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A prospective study on role of magnetic resonance imaging in management of acute spinal trauma and assessing the extent of neurological deficit

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Abstract

Background: For Imaging neurological parts, like the spinal cord, magnetic resonance imaging (MRI) has been the gold standard. The use of magnetic resonance imaging (MRI) in the acute management of patients with spinal cord injuries has risen dramatically.

Objectives: This study was conducted to evaluate the diagnostic role of magnetic resonance imaging in management of acute spinal trauma and to assess the extent of neurological deficit.

Material and Methods: Thirty patients of spinal trauma. The patients undergoing MR imaging, magnetic resonance images were analysed and skeletal injuries, signal changes in vertebrae, ligaments, soft tissues were noted. Associated spinal cord injury findings were also noted, which helped in assessing the initial neurological deficit and compared with (ASIA) impairment scale.

Results: Out of 30 patients of spinal trauma. 53.3 % injuries were in cervical region and 46.6% in thoracolumbar region. Most of the traumatic spinal injuries in cervical spine were unstable. (68.75%) and thoracolumbar spine were stable injuries (42.85%). Unstable spinal injuries (56.66%) in cervical and thoracolumbar were operated and stabilised. Cord oedema (36.6%) and next cord compression (33.3%) were common presentations of cord injuries; cord transection and compression have worse neurological deficit and presented with ASIA score A/B at the time of admission.

Conclusion: CT provides superior depiction of bony anatomy but important limitation of this technique is inability to provide screening for ligamentous injury and spinal cord lesions. MRI is superior in this regard. Because of its high contrast resolution, absence of bony artifacts, multiplanar ability, and variety of pulse sequences, MRI allows for a more precise diagnosis of spinal trauma.

Keywords: spinal trauma, MRI-stable vs unstable injuries, acute spinal cord injury, ASIA impairment scale, ligamentous injury

Introduction

Spinal trauma is a common cause of disability. The common causes of spinal trauma are blunt injuries – motor vehicle accidents, falls, diving accidents, sport injuries, assaults. Penetrating injuries like stab wounds or gunshot wounds are rare causes of spinal trauma.

Diagnostic imaging, particularly MRI plays a crucial role in evaluating and detecting spinal trauma. MRI may detect subtle bone marrow, soft tissue, and spinal cord defects that may not be visible in other imaging modalities. Early detection often leads to prompt and accurate diagnosis, expeditious management and avoidance of unnecessary procedures.

Because of its high contrast resolution, absence of bony artifacts, multiplanar ability, and variety of pulse sequences, MRI allows for a more precise diagnosis of spinal trauma. More appropriate information on neural and extra neural injuries requiring surgery can be obtained. The purpose of this study was to study role of mri in acute spinal trauma and identifying stable and unstable injuries and associated cord injury which helps in planning the correct treatment.

MRI has revolutionised the evaluation of spinal trauma due to its high resolution. It is useful in detecting (a) altered signal intensities in vertebral bone marrow which are inapparent on plain films (b) ligamentous injuries (c) traumatic intervertebral disc herniations (d) epidural, pre and paravertebral haematoma and most important of all (e) spinal cord and nerve root injuries [1, 2]

MR imaging is also useful to differentiate benign versus malignant vertebral fractures. MR imaging findings indicative of metastatic compression fractures include: convex posterior border of the vertebral body (expansion of the vertebral body due to the underlying tumor), abnormal signal intensity involving pedicles or posterior elements, epidural mass, encasing epidural mass, focal paraspinal mass, and other spinal metastases; in case of acute osteoporotic compression fractures there will be low-signal-intensity band on T1- and T2- weighted images, spared normal bone marrow signal intensity of the vertebral body, retropulsion of a posterior bone fragment, and multiple compression fractures.[3] However, on conventional MR imaging, Acute healing compression fractures may resemble metastatic lesions in appearance. Advanced imaging techniques like diffusion weighted imaging, MR spectroscopy; Chemical shift imaging may be useful in differentiating benign versus malignant fractures. Pathologic fractures with metastatic tumour infiltration tend to be associated with restricted diffusion (high signal intensity on diffusion-weighted scans and low signal on apparent diffusion coefficient maps), as opposed to vertebral bone marrow oedema from benign fracture [4, 5]. MR spectroscopy has shown increase in saturated fats in osteoporotic fractures [6]. On in-phase/opposed-phase chemical shift imaging, a significant difference in signal intensity was found between benign compression fractures and malignancy [7, 8].

