In the Name of God

Approach to Fractures

Dr.Ali Hajihashemi

Assistant Professor of Radiology
Isfahan University of Medical Sciences

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Topics

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Types of axial fx

02

Post surgical findings

03

Union and non-union

Types of Fractures

01 Skull

02 spine

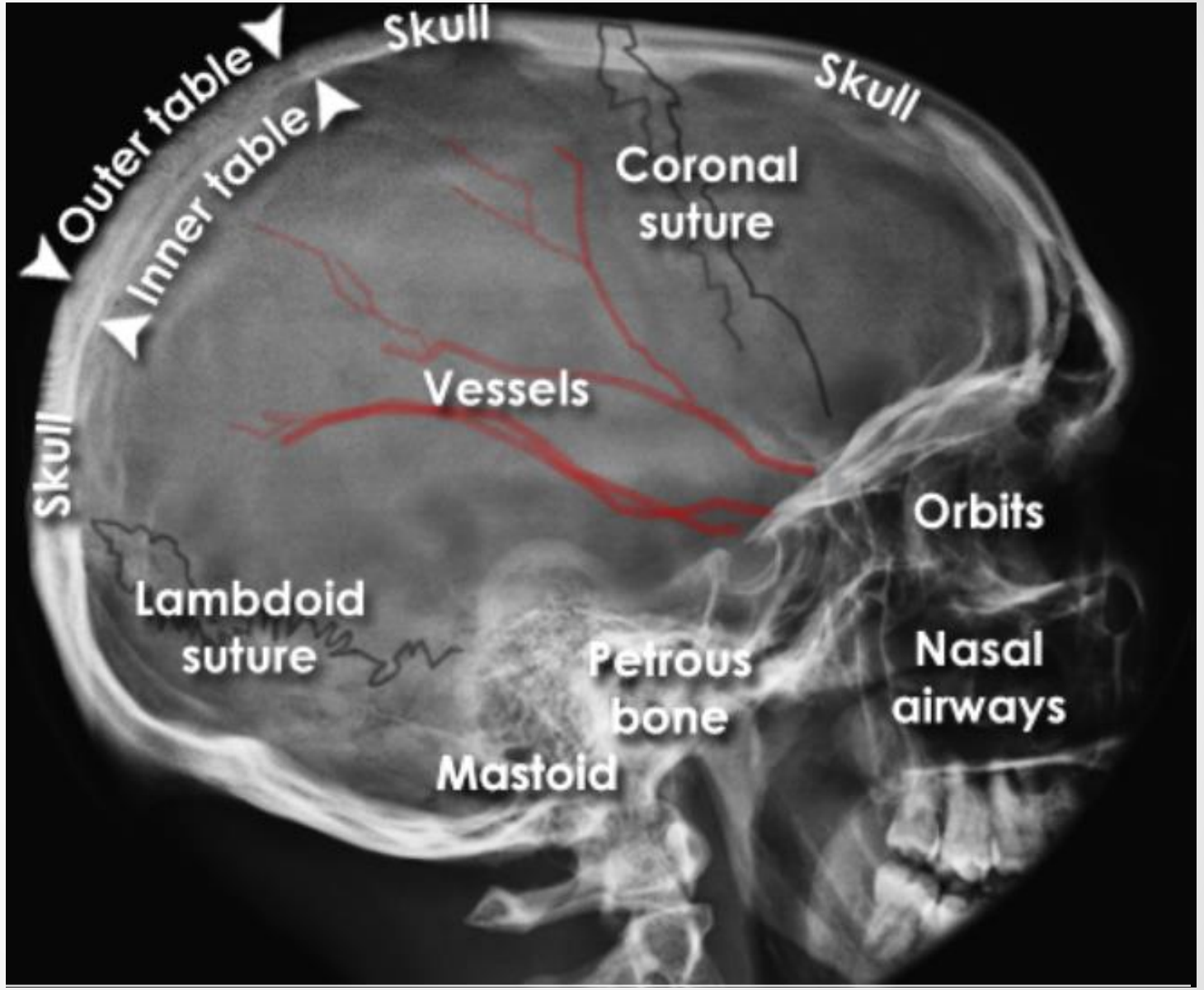
