Radiology of acute thoracic and lumbar spine injuries

Introduction

Thoracolumbar vertebral fractures typically involve high velocity trauma such as road traffic collisions, falls from height or sporting accidents, and are a major cause of spinal injury.

Plain radiographs remain the first-line investigation, but interpretation can be difficult because of the variety of injury patterns and sometimes subtle radiographic signs.

This article reviews the normal anatomy, systematic interpretation of thoracic and lumbar radiographs and typical injury patterns.

Anatomy

The vertebral column can be considered as a series of linked pairs of vertebrae.

Each vertebra comprises a rounded body anteriorly and the vertebral arch posteriorly. The pedicles form the sides of the arch, and the laminae complete the arch posteriorly. Each vertebral arch gives rise to seven processes: two transverse, four articular processes (two superior and two inferior), and the spinous process.

The vertebrae articulate by means of the intervertebral discs between the vertebral bodies and the synovial facet joints between the superior and inferior articular processes of adjacent vertebrae. They are supported by a number of strong ligaments: the anterior longitudinal ligament, posterior longitudinal ligament and the posterior ligaments (i.e. supraspinous, interspinous, intertransverse and ligamentum flavum).

The 'three-column spine'

In assessing vertebral fractures, the vertebral column is described as having three biomechanical columns (*Figure 1*).

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The anterior column comprises the anterior longitudinal ligament, the anterior two thirds of the vertebral body and the anterior part of the annulus fibrosus. The middle column comprises the posterior longitudinal ligament, the posterior part of the annulus fibrosus and the posterior margin of the vertebral body. The posterior column comprises the posterior ligaments and the posterior bone arch.

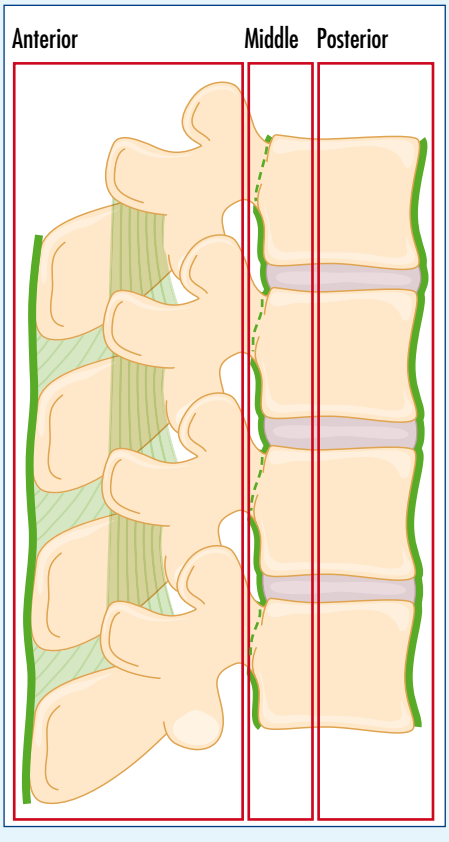
Disruption of any two columns denotes an unstable injury.

Radiological assessment and classical signs

The ABCS system of radiological assessment is followed for systematic evaluation.

- Adequacy
- Alignment
- Bones
- Congruity
- Soft tissue.

Figure 1. Lateral diagram of the spinal column showing the three biomechanical columns.



Adequacy

Anteroposterior and lateral views should be obtained. In the thoracic spine, the seventh cervical vertebra (C7) to the first lumbar vertebra (L1) should be visualized on both views. In the lumbar spine, the twelfth thoracic (T12) to the first sacral vertebra (S1) should be visualized on the lateral view and T12 to the inferior aspect of the sacroiliac joints on the anteroposterior view.

Computed tomography scanning is a useful addition for more detailed evaluation of fracture morphology, degree of spinal canal compromise and associated soft tissue injuries.

