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Radiological evaluation of Thoracic and Lumbar spine

[1]Dr. Kshitij Z Badade, MBBS, MS Orthopaedics, Assistant Professor Orthopaedics Department MGM Medical College & Hospital, Navi Mumbai, Maharashtra, India.

Corresponding Author: Dr. Kshitij Z Badade, MBBS, MS Orthopaedics, Assistant Professor Orthopaedics Department MGM Medical College & Hospital, Navi Mumbai, Maharashtra, India.

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Abstract

Based on the patho-morphological criteria, the AO committee has divided thoraco-lumbar spine injuries into three kinds (A: Compression; B: Distraction; C: Axial torque and rotational deformity). Each of these categories is further classified into three groups and three subgroups to indicate the degree of instability and the progression of morphological damage.

Injuries to the spine account for a sizeable share of musculoskeletal injuries worldwide. The thoracic and lumbar areas account for 75% to 90% of spinal fractures, with thoracolumbar junction injuries being the most frequent (T10-L2).

Three types of spinal injuries were identified by Watson-Jones: simple wedge fracture, comminuted fracture, and fracture-dislocation. The first of its type, this classification system provided a treatment plan. This methodology suggested various reduction techniques for treating various spinal fractures. Chance described a unique injury brought on by abrupt forward flexion. The anterior flexion injury, often known as a seat-belt injury, was accompanied with distraction injury at the level of the posterior elements. This distraction injury is defined by a transverse fracture line through the posterior part of the vertebral body that extends into the posterior parts of the spine, and a compression fracture of the anterior part of the vertebral body.

The following criteria were used by Nicoll to group 166 thoracolumbar fractures in coal miners:

(1) Anterior wedge fractures;

(2) Lateral wedge fractures;

(3) Fracture dislocations; and

(4) Isolated neural arch fractures.

For the first time, Nicoll distinguished between stable and unstable fractures based on the fact that the interspinous ligament's health is a key factor in determining stability. Subsequent classifications were made using this as a foundation. Two-column theory was described by Holdsworth. The anterior column is made up of the posterior longitudinal ligament (PLL), the surrounding intervertebral disc, the body of the vertebra, and the anterior longitudinal ligament (ALL) (PLL). Pedicles, facet joints, transverse processes, Ligamentum flavum, spinous processes, interspinous and supraspinous ligaments, and pedicles are components of the posterior column. Additionally, he asserted that the main factor influencing spinal stability is the posterior column. Kelly and Whiteside expanded on Holdsworth's two-column

theory by describing the neural arches as a hollow posterior column and the anterior vertebral bodies as a solid column. They emphasized the importance of the posterior parts in maintaining spinal stability and mentioned that more instability indicates more severe types of injury.

Later, Denis developed a three-column theory and divided the spine's sagittal profile into three columns. He added the middle column to the previously mentioned front and posterior columns. According to this idea, the middle column, made up of the PLL, the posterior half of the disc, the posterior annulus, and the posterior half of the vertebral body, is in the neutral axis of the spine.

It is thought that the middle column makes the biggest contributions to mechanical stability and can withstand the most axial load during flexion and extension movements. Compression and burst fractures are two separate fracture forms established by the middle column idea. While burst fractures include both the anterior and middle columns, compression fractures only affect the anterior column. Then, a transverse injury affecting all anterior, middle, and posterior columns is reclassified as a chance fracture.

The AO classification, which incorporates the three-column model put forward by Denis, was the next significant advancement in the classification of spinal injuries.

According to the patho-morphological criteria, it divides thoracolumbar spinal injuries into three groups: compression injury (Group A), distraction injury (Group B), and translation or rotation injury (Group C). Within each group, there are up to nine subtypes based on factors like morphology, fracture site, osseous or ligamentous disruption, and direction of displacement. Groups A through C depict a continuum of gradually increasing damage severity and instability, with a concomitant rising likelihood of the need for surgical stabilization, according to one of its main justifications. The AO method places a strong emphasis on the significance of soft-tissue injuries to the spine's intervertebral discs, posterior ligamentous complex, and anterior longitudinal ligament.

The Spine Trauma Study Group created the most recent classification, known as TLICS. This system bases the injury severity score on three factors: the patient's neurologic condition, the integrity of the posterior ligamentous complex, and the injury's morphology. A score is determined for each category, with a lower score given to a less serious injury and a greater score given to a more serious injury needing urgent treatment.

To determine whether to use surgical or nonsurgical care, the overall score is used as a guide. The TLICS places a strong emphasis on the value of MRI in determining PLC damage. Plain x-rays, computed tomography (CT), and magnetic resonance imaging (MRI) scans are all used in the radiological examination of the spine.

The goals of radiographic evaluation are:

- Identify the location and extent of injury
- Determine features of vertebral instability
- Assess the severity of neurological compression and injury
- Classify injury patterns
- Identify multilevel injuries

A. Plain X-rays

1. AP X-ray
2. Lateral X-ray

B. CT scan

C. MRI scan

A. Plain X-rays

Introduction

Good quality plain x-rays in two planes (antero-posterior and lateral) must be performed in all patients with suspected spinal trauma.

The appropriate x-ray is performed based on local tenderness or deformity, and the presence of neurology (in case of neurological injury).

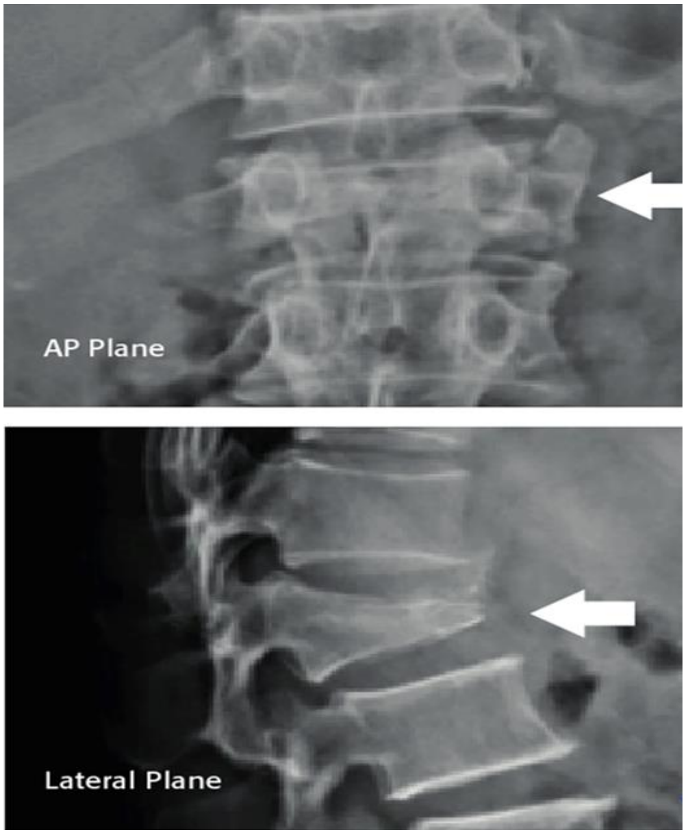


Fig 1: AP & Lateral X ray

2. In trauma situations, it is not always possible to turn the patient, and hence a cross-table lateral view facility can be used.

