Chapter 3
The neck

Background

- **In multiple trauma a very high index of suspicion must be maintained for neck injuries because of the potentially devastating consequences of missing such lesions at the outset**; whatever other findings dominate the clinical picture, the presence of a lesion must invariably be assumed in the first instance.
- In practice this boils down to immediate immobilization of all suspect necks at the scene, which is how they will usually present in A & E, and **the support must remain in place until the patient is stabilized and all appropriate clinical and imaging evaluations are completed.**

  Crucial X-ray fact: Following some neck injuries, the position of the bones and joints at the moment of impact may be totally different from that at which they are later seen at the instant the X-ray is taken, due to temporary traumatic dislocation which damages the cord but then spontaneously reduces.
- Conventional X-rays to show the current alignment on arrival in A & E, however, including a 'shoot-through', or horizontal beam lateral are mandatory and may provide the necessary initial radiological information. If not, early progression to CT or MRI will be necessary to **'clear the neck'** before the green light can be given to remove any immobilization device, **the order for which should come only from a senior doctor.**
- Road traffic accidents, accidents at work, at home or during sports activities form the bulk of the injuries. Trampolines, diving into impossibly shallow pools or being thrown from a horse are other potent causes. Unfortunately, irreparable damage is sometimes done by subsequent mishandling of casualties after the initial injury has been inflicted. (**Moral:** Don't mess about with necks!)

Point of interest: It is said a significant number of fatalities occurred among those who jumped from the *Titanic* because their necks were thrown back and snapped by their buoyant life-jackets when they hit the sea.

A look at the guidelines in neck injuries

As with head injuries and the brain, the RCR guidelines are designed to optimize the pick-up rate of injuries, in this case to the cord, to minimize any chance of damage to an uninjured cord in the presence of an unstable neck, and indeed to prevent a partially transected cord being turned into a completely transected one by inappropriate handling or premature movement.

In common with the brain, the spinal cord is completely invisible on plain X-rays. So too are the ligaments that maintain the neck's stability. Any deductions from conventional films are therefore made indirectly.

Clinical reasons why the diagnosis may get overlooked

- A lack of knowledge by the doctor of the mechanism and severity of injury.
- Patient unconscious on arrival due to head injury or other condition causing a fall (e.g. stroke).
- Multiple injuries, e.g. a 'red blanket' or emergency case, such as a sky-diver or crashed pilot with flail chest, vascular injury or massive haematuria, causing distraction and dominating the clinical picture.
- Minimal neurological signs giving a false sense of security – but an unstable neck. A disaster waiting to happen.

So who gets what imaging?

Because there is so much at stake, the imaging requirements of patients with various categories of neck injury merit close attention to detail. The RCR guidelines identify the following groups.

1. Conscious patients with apparent head and/or facial injury only

These patients do not need any X-rays routinely, but still need to be checked to exclude evidence of cervical injuries. The necessary criteria to exempt them from X-ray examinations are that they:

- Are fully alert and not intoxicated by alcohol or drugs.
- Show no neurological deficit.
- Have no midline posterior cervical tenderness.
- Have no other major, more painful injuries (patients may just complain about what hurts most), distracting attention from the neck.

2. Unconscious patients with head injury (or suspected head injury)

NB No one must manipulate the neck at this stage. These cases require high quality X-rays of the entire cervical spine from the odontoid to T1/T2, but these may not be achievable in muscular or obese individuals despite traction/oblique views, etc. Advice? Go directly to CT or MRI. If multiply-injured, the entire head, neck, chest and abdomen assessments may best be accomplished at the same time by CT anyway. If MRI is available this may be preferable for the spinal cord but restlessness may compromise both modalities. Anaesthetic assistance with light sedation may be invaluable.

3. Neck injury with pain

These patients warrant cervical spine films in the first instance. If the X-rays are problematical or the findings not straightforward, go and discuss them with your seniors and the radiologists regarding possible CT/MRI for further evaluation. **A painful neck will usually have a cause.**

4. Neck injury with neurological deficit

These warrant urgent orthopaedic or neurosurgical assessment and plain X-rays of diagnostic quality as a baseline. However, if necessary, go directly to MRI to assess:

- The cord itself.
- Extrinsic cord compression.
- Soft tissue injuries (ligaments).
- Fractures at multiple levels.

Or CT myelography if MRI is not available.

5. Neck injury with pain and suspect ligamentous injury (e.g. self-reduced subluxation from moment of impact)

These require X-ray assessment in flexion and extension, if necessary with screening (i.e. real-time X-rays) to show any latent instability. A doctor must be in attendance (preferably the one who requested the examination) and any movements should only be initiated by the patient and not forced. The patient should be warned to stop if he or she experiences excess pain or paraesthesiae down the arms.

Radiography

The objective is to demonstrate all the relevant anatomy, which may be much easier said than done in a thick-set severely injured and unconscious patient.

Standard views include:

- A lateral film which shows all the vertebrae in the cervical spine, from C1 to the top of T1 in the thoracic spine (Fig. 3.1). This may be the only plain film taken in severe trauma.
- The AP view (Fig. 3.4).
- An open-mouth view of the C1/C2 vertebrae (atlas and axis), also known as a 'peroral' or 'peg' view (Fig. 3.5, p. 69).

NB In well-built or obese individuals the shoulders may completely obscure much of the cervical spine, from as high as C3 down in some cases, but generally the problem is of the view being cut off at around C7/T1.

Crucial fact: The implications of this are that, if using conventional films, you must consciously check to see if all the relevant anatomy has been included. Unless you can tell at a glance that the view gets well down into the thoracic spine, **you must count the number of vertebrae from C1 down**, and the films as a minimum must demonstrate the upper end-plate of T1 (or preferably all of it). If using digital radiography you should be able to bring up the relevant anatomy purely by image manipulation.

What should be done if this cannot be achieved with conventional films? Traditionally the radiographer has several options:

- *Films of increased penetration.* These may solve the problem but tend to come out very dark and be hard to interpret, even with a bright light.

