauma; Magnetic Resonance Imaging; Spinal Cord Injury; Ligamentous Injury; Vertebral Fracture; MRI Spine.

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INTRODUCTION

Spinal trauma is a major public health problem and a leading cause of morbidity and long-term neurological disability worldwide. It commonly affects young and middle-aged individuals, resulting in significant personal, social, and economic burden. Road traffic accidents, falls from height, sports injuries, and occupational accidents are the predominant causes of traumatic spinal injuries. Damage to the spinal column and spinal cord can result in varying degrees of neurological impairment, ranging from transient sensory deficits to permanent paralysis .

Early and accurate evaluation of spinal trauma is essential for appropriate clinical management and prevention of secondary spinal cord injury. Conventional imaging modalities such as plain radiography and computed tomography (CT) are widely used in the initial assessment of trauma patients and are effective in detecting osseous injuries. However, these modalities have limited ability to evaluate spinal cord integrity, ligamentous structures, intervertebral discs, and paraspinal soft tissues, which are critical determinants of spinal stability and neurological outcome .

Magnetic Resonance Imaging (MRI) has emerged as the imaging modality of choice for comprehensive assessment of spinal trauma due to its superior soft tissue contrast and multiplanar imaging capability. MRI allows direct visualization of the spinal cord, nerve roots, intervertebral discs, ligaments, and surrounding soft tissues without exposure to ionizing radiation. It is highly sensitive in detecting spinal cord edema, contusion, hemorrhage, ligamentous disruption, epidural hematoma, and traumatic disc herniation, many of which may not be evident on conventional imaging .

The human spine, or vertebral column, is a highly specialized and complex structure that serves as the central support of the axial skeleton, protects the spinal cord and nerve roots, and allows flexible movement of the trunk. It is composed of 33 vertebrae, categorized into five regions: 7 cervical (C1–C7), 12 thoracic (T1–T12), 5 lumbar (L1–L5), 5 sacral (S1–S5, fused), and 4 coccygeal (Co1–Co4, fused). Each vertebra consists of a vertebral body, which primarily bears axial load, and a vertebral arch, which surrounds the spinal canal containing the spinal cord and its meninges. The vertebral body, pedicles, laminae, transverse and spinous processes, and facet joints together provide structural stability and allow controlled motion.Between vertebral bodies lie intervertebral discs, fibrocartilaginous structures composed of the central nucleus pulposus and surrounding annulus fibrosus, which function as shock absorbers, distribute mechanical loads, and permit flexibility in multiple planes of motion. Intervertebral discs are thickest in the cervical and lumbar regions, corresponding to areas of high mobility. The facet (zygapophyseal) joints guide and limit spinal movement, preventing excessive rotation and translation. Together, discs and facet joints allow flexion, extension, lateral bending, and axial rotation while maintaining stability .

Understanding spinal anatomy and biomechanics is crucial in interpreting trauma-related imaging findings, particularly on MRI, where subtle ligamentous, discal, or cord injuries may not be visible on plain radiographs or CT. Knowledge of regional differences in mobility, load-bearing capacity, and ligamentous support allows accurate prediction of injury patterns, assessment of stability, and aids in planning conservative or surgical interventions

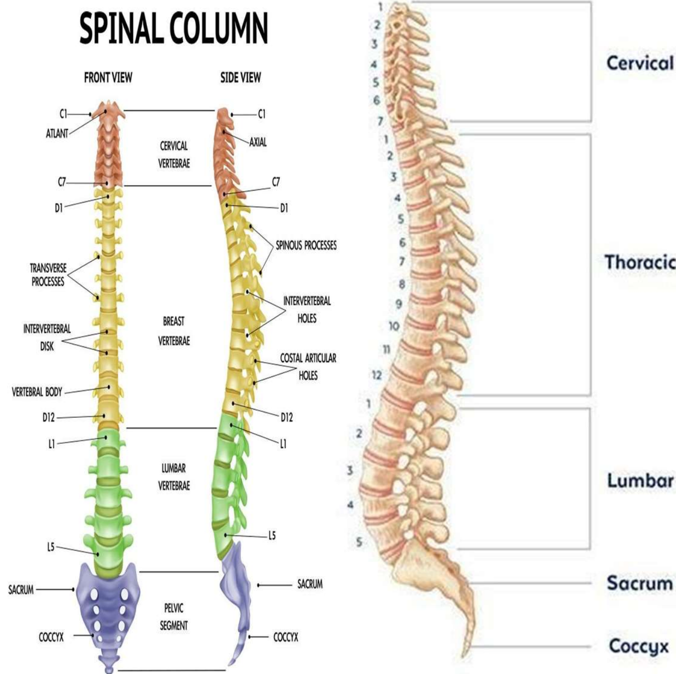
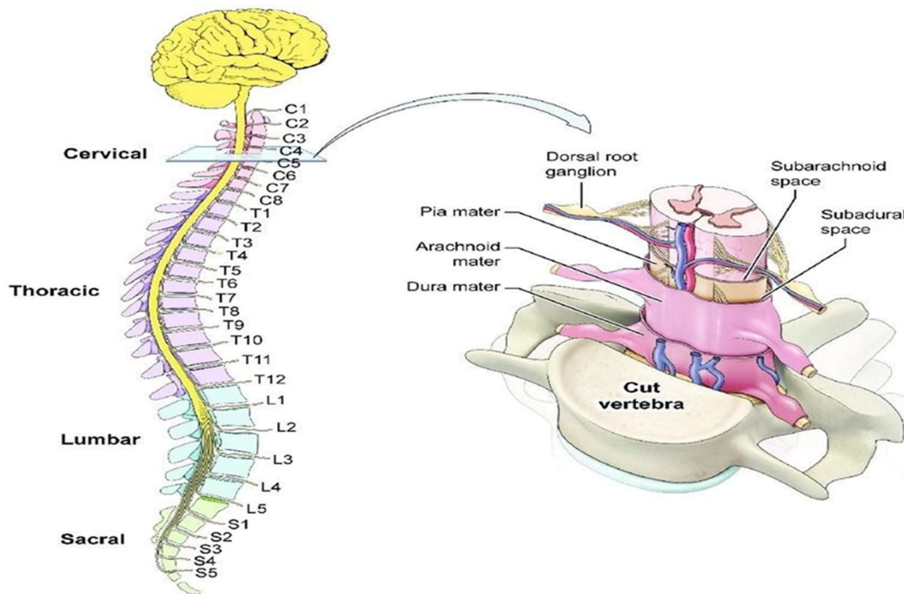