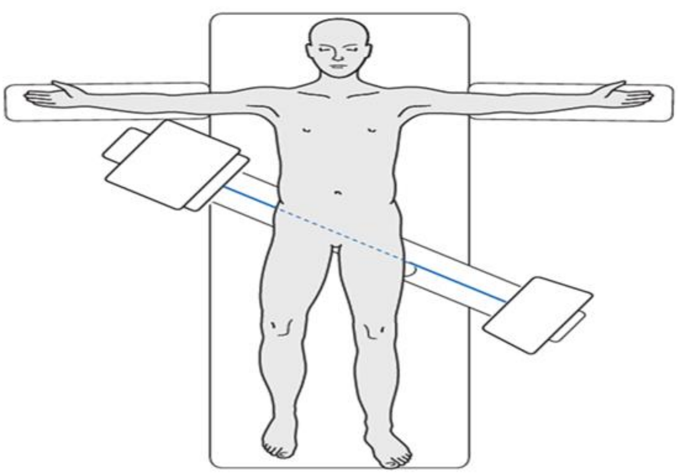


Fig 2: A cross-table lateral view

3. It is important that the whole spine radiological survey is available to identify multilevel injury, which is present in up to 15% of patients.

Moreover, it is important to have both AP and lateral x-rays available.

If the x-rays are not satisfactory or inconclusive, a CT scan must be performed.

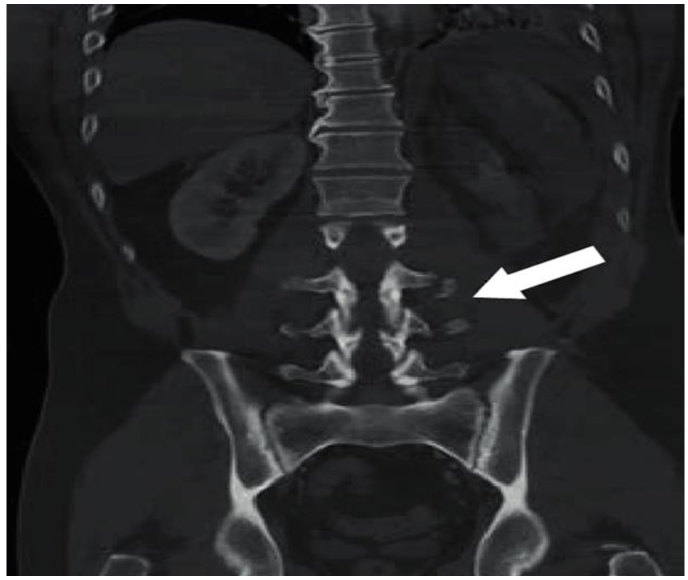


Fig 3: CT scan

1. AP X-ray

Landmarks and lines on AP View

•Spinous process to pedicles- Should be symmetric

•Interpedicular distance- May be widened in burst fractures

•Translation

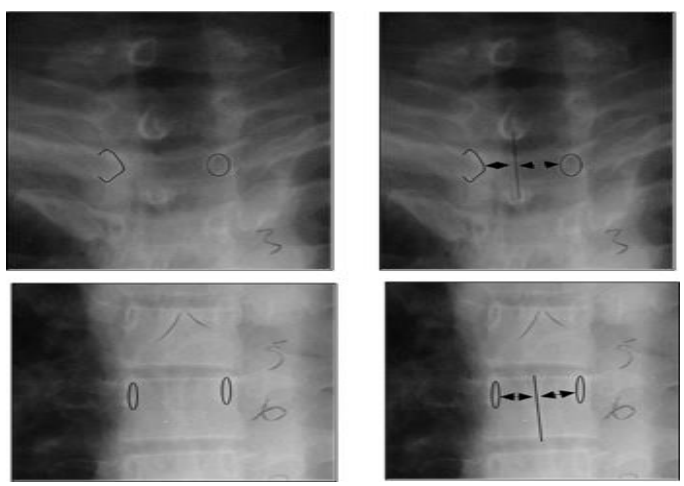


Fig 4: Landmarks and lines on AP View

In the antero-posterior film, the following factors are**i.** observed:

What is seen

- Isolated fractures of the transverse process

What it indicates

- A0 fracture

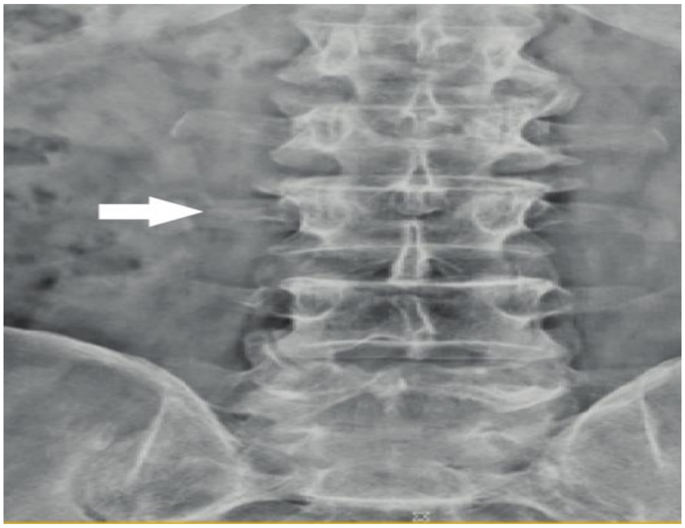


Fig 5: Isolated fractures of the transverse process (indicates: A0 fracture)

What is seen

- Loss of vertebral body height (compare with the adjacent normal vertebra)

What it indicates

- Collapse of vertebral body (A type injuries)

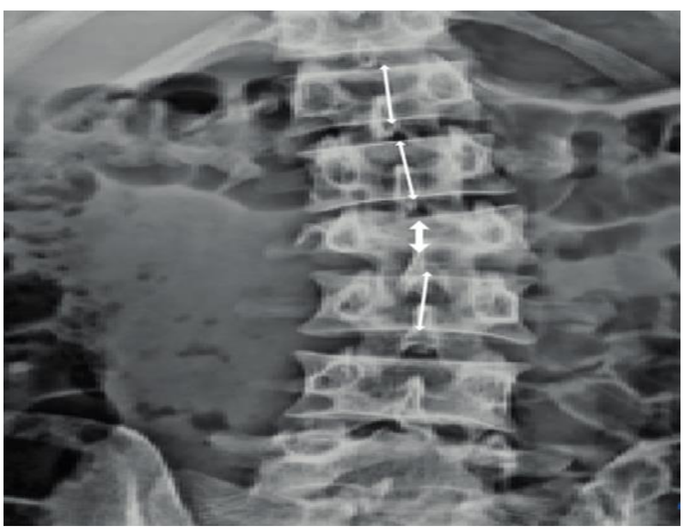


Fig 6: Loss of vertebral body height (indicates: Collapse of vertebral body)

What is seen

- Widening of inter-pedicular distance (Widening is identified by drawing a straight line along the medial border of the pedicles of two adjacent vertebrae)