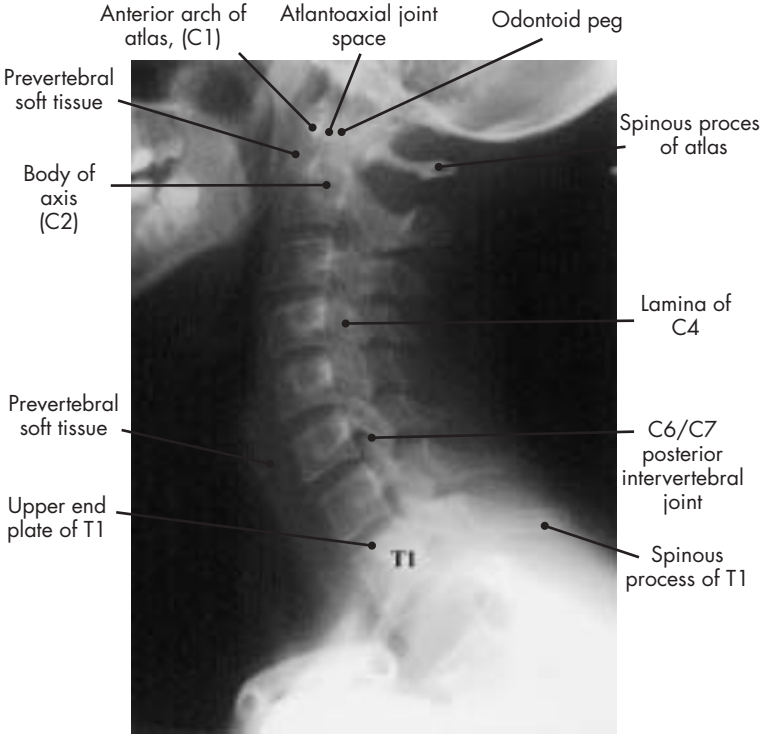


Fig. 3.1 *X-ray heaven! Excellent lateral view of neck showing vertebrae down to T1 and beyond.*

- *Films with arm traction gently pulling the shoulders down* out the way (traction views) (Fig. 3.9, p. 75).
- *'Swimmers' views'* (taken with one arm up and one arm down) (Fig. 3.2), but this may not be possible, e.g. with fractured shoulder girdles.
- *'Trauma obliques'*. By angulation these project the shoulders out of the way, and the view is no longer lateral, but may be sufficient to confirm normal alignment and integrity of the vertebral bodies.

Fig. 3.2 ***A*** *Attempted lateral showing only down to C6.* ***B*** *'Swimmer's view' with slight obliquity and arm elevated in a 'Hail Caesar!' Roman salute showing down to T1 upper end-plate.*

All these views should be attainable without moving the patient as a whole.

Question: Why all this fuss about the cervicodorsal junction?

Answer: Because this is where the curve of the spine reverses and is particularly susceptible to trauma. Many injuries have been overlooked here in the past, with subsequently devastating consequences for the patient **(because somebody did not bother to count the vertebrae)**.

Anatomy

Look at Figure 3.3:

- This shows the lateral view of a normal neck.
- A normal neck in 'neutral' (i.e. relaxed) position describes a gentle forward curve convex anteriorly, which constitutes the cervical lordosis. This curve

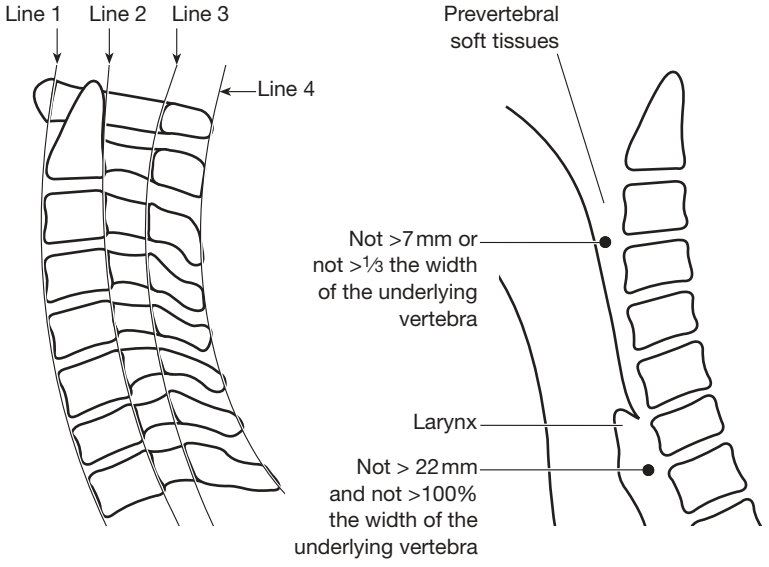


Fig. 3.3 *Lateral view of the neck showing normal alignment lines to be checked.*

may be lost or reversed in trauma due to spasm, or chronically with degenerative disease.

- Lines drawn connecting the anterior and posterior aspects of the vertebral bodies and anterior aspects of the bases of the spinous processes will run parallel to each other. Interruption of these lines is used in the assessment of traumatic displacements. Sometimes line 3 bypasses C2 by a whisker.
- The first two lines anteriorly correspond to the ligaments holding the bones together, i.e. the anterior and posterior longitudinal ligaments.
- Because of overlying mastoids and earlobes, the craniocervical junction (or occipitoatlantal joint) is not clearly discernible on the lateral view, but the gap between the anterior arch of the atlas and the odontoid process or dens is visible (Greek *odous, odontos* = tooth, Latin *dens* = tooth from its tooth-like shape). The dens is anatomically part of C2 but functions as the body of C1.

In an adult this should not exceed 3 mm. In a child it should not exceed 5 mm.

- Note how the shoulder partially opacifies the level of T1 and the area behind it on the lateral X-ray (Fig. 3.2).

NB Physiological subluxations can occur on children's X-rays, simulating dislocations, particularly of C2 on C3 and C3 on C4 on forward flexion. In such circumstances there may be steps in lines 1 and 2 but line 3 will remain intact. All three lines are out of alignment with a real subluxation.

Prevertebral soft tissues

Look at the prevertebral soft tissues in front of the spine contrasting sharply with the dark air in the pharynx and below the larynx in the trachea. Between the base of the skull and the odontoid these form a gentle anterior concave margin but may become convex here in adenoidal enlargement. They are normally convex over the anterior tubercle of the atlas, then concave immediately below it. Where these retropharyngeal and retrotracheal soft tissues normally run almost parallel to the spine, e.g. between C2 and C4 and C5 to C7, they should not exceed around 7 mm and 22 mm in width, respectively, as a rough guide.

Swelling of these tissues may occur in trauma **but an absence of such swelling does not exclude significant trauma.** Other causes for swelling include infected impacted foreign bodies, spontaneous retropharyngeal abscess, tonsillitis, osteophytes and malignant disease.

NB False swelling may appear to be present on shoot-through laterals due to pooling of blood and saliva in unconscious patients but will have a sharp anterior margin due to this fluid level or flexion of the neck in children.