Image Showing Anatomy Whole Spine



Classification of Spinal Trauma

Spinal trauma encompasses a wide spectrum of injuries, ranging from minor vertebral fractures to severe spinal cord injuries with permanent neurological deficits. Accurate classification of spinal trauma is essential for guiding clinical management, determining spinal stability, and predicting prognosis. Several classification systems have been proposed, based on anatomical location, mechanism of injury, morphological pattern, and neurological involvement.

Anatomical Classification

Spinal injuries are often categorized according to the region of the spine involved:

Cervical spine trauma: Most mobile and susceptible to injury; common in high-velocity road traffic accidents. Injuries include fractures of the odontoid process, Jefferson fractures, Hangman’s fracture, and subaxial cervical fractures.

Thoracic spine trauma: More stable due to the rib cage; commonly affected by axial loading and compression. Injuries include compression fractures, burst fractures, and fracture-dislocations.

Lumbar spine trauma: Bears the highest load; susceptible to flexion-distraction injuries and burst fractures.

Sacral and coccygeal trauma: Usually from high-energy falls; often associated with pelvic fractures.

Mechanism-Based Classification
Understanding the mechanism of injury is crucial in predicting spinal instability and neurological compromise. Common mechanisms include:

Flexion injuries: Result from forward bending, causing anterior vertebral compression or anterior ligamentous disruption.

Extension injuries: Usually result in posterior element fractures or ligamentous tears.

Axial compression: Leads to burst fractures of the vertebral body.

Flexion-rotation: Causes complex fractures and dislocations, often unstable.

Distraction injuries: Result in tension forces, leading to disruption of posterior ligamentous structures.

Morphological Classification
Several systems classify spinal trauma based on fracture morphology:

1.1 Epidemiology and Causes of Spinal Injuries

Spinal injuries are a significant public health concern globally, contributing to high rates of morbidity, long-term disability, and socioeconomic burden. The annual incidence of spinal trauma varies widely across countries, with estimates ranging from 10 to 60 cases per million population, depending on regional factors, trauma reporting systems, and healthcare access. Males are disproportionately affected, with a male-to-female ratio of approximately 2:1 to 3:1, reflecting higher exposure to high-risk activities and occupational hazards. The most vulnerable age group is 15–45 years, representing the economically productive segment of the population.

Causes of Spinal Injuries
Spinal injuries typically result from high-energy trauma, although low-energy injuries can occur, particularly in elderly populations with osteoporotic bones. The primary causes include:

Road Traffic Accidents
RTAs are the leading cause of spinal trauma worldwide, accounting for approximately 40–60% of cases. High-speed collisions, motor vehicle accidents, and two-wheeler crashes are major contributors. Cervical spine injuries are especially common in RTAs due to hyperflexion or hyperextension mechanisms.

Falls From Height
Falls from trees, rooftops, ladders, or scaffolding are responsible for 20–30% of spinal injuries in developing countries. Thoracolumbar injuries are frequently seen in these cases due to axial compression forces.

Sports and recreational Activities
High-impact sports such as gymnastics, football, rugby, skiing, and diving contribute to a smaller but significant proportion of spinal trauma, particularly among adolescents and young adults. Cervical spine injuries are most common in these cases.

Occupational Accidents
Work-related falls, heavy load handling, and industrial accidents may lead to spinal fractures, especially in construction workers, laborers, and agricultural workers.

Violence and Assult
Penetrating injuries such as gunshot or stab wounds, as well as blunt trauma from physical assault, contribute to spinal cord injuries in a minority of patients.

Pathological Fractures
Spinal fractures may also occur in the setting of weakened bone due to osteoporosis, tumors, infections, or metabolic bone diseases, even after minor trauma. These injuries are more common in the elderly population.

Regional and Demographic Considerations
The pattern and cause of spinal injuries can vary according to geographic region, socioeconomic status, and urbanization. In developing countries, falls from height and occupational injuries are more prevalent, whereas in developed countries, RTAs dominate. Age and gender distribution also influence injury patterns: cervical spine injuries are more common in younger adults, thoracolumbar injuries in older adults, and the male population is more frequently affected.

Clinical Significance
Understanding the epidemiology and causes of spinal trauma is critical for prevention strategies, emergency preparedness, and resource allocation. It also helps clinicians anticipate injury patterns, assess risk of neurological involvement, and implement timely imaging and management strategies. MRI plays a key role in evaluating both bony and soft tissue injuries across different mechanisms of trauma, providing critical information for treatment planning and prognosis.

Clinical Presentation and Neurological Assessment

The clinical presentation of spinal trauma varies widely depending on the location, type, and severity of injury, as well as the involvement of the spinal cord and nerve roots. Pain is often the earliest and most common symptom, which may be localized to the site of injury or radiate along the affected dermatomes. Cervical spine injuries typically present with neck pain, stiffness, or discomfort radiating to the shoulders and upper limbs, whereas thoracic and lumbar injuries are associated with mid-back or lower back pain. The intensity of pain often increases with movement or palpation of the spine, reflecting underlying bony or soft tissue injury.

A detailed neurological assessment is essential for evaluating the extent of spinal cord involvement and predicting prognosis. Motor function is assessed by examining muscle strength in specific myotomes of the upper and lower limbs, while sensory evaluation includes testing for light touch and pinprick perception across dermatomes. Reflex testing, including deep tendon and superficial reflexes, helps determine upper motor neuron involvement. Autonomic function, particularly bowel and bladder control, is evaluated to identify disruption of autonomic pathways. The American Spinal Injury Association (ASIA) Impairment Scale (AIS) is widely used to classify spinal cord injuries, ranging from AIS A, indicating complete loss of motor and sensory function below the injury level, to AIS E, representing normal function. MRI findings, such as cord edema, contusion, and hemorrhage, have been shown to correlate closely with ASIA grading, highlighting their prognostic significance.