Materials And Methods

Place of Study: Yashoda Super speciality Hospital, somajiguda, Hyderabad, Telangana.

Study Population: Patients presenting to Yashoda hospital, somajiguda, hyderabad with a history of spinal injury, undergoing MR Imaging in the Department of Radio diagnosis.

Study design: A Prospective, Hospital based Observational study.

Time frame to address the study: March 2019 to August 2020.

Sample size: n= (Z α/2) 2 (1 –p) / d 2

p: Proportion to be estimated d:The accuracy of estimate(how close to the true proportion) Z α/2: A normal deviate reflects the type I error Thirty patients with history of spinal injury, undergoing MR Imaging in the Department of Radiodiagnosis in Yashoda super speciality hospital were included in study

Inclusion criteria

1. All patients with history of traumatic spinal injuries up to 80yrs were included in the study.
2. Those who gave informed consent and willing to participate in the study.

Exclusion criteria

1. Hemodynamically unstable patients
2. patients with metallic implants and pacemakers,
3. Patients with claustrophobia.

Methodology

Criteria for patient selection

The patients referred to the department of radiodiagnosis who had history of Spinal trauma

Ethical clearance was obtained from our Institutional Review Board.

Informed consent was taken before enrolling the patient in the study. A detailed history was taken and clinical examination was performed. Besides the patient demographic details, chief complaints and relevant general and systemic examination findings were documented in a proforma.

Investigations: All subjects underwent MRI Brain Scan with a 1.5 Tesla MR Scanner.

Materials: MRI scanner (1.5 T Signa HDxt GEMSGEMS)

Technique of examination: All subjects were screened before entry into the MRI scanning room for ferromagnetic objects, cardiac pacemakers, aneurysmal clips etc. Subjects were examined in the supine position on the MRI after proper positioning and immobilization. The standard spine coil was used for the scan.

Statistical Analysis: The statistical analysis was done using SPSS 21 software and the data was presented in the form of tables.

Ethical Clearance: The ethical clearance was obtained from the institutional ethics committee prior to the commencement of the study.

Observation and Results

Thirty patients who presented to our hospital with the history of spinal trauma and underwent Magnetic Resonance Imaging were included in our study.

Table 1: Distribution based on gender, age group, Region of injury

Gender	Total
Males	23 (76.6%)
Females	7 (23.3%)
Total	30 (100%)
Age Groups	
0-10	1 (3.3%)
11-20	1 (3.3%)
21-30	9 (30.0%)
31-40	6 (20.0%)
41-50	6 (20.0%)
51-60	4 (13.3%)
61-70	1 (3.3%)
71-80	2 (6.6%)
Region	
CERVICAL	16 (53.3%)
DORSAL	7 (23.3%)
LUMBAR	7 (23.3%)

It was observed that there was a male predominance in our study. Out of the 30 patients, 23 were males (76.6%) and 7 (23.3%) were females. The age range of the patients varied from 01 to 80 years. The mean age was years. The commonest age group was 21-30 yrs in the cervical and dorsal regions.

Table 2: Skeletal Level of Injury

Cervical		Dorsal		Lumbar	
Level	**No. of Cases**	**Level**	**No. of Cases**	**Level**	**No. of Cases**
C1	1	D1-D5	1	L1	4
C2	-	D6-D10	2**	L2	1
C3/C4	1	D11-D12	4	L3	-
C4/C5	2			L4	1
C5/C6	8			L5	1
C6/C7	3				
C7/D1	1*				

*cervicodorsal junction (C7/D1) was involved in 1 case. ** Along with D9; D11 also involved.

Of the 30 patients, 16 had injury to the cervical spine, 7 to the dorsal spine and 7 to the lumbar spine. In the cervical spine commonest level of involvement was C5/C6; in the dorsal spine, D11/D12 was commonly involved and in the lumbar spine L1vertebra was commonly involved

Table 3: Cervical injuries in Cervical, dorsal and Lumbar spine

Cervical Spine		
Hyperflexion sprain	2	Stable injury
Flexion compression fracture	2	Stable injury
Flexion tear-drop fracture	1	Unstable injury
Bilateral facetal dislocation	7	Unstable injury
Unilateral facetal dislocation	1	Stable
Unstale Burst fracture	3	Unstable
Posterior element fractures	-	Stable
Dorsal Spine		
Simple Wedge compression fracture without posterior disruption	2	Stable injury
Burst fracture	2	Unstable injury
Posterior element fractures	1	Stable injury
Subluxations/dislocations	2	Unstable injury
Lumbar Spine		
Simple Wedge compression fracture without posterior disruption	4	Stable injury
Burst fracture	1	Unstable injury
Chance fracture	1	Unstable injury
Posterior element fractures	1	Stable injury

In the cervical spine, subluxation with bilateral facet dislocation was the commonest pattern of skeletal injury which is unstable and needs surgical intervention most of the times; whereas in the dorso lumbar spine, wedge compression fracture was the commonest pattern.