Look at Figure 3.4:

- This is an AP view of the neck. Its clear segmental form is apparent with the body of each bony vertebra being separated by a radiolucent intervertebral disc, in vertical alignment. The diverging beam is angled slightly up about 15–20° to get through as many of the discs as possible but increasing obliquity will blur their margins.
- The spinous processes, some of which are often bifid (or forked), define the midline, as does the overlying air column of the trachea, which is therefore a sensitive indicator of rotation. When the trachea does *not* overlie the spinous

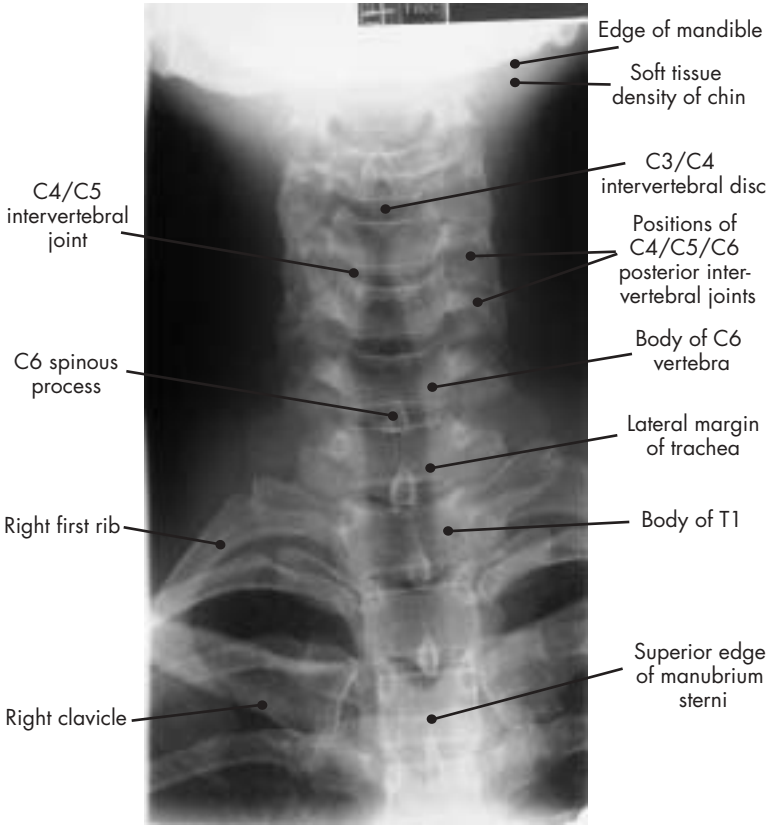


Fig. 3.4 *AP view of the neck (there is slight rotation to the right).*

processes, this may also be due to anatomical rotation, pathological displacement of the trachea or malalignment of a vertebral body (scoliosis). In older patients the lower trachea will deviate naturally to the right to negotiate an unfolded aorta.

- The Luschka joints and their uncinate processes (Latin *uncus* = hook) are usually clearly visible over several levels at and adjacent to the central X-ray beam, but become progressively distorted and less sharp due to obliquity.

Normal variants

- The joints between the lateral masses are out of alignment with the beam in this projection so do not show up. Note the steep downward directions of the posterior intervertebral joints on the lateral view (Fig. 3.1). Steep downward angulated views running parallel to these axes can be taken (i.e. 'pillar view') to demonstrate occult lateral mass fractures if required.

This illustrates a fundamental principle worth knowing: **the best view of a disc or joint space will come from a beam centred on and parallel to its axis** – and the same of course is true of a fracture line.

The atlantoaxial joint

Looking is not the same as seeing in radiology and you must learn to 'see' the anterior atlantoaxial joint space on the lateral view (Fig. 3.1) and be able to resolve it in your 'mind's eye', as Shakespeare called it. The joint space should not exceed 3 mm in an adult or 5 mm in a child. It usually increases minimally in flexion compared with extension, more so in children.

Look at Figure 3.5. This shows the frontal anatomy of the adult odontoid, which looks like a meditating Norman knight in armour with huge shoulder pads, and the appearance of the lateral atlantoaxial joints. The spinous processes look like steepled fingers resting on his sword.

Important fact: The odontoid peg is bedevilled by a number of dark bands and edges which cross over it, simulating fractures, including the top of the tongue and the dark edge along the margin of the shadow of the occiput – a so-called Mach band effect. The margins of teeth will also sometimes produce such an edge but should be fairly obvious. Apart from these, the main anatomical and artefactual edges can usually be traced well beyond either side of the odontoid.

Radiographic hint: Asking the patient to say 'Aahhh!' at the instant of filming will lower the tongue and help to remove at least one confusing edge from the odontoid.

Normal variants

Paediatric patients

An important variant is the normal synchondrosis, which is present in very young children, causing a genuine lucent (but cartilaginous) defect at the base of the odontoid. This may also be discernible on the lateral film and very rarely will

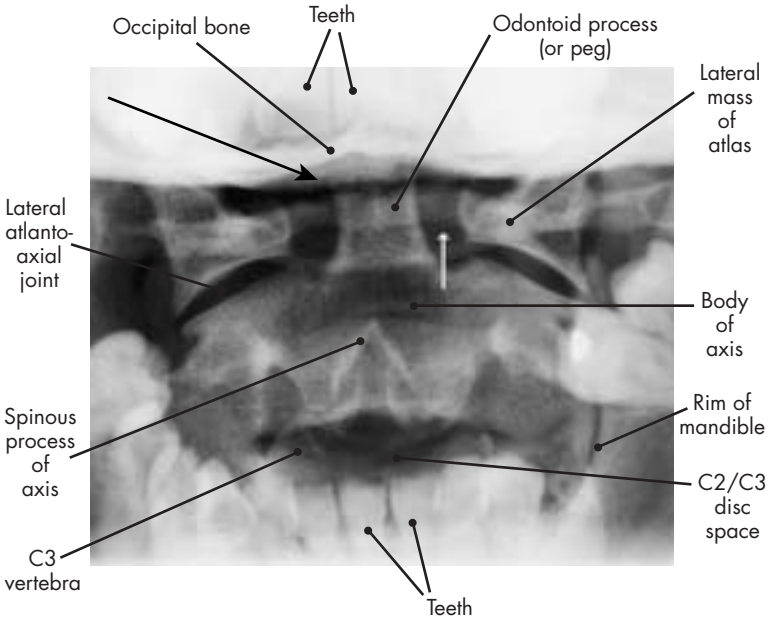


Fig. 3.5 *'Open mouth' view of the odontoid. Black arrow indicates soft tissue fold at the back of neck; white arrow indicates dorsum of tongue.*

persist as a sclerotic-margined remnant in the adult. Odontoid peg views are, of course, very difficult to obtain in infants.