Alignment

On the lateral radiograph (*Figure 2a*), the vertebral column should form a smooth, unbroken, S-shaped curve, kyphotic in the thoracic spine and lordotic in the lumbar spine. Smooth lines can be traced along the anterior and posterior borders of vertebral bodies, and the anterior borders of the spinous processes, with no steps or breaks.

On the anteroposterior radiograph (*Figure 2b*), the lateral margins of the vertebral bodies, the spinous processes, tips of transverse processes and pedicles should align. The distance between the pedicles should gradually widen from the first to the fifth lumbar vertebrae. Abnormal widening indicates splaying of fracture fragments.

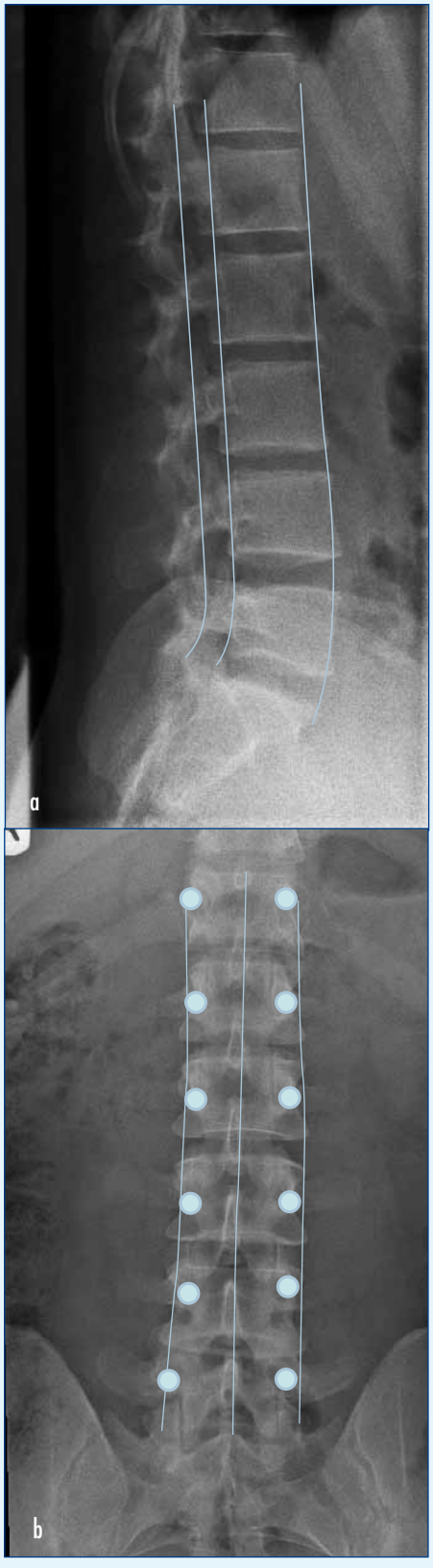
Bones

Careful examination of each vertebra on both lateral and anteroposterior radiographs may reveal a step, buckle or break in the cortical margin or trabecular pattern, nearby avulsion fragments or loss of vertebral body height. Each vertebra should be the same height anteriorly and posteriorly, and a similar height to the adjacent vertebrae. Loss of the usual concavity of the posterior margin of the vertebral body indicates significant posterior displacement of the middle column.

Congruity

The width of the intervertebral disc space should be uniform, and the distance

Figure 2. a. Normal lateral and (b) anteroposterior radiographs of the lumbar spine showing the normal alignment of the vertebral bodies, spinous processes and pedicles. Note the gradual widening of the interpedicular distance from the first to the fifth lumbar vertebrae.



between the tips of adjacent spinous process no more than 1.5 times the interspinous distance above or below. Distraction of either the intervertebral disc space or the interspinous distance indicates significant ligamentous injury and instability of that column.

Soft tissues

In the thoracic spine, the left paraspinal line should be closely applied to the vertebrae. Displacement or widening suggests a paraspinal haematoma. There is no paraspinal line on the right or in the lumbar spine.