Table 4: Cord Injuries

Region	**ASIA grade**					**Total**
	A	B	C	D	E	
Cervical	8	3	1	3	1	16
Dorsal	3	2		1	1	7
Lumbar			1	2	4	7
Total	11 (36.6%)	5 (16.6%)	2 (6.6%)	6 (20%)	6 (20%)	30

The various types of cord injuries noted were SCIWORA (spinal cord injury without radiographic abnormality), edema, haemorrhage, transection, compression, syrinx.
Spinal cord compression and edema were the common pattern of cord injury in our study. Out of two cases of SCIWORA one case showed cord edema and another showed cord hemorrhage in cervical spine.
Out of ten cases of cord compression 6 were associated with cord edema and 3 were associated with cord hemorrhage.
SCIWORA (Spinal Cord Injury Without Radiographic Abnormality): This was noted in 2 cases in hyperflexion injury in the cervical region and mode of injury in two cases was RTA.

Table 5: ASIA grade at admission – cord injury

Asia Score	**Sciwora**	**Cord edema**	**Cord hemorrhage**	**Cord compression**	**Cord transection**
A	-	4	4	6	1
B	-	4	2	4	-
C	1	2	1		-
D	1	1	-	-	-
E	-		-	-	-
Total	2	11	7	10	1

The neurological status of the patients at the time of admission was graded according to the ASIA classification. The commonest grade at presentation was A in the cervical and dorsal regions and E in the lumbar region.

Out of 10 cases of cord compression 3 were associated with haemorrhage and 7 were associated with edema.

Out of 2 cases of SCIWORA one showed cord edema and another showed cord haemorrhage

Table 6: Intervertebral Disc Injury

Region	Intervertebral Disc Edema	Post Traumatic Disc Herniation	Epidural Haematoma
Cervical	7	4	6
Dorsal	3	2	3
Lumbar	1	-	2
Total	11	6	11

Altered signal intensity – hypointense on T1WI, hyperintense on T2WI suggestive of edema was noted in 11 cases

This was noted in 11 cases associated with skeletal, cord injuries or both. No single case of isolated epidural haematoma was noted. In 11 cases, 4 were associated with skeletal injuries, 1 with cord injury and 6 were associated with both cord and skeletal injuries**.**

Table 7: MRI with Surgical Correlation

Structure	No. of Cases Injured	
	MRI	Surgery
Skeletal/ vertebral body	10	10
ALL	5	3
PLL	9	9
Cord haemorrhage	7	7
Cord transection	1	1
Traumatic Disc herniation	6	6
Ligamentum flavum	7	9
Posterior elements	2	4
Interspinous ligament	9	7
Facet joints	9	9

In our hospital, anterior approach was commonly used for cervical spine and posterior approach was commonly used for dorsolumbar spine. But the approach varies depending on the predominant spinal column injured.

Of the 17 cases operated, 11 through anterior approach and 6 through posterior approach. In anterior approach, vertebral body fractures or subluxations were noted in 11 patients. ALL injury in 3 patients; PLL in 9 patients; disc injury in 6 patients; cord haemorrhage in 7 patients and cord transection in 1 case.

In posterior approach, injury to Ligamentum flavum was noted in 7 patients; Interspinous ligament injury was noted in 7 cases; posterior element osseous injury was noted in 2 patients

In our study 10 cases of vertebral injury were confirmed in surgery (100%). 9 cases of facet joint dislocation were confirmed in surgery(100%).9 cases of PLL disruption were confirmed in surgery (100%), out of 5 ALL injury 3 were confirmed in surgery(60%), Out of 9 cases of interspinous ligament injury 7 were confirmed in surgery (77.7%) .6 cases of traumatic disc herniation, all were confirmed in surgery (100%) and 7 cases cord haemorrhage and 1 case of cord transection all were confirmed in surgery (100%) Only 2 (50%) cases of posterior element fracture detected on MRI, in surgery 4 cases were confirmed. Out of 9 cases of ligamentum flavum injury which were confirmed on surgery, MRI diagnosed only 7 (77.7%) of them.