Elderly patients

Degenerative changes in a sense are physiological, giving rise to disc space narrowing, sclerosis and osteophyte formation, the classic signs of osteoarthritis of the spine (cervical spondylosis). In addition, however, particles of bone can appear on the anteroinferior aspects of such vertebral bodies and anterior disc spaces and may be confused with 'teardrop' fractures (a manifestation of hyperflexion injury). These are due to incompletely fused epiphyseal ring remnants. In addition, severe hypertrophic degenerative disease in the posterior intervertebral joints can cause one vertebra to move gradually forward relative

to another, producing a *subluxation of degenerative origin* (Fig. 3.6), which may be impossible to prove as non-acute unless there are previous films.

Breaking your neck

This sounds dramatic – and it is, although technically speaking both a small chip fracture and a complete fracture dislocation constitute a 'broken neck', a

Fig. 3.6 *Degenerative subluxations of C4 on C5 (arrow) and C5 on C6. Note the posterior disk space narrowing and posterior intervertebral joint sclerosis due to osteoarthritis. There was no history of trauma.*

distinction often lost on some newspapers. Active lives can, however, be over in an instant, sometimes due to thoughtlessness, like letting your tractor roll over, or driving too fast on an icy road, which delivers your spinning car into a tree. All your tomorrows pass down through that narrow space that is the cervical spinal canal, so just bear it in mind the next time you decide to go skydiving, and jump out of a fully serviceable aeroplane.

With regard to neck injuries, there are four basic mechanisms:

- flexion
- extension
- rotation
- compression

but combinations of these will often contribute to the injury.

Flexion injuries

Flexion injuries are the commonest type of trauma to affect the neck, particularly at its lower end, and the most frequent components of these include:

- Simple wedge fractures.
- Posterior ligamentous tears.
- Facet joint dislocations.
- Combined fracture/dislocations of vertebral bodies.

However, look at Figure 3.7.

A memorable patient: a flexion dislocation of the head

This patient lost control of his vehicle at high speed. Note the massive prevertebral swelling.

The head can dislocate completely backwards or forwards given sufficient extension or flexion forces at the occipitoatlantal joint. Many of these patients die at the scene. If they survive, the injury is unstable, but with modern intensive care techniques some of them do survive.

Simple wedge fractures

These are due to downward compression of the superior end-plate of a vertebra at its anterior aspect, giving this injury its 'wedge' shape and its name. It may be

Fig. 3.7 *A dislocation of the head. The odontoid is now behind the mastoid process instead of adjacent to it. Just about as bad as it gets.*

associated with buckling of the upper anterior wall cortex creating a small step (look at Figure 3.8, p. 74).

NB The inferior end-plate and posterior vertebral body cortex are intact. If the degree of compression is less than 25%, the traumatic force applied is

unlikely to have been sufficiently severe for ligamentous rupture to occur and the supraspinous ligament will hold, rendering this injury stable. Beyond 25% of **compression, ligamentous rupture and instability should be assumed.**

Important normal variant Some cervical vertebrae are already anatomically wedge-shaped. Look for prevertebral swelling and cortical breaks as further evidence of suspect trauma.

A nasty dose of reality

Look at Figure 3.9A. This is the film of a patient whose car ran into the back of a stationary vehicle. This shows a 'normal' neck with no fractures and good alignment. Unfortunately, if you count the number of vertebrae there are only **six**. A second lateral X-ray was then performed with arm traction. Look now at Figure 3.9B. This now shows **seven** vertebrae with a burst fracture of C7.

Moral: In practice, the aim must be to ensure that all the relevant anatomy is demonstrated radiographically, from C1 to the top of T1. Horrendous fracture/dislocations have been missed here in the past, with permanent damage to the cord when patients with inadequate films were discharged and started to move their necks. With CT and MRI available there is no longer any excuse for failing to achieve an adequate demonstration of the neck. Not for nothing has this area been called 'the A & E doctor's graveyard!', although it's actually the patient who may end up in the graveyard, not the doctor!

Ligamentous ruptures

In some patients sudden severe flexion will tear the interspinous and supraspinous ligaments, rendering the neck unstable. The neck may look normal in the neutral position. Any flexion allowed at this point would, however, cause the spinous processes to separate from each other ('fanning') and may lead to permanent cord damage. In the longer term, if the ligaments do not heal, this can lead to delayed instability.

Facet joint dislocations

Bilateral unstable 'jumped facets' An element of rotation associated with a flexion injury can cause the facet joint capsules to rupture and the facet joints to sublux or dislocate. These are unstable. Look at Figure 3.10. Note:

Fig. 3.8 *Wedge fracture of C5.*

- The considerable anterior positioning of C5 upon C6, with interruption of the anterior and posterior longitudinal lines. (The apparent forward positioning is exacerbated by the big osteophyte on C5.)
- The anterior positioning of the C5 facets relative to C6 – the arrow points to the position where they should be articulating with the C6 facets behind.

A B

Fig. 3.9 ***A*** *Lateral view of neck showing only down to C6.* ***B*** *Same patient with arm traction revealing down to C7 where there is a burst fracture.*

- This is a *bilateral facet joint dislocation*. All the ligaments of the spine are ruptured in this condition and there is a high risk of cord injury.

NB If both facets have completely 'jumped' there will be no rotational element but up to a 50% or more anterior over-riding.

The appearance of facet joints on lateral films is a source of endless angst and difficulty, usually due to anatomical variations, slight degrees of flexion and obliquity, and occasional reversal of the cervical lordosis which makes facets 'ride up' on the ones beneath them. If, however, there is ongoing concern about facet joint injuries, 45° oblique films can be used to confirm or exclude the normal relationships.

Unilateral facet dislocation (stable) (Figs 3.11, 3.12) This is a more subtle injury than the bilateral version but, again, it will not usually occur without some visible forward movement of the affected vertebra on the one below. Such movement

Fig. 3.10 *A C5/C6 dislocation with jumped facets (arrow). The patient hit a brick wall on his motorcycle. These are unstable with up to 50% over-ride.*

can, however, be minimal or masked by obliquity, and difficult to appreciate (but not >25%). If only one facet has 'jumped', the affected vertebra should also show:

- Some rotation of its spinous process to the opposite side on the AP view.
- Increased clarity of the affected lateral mass posterior to the intervertebral joint due to altered positioning.