03 Sacrum & pelvis

04 Sternum & ribs

05 Face

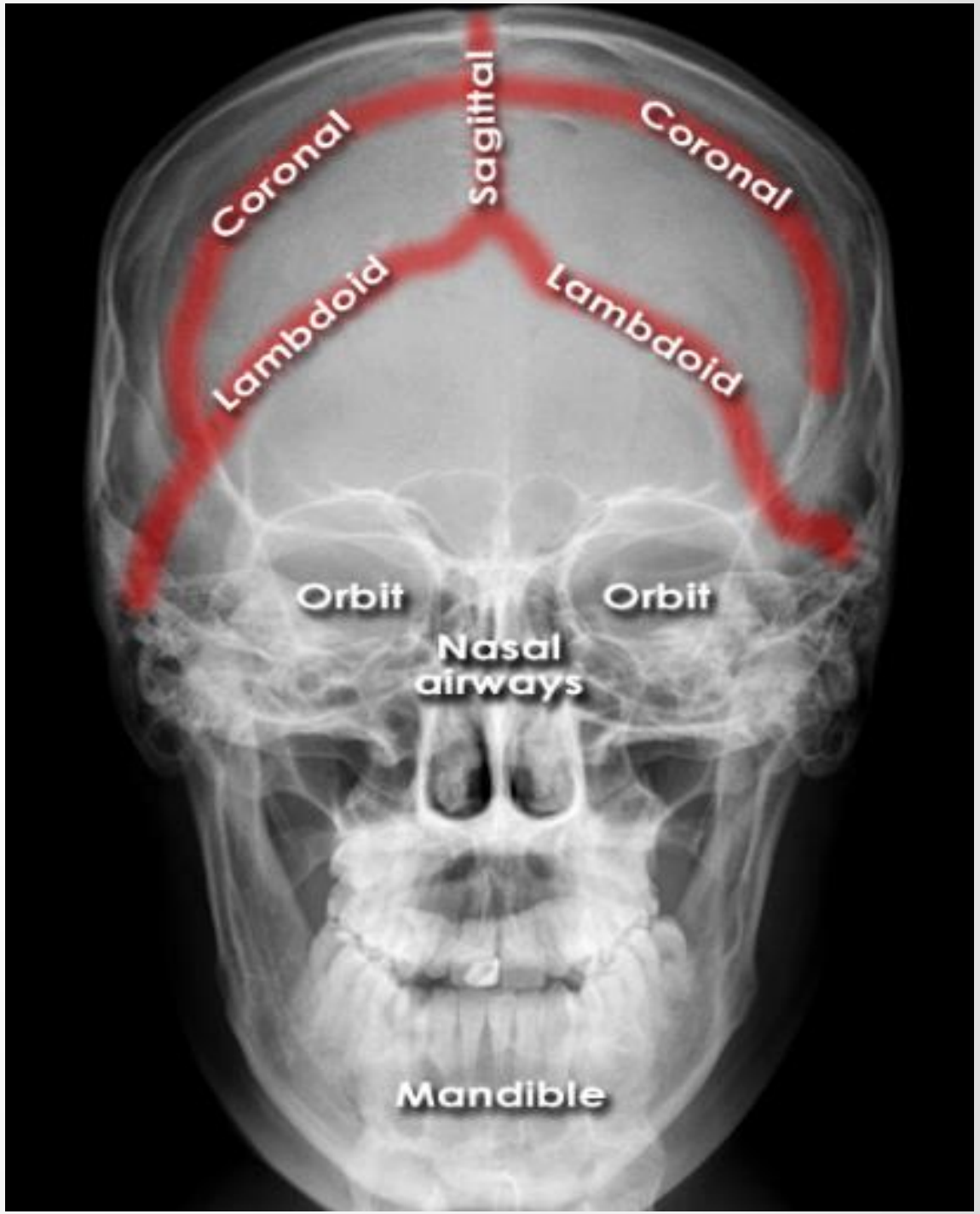
Normal skull - Lateral

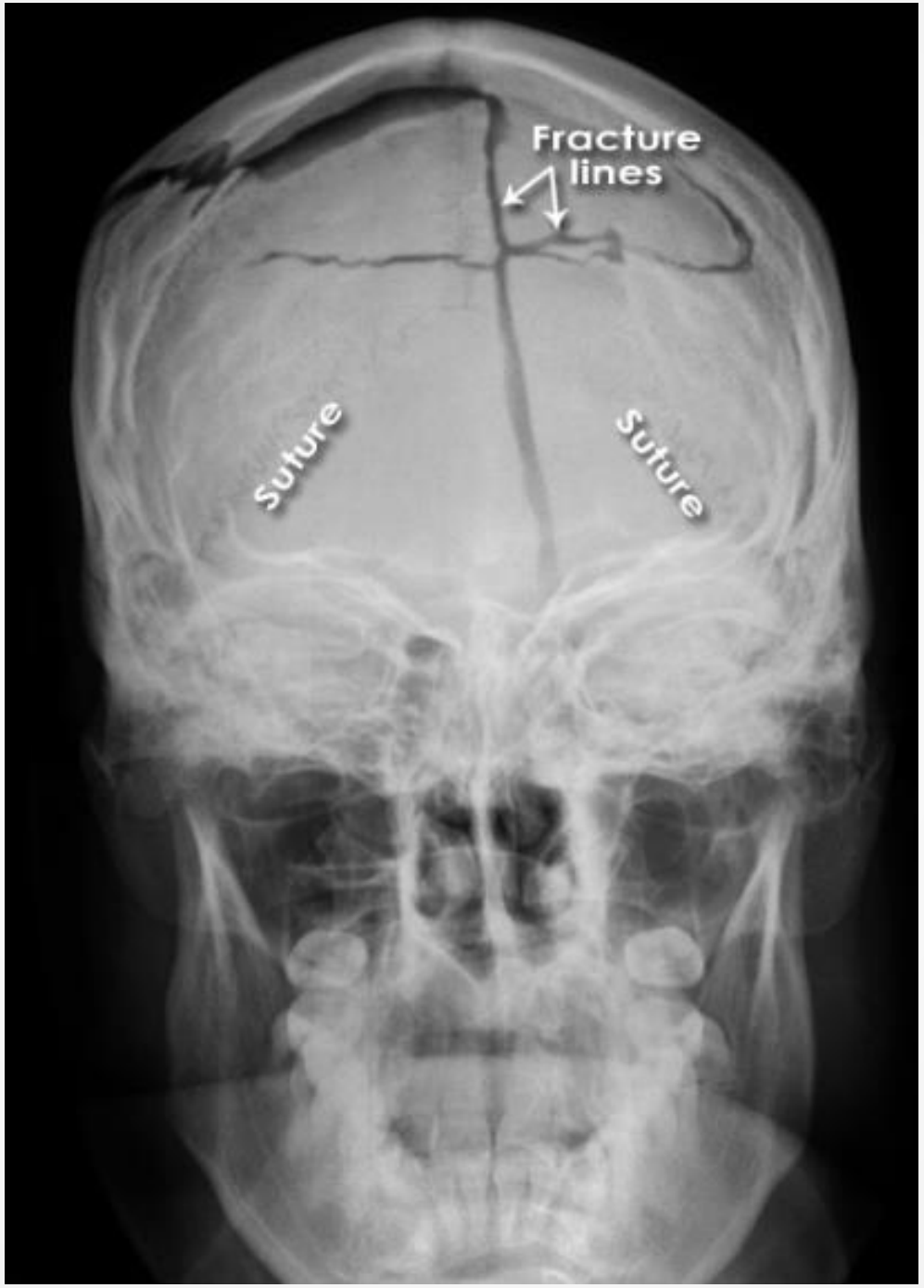
- Anatomically the skull has inner and outer surfaces or 'tables'
- Skull X-rays show the course of vessels which indent the inner table
- These vascular indentations branch and taper - whereas fractures do not usually branch or taper