What it indicates

- Increase in the inter-pedicular distance indicates a burst fracture–an A3/4 injury

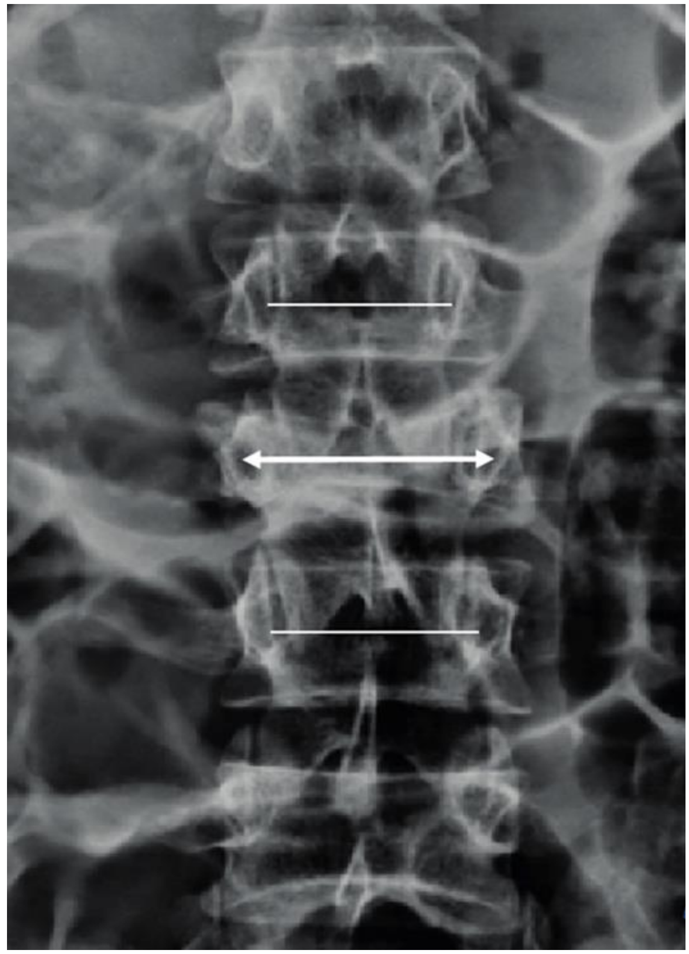


Fig 7: Widening of inter-pedicular distance (indicates: a burst fracture)

What is seen

- Vertebral translation (as indicated by lateral displacement of the body or altered spinous process alignment)

What it indicates

- C type injury

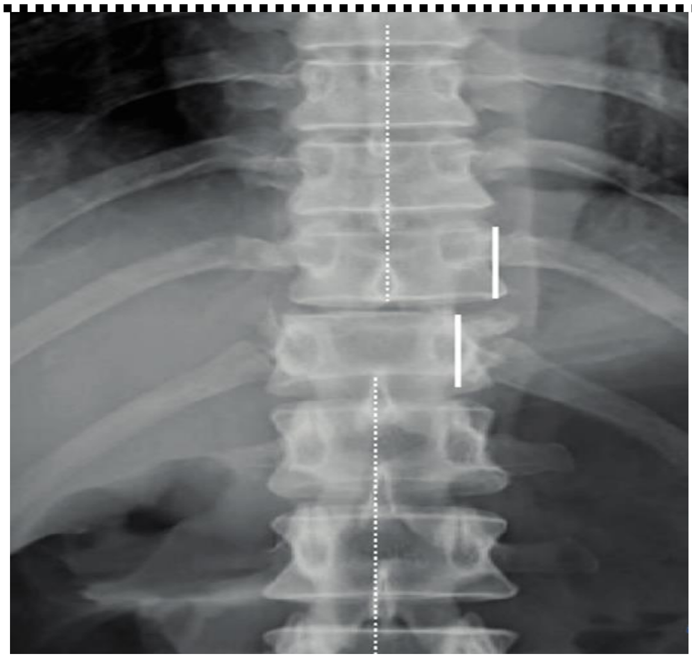


Fig 8: Vertebral translation (indicates: C type injury)

What is seen

- Increased inter-spinous distance (compared with adjacent levels)

What it indicates

- Distraction failure of the posterior tension band–type B injury (B1 or B2)

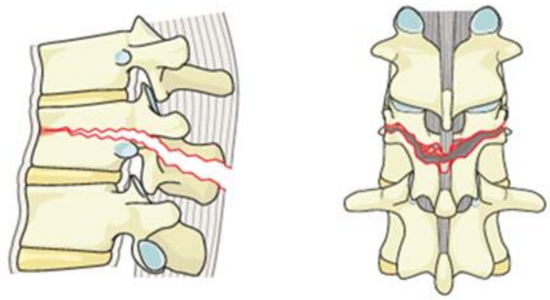
Fig 9: Increased inter-spinous distance (indicates: Distraction failure of the posterior tension band)

What is seen

- Horizontal split in the body at the level of the pedicles

What it indicates

- B1 injury



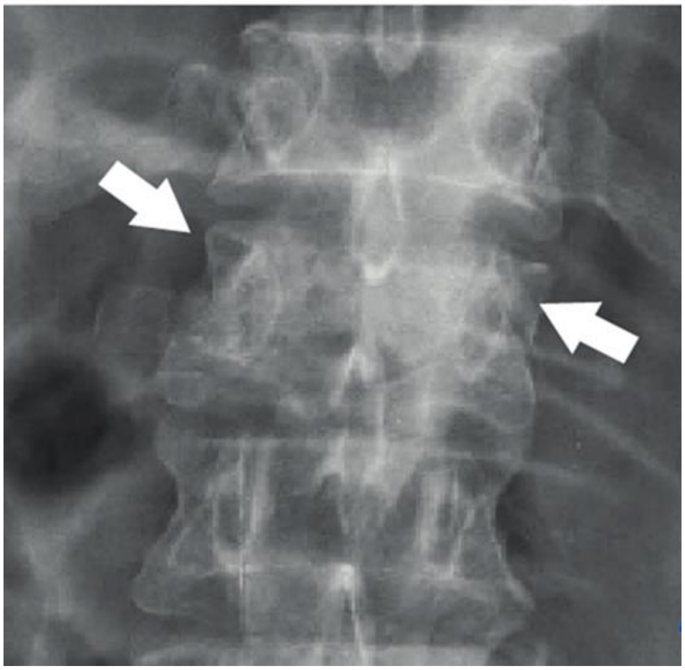


Fig 10: Horizontal split in the body at the level of the pedicles (indicates: B1 injury)

2. Lateral X-ray

Landmarks and lines on Lateral View

- Posterior vertebral body line
- Anterior vertebral body line
- Inter-spinous Distance
- Translation

