Interpretation of thoracolumbar spine radiographs

Introduction

Thoracolumbar vertebral trauma is a major cause of spinal cord injury. Such severe disruption invariably results from significant force, although this is relatively uncommon. However, more minor injuries are frequently encountered yet still may cause uneasiness in their assessment.

Plain radiographs remain the first-line investigation, but interpretation can be difficult because of the variety of possible injuries, and their sometimes subtle appearances. Understanding of normal anatomy is key to avoiding errors in the management of these injuries. This article provides a systematic approach to interpreting thoracic and lumbar radiographs and describes the common conditions requiring these X-rays along with radiological signs.

Interpretation of thoracic and lumbar radiographs

The routine radiographs of the thoracolumbar spine include a minimum of the anteroposterior and lateral view. Additional oblique views may allow assessment of the intervertebral foramina, pedicles and facet joints, but are rarely of use.

Anatomy

The thoracolumbar spine is more stable than the cervical spine mainly because of the nature of the supporting ligaments, but also as a result of the intervertebral discs, facet joint alignment, the ribs and the paravertebral muscles. These ligaments include the anterior and posterior longitudinal ligaments, which support the vertebral bodies, and a posterior ligament complex consisting of the supraspinous ligaments, interspinous ligaments and ligamentum flavum (supporting the posterior bony elements). An intact posterior longitudinal ligament usually renders the spine stable. Stability is obtained at the expense of the range of movement, which is clearly inferior to that of the cervical spine. As a result usually large forces are required to cause disruption, and most commonly at the points where the spinal lordosis changes direction (i.e. the cervicothoracic junction (discussed in a previous article), the thoracolumbar junction and the lumbosacral junction).

The spinal cord usually terminates at the lower L1 vertebral level (L3 at birth), although its meningeal coverings pass caudally into the sacral canal enveloping nerve roots termed the cauda equina. External to the meningeal coverings is a potential space termed the extradural (or epidural) space, which contains fat, blood vessels and the exiting nerve roots. In the thoracic spine this space is limited in capacity by the significant cord width and relatively narrow bony canal, hence making an injury more likely to impinge the cord. More caudally in the lumbar canal the bony width is wider, the cauda equina thinner and this potential space is more able to compensate for an unstable injury.

Dr Steven D Allen *is Radiology Specialist Registrar,* **Dr Chris J Harvey** *is Consultant Radiologist and* **Dr Declan O'Regan** *is Radiology Research Fellow, Department of Imaging, Imaging Sciences Department, Hammersmith Hospital, Imperial College Faculty of Medicine, London W12 0NN*

Correspondence to: Dr SD Allen

Developmental anatomy

The vertebral bodies develop from at least three ossification centres, which may not fuse dorsally resulting in spina bifida (usually lumbosacral in location), or fuse in an abnormal fashion resulting in hemivertebrae or lumbarization of the upper sacrum (incomplete fusion) or sacralization at L5 (fusion of L5 to ala of sacrum).

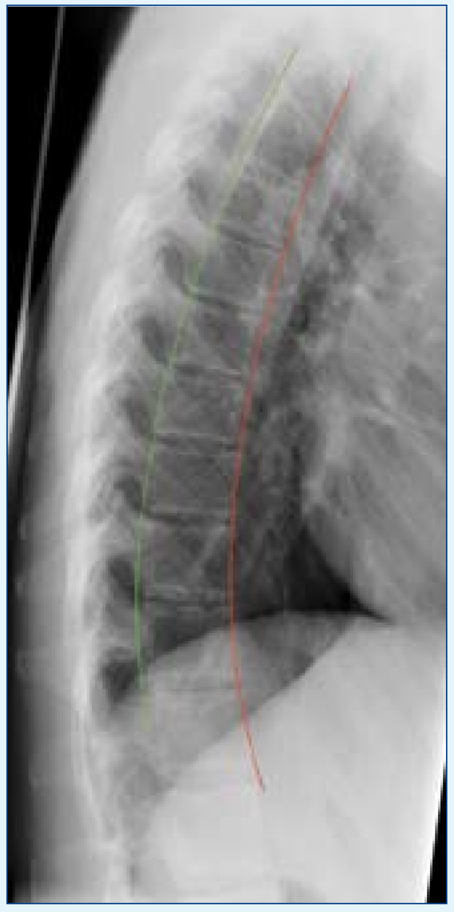
Systematic radiological assessment

The patient's name, date of birth and date on the film should always be checked.