Role of Imaging Modalities in Spinal Trauma

Imaging plays a central role in the evaluation and management of spinal trauma, providing essential information regarding the location, severity, and nature of injuries. Accurate imaging not only aids in the diagnosis of vertebral fractures, ligamentous injuries, and spinal cord pathology but also guides clinical decision-making regarding conservative versus surgical management. The choice of imaging modality depends on the mechanism of injury, patient condition, and the specific clinical question to be answered. Plain radiography is often the first-line imaging modality in acute spinal trauma due to its wide availability, rapid acquisition, and ability to identify gross bony injuries. It is particularly useful for detecting vertebral fractures, dislocations, and alignment abnormalities.Magnetic Resonance Imaging (MRI) has emerged as the gold standard for evaluating spinal cord, ligamentous, and soft tissue injuries. Its excellent soft tissue contrast and multiplanar imaging capability allow direct visualization of the spinal cord, nerve roots, intervertebral discs, ligaments, and paraspinal soft tissues. MRI is highly sensitive in detecting spinal cord edema, contusion, hemorrhage, and compression, as well as subtle ligamentous injuries that may not be evident on CT or radiographs. It is particularly valuable in patients presenting with neurological deficits, as it provides information on both the severity and prognosis of spinal cord injury. Additionally, MRI can identify associated epidural hematomas, paraspinal soft tissue injuries, and disc herniations, which may influence management decisions.

Advantages of MRI over Other Imaging Modalities

Magnetic Resonance Imaging (MRI) has become the cornerstone in the evaluation of spinal trauma due to its superior soft tissue contrast, multiplanar imaging capability, and non-invasive nature. While conventional imaging modalities such as plain radiography and computed tomography (CT) remain useful for initial assessment and detection of bony injuries, MRI offers several distinct advantages that make it indispensable in comprehensive spinal trauma evaluation.

MRI sequences such as STIR (Short Tau Inversion Recovery) and Gradient Echo (GRE) increase sensitivity to soft tissue and marrow edema, further enhancing the detection of occult injuries. MRI can also identify subtle hemorrhages, edema, or ischemic changes within the spinal cord, which have direct implications for prognosis and surgical planning.In summary, MRI offers comprehensive evaluation of both bony and soft tissue structures, superior sensitivity for spinal cord and ligamentous injuries, non-ionizing imaging, and multiplanar visualization, making it the preferred imaging modality in the assessment of spinal trauma. Its ability to provide detailed anatomical and pathological information significantly enhances diagnostic accuracy, guides treatment planning, and contributes to improved patient outcomes

Aim of The Study

The aim of the Study is to evaluate the role of Magnetic Resonance Imaging (MRI) in the assessment of spinal trauma by identifying vertebral, ligamentous, intervertebral disc, spinal cord, and associated soft tissue injuries, and to determine its diagnostic and prognostic significance in patients with spinal injuries.

Objectives:

1. To evaluate vertebral body injuries in patients with spinal trauma using MRI.
2. To assess spinal cord abnormalities such as edema, contusion, and hemorrhage.
3. To identify ligamentous injuries including anterior and posterior longitudinal ligaments, ligamentum flavum, and interspinous ligaments.
4. To evaluate intervertebral disc injuries associated with spinal trauma.

MATERIALS AND METHODS

Study Design

The present study was a prospective observational study conducted in the Department of Radiodiagnosis at MMU MULLANA Hospital Ambala. The study was designed to evaluate the role of Magnetic Resonance Imaging (MRI) in the assessment of spinal trauma, with particular emphasis on the detection of spinal cord, ligamentous, discal, and vertebral injuries.A total of 60 patients with a clinical suspicion or confirmed history of spinal trauma were included in the study. All patients underwent MRI of the spine using a GE HDXT 1.5 Tesla MRI scanner. Patients

were selected based on predefined inclusion and exclusion criteria to ensure uniformity and diagnostic reliability. MRI examinations were performed according to a standardized trauma protocol, enabling comprehensive evaluation of the cervical, thoracic, and lumbar spine as indicated by the clinical presentation.The study focused on detailed analysis of MRI signal changes within the spinal cord, including cord edema, contusion, and hemorrhage, as well as assessment of ligamentous disruptions, intervertebral disc injuries, vertebral fractures, spinal canal compromise, and paraspinal soft tissue abnormalities. MRI findings were systematically correlated with clinical presentation and neurological status at the time of admission.

The study design aimed to provide a non-invasive, radiation-free, and comprehensive imaging-based assessment of spinal trauma, highlighting the diagnostic and prognostic value of MRI in acute and subacute spinal injuries. The findings were intended to support the role of MRI as an essential imaging modality for accurate diagnosis, management planning, and outcome prediction in patients with spinal trauma.

Study Population and Selection Criteria

The study included 60 patients who presented with a clinical history or suspicion of spinal trauma and underwent Magnetic Resonance Imaging (MRI) of the spine at MMUHospital, Mullana Ambala during the defined study period. Both male and female patients, aged 18 to 75 years, were included in order to obtain a representative sample of the adult population affected by spinal injuries.

Inclusion and exculsion Criteria

1. Adult patients aged 18 years and above
2. Patients with a history of spinal trauma
3. Patients presenting with spinal pain, restricted mobility, or neurological deficits following trauma
4. Patients referred for MRI evaluation of the spine
5. Patients with suspected or confirmed injury involving the cervical, thoracic, or lumbar spine

Exclusion Criteria:

1. Patients with contraindications to MRI, such as cardiac pacemakers, cochlear implants, intracranial aneurysm clips, or other non–MRI-compatible metallic implants
2. Patients with severe claustrophobia or inability to remain still during MRI examination
3. Patients with polytrauma requiring immediate life-saving intervention, where MRI could not be safely performed
4. Patients with previous spinal surgery, which could alter normal anatomy and interfere with image interpretation

Study Setting

The study was conducted in the Department of Radiodiagnosis at MMU Hospital Mullana Ambala a tertiary care hospital equipped with advanced imaging facilities. The imaging examinations were performed using a GE HDXT 1.5 Tesla Magnetic Resonance Imaging (MRI) system, which provides high-resolution multiplanar imaging and excellent soft tissue contrast for comprehensive spinal evaluation.All MRI examinations were carried out in the department's dedicated MRI suite, under the supervision of experienced radiologists and trained MRI technologists. Standardized MRI protocols for spinal trauma were followed, including appropriate patient positioning, sequence selection, and image acquisition parameters to ensure uniformity and diagnostic accuracy.