Normal skull - AP

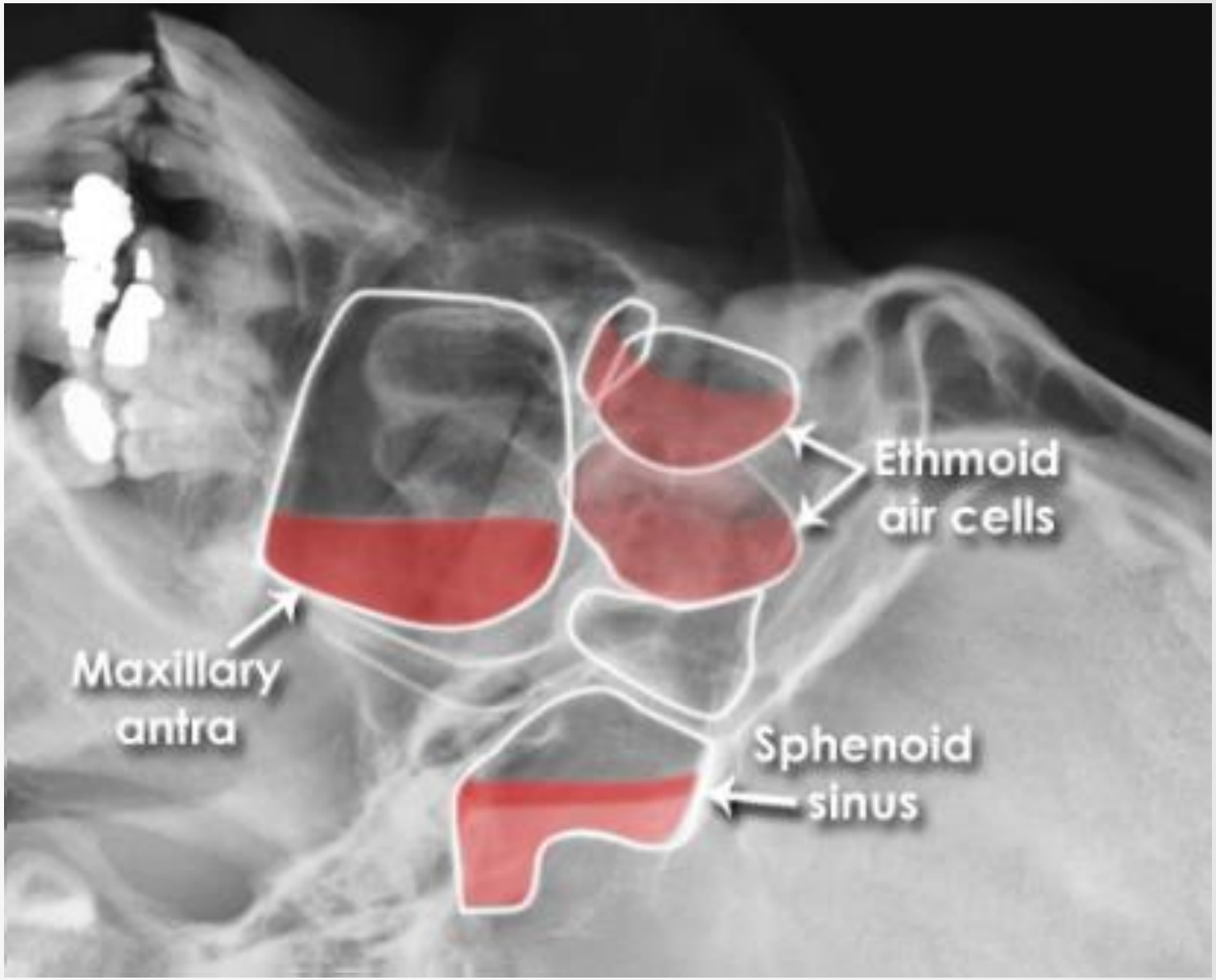
- Sutures have a saw-tooth appearance which distinguishes them from fractures which form smooth lines




Fracture lines
Suture
Suture

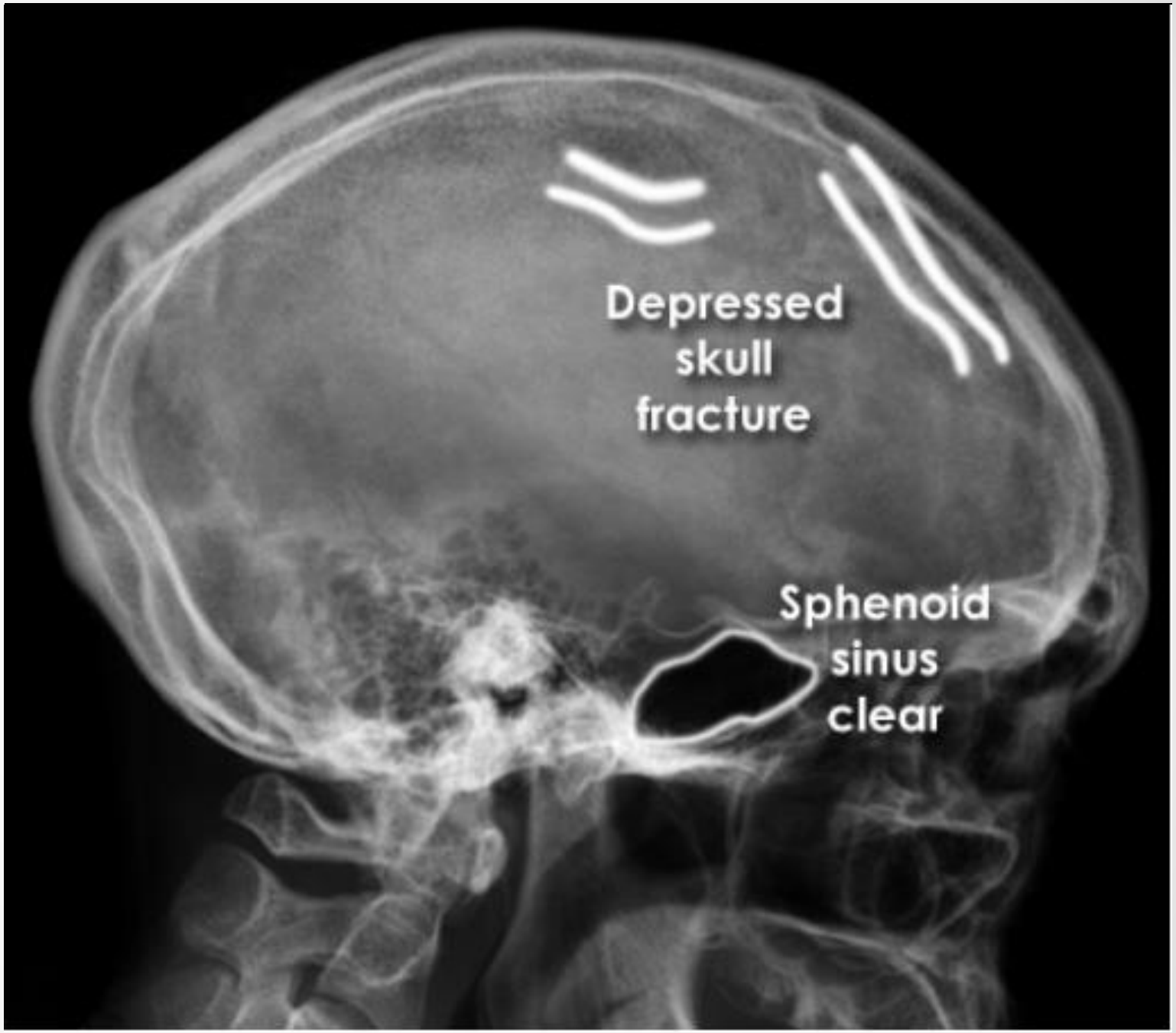
Sphenoid air-fluid level

- No fracture is visible
- The air-fluid level seen in the sphenoid sinus is due to haemorrhage or CSF leakage due to basal skull fracture
- The other paranasal sinuses also contain blood due to facial bone injury