Film quality: All five lumbar vertebrae and the sacrum should be visualized on both the anteroposterior (AP) and lateral views of the lumbar spine. Similarly all the thoracic vertebrae should be visualized on both the AP and lateral views of the thoracic spine.

Bone and joint alignment: The lateral view should be examined first as pathology is more commonly seen on this. The anterior and posterior longitudinal lines should be smooth curves, with a direction change at the thoracolumbar junction. The posterior elements should also follow this curve although overlying ribs often obscure this in the thoracic spine (*Figure 1*). The sacrum should show a kyphosis, which smoothly continues from the normal lumbar lordosis (*Figure 2*). On the AP view, the spinous processes should align (*Figure 3*); if malaligned they may have rotated to the side of an injury. The paraspinal line should be closely applied to the vertebral bodies in the thoracic region, and the distance between the pedicles gradually increases in the lumbar region (from L1 to L5)(*Figure 4*). The facet joints should align on both views.

Figure 1. Normal lateral thoracic spine radiograph showing normally aligned anterior longitudinal (red line), and posterior longitudinal (green line) lines. The normal smooth thoracic kyphosis is demonstrated. The posterior elements are also seen to follow this curve although overlying ribs obscure this to some extent.



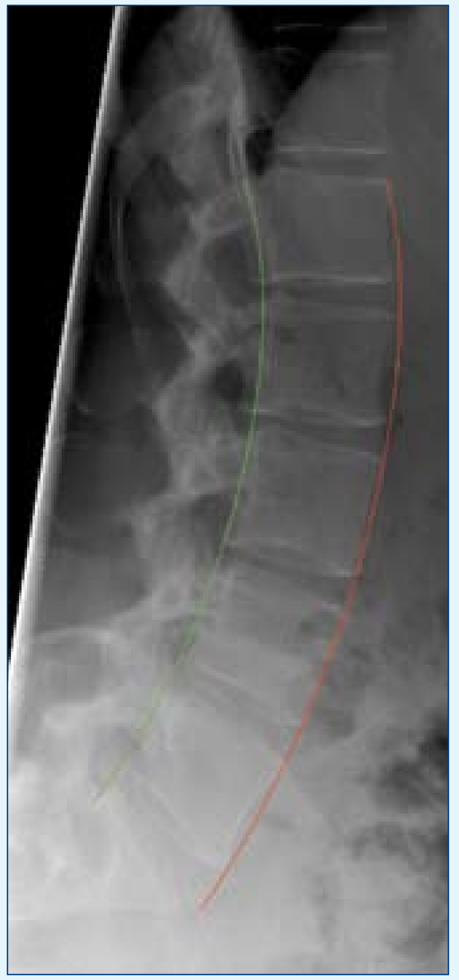


Figure 2. Normal anteroposterior thoracic spine radiograph, showing normally aligned spinous processes (red line) and pedicles (green lines). If malaligned they may have rotated to the side of an injury.

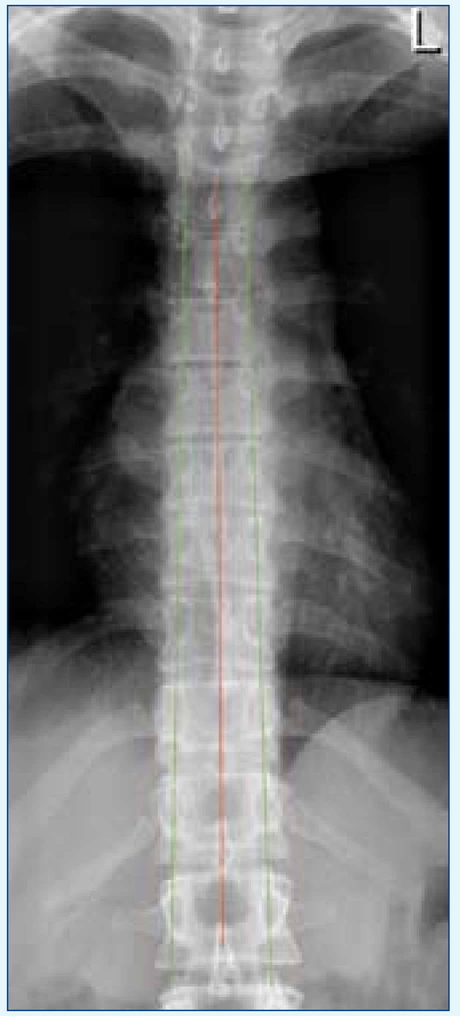


Figure 3. Normal lateral lumbar spine radiograph showing normally aligned anterior longitudinal (red line), and posterior longitudinal (green line) lines. The normal smooth lumbar lordosis is demonstrated. The sacrum shows a kyphosis, which smoothly continues from the normal lumbar lordosis.