Imagine a ship coming straight at you – it then turns to starboard (the ship's right, your left). The prow then moves off to your left and the stern begins to stick out to the right. Similarly, the spinous processes will come out of alignment in a unilateral facet dislocation and move to the dislocated side.

Perched facets (the 'in-betweenies') An in-between condition can occur, between normality and established dislocation, when the facet joints become 'perched' upon each other with point to point contact.

NB Although associated with degrees of displacement and occasional root symptoms, facet dislocations are not usually associated with neurological deficits and are treatable by traction and manipulative reduction.

Fracture dislocations

When flexion violence is sufficiently severe to cause a fracture and dislocation, cord compromise with quadriplegia is likely. The initial films will give likely warning of the severity of the injury and cord damage will be both clinically apparent and anatomically demonstrable by MRI.

Odontoid peg fractures

These are usually divided into three types (Fig. 3.13):

1. Through the upper peg – stable.
2. Through the base of the peg – unstable.
3. Through the base of the peg and into the body of the axis – stable.

These fractures are very painful and the patient may think his head is 'going to fall off'. Unfortunately it is easy to miss them, or misdiagnose their presence when absent. The radiographer will assist you by taking an open-mouthed AP view if possible – the problem is one of interpretation.

Fig. 3.11 *Unilateral facet dislocation. Sudden forced flexion of the neck in a rugby scrum. Note the prevertebral swelling. This is stable.*

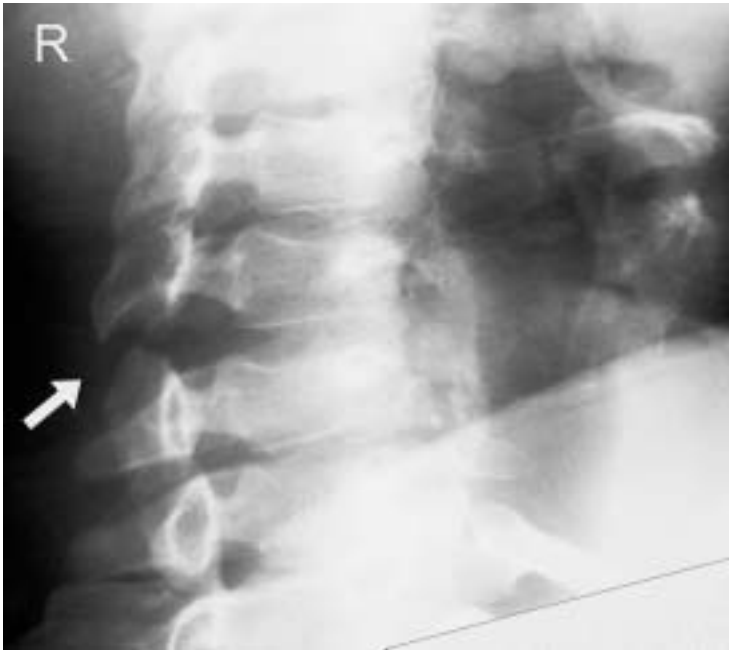


Fig. 3.12 *Oblique view of same patient as in Fig. 3.11, showing the dislocated C5/6 facet. This is stable.*

Important mnemonic: Scarlet and Black!

There are many red herrings that can cause black lines to cross the odontoid and simulate a fracture, such dark bands often accompanying the white edges of bony structures, known as the *Mach effect*, which has already been demonstrated (Fig. 3.5).

NB Whilst mainly a flexion injury, which causes the top of the peg to move forwards, an extension injury as here (Fig. 3.14) may cause it to go posteriorly.

An interesting congenital abnormality

Look at Figure 3.15. The tip of the odontoid is separate from its lower part. This is a congenital non-fusion of the odontoid (Os odontoideum), with no history of

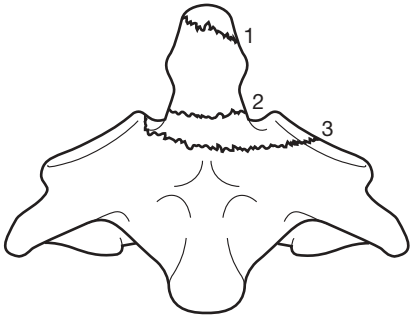


Fig. 3.13 *Odontoid peg fractures (see text).*

trauma. Real fractures can look like this but note the smooth sclerotic margins, indicating that it is not acute.

Clay shoveller's fracture (Fig. 3.16, p. 83)

This is a fracture of a spinous process caused by sudden severe flexion stress or a direct blow. The AP view of the neck may show what looks like two adjacent spinous processes – 'the ghost sign'. Its differential diagnosis includes non-fusion of an accessory ossification centre at the spinous process (so the history is important) or normal variant anatomical calcification in the ligamentum nuchae. Its name is supposed to have arisen from clay miners in Australia, and a high incidence of it was recorded in Germany during the construction of the autobahns – using shovels without crossbars.

'Teardrop' fracture (flexion injury of lower cervical spine) (Fig. 3.17B)

Despite its quaint name, **this is the most vicious and unstable injury to the cervical spine,** as 'everything goes': all the ligaments rupture and there will often be one or more fractures in the anterior and posterior parts of the affected vertebra, leading to paraplegia.

Some patients may suffer an incomplete *anterior cord syndrome*: loss of pain and temperature sense due to involvement of the spinothalamic tracts, but preservation of proprioception due to sparing of the dorsal columns.

Time to revisit some anatomy: two important lookalikes

- A normal cervical vertebra will often have a small corticated chin reminiscent of the little goatee beard of King Charles I of England (Fig. 3.17A). The

Fig. 3.14 *Fractured odontoid with backward displacement (the arrow points to where the odontoid should be).*