GE HDXT 1.5 TESLA MRI SCANNER

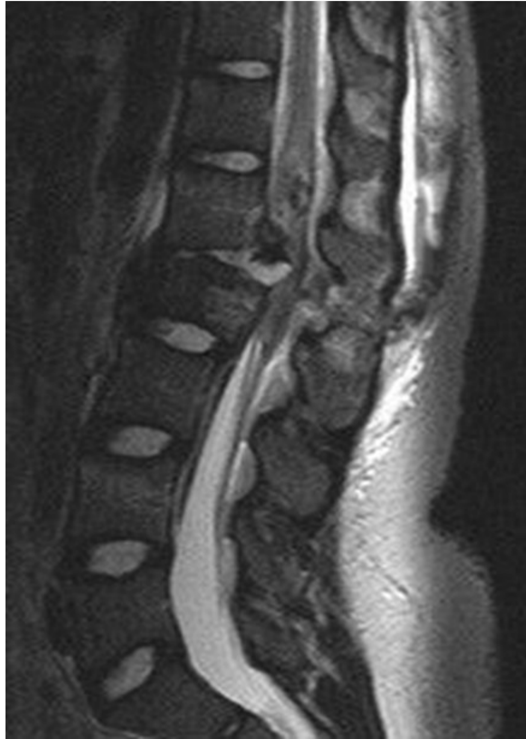
MRI Scanner Specifications

- **Scanner Type:** Superconducting MRI system
- **Magnetic Field Strength:** 1.5 Tesla
- **Manufacturer / Model:** GE Healthcare HDXT
- **Magnet Type:** Closed-bore superconducting magnet
- **Bore Diameter:** 60 cm
- **Gradient System:** High-performance gradients with fast slew rate suitable for trauma imaging
- **Radiofrequency Coils:** Dedicated spine coils and phased-array surface coils for cervical, thoracic, and lumbar spine imaging
- **Imaging Planes:** Axial, sagittal, and coronal planes
- **Pulse Sequences Used:**
  - T1-weighted spin echo
  - T2-weighted fast spin echo
  - STIR (Short Tau Inversion Recovery) for edema and ligamentous injury
  - Gradient Echo (GRE) sequences for detection of hemorrhage
- **Slice Thickness:** 3–4 mm with minimal interslice gap for optimal spinal cord and soft tissue evaluation
- **Field of View (FOV):** Adjusted according to spinal region (cervical, thoracic, lumbar)
- **Matrix Size:** High-resolution matrix for detailed anatomical assessment
- **Scan Time:** Optimized protocols to minimize motion artifacts in trauma patients
- **Post-Processing Capabilities:** Multiplanar reconstruction and image review on dedicated workstations
- **Image Analysis Tools:** Integrated software for evaluation of spinal cord signal changes, ligamentous disruption, disc injuries, vertebral fractures, and spinal canal compromise

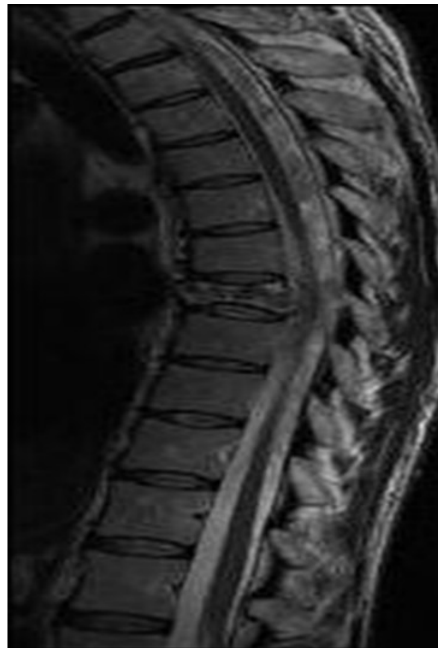
Data Collection and Documentation

Data collection in the present study was carried out in a systematic and standardized manner to ensure accuracy, reproducibility, and completeness of information related to spinal trauma assessment using MRI. All relevant clinical, demographic, and imaging data were prospectively recorded for each patient at the time of enrollment and during image interpretation.Demographic details including age, sex, and patient identification number were documented for all study participants. A detailed clinical history was obtained, focusing on the mechanism of injury such as road traffic accidents, falls from height, assault, or sports-related trauma. The time interval between injury and MRI examination was recorded, as it has a significant impact on the appearance of spinal cord edema, hemorrhage, and soft tissue injuries on MRI. Clinical symptoms such as pain severity, limb weakness, sensory deficits, and bladder or bowel dysfunction were also documented.

Neurological status was assessed at presentation using standard clinical examination and, where available, classified according to established grading systems such as the American Spinal Injury Association (ASIA) impairment scale. These findings were documented to allow correlation between MRI findings and neurological deficits, thereby enhancing the clinical relevance of imaging observations.MRI data were collected from the hospital's Picture Archiving and Communication System (PACS). All images were reviewed on high-resolution diagnostic workstations using standardized windowing and zoom settings. Imaging findings were documented for vertebral body fractures, alignment abnormalities, intervertebral disc injuries, ligamentous disruptions, spinal canal compromise, spinal cord edema, contusion, hemorrhage, and epidural or paraspinal soft tissue collections. Each lesion was recorded with respect to its spinal level, extent, and imaging characteristics.To minimize observer bias, MRI scans were independently evaluated by experienced radiologists with expertise in musculoskeletal and neuroimaging. Any discrepancies in interpretation were resolved through consensus review. Findings were documented using a structured reporting format to maintain uniformity and facilitate statistical analysis.All collected data were entered into a pre-designed data collection proforma and subsequently transferred to an electronic database for analysis. Confidentiality of patient information was strictly maintained by anonymizing imaging data and restricting access to authorized personnel only. This comprehensive and methodical approach to data collection and documentation ensured reliable correlation between clinical presentation and MRI findings, forming a robust foundation for evaluating the role of MRI in spinal trauma.