Figure 4. Normal anteroposterior lumbar spine radiograph, showing normally aligned spinous processes (line). The distance between the pedicles gradually increases (from L1 to L5).

Bony density and margins: The cortical surfaces of each of the vertebrae should be systematically examined for irregularities. Vertebral bodies and discs should be of uniform height, increasing in size caudally. However, the L5/S1 disc may be slightly narrower than that of the L4/L5 disc. As with any other bone, the cortices should be smooth and regular, and depressions or steps should be considered as suspicious for a fracture. Similarly loss of the normal trabecular pattern and overlapping of bone fragments may indicate a significant injury.

Visualization of the posterior elements of the upper thoracic vertebrae is often poor as a result of overlapping ribs, and scapulae. Significant clinical concern in this area may be an indication for computed tomography.

Soft tissues: Soft tissue swelling causing disruption of the paraspinal line or psoas shadow is seen best on the AP view, and may be present in association with a significant injury (*Table 1*).

Spinal trauma

Flexion injuries

The majority of fractures result from flexion injuries, usually causing anterior compression (wedging) and posterior distraction (*Figure 5*), although lateral flexion will result in lateral compression. This

Table 1. Common errors
Avulsed endplate fractures can be subtle and may be associated with a significant injury. The bony cortices of each vertebra should be carefully assessed
A widened interpedicular space may be the only sign of a fracture on the anteroposterior radiograph so should be carefully assessed
Axial compression injuries may result in a loss of disc height with sometimes no obvious fracture. The disc may be retropulsed into the canal causing neurological compromise. Disc heights should be carefully assessed in injuries of this type
Isolated transverse and spinous process fractures are common, but they may be subtle. They can be associated with other severe injuries. They may require a bright light to be discovered

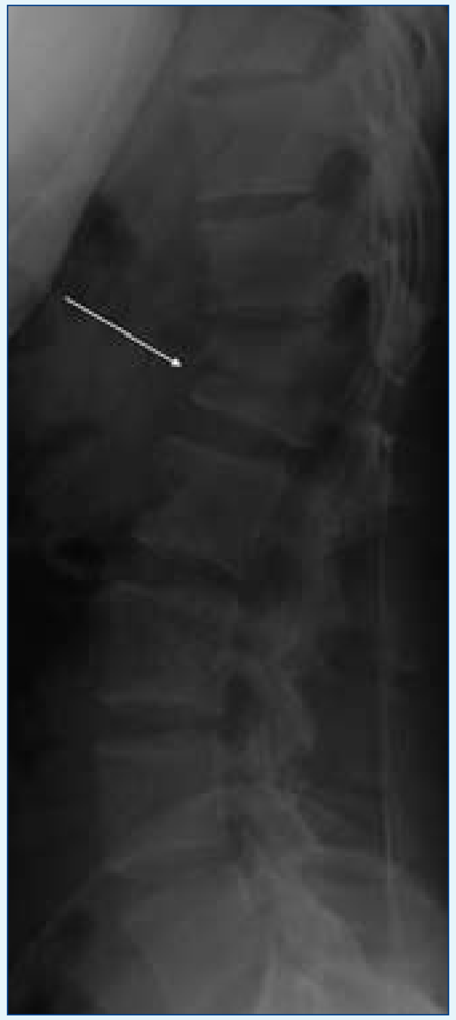


Figure 5. Lateral lumbar spine radiograph showing an acute anterior wedge fracture of the L1 vertebral body, as visualized by loss of anterior vertebral body height (arrow). The majority of spinal fractures result from flexion injuries, usually causing anterior compression (wedging).

occurs most commonly at T12–L2 in adults, and at T4–5 in children. If posterior vertebral height is maintained, these fractures are usually stable as the posterior longitudinal ligaments are usually intact. If the force is sufficient, however, there can be disruption of the posterior ligamentous complex, and multiple vertebrae may be significantly wedged with associated loss of disc height leading to an unstable injury (*Figure 6*).