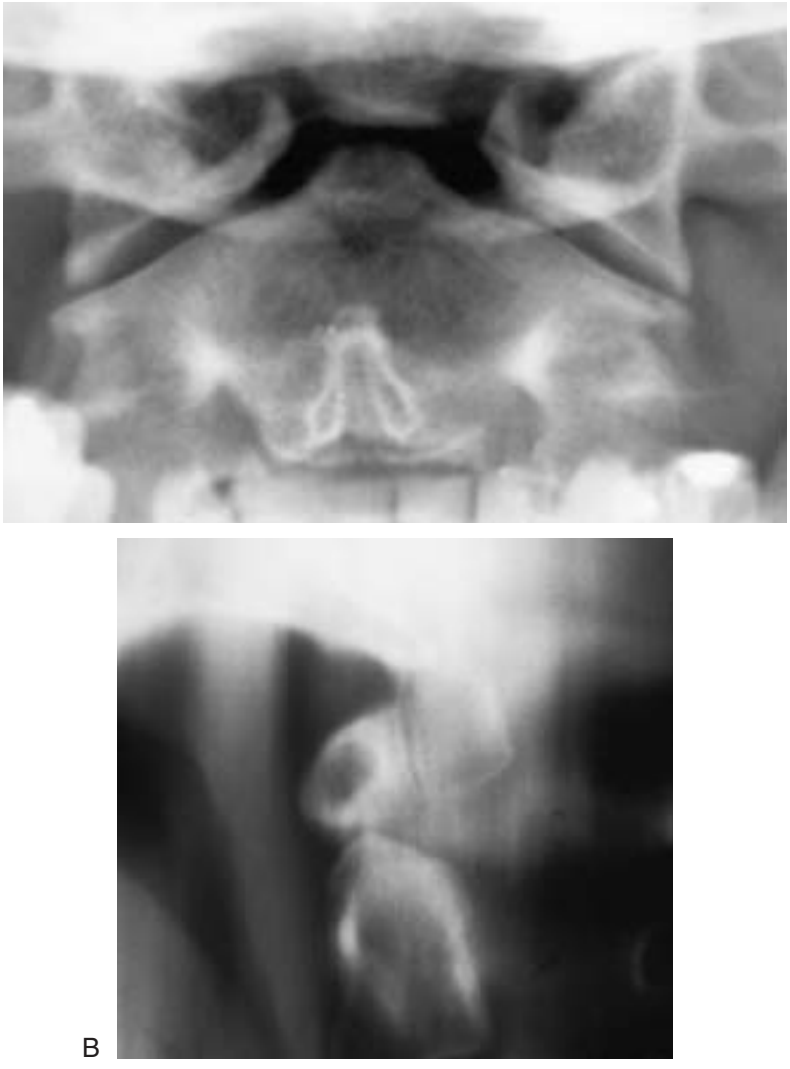
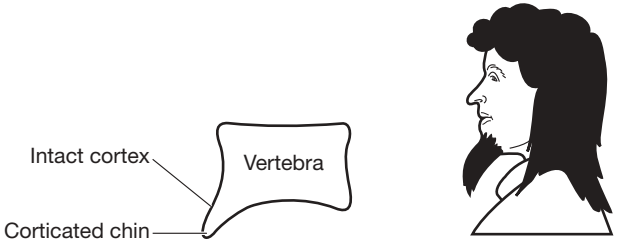


Fig. 3.15 *Congenital non-fusion of the odontoid.* ***A*** *AP;* ***B*** *lateral tomogram – a vertical 'slice' through the atlantoaxial joint area.*

Fig. 3.16 *Clay shoveller's fracture.*



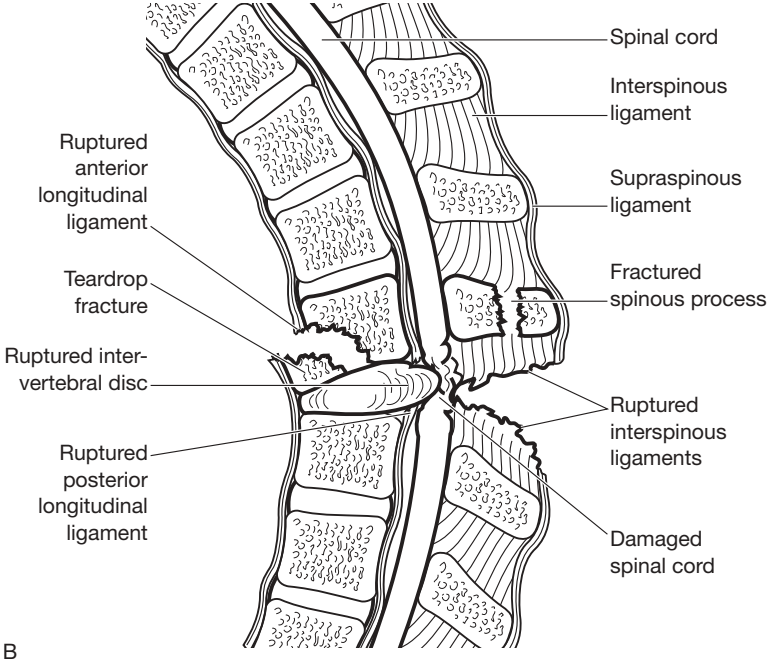


Fig. 3.17 ***A*** *Vertebra with 'corticated chin'.* ***B*** *Flexion teardrop fracture and associated injuries.*

anomaly (Fig. 3.17a) becomes more prominent with age, and sometimes undergoes osteophytic enlargement in osteoarthritis. Little detached bony fragments also often present in front of the disc spaces as a result of incompletely fused epiphyseal remnants.

- When looking for a teardrop fracture (Fig. 3.17B), check for an incompletely corticated chin and corresponding defect on the adjacent vertebral body. A further fracture and variable backward dislocation of the vertebra above will also be present with interruption of the 'spinal lines', depending on the severity of the injury.

Extension injuries

These are commonest in the upper cervical spine and usually less devastating than flexion injuries, but they can still be very serious and will occasionally lead to death. They include:

- Odontoid fracture.
- Fracture of the posterior arch of C1.
- Hyperextension fracture dislocation.
- Hangman's fracture.
- Extension teardrop fracture.

Odontoid fractures (as above).

If due to flexion, the peg may go forwards. If due to extension, the peg may go back.

Fracture of the posterior arch of C1

Careful inspection of this difficult area may show a fracture line or cortical discontinuity. This injury is stable.

Important normal variant Sometimes there are congenital defects in the posterior arch of the atlas. See also the Jefferson fracture (pp 88, 90).

Hyperextension fracture dislocation

Sufficient hyperextension trauma can cause a severe fracture dislocation with

backward displacement of the superior components. If it has occurred, it should be apparent on the initial film taken on the patient's arrival.

Two special cases

- *Prolapsed intervertebral disc*. Sometimes when a fracture is found the clinical signs may be out of proportion to the visible radiographic abnormality. An MRI scan may then show that a *simultaneous disc protrusion* has occurred which has severely damaged the cord.
- *The geriatric neck*. Because an elderly patient's rigid neck will inevitably harbour extensive degenerative changes, consisting of osteophytic lipping and ligamentous thickening, an abrupt extension injury can wrinkle the posterior longitudinal ligament (attached to the posterior aspect of the vertebral body) and compress the anterior spinal artery, leading to cord damage. This causes the *anterior spinal artery syndrome,* which will weaken the arms but spare the legs.