Skull - Depressed fracture

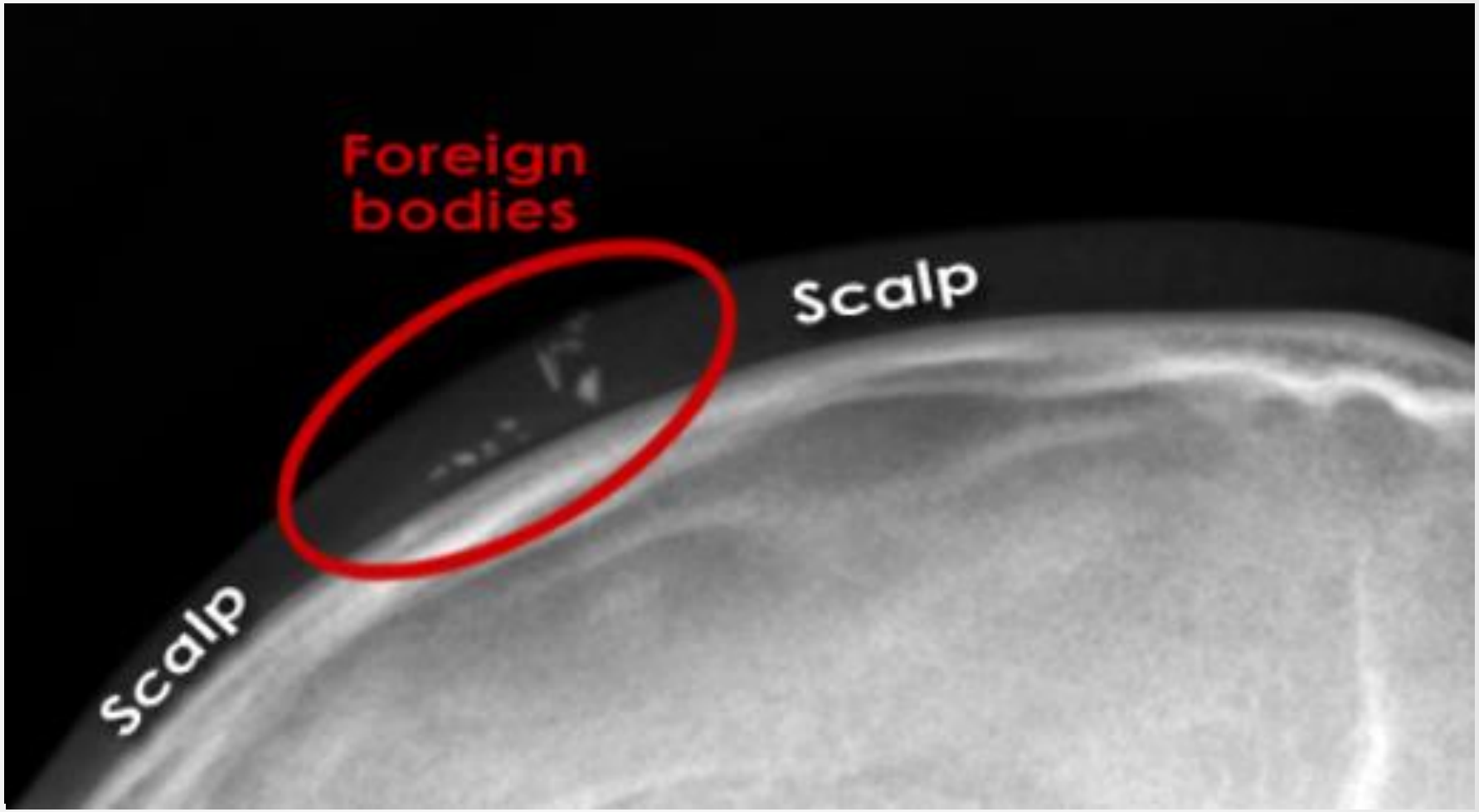
- Displaced or depressed skull fractures may result in overlapping bone which causes white lines of increased density
- **Note**: The sphenoid sinus is clear - however this does not exclude a basal skull fracture



Scalp foreign bodies

- A dedicated soft tissue X-ray taken at an appropriate angle clearly shows several foreign body fragments in the scalp - glass in this case