Discussion

The purpose of MR imaging in spinal trauma:

a) To identify vertebral injury and to classify them into stable and unstable injury that compromises spinal canal which may helps in planning of correct treatment.
b) To identify ligamentous injuries
c) To assess the type and extent of cord injury
d) To assess the potential for surgical decompression

Most surgeons agree that neurological status, spinal stability, deformity of the injured lesion, degree of canal compromise, and associated general problems are the most significant factors that need to be considered when deciding on operative or non-operative treatment for patients with a spine fracture.

The TLICS system is very useful system for decision of surgical indication in acute traumatic thoracolumbar injury. However, the decision of treatment in TLICS score 4 should be carefully considered. Furthermore, definite criteria of posterior ligamentous complex (PLC) injury may be necessary because the differentiation of PLC injury between TLICS score 2 and 3 is very difficult.[9]

Our study of MRI evaluation of spinal trauma consisted of 30 patients who presented to our hospital with the history of spinal trauma and underwent MR imaging of the spine. Of the 30 patients, 17(56.66 %) were operated ad 13(43.33%) were treated conservatively. Surgical findings were noted depending on the approach. Imaging findings were compared with the surgical findings in feasible cases.

On MRI, intervertebral disc was involved in 6 cases whereas in surgery in 5 cases. On MRI, in our study 10 cases of vertebral injury were confirmed in surgery (100%). 9 cases facet joint dislocation were confirmed in surgery (100%).9 cases of PLL disruption were confirmed in surgery (100%), out of 5 ALL injury 3 were confirmed in surgery (60%). Out of 9 cases of interspinous ligament injury 7 were confirmed in surgery (77.7%) 6 cases of traumatic disc herniation, all were confirmed in surgery (100%) and 7 cases cord haemorrhage and 1 case of cord transection all were confirmed in surgery (100%). Only 2 (50%) cases of posterior element fracture detected on MRI, in surgery 4 cases were confirmed. Only 7 (77.7%) cases of ligamentum flavum injury were detected on MRI whereas in surgery 9 were confirmed. These results were comparable to study by Zhuge *et al* (2013) [10] and Kliewer *et al* (2005) [11]. In a study by Goradia & Linna *et al,* [12] found that MR imaging was highly sensitive for injury to the intervertebral disc (93%), posterior longitudinal ligament (93%), and interspinous soft tissues (100%), but was less sensitive in assessing injury to the anterior longitudinal (71%) and flavum (67%) ligaments. Though MRI overestimates Anterior longitudinal ligament injury, Interspinous ligament injury and underestimates Ligamentum flavum injury; it has good sensitivity in depicting ligamentous injuries.

Limitations

- Limited detection of posterior element fractures
- Prolonged examination time which may be problematic in unstable patients and can
- lead to motion artifacts.
- Mechanical ventilators and orthopedic devices must be compatible with magnet.

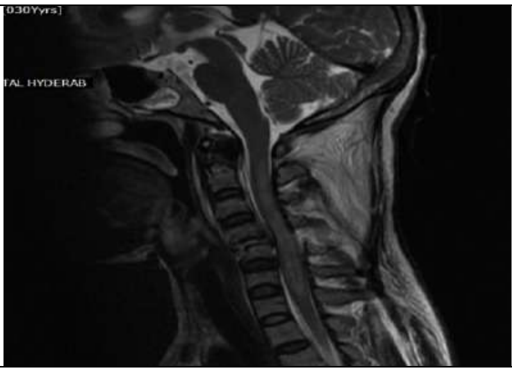
Conclusion

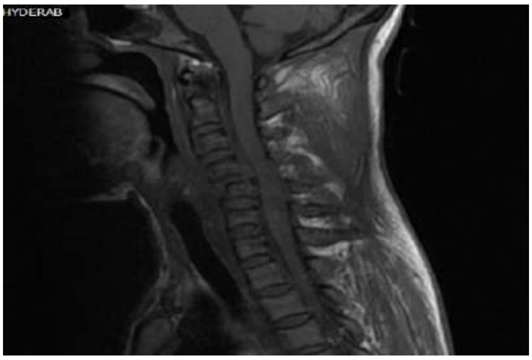
Magnetic Resonance Imaging is the best diagnostic tool in patients with acute spinal trauma for depicting the altered signal intensities in vertebral bone marrow, ligamentous injuries, traumatic intervertebral disc herniations, paraspinal soft tissues, epidural, pre and paravertebral haematoma which are inapparent on plain films, and CT, and highly sensitive in depicting spinal cord and nerve root injuries which helps in predicting initial neurological deficit. MRI useful in identifying stable and unstable injuries, as determination of spinal stability, is very important because treatment strategies rely on this.