Injuries

There are four recognized fracture patterns in the thoracolumbar spine: compression, burst, chance or 'seatbelt' and fracture-dislocation.

Compression

This is the commonest form of vertebral fracture (*Figure 3*), resulting from axial loading in anterior or lateral flexion (e.g. fall from a height, landing with spine flexed). In osteoporotic patients, these may occur with minimal or no trauma. The middle column remains intact, acting as a hinge, and the anterior column is compressed. When only the anterior column is affected, these are relatively stable injuries and are rarely associated with neurological injury. In the most severe cases distraction forces may disrupt the posterior column, resulting in instability.

Burst

Burst fractures (*Figure 4*) are caused by vertical compression (e.g. fall from a height with spine in neutral position) resulting in failure of the anterior and middle columns. They

Figure 3. a. Line diagram and (b) part of a radiograph showing a lateral view of a compression fracture. There is loss of height of the anterior part of the vertebral body, but the middle and posterior columns are intact.

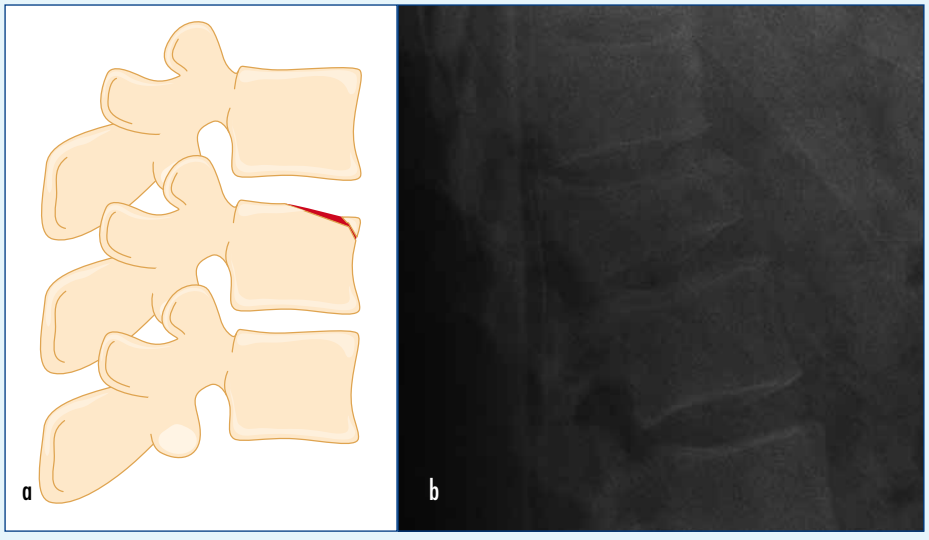
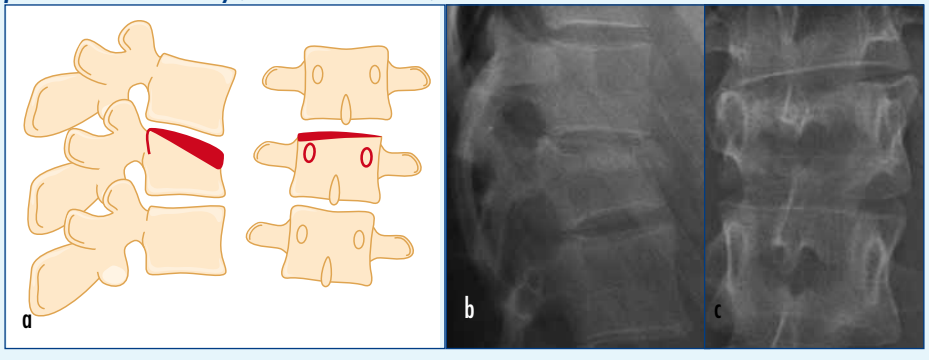


Figure 4. a. Line diagrams and (b) radiographs showing lateral and anteroposterior views of a burst fracture. Compression forces have caused loss of vertebral body height anteriorly (anterior column failure) and the widening of the interpedicular distance with loss of the normal concavity of the posterior part of the vertebral body (middle column failure).



are often comminuted, with bone fragments retropulsed into the spinal canal, and are associated with neurological injury in around 50% of cases. As two of the three columns are disrupted, these are unstable fractures.