Request :
foreign body X-rays



Types of Fractures

01 Skull

02 spine

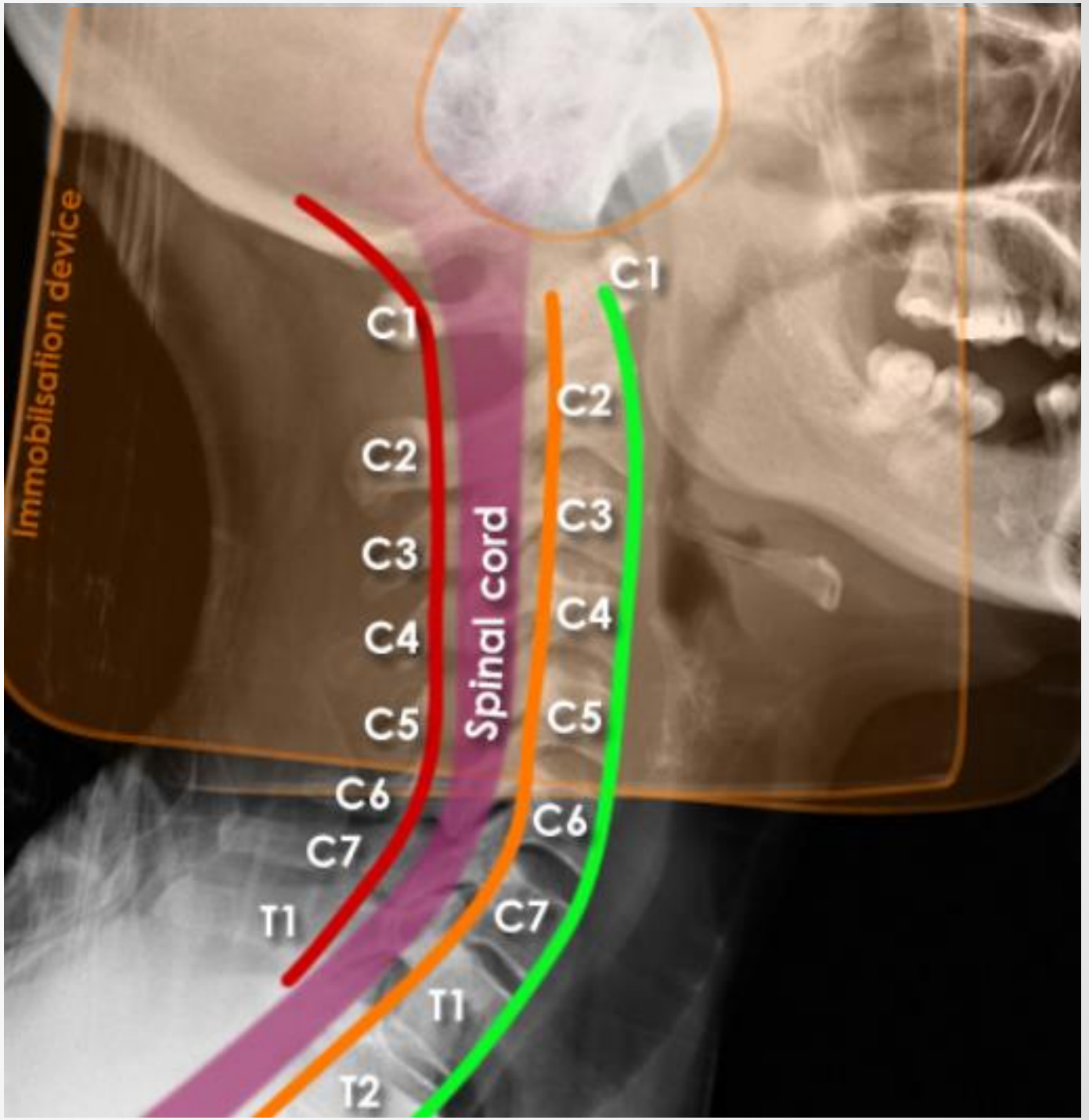
03 Sacrum & pelvis

04 Sternum & ribs

05 Face

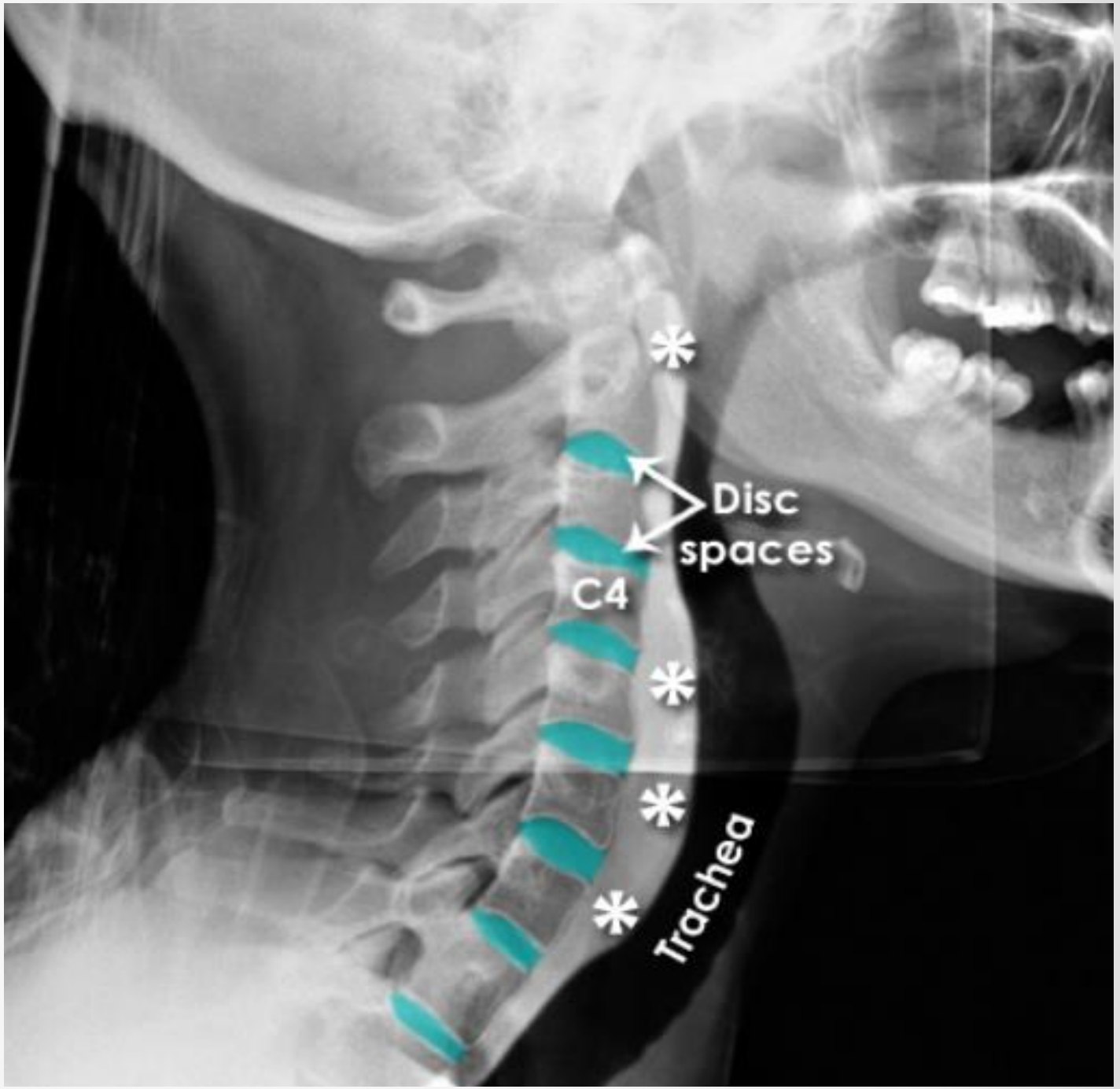
C-spine systematic approach - Normal Lateral 1

- **Coverage** - All vertebrae are visible from the skull base to the top of T2 (T1 is considered adequate)
- - If T1 is not visible then a repeat image with the patient's shoulders lowered or a 'swimmer's' view may be necessary
- **Alignment** - Check the Anterior line (the line of the anterior longitudinal ligament), the Posterior line (the line of the posterior longitudinal ligament), and the Spinolaminar line (the line formed by the anterior edge of the spinous processes - extends from inner edge of skull)
- - **GREEN** = Anterior line
- - **ORANGE** = Posterior line
- - **RED** = Spinolaminar line
- **Bone** - Trace the cortical outline of all the bones to check for fractures
- **Note**: The spinal cord (not visible) lies between the posterior and spinolaminar lines