CT provides a superior depiction of bony anatomy but the important limitation of this technique is the inability to provide screening for ligamentous injury and spinal cord lesions. MRI is superior in this regard.

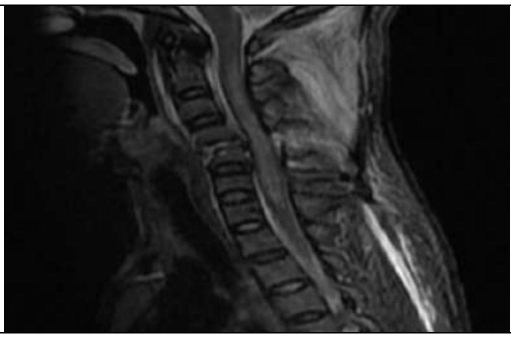
MRI such as high contrast resolution, absence of bony artifacts, multiplanar capability, and choice of various pulse sequences make it possible to diagnose spinal trauma more accurately.

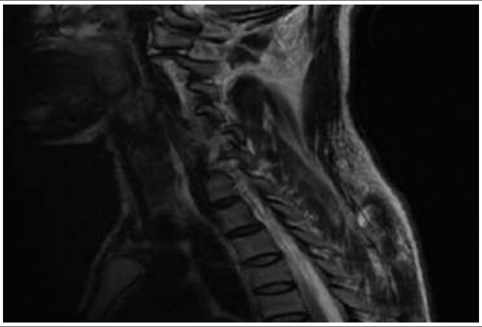
Case Number-1



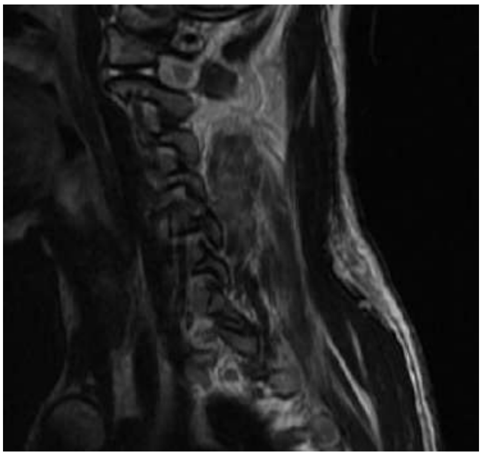


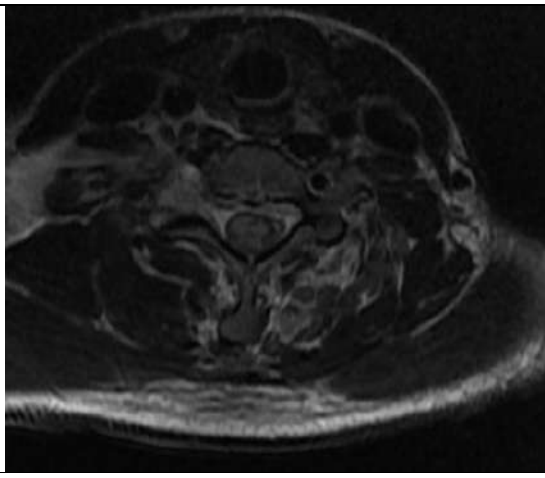
Mid sagittal T2WI and T1WI – subluxation of C4 over C5 with fracture of anterosuperior aspect of C5, cord haemorrhage (C2-C7), C4/C5 IVD edema.





Sagittal STIR – Ligamentum flavum and Interspinous ligament disruption at C4/C5
Right parasagittal T2WI – Facet joint dislocation at C4/C5.