T2WI MRI Image showing Acute Spinal Trauma of Lumbar Spine



MRI Image Showing T8 vertebral compression fracture, with posterior protrusion of bone causing a moderate degree of central spinal stenosis,

Statistical Analysis

The collected data were systematically compiled and analyzed to evaluate the role of magnetic resonance imaging (MRI) in the assessment of spinal trauma and its correlation with clinical and neurological findings. All demographic, clinical, and imaging variables were entered into a structured database and subjected to statistical evaluation using standard statistical software, such as the Statistical Package for the Social Sciences (SPSS), version [insert version].Descriptive statistics were used to summarize baseline characteristics of the study popula tion. Continuous variables such as age were expressed as mean ± standard

deviation, while categorical variables including sex, mechanism of injury, spinal level involved, and types of MRI findings were presented as frequencies and percentages.MRI findings related to vertebral fractures, ligamentous injuries, intervertebral disc involvement, spinal cord edema, contusion, hemorrhage, and spinal canal compromise were analyzed individually and in combination. The distribution of these findings across different spinal regions (cervical, thoracic, and lumbar spine) was evaluated.Inferential statistical tests were applied to determine the association between MRI findings and neurological status. The Chi-square test or Fisher's exact test was used to assess relationships between categorical variables, such as the presence of spinal cord signal changes and severity of neurological deficit.

DAIGNOSTIC CASE STUDY

Case 1.

A 34-year-old male presented to the emergency department following a road traffic accident.

Clinical Presentation

The patient complained of severe neck pain and restricted cervical movements. Neurological examination revealed weakness in all four limbs with reduced motor power (Grade 3/5) and decreased sensation below the C5 dermatome. The patient was hemodynamically stable at presentation.

Imaging Modality

Magnetic resonance imaging (MRI) of the cervical spine was performed using a GE HDXT 1.5 Tesla MRI scanner.

MRI Protocol

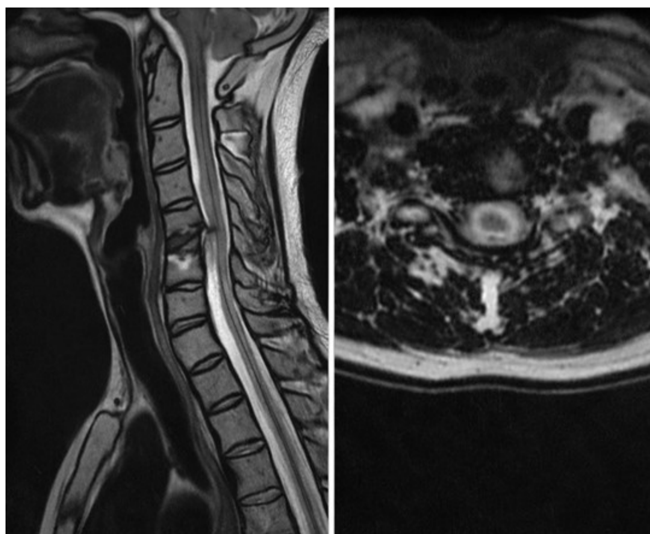
Imaging sequences included sagittal and axial T1-weighted images, T2-weighted images, STIR sequences, and axial gradient-echo images.

MRI Findings

MRI demonstrated loss of normal cervical lordosis and a compression fracture of the C5 vertebral body with associated marrow edema. Hyperintense signal on STIR images indicated injury to the posterior ligamentous complex at the C4–C5 level. Intramedullary T2 hyperintensity was noted within the spinal cord at the C5 level, consistent with spinal cord edema. Mild epidural soft tissue caused moderate narrowing of the spinal canal.

Diagnosis

Unstable cervical spine injury with spinal cord edema secondary to trauma.



Case Study 2 .

A 47-year-old male presented to the emergency department following a fall from height (approximately 10 feet).

Clinical Presentation

The patient complained of severe mid-back pain and inability to move both lower limbs. On neurological examination, motor power in both lower limbs was reduced to Grade 2/5 with loss of pain and temperature sensation below the T8 dermatome. Bladder sensation was diminished, suggesting thoracic spinal cord involvement.

Imaging Modality

MRI of the thoracic spine was performed using a GE HDXT 1.5 Tesla MRI scanner.

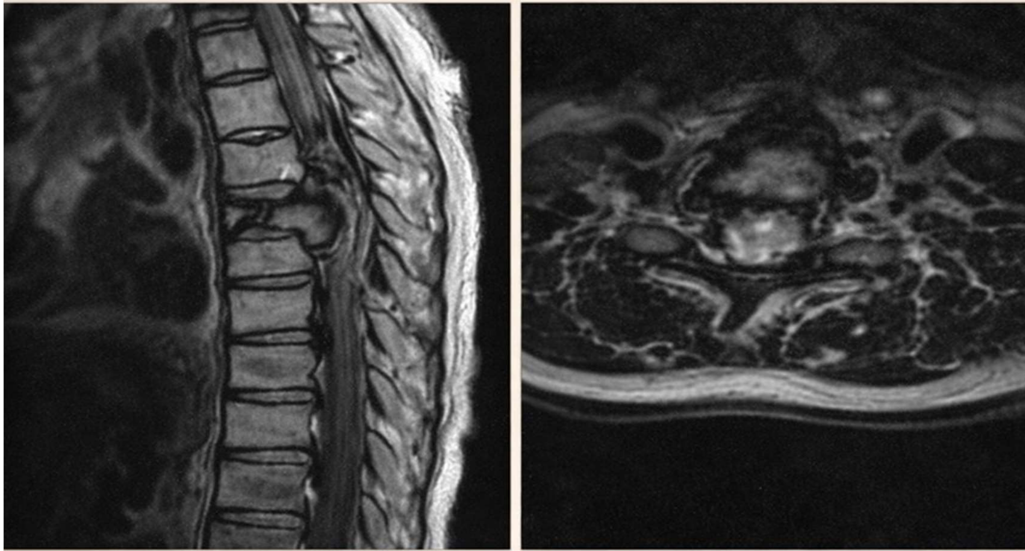
MRI Protocol

Sagittal and axial T1-weighted, T2-weighted, STIR, and axial gradient-echo sequences were acquired as part of the standard spinal trauma protocol.