The flexion-distraction injury or 'Chance fracture' occurs usually as a result of restraint by a seatbelt. This usually occurs at L1–3, is frequently unstable and is associated with other visceral injuries. It consists of a horizontal fracture through the body, pedicle and posterior elements (*Figure 7*).

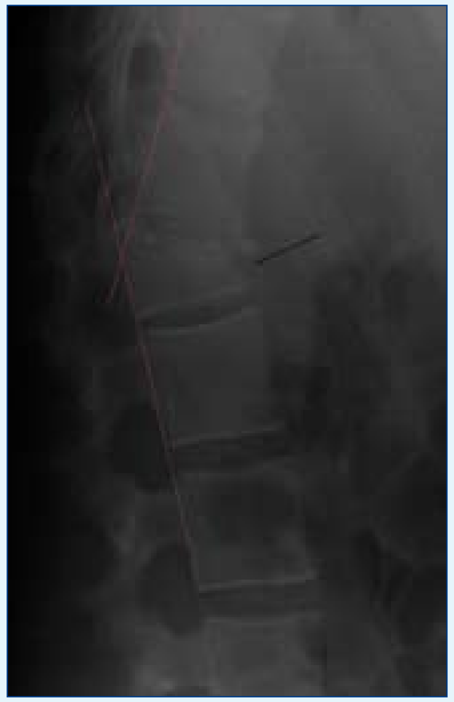


Figure 6. Lateral lumbar spine radiograph showing an acute anterior wedge fracture of a lumbar vertebral body (arrow). The force is sufficient, however, to have caused disruption of the posterior longitudinal ligament, as indicated by malalignment of the posterior aspect of the vertebral body with respect to the adjacent levels (lines). This is a potentially unstable injury.

Flexion-rotation injuries are unusual but extremely unstable usually resulting in neurological impairment. The characteristic findings are rotation between adjacent vertebrae and vertebral dislocation. Associated fractures are common.

Shearing injuries

These severe injuries usually result from a force causing anterior or posterior displacement of a vertebra with respect to the one below, by often more than 25%. This may involve disruption of all of the intervertebral ligaments and is highly unstable.

Hyperextension injuries

These injuries are rare but can occur if the patient falls and hyperextends over an object. These injuries are more frequent in patients with ankylosing spondylitis and can occur with more minor trauma. Radiographical findings include widening of the anterior part of the disc space, an avulsion fracture of the anterior superior vertebral corner, and occasionally a posterior arch fracture in severe cases.

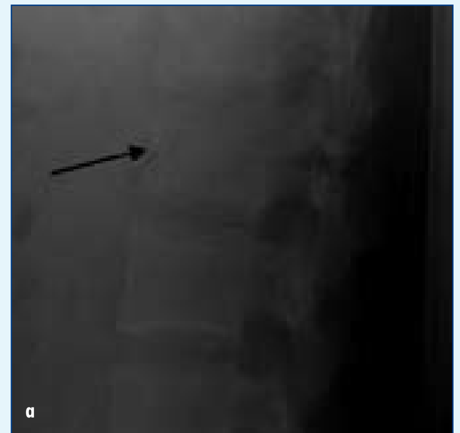


Figure 7. A patient with a flexion-distraction injury or 'Chance fracture' of the L2 vertebral body. This is frequently unstable and is associated with other visceral injuries. It consists of a horizontal fracture through the vertebral body, pedicle and posterior elements. a. A lateral lumbar spine radiograph showing a horizontal fracture of the vertebral body (arrow). b. A sagittal T2-weighted magnetic resonance image showing the L2 body fracture (white arrow). The injury to the posterior elements is appreciated as shown by high signal soft tissue abnormality (black arrow).

Axial compression injuries

This type of injury usually results from a fall from a height, and causes the vertebral bodies to compress the intervertebral disc, which may herniate posteriorly into the canal, and may disrupt the longitudinal ligaments. In more extreme cases the vertebral bodies themselves 'burst' from within, with variable displacement of the fragments (*Figure 8*). These injuries can occur from T4–L5, although most commonly at L1. Radiographical findings include a widened interpedicular distance, anterior wedging and a vertical fracture line (*Figure 9*). Retropulsed endplate fractures are also seen. These injuries can be unstable, particularly if there are rotational components to the mechanism of injury, or compression of more than 50% has occurred. Neurological injury and other associated fractures are frequent.