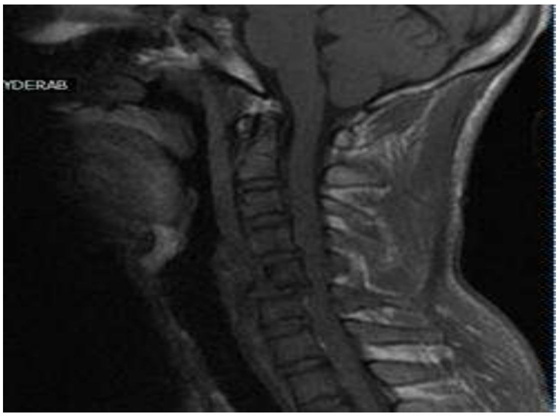


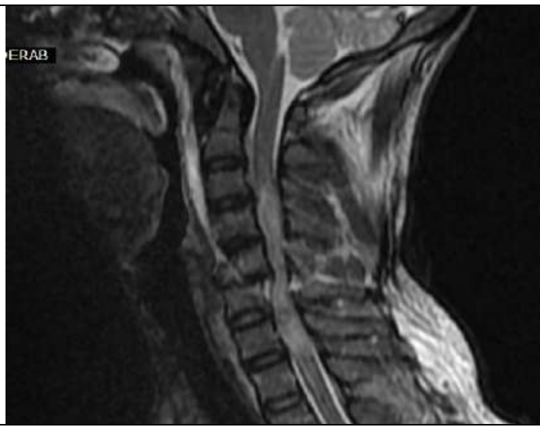


Left parasagittal T2WI – normal alignment of facet joints; axial T2WI –cord haemorrhage and loss of flow void in right vertebral artery.

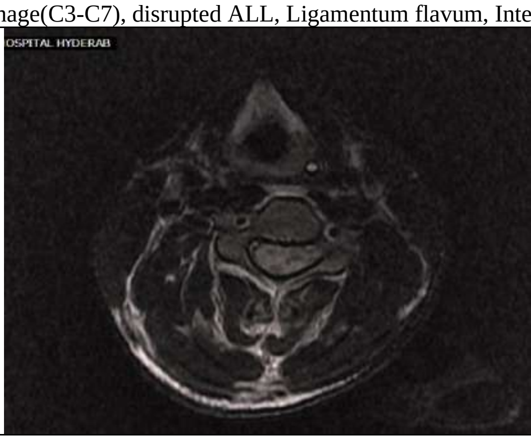
Case Number-2

Lateral Radiograph of Cervical spine – fracture fragment infront of C5 vertebral body.



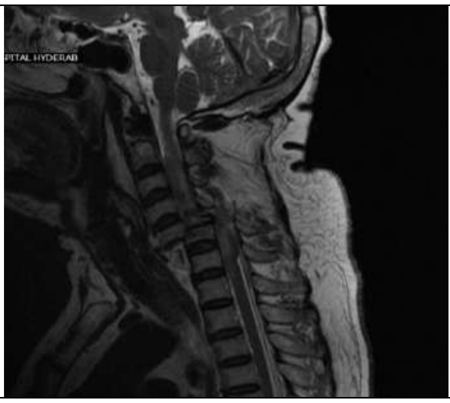


Mid sagittal T2W, T1W, STIR images - Tear-drop fracture of C5vertebral body with cord compression by retropulsed C5 and cord haemorrhage(C3-C7), disrupted ALL, Ligamentum flavum, Interspinous ligament.



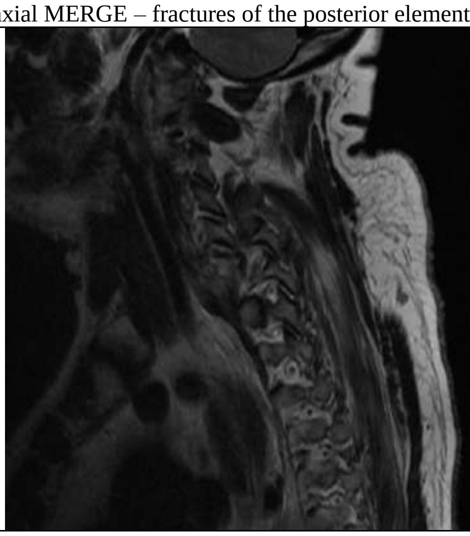
Axial T2WI – cord haemorrhage

Case Number-3



Midsagittal T2WI and T1WI – dislocation of C5 over C6 with cord transection and haemorrhage, Disruption of ligaments.

Midsagittal STIR – cord transection , soft tissue edema; axial MERGE – fractures of the posterior elements.