Chance or 'seat-belt' fracture

This is a transverse fracture through the vertebral body and posterior arch (*Figure 5*), but without dislocation or subluxation. It is caused by flexion about an axis anterior to the vertebral body (e.g. road traffic collision when the individual is restrained only by a lap belt). As all three columns are involved these fractures are unstable and, owing to the mechanism of injury, are often associated with retroperitoneal or abdominal visceral injuries.

Fracture-dislocation

These are the least common, usually caused by severe blunt trauma, resulting in failure of all three columns with consequent subluxation or dislocation (*Figure 6*). These are highly unstable, and neurological injury is common.

Conclusions

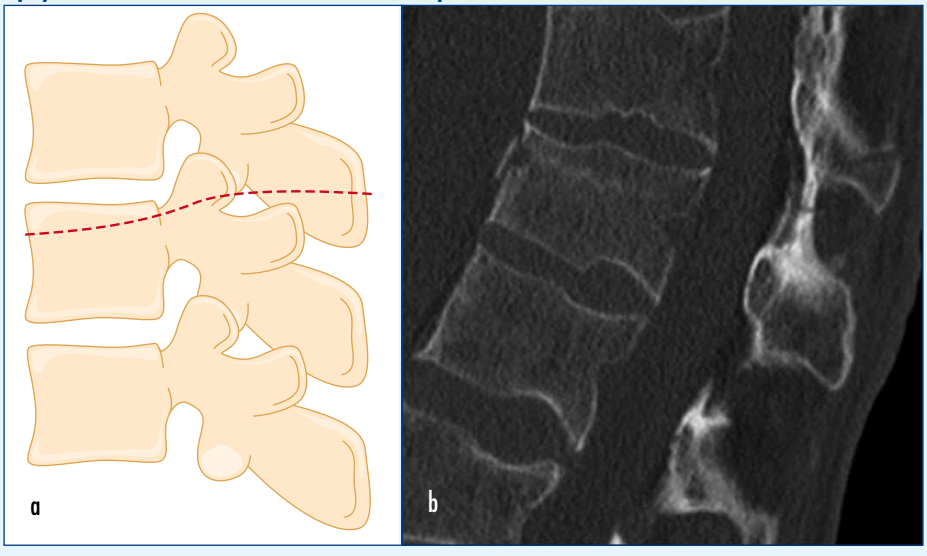
Plain radiograph is the initial imaging investigation in the assessment of injuries of thoracolumbar spine. Systematic assessment of the thoracolumbar radiograph is paramount as findings can be subtle. It is imperative that these injuries are detected on plain films as early detection determines subsequent management. BJHM

Conflict of interest: none.

Further reading

Raby N, Berman L, De Lacey G (2005) *Accident and Emergency Radiology – a survival guide.* WB Saunders, London

Figure 5. a. Line diagram and (b) sagittal computed tomography image illustrating a 'chance' or 'seatbelt' fracture. In this example, there is a transverse fracture through the vertebral body, pedicles (not visible on the computed tomography image) and the spinous process of the vertebra above. This is an unstable injury as all three biomechanical columns are disrupted.



KEY POINTS

- Disruption of any two of the three columns denotes an unstable injury.
- Injury often involves more than one vertebral level.
- A small avulsion fragment may signify major ligamentous disruption.
- Plain radiographic changes can be subtle. Careful, systematic evaluation is vital.

Figure 6. a and b. Line diagrams, (c) sagittal and (d) coronal computed tomography images illustrating a fracture dislocation. There is vertebral malalignment in both views, indicating gross ligamentous disruption, with an associated avulsion fracture of the spinous process.