The hangman's fracture (fracture dislocation of C2 on C3) (Fig. 3.18)

It is relevant for the A & E doctor to understand the distinction between 'hanging' causing death by protracted strangulation, a ghastly fate suffered by countless thousands over the ages, and even those today who commit suicide, and the judicial execution called 'hanging' due to a drop, which, if carried out 'efficiently', would lead to virtually instantaneous death. Emergency cases will still sometimes present at A & E half-strangled, having just been found and cut down in time. These patients may have suffered a fractured larynx, damaged trachea, etc., and may exhibit extensive surgical emphysema.

Traditionally the hangman would visit the condemned man before the execution to obtain the height, weight and assess the thickness of the neck. A specific drop could then be calculated from tables, plus any further nuances and adjustments based on past experience. At the end of the drop, the knot placed under the left side of the mandible on top of the hood would throw the head back, distract the neck and inflict the fatal injury. With too much or too little drop, a 'hanging' could cause decapitation or strangulation.

What is today called a *hangman's fracture* or *traumatic spondylolisthesis* is a fracture through the pars interarticularis of C2. This may present as an isolated crack (type I) or continue down into the intervertebral disc (type II) and in severe cases go on to a complete fracture dislocation (type III). Needless to say, these days it is usually caused by a road traffic accident in which the head strikes the

Fig. 3.18 *Hangman's fracture. Note the crack in the posterior lamina and forward dislocation of C2 on C3 (top arrow). Note also the gap between the spinous processes of C2 and C3 ('fanning', middle arrow) and also the previous trauma to C6 (bottom arrow).*

windscreen, so perhaps it is time it was called a 'windscreen fracture'. This injury is unstable.

Extension teardrop fracture

This is similar in appearance to its 'big brother' the flexion teardrop fracture, but much less serious. It is due to an extension injury with avulsion of a small fragment or fragments of bone, but there is no subluxation and this injury is stable. It usually occurs around C2 or C3 and there is likely to be prevertebral swelling of more than 7 mm with this injury.

The atlantoaxial joint

On the lateral view of the neck the anterior arch of the atlas normally sits 2–3 mm in front of the odontoid peg, forming the anterior atlantoaxial joint space. Following trauma, the surrounding ligaments may rupture, leading to atlantoaxial subluxation, i.e. a gap forming here of more than 3 mm in an adult and more than 5 mm in a young child (a child's neck normally being more mobile).

NB The atlantoaxial joint may also destabilize laterally, although such lateral displacements can be simulated by lateral head flexion and obliquity of positioning, but when positional there will be no offset (see below).

Important point: Many pre-existing diseases may lead to atlantoaxial subluxation, the most important of which is rheumatoid arthritis. Often the films look normal in the neutral position but a subluxation is unmasked by forward flexion (Fig. 3.19), and rarely by extension or lateral flexion. The most important application of this knowledge (other than when sitting examinations) lies in the checking of rheumatoid necks before excessive hyperextension for intubation in anaesthesia, which can be fatal.

Compression injuries

It does not take too much imagination to realize what may happen if a patient falls from a height on to the top of his head or a concrete block falls and hits it. Exactly the right spot needs to be struck to transmit a truly vertical force and most impacts will cause sudden severe flexion or extension to occur. Such vertical forces may, however, break and disturb the ring of the atlas, causing a *Jefferson fracture* (Fig. 3.20). This is identified by inferolateral displacement of both lateral components beyond the articular margins of the axis on the AP view of the

upper neck. This plain film finding is known as a *bilateral offset*. If identified, or even suspected, further evaluation by CT is warranted. Alternatively, a 'burst fracture' of a vertebral body may occur at a lower level, causing comminution (i.e. shattering). A CT scan will demonstrate any spicules of bone extending into the spinal canal (Fig. 5.4, p. 112).

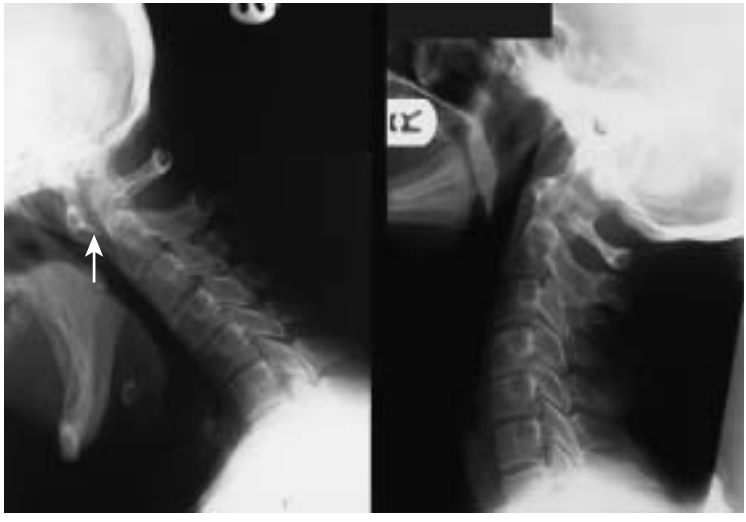
Hard to spot, but requiring a high index of suspicion too, is a fracture of the occipital condyles, so do not switch off that CT machine just yet.

Question: Is it true a patient with a congenital defect in the posterior arch of C1 can have a bilateral offset without trauma?

Answer: Yes.

Rotational injuries

The more one understands about neck injuries, the more it becomes apparent that multiple forces are at work necessitating extending the concept of injury



A B

Fig. 3.19 ***A*** *Flexion and* ***B*** *extension views of neck showing atlantoaxial subluxation (arrow) on full forward flexion and reduction in full extension.*

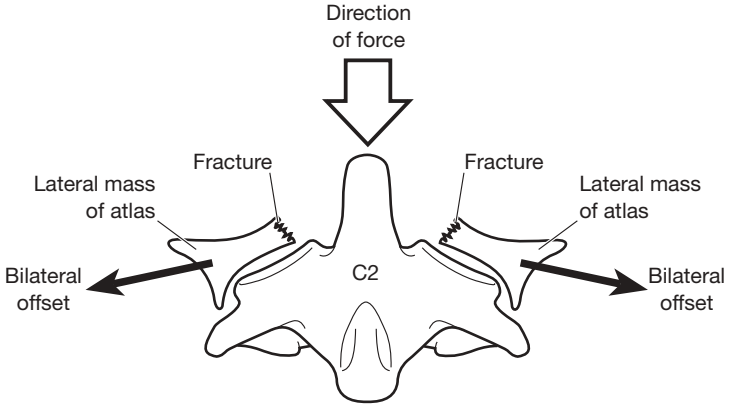


Fig. 3.20 *A Jefferson fracture.*

from simple flexion and extension events. Rotational forces contribute to dislocations at the craniocervical junction, 'rotary dislocations' at C1/C2 and unilateral facet joint dislocations at a lower level. Even more complex shearing and distraction forces may cause lateral mass and transverse process fractures, as well as disc space narrowing or even widening with hyperextension. Confirmation of the esoteric signs of such findings is a job for the radiographer to demonstrate, radiologist to interpret and the orthopaedic or neurosurgeons to treat.