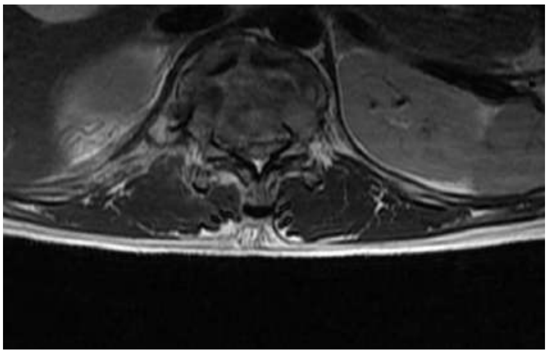


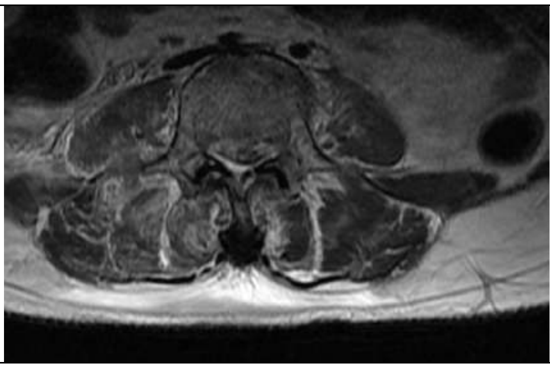
Parasagittal T2W images – bilateral Facet joint dislocation.

Case Number-4

Midsagittal T2WI, T1WI - Burst fracture of D12, retropulsed fragment causing compression over cord, cord haemorrhage.

Midsagittal STIR- Burst fracture of D12, compression fracture of D10, marrow edema of D11, L4.



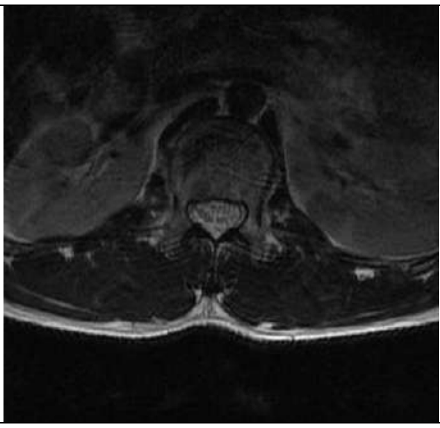


Axial T2WI – Burst fracture with cord compression and right paravertebral softtissue contusion

Case Number-5

Lateral radiograph of lumbar spine – Anterior wedging of L1; midsagittal T2WI- Anterior wedge compression fracture of L1.

Midsagittal T1WI, STIR- Anterior wedging of L1 with marrow edema of L3, L4.

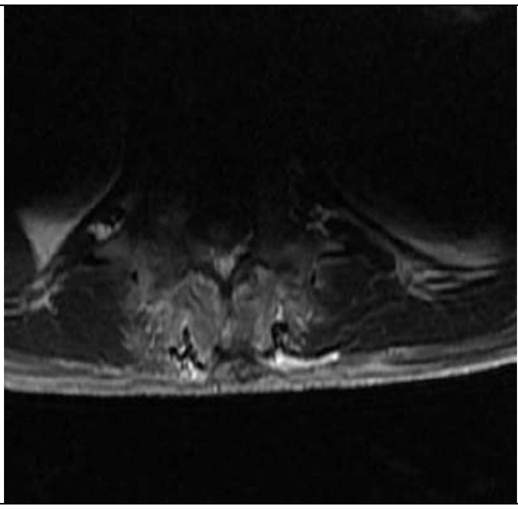


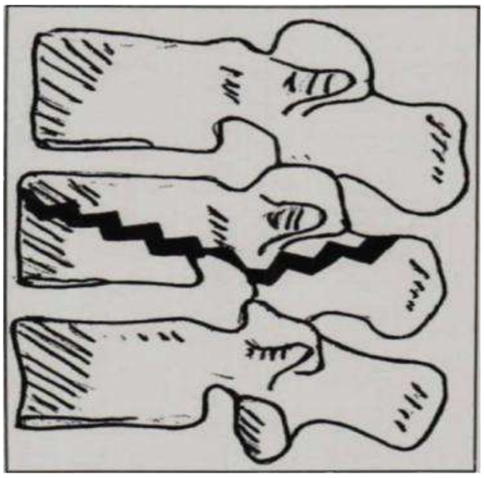
Axial T2WI – hypointensity in the L1 vertebral body with normal spinal canal.

Case Number-6

Mid and parasagittal T2WI – horizontal hypointensity in the L1 vertebral body extending into pedicle with disruption of Ligamentum flavum and Interspinous ligaments- Chance fracture.