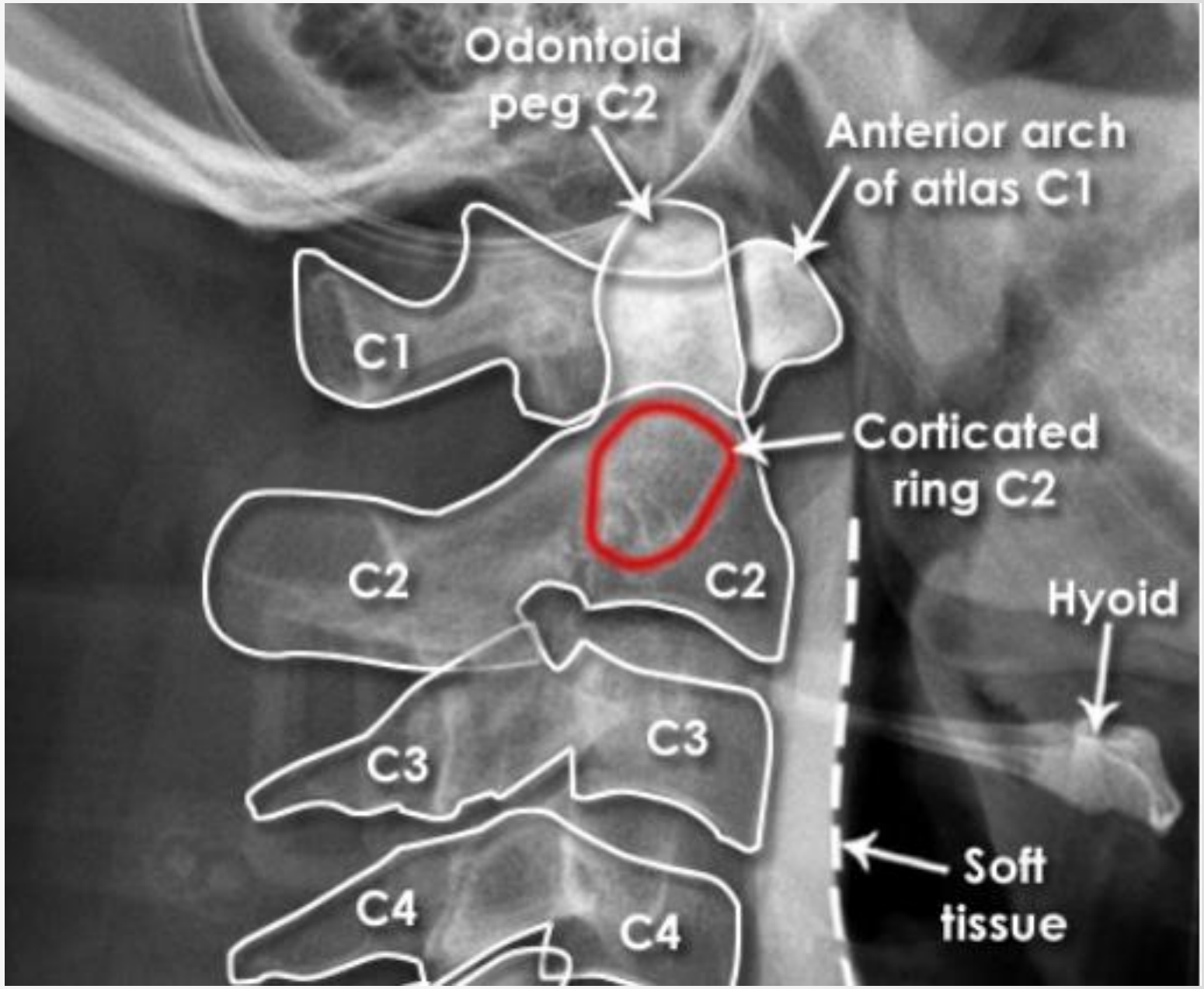
C-spine systematic approach - Normal Lateral 2

- **Disc spaces** - The vertebral bodies are spaced apart by the intervertebral discs - not directly visible with X-rays. These spaces should be approximately equal in height
- **Pre-vertebral soft tissue** - Some fractures cause widening of the pre-vertebral soft tissue due to pre-vertebral haematoma
- - Normal pre-vertebral soft tissue (asterisks) - narrow down to C4 and wider below
- - Above C4 ≤ 1/3rd vertebral body width
- - Below C4 ≤ 100% vertebral body width
- **Note**: Not all C-spine fractures are accompanied by pre-vertebral haematoma - lack of pre-vertebral soft tissue thickening should **NOT** be taken as reassuring
- **Edge of image** - Check other visible structures



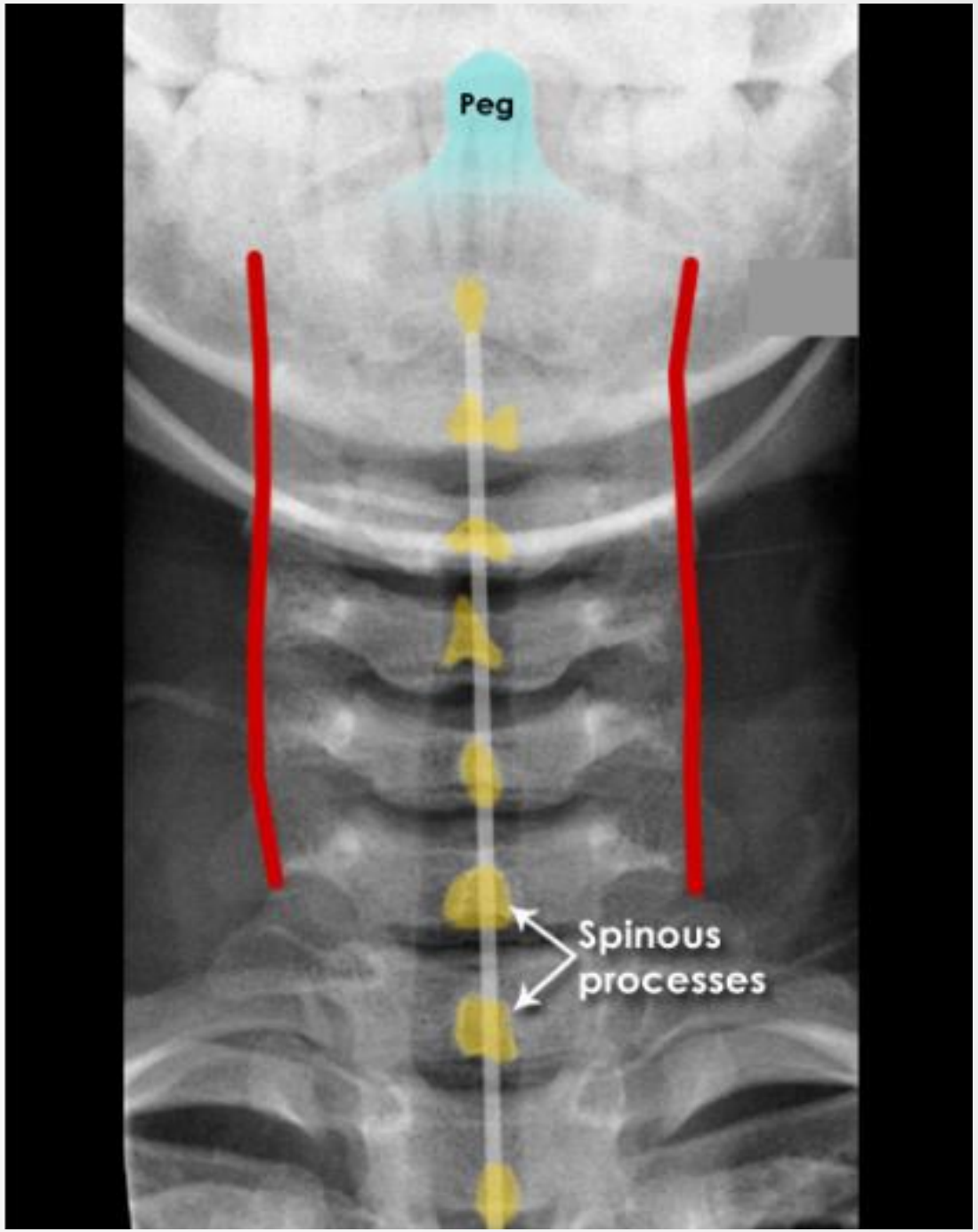
C-spine normal anatomy - Lateral (detail)