Whiplash injury

This is a combined flexion/extension injury caused at the moment of a collision ahead or shunt from behind, the second movement being a recoil from the first. The headrests in modern vehicles are designed to cushion the extension impact but in older vehicles only the chin on the chest limits forward movement, but now hopefully our quick-acting airbags will inflate spontaneously in our faces.

The severity or speed of the impact will determine whether or not ligamentous or neurological damage is sustained.

Summary of normal variants that may cause diagnostic confusion

- Congenital non-fusion of the odontoid.
- Dark bands from overlying bony and soft tissue structures (tongue, tonsils).
- Congenital defects in the arch of the atlas.
- Block vertebrae with failure of segmentation.
- Small developmentally detached fragments of bone at the lower anterior margin of a vertebral body (limbus vertebra).
- Persistent developmental wedge-shape of a vertebra (most vertebrae from C3 to C7 look the same).
- Increased mobility of the neck in children, causing 'pseudosubluxations'.
- Extensive gaps between spinous processes simulating 'fanning'. Interpret this apparent finding with caution and compare against any previous films.
- Ring apophyses causing bony spicules on developing vertebral bodies (children).
- Sagittal chunks of calcification in the ligamentum nuchae.
- Accessory ossification centres at spinous processes (simulating clay shoveller's fractures).
- Normal upward riding of facet joints on forward flexion and reversal of normal lordosis in, for example, 'the military position' (chin on chest).
- Wide prevertebral soft tissues in children (see p. 190).

Check Keats & Anderson (2001) for more examples.

Non-traumatic neck pain

Patients will frequently arrive in A & E with a sore neck. The vast majority will have degenerative osteoarthritis. A few will have rheumatoid arthritis and a very few will be presenting with a metastasis. Think also about retropharyngeal infection, plus very rarely a cord tumour.

Some general principles in dealing with necks

- Maintain a high index of suspicion for neck trauma in all patients but particularly in those with head and facial injuries.
- Try and establish the mechanism of injury from the patient, relatives, police or paramedics.
- Consider every injured neck unstable until proved otherwise.
- Do a thorough neurological examination.
- Get senior help early with severe neck injuries – if such patients have not already been commandeered as departmental policy.
- Ensure a thorough X-ray examination is done, or the optimum possible.
- Remember to move rapidly to CT/MRI if conventional films do not give the answer. Plain films have their limitations.
- Remember the false fullness of prevertebral tissues in children due to expiration, flexion, crying and swallowing.
- In every injury think: **What has happened to the ligaments?**
- Always look for more than one injury: 8% of patients will have another one.
- Forget Kia-Ora, the drink, and think about SCIWORA (Spinal Cord Injury Without Radiographic Abnormality). In this entity you can have a severe neurological injury with a normal X-ray. The patient's best chance then lies with you (1) doing a thorough neurological examination, and (2) having the nous to treat the patient not the X-ray.
- Remember the concept of delayed instability – early spasm and pain can mask it. Do flexion/extension views at 14 days if the patient is still in pain, if not contraindicated, and **make sure the patient stays in a collar in the meantime.**

Summary of approach to radiographic analysis of trauma neck X-rays

- Confirm the patient's name, date of birth and date of X-ray prior to any assessment of each film. Do not forget to ask the $64 000 question: **Who's neck is it anyway?** It's too easy in the excitement of a major incident to overlook this. Remember you may have six neck injuries in A & E simultaneously after a train crash – and three 'unknowns'.
- Check the radiographic quality and confirm you have lateral views from C1 to the top of the T1 vertebra. If not, the radiographer will already have attempted a swimmer's view or trauma obliques. Getting down to C7/T1 may show up 90% of relevant injuries if other circumstances are favourable.
- Check left and right.
- Consider the need for CT/MRI .
- In the light of the known or likely mechanism of injury, check for any immediately apparent gross abnormality – some will hit you right between the eyes – e.g. a complete 2 cm anterior separation of C3 upon C4, which will be obvious.
- If there is no immediately obvious abnormality, carry out a systematic analysis of the films, but do it afterwards anyway, and do not stop looking just because you have found one abnormality.
- Check the four main 'magic lines' for smooth continuity or steps (Fig. 3.3).
- Check the prevertebral soft tissues for swelling.
- Check for evidence of preceding disease, especially severe rheumatoid arthritis or osteoarthritis. These may be associated with degenerative or rheumatoid subluxations and separate bony particles anterior to the spine (to be distinguished from teardrop fractures and narrowing of the disks).
- Check the atlantoaxial joints for widening on the lateral views and asymmetry on the AP view.
- Check the atlantoaxial joints for bilateral offset, indicating Jefferson fractures.
- Check the odontoid and follow all the dark lines crossing it to make sure that they go all the way beyond it before diagnosing a fracture.

Summary *continued*

- Look through the bones and do not just give up because the anatomy looks complex.
- Put a bright light on the dark areas if necessary (e.g. spinous processes), or make optimum use of image manipulation at your workstation.
- If there is bony overlap of vertebral bodies assess its degree and look for facet dislocation or locking. Up to 25% = unilateral; >50% = bilateral. Bony overlap of >3.5 mm with a fracture indicates instability.
- Look for 'fanning' of the spinous processes: suspect it if more than 12 mm separation is visible, which may indicate instability, but remember that even wider separation can be a normal variant. Check against previous films and remember flexion will accentuate it. >10% of angulation between vertebrae = instability.
- Check the AP film for malalignment of the spinous processes. They should be in line and equidistant.
- Check for disc narrowing and widening or air in the discs (distraction/chronic degeneration).
- Look around and through the films at the skull base and cranial cavity (lateral and AP) and do not miss something gross like a dislocation of the head. (p. 72).
- Ask yourself again: **Do I need more views now? Do I need CT/MRI urgently? Should I contact the neuro- or orthopaedic surgeons?**