Midsagittal T1WI- hypointensity in L1; STIR – hyperintensity of D12, L1, L2





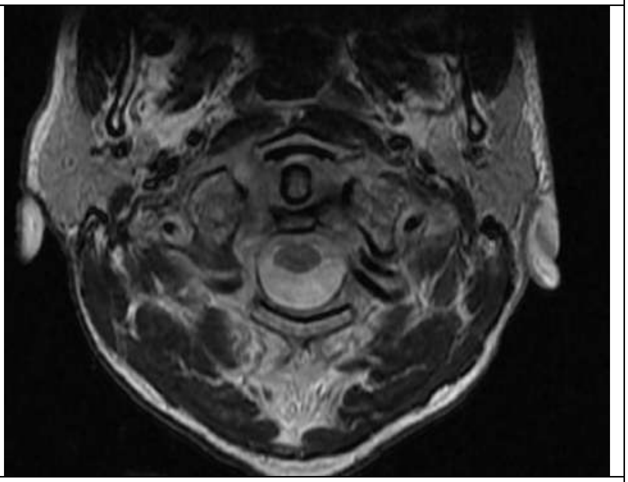
Axial T2WI – paraspinal muscle edema. Diagram of Chance fracture.

Case Number- 7

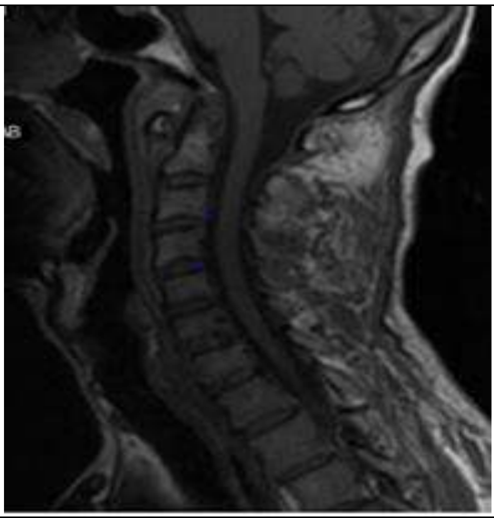
Midsagittal T2WI, STIR – compression collapse of D9, D11, L1 vertebrae with linear hyperintensity in the D11 vertebral body – acute compression fracture.

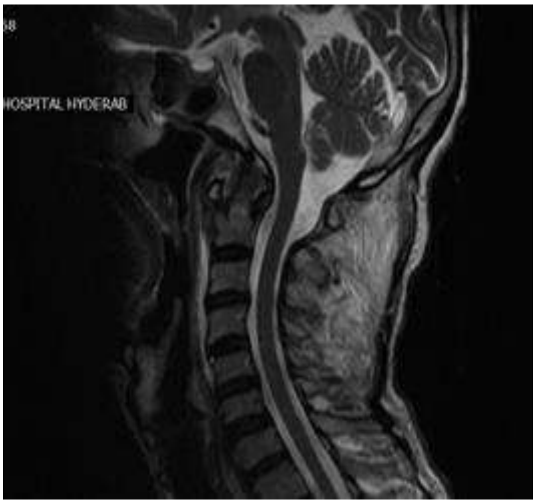
Midsagittal T1WI - Fatty marrow changes; axial T2WI- normal spinal cord

Case - 8

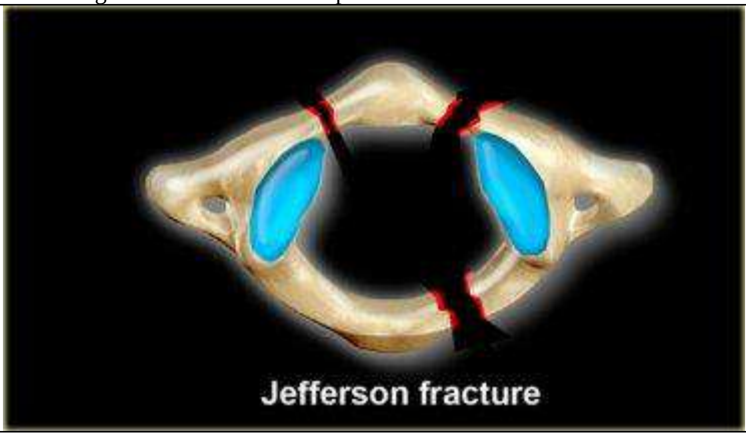


Lateral radiograph of cervical spine – fracture of posterior arch of Atlas.
Axial T2WI – fracture of anterior and posterior arch of Atlas.





Mid sagittal T1WI and T2WI – prevertebral haematoma from C2 to C5.



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