MRI Findings

MRI demonstrated a burst fracture of the T7 vertebral body with significant loss of vertebral height and posterior wall

retropulsion into the spinal canal. STIR images showed extensive marrow edema within the T7 vertebra. There was disruption of the posterior ligamentous complex, indicated by high signal intensity on STIR sequences.



RESULT

The present study evaluated a total of 60 patients who underwent magnetic resonance imaging for assessment of spinal trauma. The study population demonstrated a clear male predominance, with 42 patients (70%) being males and 18 patients (30%) females. This gender distribution reflects the higher exposure of males to high-energy trauma in the studied population.Analysis of the mechanism of injury revealed that road traffic accidents were the most common cause, accounting for 38 cases (63.3%), followed by falls from height in 17 patients (28.3%). Other mechanisms of injury constituted a minor proportion of cases. These findings highlight the significant contribution of high-velocity trauma to spinal injuries. Regarding the anatomical distribution of spinal involvement, cervical spine injuries were the most frequently observed, identified in 26 patients (43.3%). This was followed by thoracic spine involvement in 18 patients (30%) and lumbar spine injuries in 16 patients (26.7%). The higher incidence of cervical spine injuries underscores the vulnerability of the cervical region to traumatic forces, particularly in road traffic accidents. MRI detected vertebral fractures in 44 patients (73.3%), demonstrating its high sensitivity in identifying osseous injuries. In addition to vertebral fractures, MRI was particularly effective in detecting spinal cord abnormalities, which wer e observed in 31 patients (51.7%). Among these, spinal cord edema was the most common finding, seen in 19 patients (31.7%), followed by cord contusion in 8 patients (13.3%) and cord hemorrhage in 4 patients (6.7%). The presence of spinal cord signal changes on MRI was associated with more severe neurological deficits.

Ligamentous injuries were identified in 29 patients (48.3%), emphasizing the importance of MRI in evaluating spinal stability, which cannot be reliably assessed by conventional radiography or computed tomography alone. Additionally, epidural hematoma was detected in 9 patients (15%), contributing to spinal canal compromise and neurological impairment in several cases.Overall, MRI findings demonstrated a strong correlation with clinical and neurological deficits, providing critical information regarding the extent of injury, spinal stability, and spinal cord involvement. The comprehensive evaluation offered by MRI significantly aided in determining injury severity, guiding clinical management, and predicting neurological prognosis in patients with spinal trauma.

Demographics of the study Population

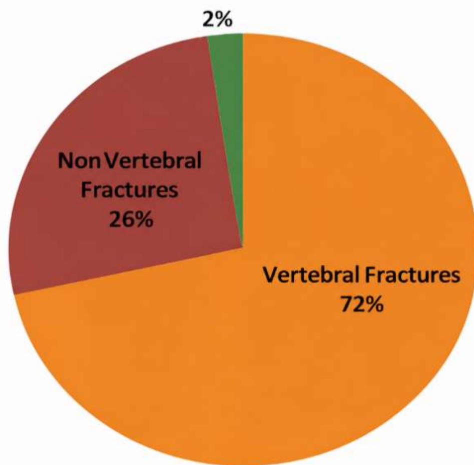
Parameter	Category	Number of Patients (n)	Percentage (%)
Gender	Male	42	70.0
	Female	18	30.0
Mechanism of Injury	Road Traffic Accident	38	63.3
	Fall from Height	17	28.3
	Other Causes	5	8.4
Spinal Level Involved	Cervical Spine	26	43.3
	Thoracic Spine	18	30.0
	Lumbar Spine	16	26.7

Mechanism of Injury Distribution

Analysis of the mechanism of injury in the present study revealed that road traffic accidents were the leading cause of spinal trauma, accounting for 38 out of 60 patients (63.3%). This high proportion reflects the significant impact of high-velocity injuries on the spine, particularly in regions with increasing vehicular traffic and limited road safety measures. Road traffic accidents were commonly associated with severe spinal injuries, including vertebral fractures and spinal cord involvement.Falls from height constituted the second most common mechanism of injury, observed in 17 patients (28.3%). These injuries were frequently noted among individuals involved in occupational activities such as construction work, agricultural labor, and domestic activities. Falls from height often resulted in thoracic and lumbar spine injuries due to axial loading forces transmitted through the spine