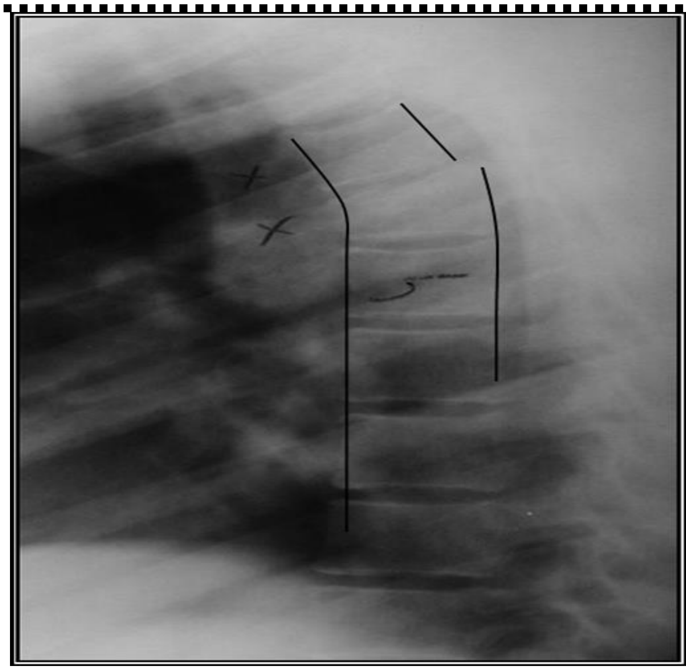


Fig 11: Landmarks and lines on Lateral View

What is seen

- Loss of anterior vertebral body height (the anterior vertebral body height is measured along the anterior vertebral border from the superior to the inferior end plate and compared to the adjacent normal vertebra)

What it indicates

- Type A injuries

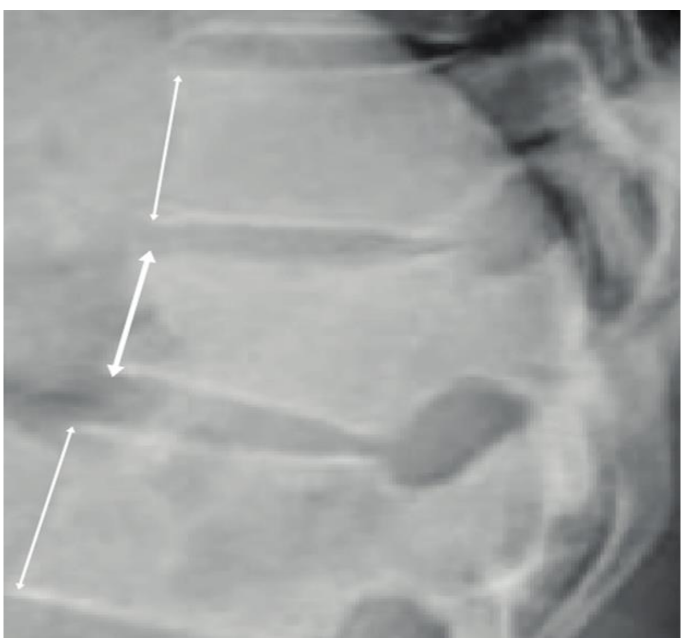


Fig 12: Loss of anterior vertebral body height (indicates: Type A injuries)

i. **What is seen**

- Kyphosis >30 degrees and Vertebral body collapse >50%.

What it indicates

- Type A injuries

What is seen:

- Spinous process widening

What it indicates:

- Posterior ligamentous complex injury and instability

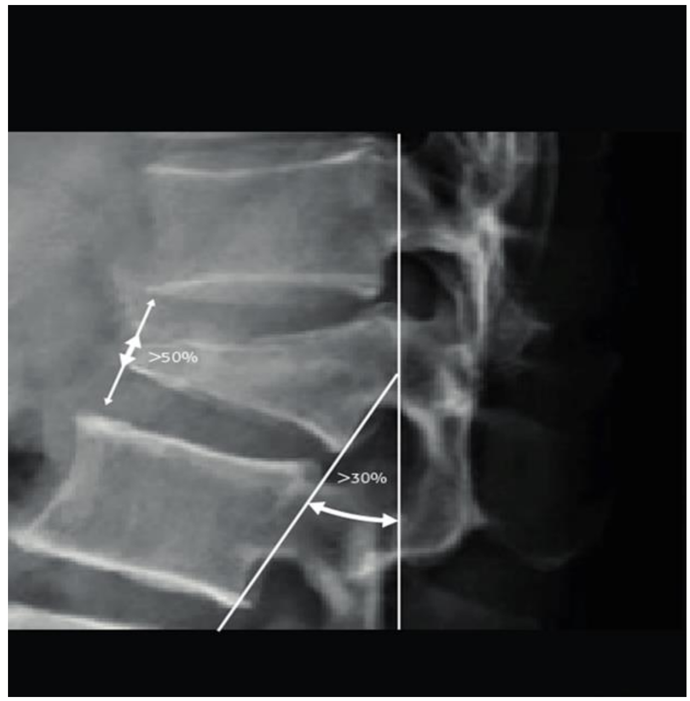


Fig 13: Kyphosis >30 degrees and Vertebral body collapse >50% (indicates: Type A injuries)

What is seen

- Loss of posterior vertebral body height or posterior cortical disruption (the posterior vertebral body height is measured along the posterior vertebral border from the superior to the inferior end plate and compared to the adjacent normal vertebra)

What it indicates

- Involvement of the posterior wall of the vertebral body with possible retropulsion into the spinal canal—A3/A4 injuries.

Note: CT is indicated to assess the extent of bony injury.

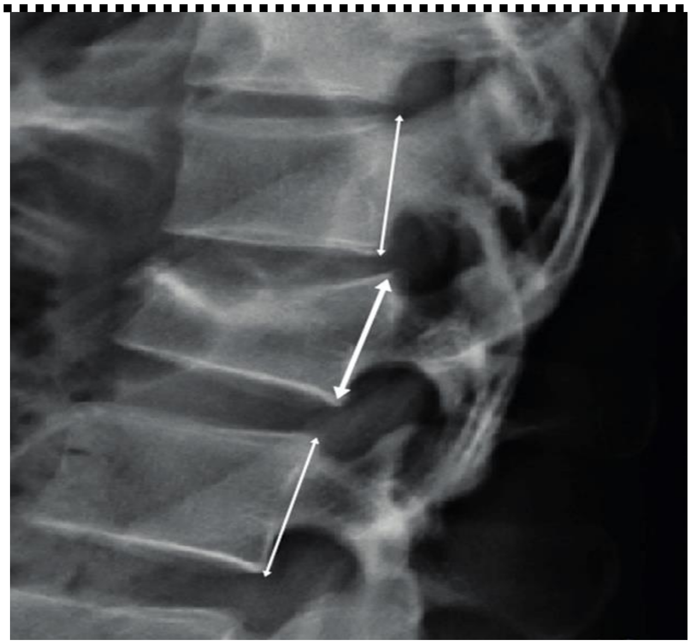


Fig 14: Loss of posterior vertebral body height or posterior cortical disruption

What is seen

- Loss of spinal alignment (the presence of vertebral translation can be identified by drawing a straight line along the vertebral borders. In these situations, also look at the facet joints to look for joint subluxation or dislocation)