- **Bone** - The cortical outline is not always well defined but forcing your eye around the edge of all the bones will help you identify fractures
- **C2 Bone Ring** - At C2 (Axis) the lateral masses viewed side on form a ring of corticated bone (**red ring**)
- This ring is not complete in all subjects and may appear as a double ring
- A fracture is sometimes seen as a step in the ring outline



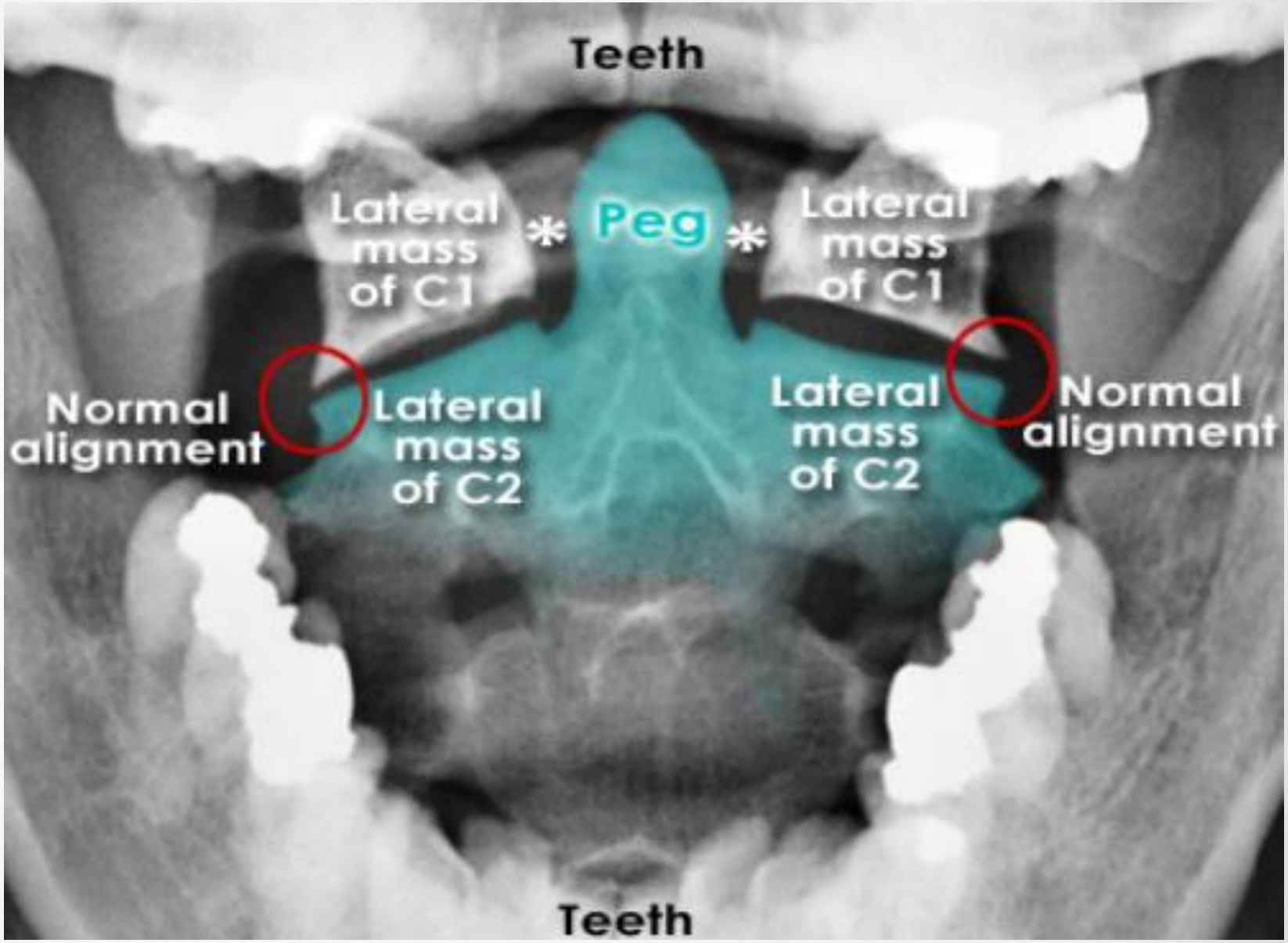
C-spine systematic approach - Normal AP

- **Coverage** - The AP view should cover the whole C-spine and the upper thoracic spine
- **Alignment** - The lateral edges of the C-spine are aligned (red lines)
- **Bone** - Fractures are often less clearly visible on this view than on the lateral
- **Spacing** - The spinous processes (orange) are in a straight line and spaced approximately evenly
- **Soft tissues** - Check for surgical emphysema
- **Edges of image** - Check for injury to the upper ribs and the lung apices for pneumothorax