MRI Findings in Vertebral Injuries

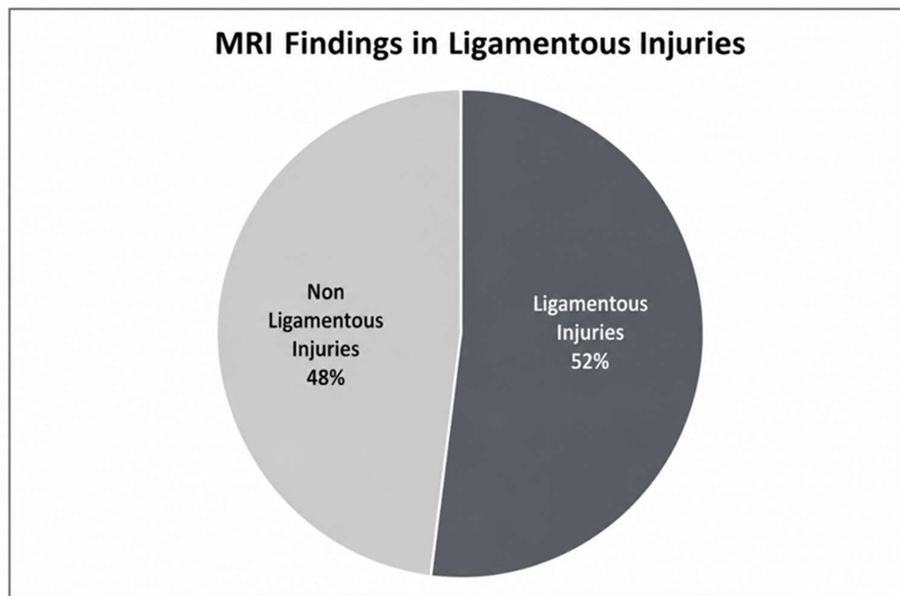
Magnetic resonance imaging (MRI) in the present study demonstrated that vertebral fractures were the most frequently observed abnormality, detected in 44 out of 60 patients (73.3%). These fractures varied in morphology, including compression fractures, burst fractures, and, less commonly, fracture-dislocations. MRI provided clear visualization of vertebral body height loss, bone marrow edema, and posterior wall involvement, which were critical in assessing fracture severity and stability.Compression fractures were most commonly noted in the thoracic and lumbar spine, characterized by wedge-shaped deformities and hypointense signal on T1-weighted images with corresponding hyperintensity on T2-weighted and STIR sequences, indicating acute trabecular bone injury. Burst fractures were predominantly observed in the thoracolumbar junction, often accompanied by posterior wall retropulsion into the spinal canal, which MRI clearly delineated, allowing accurate assessment of canal compromise.



MRI Findings in Ligamentous Injuries

Ligamentous injuries were identified in 29 out of 60 patients (48.3%), highlighting the critical role of MRI in evaluating spinal stability, which cannot be reliably assessed by plain radiographs or CT scans. The most commonly affected structures were the posterior ligamentous complex (PLC), including the interspinous ligaments, supraspinous ligament, ligamentum flavum, and facet joint capsules.MRI sequences, particularly STIR and T2- weighted images, were highly sensitive in detecting ligamentous injury, revealing hyperintense signals indicative of edema, partial or complete tears.

Figure 14:- Pie Chart Showing MRI Findings in Ligamentous Injuries



Associated Para-spinal and Soft Tissue Findings

Finding	Number of Patients (n=60)	Percentage (%)
Paraspinal muscle edema	22	36.7
Soft tissue hematoma	22	36.7
Prevertebral / posterior paraspinal swelling	22	36.7
No paraspinal or soft tissue abnormalities	38	63.3

DISCUSSION

Spinal trauma is a major cause of morbidity, often resulting from high-energy mechanisms such as road traffic accidents and falls from height. In this study of 60 patients, MRI played a pivotal role in comprehensively evaluating spinal injuries, including vertebral fractures, spinal cord abnormalities, ligamentous disruptions, and associated paraspinal and soft tissue findings. The study cohort demonstrated a clear male predominance, with 42 males (70%) and 18 females (30%), reflecting greater exposure of males to high-risk activities and environments. Road traffic accidents were the leading cause of injury, accounting for 63.3% of cases, followed by falls from height (28.3%) and other causes, including assaults or sports-related trauma (8.4%). The distribution of spinal trauma showed that the cervical spine was most frequently involved (43.3%), followed by the thoracic (30%) and lumbar spine (26.7%), highlighting the vulnerability of the cervical region to high-velocity forces and the thoracolumbar junction to axial loading .

MRI detected vertebral fractures in 73.3% of patients, providing detailed assessment of fracture morphology, bone marrow edema, vertebral height loss, and posterior wall involvement. Compression fractures predominated in the thoracic and lumbar regions, whereas cervical fractures were often associated with spinal cord injury. Spinal cord abnormalities were observed in 51.7% of patients, including cord edema in 31.7%, contusion in 13.3%, and hemorrhage in 6.7%. MRI allowed precise visualization of these injuries, correlating strongly with neurological deficits and facilitating accurate prognostication. Ligamentous injuries were present in 48.3% of patients, predominantly affecting the posterior ligamentous complex. MRI demonstrated hyperintense signals on STIR and T2-weighted images, revealing partial or complete tears, which are critical for assessing spinal stability and guiding surgical or conservative management .

In addition, MRI revealed associated paraspinal and soft tissue abnormalities in 36.7% of patients, including paraspinal muscle edema, hematoma, and posterior or prevertebral swelling. These findings were most common in high-energy trauma and often coincided with vertebral or ligamentous injuries. Detection of these soft tissue changes provided important insight into the severity of trauma and potential risks for secondary complications such as delayed neurological deficits or compartment syndrome. Collectively, these findings emphasize the unique ability of MRI to evaluate the full spectrum of spinal injuries, including subtle abnormalities that may be missed on CT or radiographs.The present study's results align with

previously published literature, highlighting the superiority of MRI in detecting cord lesions, ligamentous disruptions, and soft tissue abnormalities. Early MRI evaluation proved critical for accurate diagnosis, classification of injury severity, and correlation with neurological status.

CONCLUSION

The present study highlights the crucial role of magnetic resonance imaging (MRI) in the comprehensive evaluation of spinal trauma. MRI proved to be an invaluable imaging modality for assessing both osseous and soft tissue components of spinal injury, particularly in detecting spinal cord abnormalities, ligamentous disruptions, and associated paraspinal soft tissue injuries that are often inadequately visualized on conventional radiography or computed tomography.

In this study, road traffic accidents emerged as the most common mechanism of spinal injury, reflecting the predominance of high-energy trauma in the studied population. Cervical spine involvement was most frequently observed, followed by thoracic and lumbar spine injuries. MRI demonstrated high sensitivity in identifying vertebral fractures, spinal cord edema, contusion, hemorrhage, ligamentous injuries, and epidural hematomas, all of which have direct implications for neurological status, injury severity grading, and treatment planning.The ability of MRI to clearly delineate spinal cord pathology was particularly significant, as cord edema, contusion, and hemorrhage showed strong correlation with neurological deficits. Detection of ligamentous injuries and paraspinal soft tissue abnormalities further enhanced the understanding of spinal instability and trauma severity. These findings emphasize the superiority of MRI in evaluating occult injuries and guiding timely surgical or conservative management decisions.