What it indicates

- C type injury

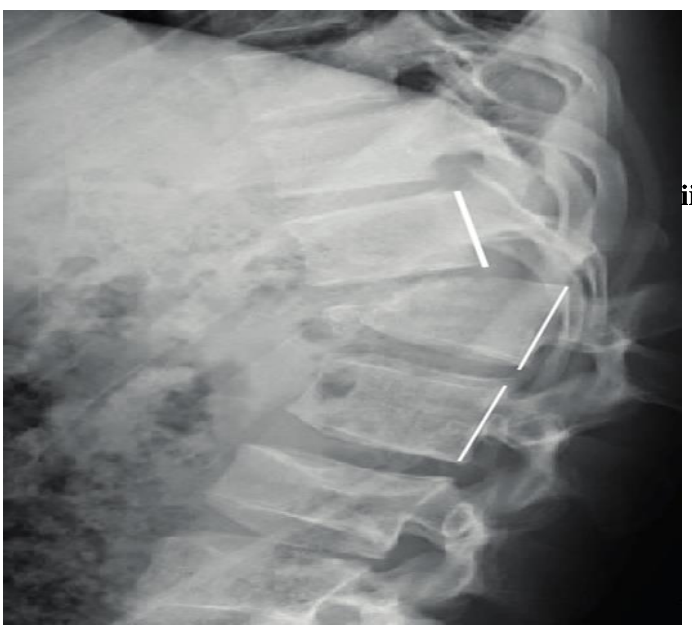


Fig 15: Loss of spinal alignment

What is seen

- Separation of the facet joints with widening of the interspinous distance

What it indicates

- B2 injury

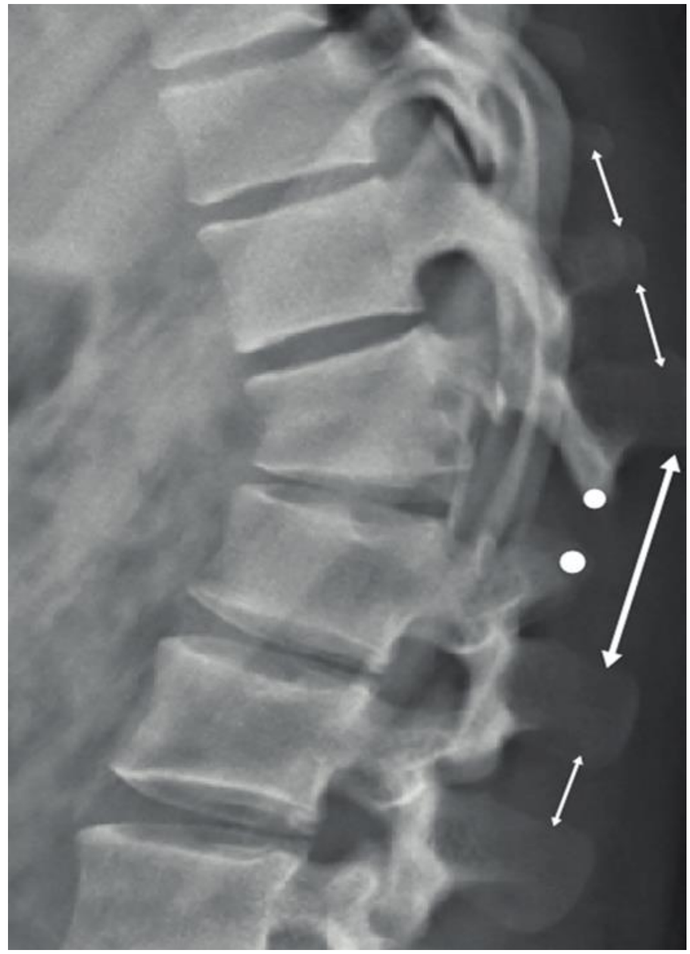


Fig 16: Separation of the facet joints with widening of the interspinous distance

ii. **What is seen**

- Spinous process fracture

What it indicates

- Presence of a spinous process fracture, which may indicate just an A0 injury. However, in the presence of A1-4 injury anteriorly, a coexistent spinous process fracture would indicate a B1/2 injury. Any such suspicion would mandate further CT evaluation
- A0 or B1/2 injury

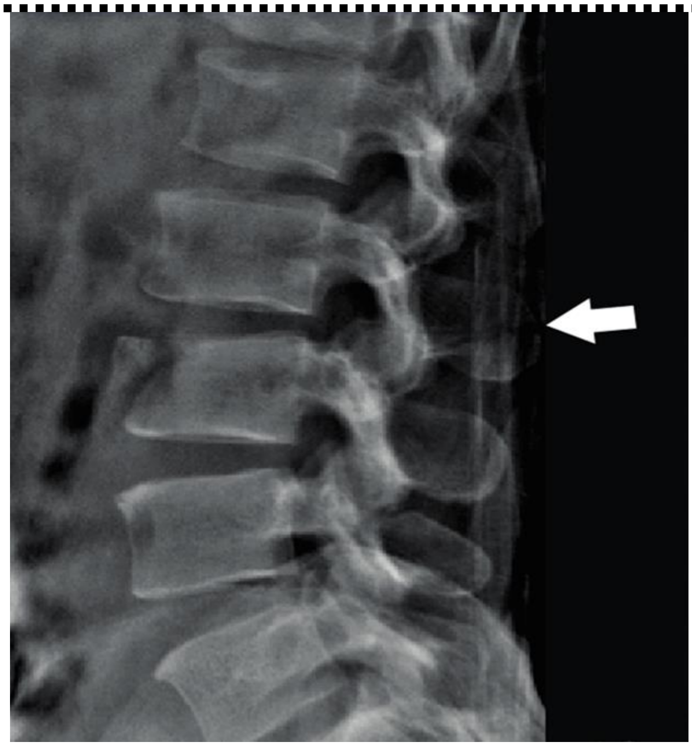


Fig 17: Spinous process fracture

B. CT scan

- More Common as initial study
- Indicated if plain x-ray is suspicious
- Best bony detail
- Request multiple planes and recon
- Axial alone can miss translation

Introduction

CT scans provide important details about the extent of bony injury in a patient with spinal injury. In many centers, CT is routinely performed as it reveals fractures that are not visible in plain x-rays in more than 20% of patients.

CT scans are part of the assessment for the AO Spine classification.

Advantages

- Most accurately depicts bony injuries
- Sensitivity and specificity > 95%
- Concomitant multi-slice CT of chest, abdomen and pelvis can be done to detect visceral injuries

What is seen in CT scans

i.