Figure 8. Lateral lumbar spine radiograph showing an acute 'burst' fracture of the L3 vertebral body. This injury has occurred as a result of a fall from a height, and has caused the vertebral body to compress the intervertebral disc. The vertebral body itself has 'burst' from within, with anterior wedging and displacement of the fragments (arrow).

Isolated transverse and spinous process fractures are not uncommon and usually result from direct trauma. They may be subtle and require a bright light to be discovered, and although they may be of no significance they can be associated with other injuries. At T1–2 and L4–5 they are associated with injuries to the brachial and lumbosacral plexuses respectively.

Non-traumatic presentations

Many patients present to the emergency department with non-traumatic back pain and although this may be disabling, in the absence of significant neurology, the vast majority of these patients will not have an urgent clinical problem. They may have one or multiple osteoporotic crush fractures, or they may have varying degrees of degenerative disease, or non-traumatic spondylolisthesis, maybe with secondary nerve root irritation and associated muscular spasm. Their pain may indeed be referred from somewhere else. However, occasionally back pain can be the result of a serious cause such as bony metastatic disease or myelomatous infiltration, or indeed a spinal infection such as osteomyelitis or discitis (*Figure 10*). This should be suspected clinically on a careful and thorough history and examination. BJHM

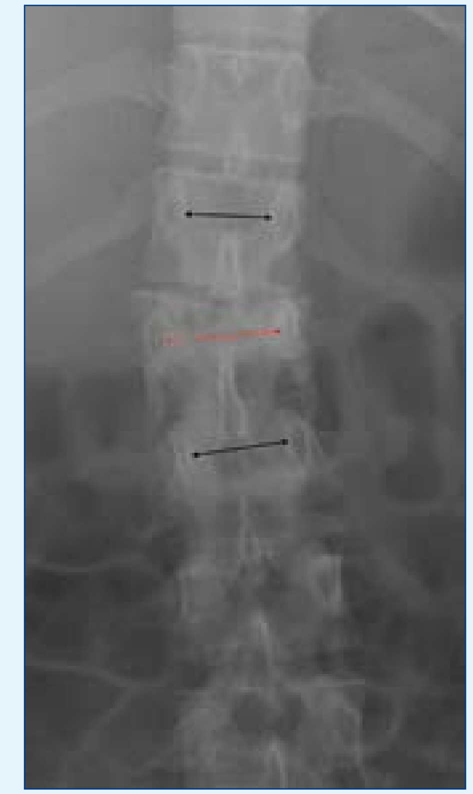


Figure 9. Anteroposterior lumbar radiograph showing an acute 'burst' fracture of the L1 vertebral body. There is slight malalignment and a widened interpedicular distance at this level when compared to the adjacent spinal levels (arrows).

Figure 10. Lateral lumbar spine radiograph showing an acute discitis. There is gas overlying the L5–S1 disc space, with associated destruction of the adjacent vertebral endplates (arrow). This has occurred secondarily to a systemic infection with Staphylococcus aureus.

Figure 7 *is reproduced with permission from Harvey et al.* Self assessment cases in surgical imaging. *Oxford University Press 2005.*
Conflict of interest: none.

Murphy MD, Batnitzky S, Bramble JM (1989) Diagnostic imaging of spinal trauma. *Radiol Clin North Am* **27**(5): 855–72
Nicholson DA, Driscoll PA (2002) *ABC of Emergency Radiology.* BMJ Publishing, London
Raby N, Berman L, de Lacey G (2005) *Accident and Emergency Radiology. A survival guide.* 2nd edn. Bailliere Tindall, London: 126–34

KEY POINTS

- Always check the name, age and date.
- Assess film quality, ensuring all the vertebrae are visualized.
- Assess the alignment of the thoracic and lumbar spine, particularly with respect to the change in curvature at the thoracolumbar and sacrolumbar junctions.
- Assess each vertebra in turn for height, shape, bony cortices and interpedicular distance. Allow for slight widening of interpedicular distances from L1–5.
- Assess the intervertebral disc spaces, facet joints and paravertebral soft tissues for uniformity.