Overall, the study confirms that MRI is the imaging modality of choice in patients with suspected spinal trauma, especially in those presenting with neurological deficits or inconclusive findings on CT. Early and accurate MRI assessment facilitates appropriate clinical decision-making, improves prognostic evaluation, and contributes to better patient outcomes. The results support the routine integration of MRI into spinal trauma evaluation protocols in tertiary care centers.

REFERENCES

1. Aarabi, B., Alexander, M., Mirvis, S. E., Shanmuganathan, K., Chesler, D., Maulucci, C., & Iguchi, M. (2011). Predictors of outcome in acute traumatic central cord syndrome due to spinal stenosis. *Journal of Neurosurgery: Spine, 14*(1), 122–130.
2. Ackery, A., Tator, C., & Krassioukov, A. (2004). A global perspective on spinal cord injury epidemiology. *Journal of Neurotrauma, 21*(10), 1355–1370.
3. American College of Radiology. (2023). *ACR appropriateness criteria® suspected spine trauma*. ACR.
4. Anderson, P. A., Muchow, R. D., & Munoz, A. (2010). Clearance of the asymptomatic cervical spine. *Journal of the American Academy of Orthopaedic Surgeons, 18*(3), 149–159.
5. Bailitz, J., Starr, F., Beecroft, M., Bankoff, J., & Anderson, C. (2009). Cervical spine injury detection. *Emergency Medicine Clinics of North America, 27*(4), 769–793.
6. Bozzo, A., Marcoux, J., Radhakrishna, M., Pelletier, J., & Goulet, B. (2011). The role of magnetic resonance imaging in the management of acute spinal cord injury. *Journal of Neurotrauma, 28*(8), 1401–1411.
7. Bracken, M. B. (2001). Pharmacological treatment of acute spinal cord injury. *Journal of the American Medical Association, 286*(13), 1597–1601.
8. Chiu, W. C., Haan, J. M., Cushing, B. M., Kramer, M. E., & Scalea, T. M. (2001). Ligamentous injuries of the cervical spine. *Journal of Trauma, 50*(3), 457–463.
9. Daffner, R. H. (2010). Imaging of cervical spine trauma. *Spine, 35*(21), S219–S225.
10. Davis, J. W., Phreaner, D. L., Hoyt, D. B., & Mackersie, R. C. (1993). The etiology of missed cervical spine injuries. *Journal of Trauma, 34*(3), 342–346.
11. Fehlings, M. G., Rao, S. C., Tator, C. H., Skaf, G., Arnold, P., Benzel, E., & Dickman, C. (1999). The optimal radiologic method for assessing spinal canal compromise. *Spine, 24*(6), 605–613.
12. Flanders, A. E., Spettell, C. M., Tartaglino, L. M., Friedman, D. P., & Herbison, G. J. (1996). Forecasting motor recovery after cervical spinal cord injury. *Radiology, 201*(3), 649–655.
13. Flanders, A. E., Schaefer, D. M., Doan, H. T., Mishkin, M. M., Gonzalez, C. F., & Northrup, B. E. (1990). Acute cervical spine trauma. *Radiology, 177*(1), 25–33.
14. Holmes, J. F., Akkinepalli, R. (2005). Computed tomography versus plain radiography. *Journal of Trauma, 58*(5), 902–905.
15. Joaquim, A. F., Patel, A. A. (2013). Spinal trauma classification systems. *Journal of Neurosurgery: Spine, 19*(1), 1–10.
16. Kao, T. H., Chen, C. Y., & Wang, Y. C. (2014). MRI predictors of neurological recovery. *Spine Journal, 14*(11), 2636–2644.
17. Kato, S., Murray, J. C., & Fehlings, M. G. (2019). Advances in imaging of traumatic spinal cord injury. *Neurosurgery Clinics of North America, 30*(1), 1–10.
18. Kulkarni, M. V., Bondurant, F. J., Rose, S. L., Narayana, P. A. (1988). Acute spinal cord injury. *Radiology, 166*(1), 239–243.
19. Kumar, R., Lim, J., Mekary, R. A., Rattani, A., Dewan, M. C., Sharif, S. Y., & Park, K. B. (2018). Traumatic spinal injury. *World Neurosurgery, 113*, e345–e363.
20. Lee, C., Woodring, J. H., Goldstein, S. J., Daniel, T.

L., Young, A. B., & Tibbs, P. A. (1987). Evaluation of cervical spine injuries. *Radiology, 164*(1), 83–87.

21. Kumar, Y., Hayashi, D., & Role of MRI in spinal trauma. (2016). *World Journal of Radiology, 8*(8), 737–748.
22. Rajasekaran, S., Kanna, R. M., & Shetty, A. P. (2017). Spinal trauma in developing countries. *Journal of Orthopaedics, 14*(1), 1–7.
23. Sharma, A., Gaikwad, S. B., Deol, P. S., Mishra, N. K., Kale, S. S., & Gupta, V. (2005). MRI in acute spinal trauma. *Clinical Radiology, 60*(9), 976–985.
24. Singh, R., & Kumar, A. (2019). MRI evaluation of spinal cord injuries. *Indian Journal of Radiology and Imaging, 29*(3), 263–271.
25. Rathore, M. F. A., Hanif, S., Farooq, F., Ahmad, N., & Mansoor, S. N. (2008). Traumatic spinal cord injuries. *Spinal Cord, 46*(6), 428–434.
26. Jain, N. B., Ayers, G. D., Peterson, E. N., Harris, M. B., Morse, L., O’Connor, K. C., & Garshick, E. (2015). Traumatic SCI epidemiology. *Spine, 40*(7), 477–487.
27. Fehlings, M. G., & Perrin, R. G. (2006). The timing of surgical intervention. *Spine, 31*(11),