What is seen

- Extent of vertebral body comminution (the extent of vertebral body comminution and the displacement of fragments is clearly visualized in CT images)

Which view

- Sagittal and axial

What it indicates:

- Severity of injury
- Extent of canal encroachment
- Exact AO Spine classification

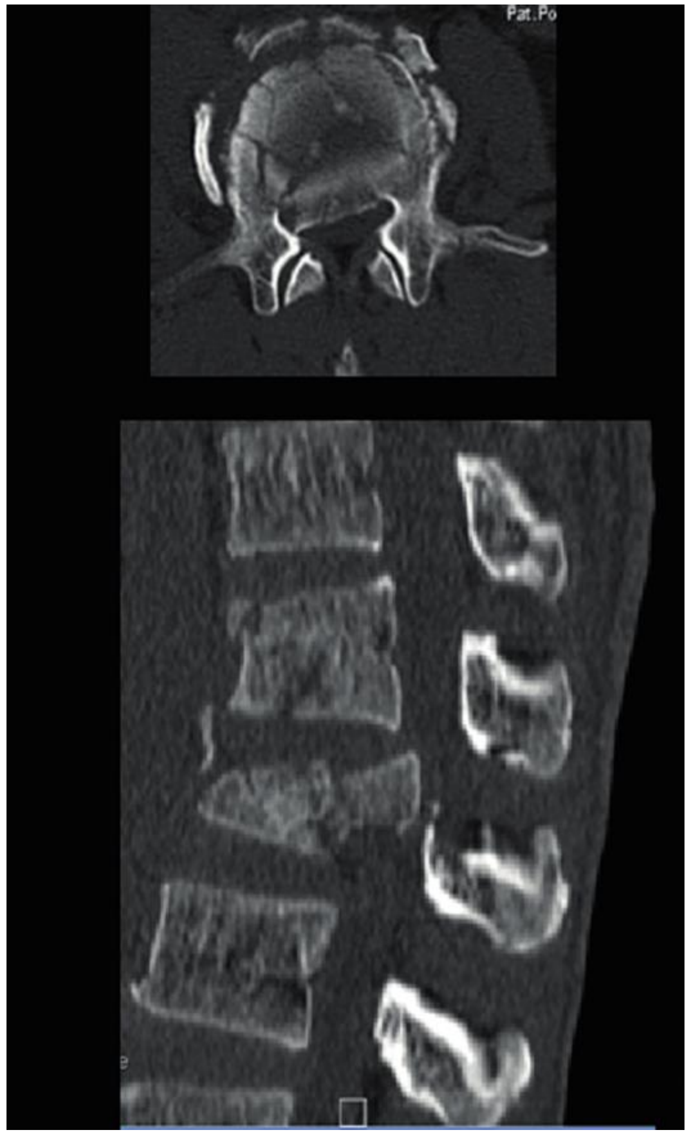


Fig 18: Extent of vertebral body comminution (indicates: Severity of injury & Extent of canal encroachment)

What is seen

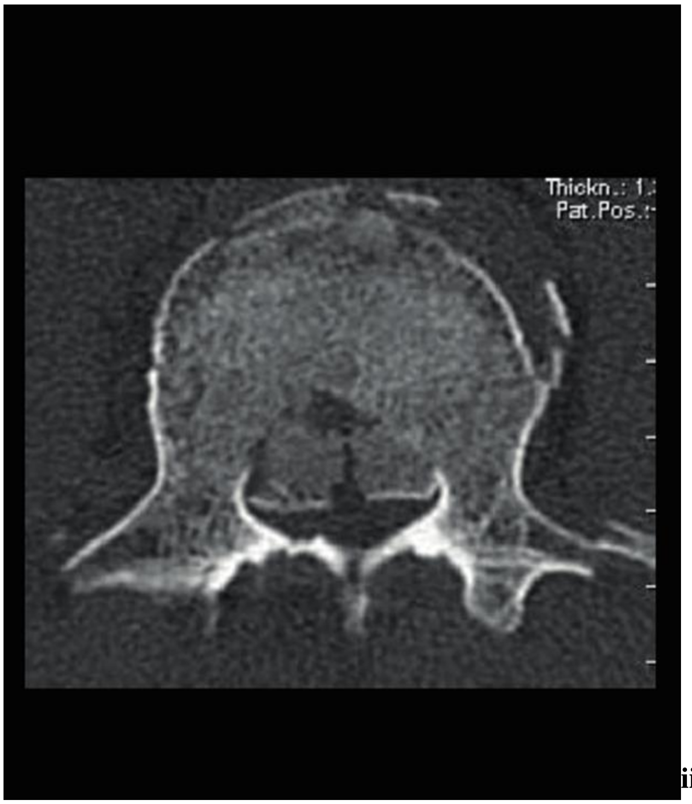
- Retropulsion of bone fragments (the amount and severity of retropulsion of bone fragments into the spinal canal is clearly depicted in the axial and sagittal CT images)

Which view

- Axial and sagittal

What it indicates

- Need for decompression when neurological damage has been detected



ii.

Fig 19: Retropulsion of bone fragments (indicates: Need for decompression when neurological damage is detected)

What is seen

- Reverse cortical sign (the retro pulsed fragment that has rotated more than 180 degrees so that the cortical surface is opposed to the cancellous surface of the main vertebral body)

Which view:

- Axial

What it indicates:

- Severe disruption of the posterior ligamentous complex
- Due to 180° rotation the fragment will not unite with the main vertebral body
- Anterior decompression is usually preferred
- Contraindication for ligamentotaxis

Fig 20: Reverse cortical sign (indicates: Severe disruption of the posterior ligamentous complex)

What is seen

- Lamina fracture

Which view:

- Coronal and axial

What it indicates

- Eventual Dural and nerve root entrapment

Note: Caution should be exercised during exposure to avoid inadvertent Dural tear and neural injury.

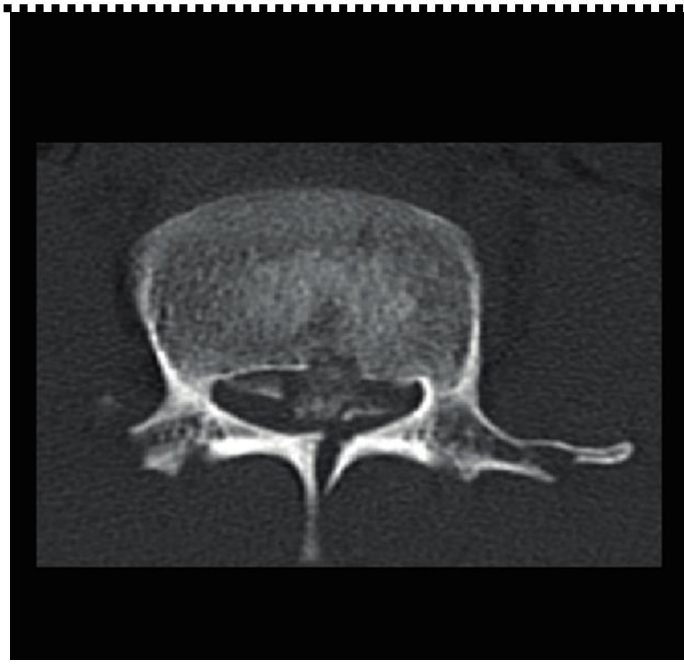


Fig 21: Lamina fracture (indicates: Eventual Dural and nerve root entrapment)

What is seen

- Pedicle fracture

Which view:

- Axial and sagittal

What it indicates:

- Instability
- Need to avoid pedicle screw fixation at this level

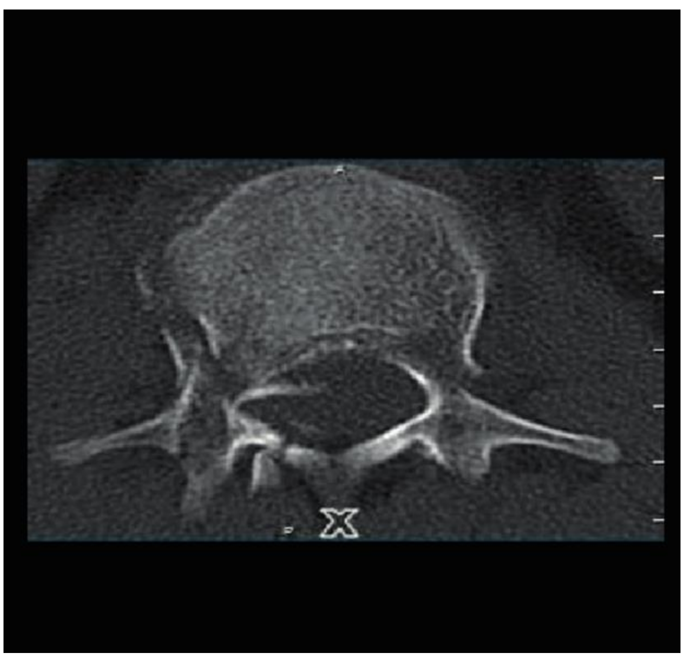


Fig 22: Pedicle fracture (indicates: Instability)

iii. **What is seen**

- Spinous process fracture

Which view

- Sagittal

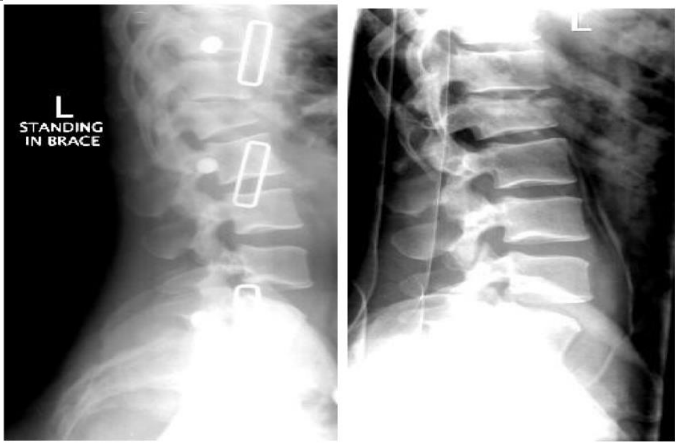
What it indicates:

- Instability—B1/2 injury

Note: Presence of an isolated vertical spinous process fracture may indicate just A0 injury. However in the presence of A1-4 injury anteriorly, a co-existent spinous process fracture would indicate a B1/2 injury.

Fig 23: Spinous process fracture (indicates: Instability—B1/2 injury)

D. **MRI Scan**



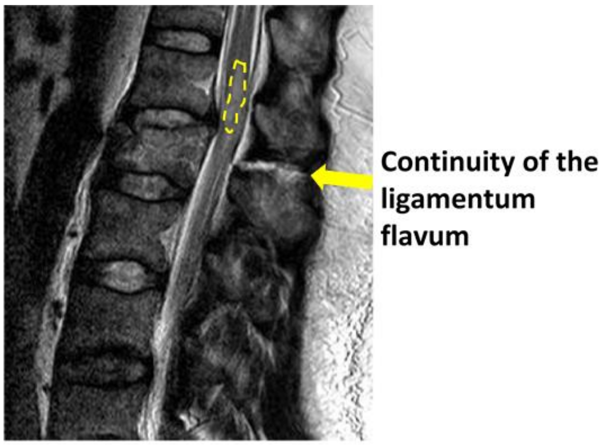


Fig 24: Assessing PLC using MRI

MRI- Best at soft tissues: Assessing PLC using MRI

MRI Can be useful to detect injuries to soft tissues, such as the posterior ligamentous complex (PLC). PLC consists of:

- Supraspinous Ligament
- Interspinous Ligament
- Ligamentum Flavum
- Facet Capsule

Introduction

MRI scans give useful information about the extent of soft tissue injury that has occurred during the spinal injury. However the availability and longer time spent in the console precludes its regular use in all spinal trauma patients, especially in polytraumatized patients and those with hemodynamic instability.

Indications

- Patients with neurological deficit
- Patients with suspicious PLC injury

Advantages

- In patients with neurological deficit, MRI accurately depicts the extent of cord compression, edema, hemorrhage and the presence of cord transection.
- Determines extent of injury to posterior ligamentous complex
- Identifies damage to disco ligamentous complex
- Helps to identify multi-level non-contiguous injuries

Disadvantages

- Cost and availability
- Delay in definitive management

What is seen

- Bony compression of spinal cord

What it indicates:

- Need for decompression, posterior or anterior

Fig 25: Bony compression of spinal cord (indicates: Need for decompression)

What is seen

- Hyperintense signal changes in cord

What it indicates

- Cord injury

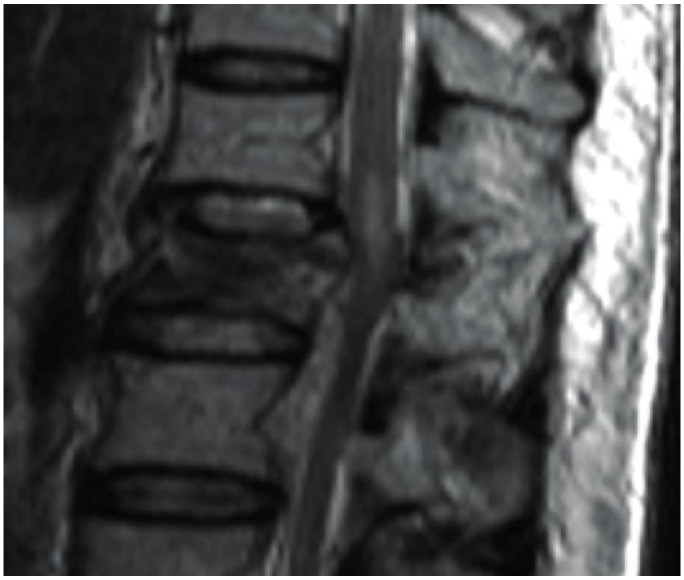


Fig 26: Hyperintense signal changes in cord (indicates cord injury)

What is seen

- Hyperintense signal in the PLC

What it indicates

- Loss of integrity of PLC

Note: Fat suppressed images show hyperintense signal changes in the PLC better indicating disruption of PLC.

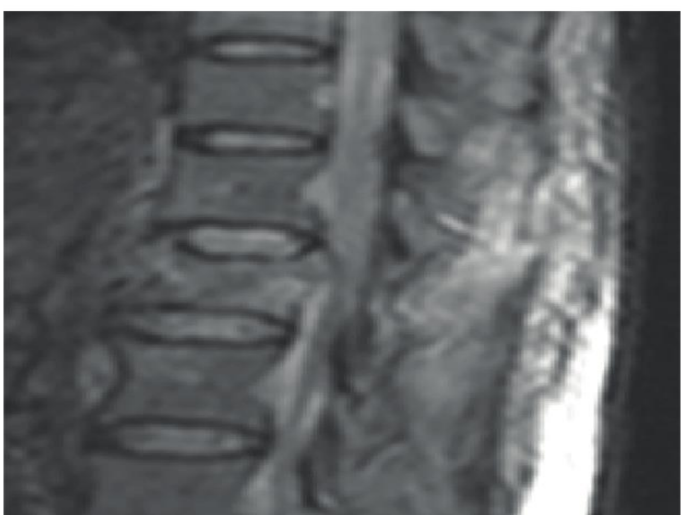


Fig 27: Hyper intense signal in the PLC (indicates: Loss of integrity of PLC)

What is seen

- Marrow edema in adjacent bones

What it indicates:

- Subtle injury of adjacent segments

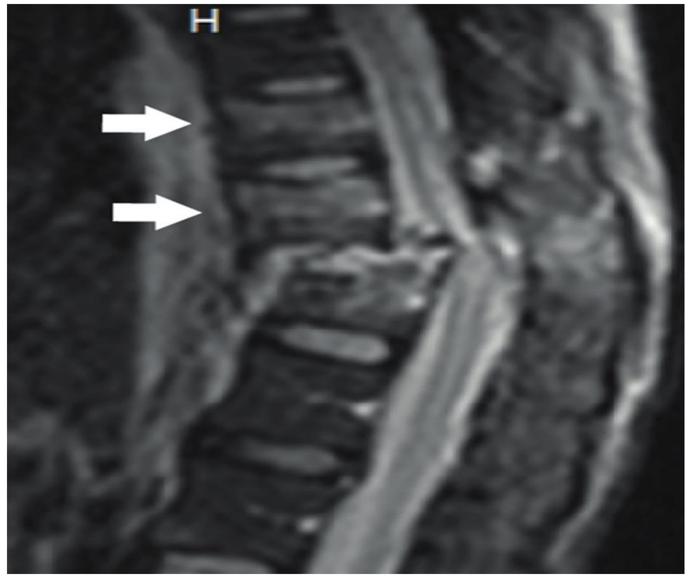


Fig 28: Marrow edema in adjacent bones (indicates: Subtle injury of adjacent segments)

i.

What is seen

- Epidural hematoma

What it indicates

- Extensive injury

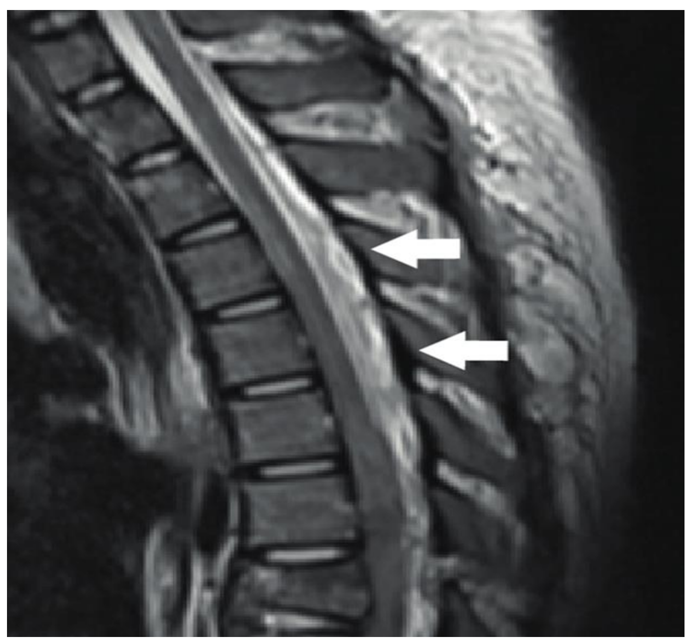


Fig 29: Epidural hematoma (indicates: Extensive injury)

What is seen

- Cord transection

What it indicates

- No chance for neural recovery

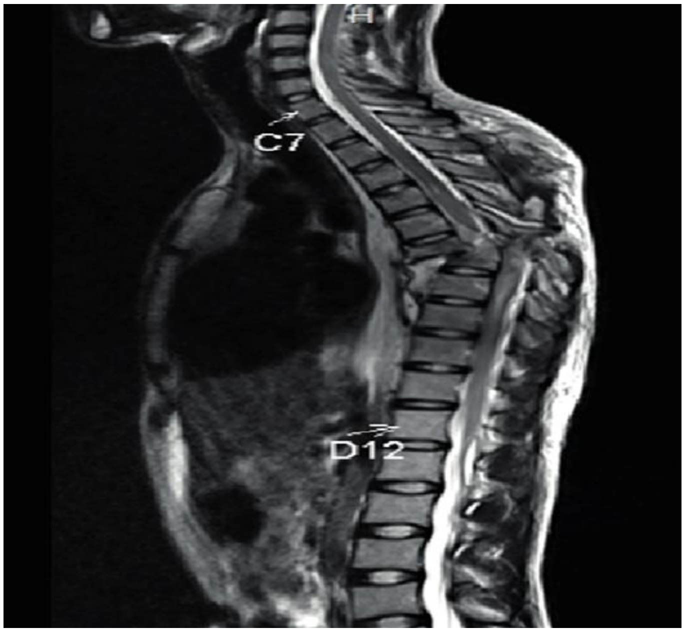


Fig 30: Cord transection (indicates: No chance for neural recovery)

What is seen

- Multilevel injury

What it indicates

- May require multilevel intervention

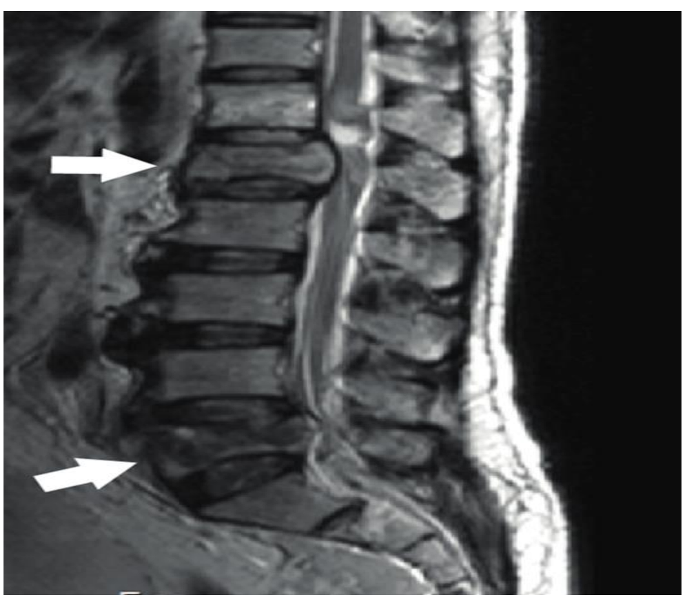


Fig 31: Multilevel injury (indicates: multilevel intervention)

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Declarations

Informed consent

Informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed

"Institutional Ethical Committee Approval"

Taken from Institutional Ethical Approval Committee, MGM Medical College & Hospital, Navi Mumbai, Maharashtra, India.

Availability of data and materials

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