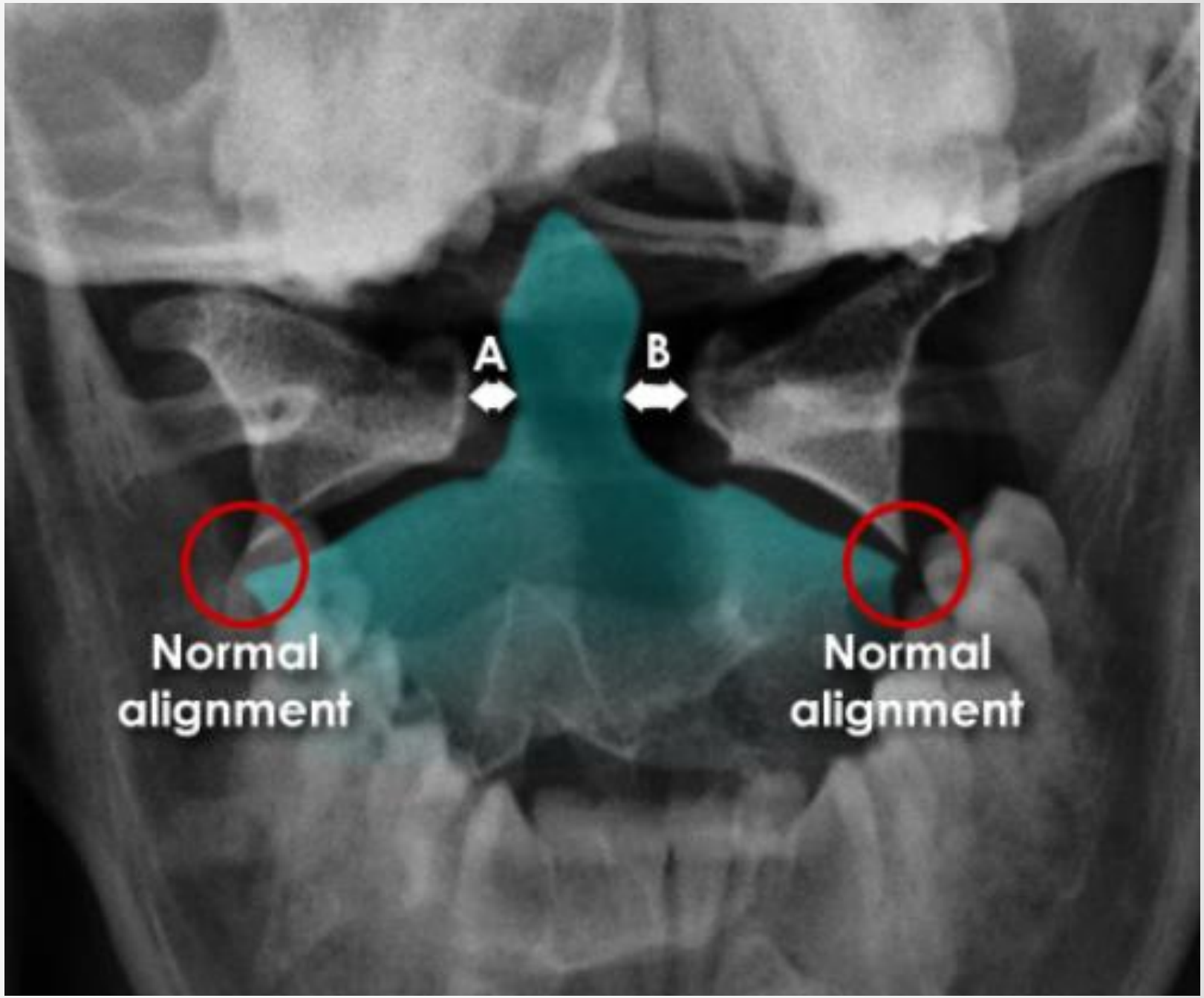
C-spine normal anatomy - Open mouth view

- This view is considered adequate if it shows the alignment of the lateral processes of C1 and C2 **(red circles)**
- The distance between the peg and the lateral masses of C1 (**asterisks**) should be equal on each side
- **Note:** In this image the odontoid peg is fully visible which is not often achievable in the context of trauma due to difficulty in patient positioning



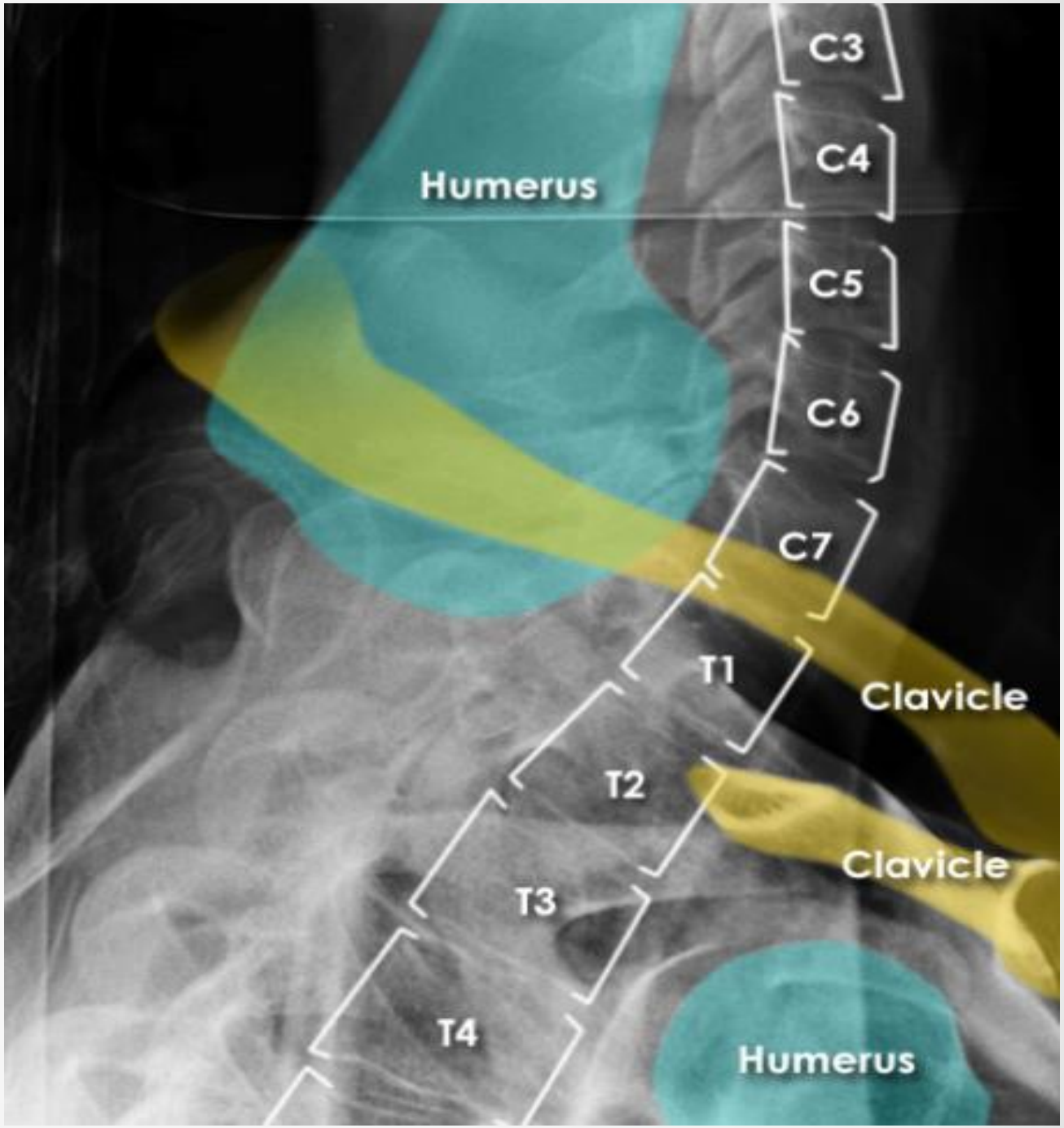
Open mouth view - Rotated

- The distance between the peg and the lateral processes is not equal - compare **A** (right) with **B** (left)
- This is because when the image was acquired the patient's head was rotated to one side
- Alignment of the lateral processes can still be assessed and is seen to be normal



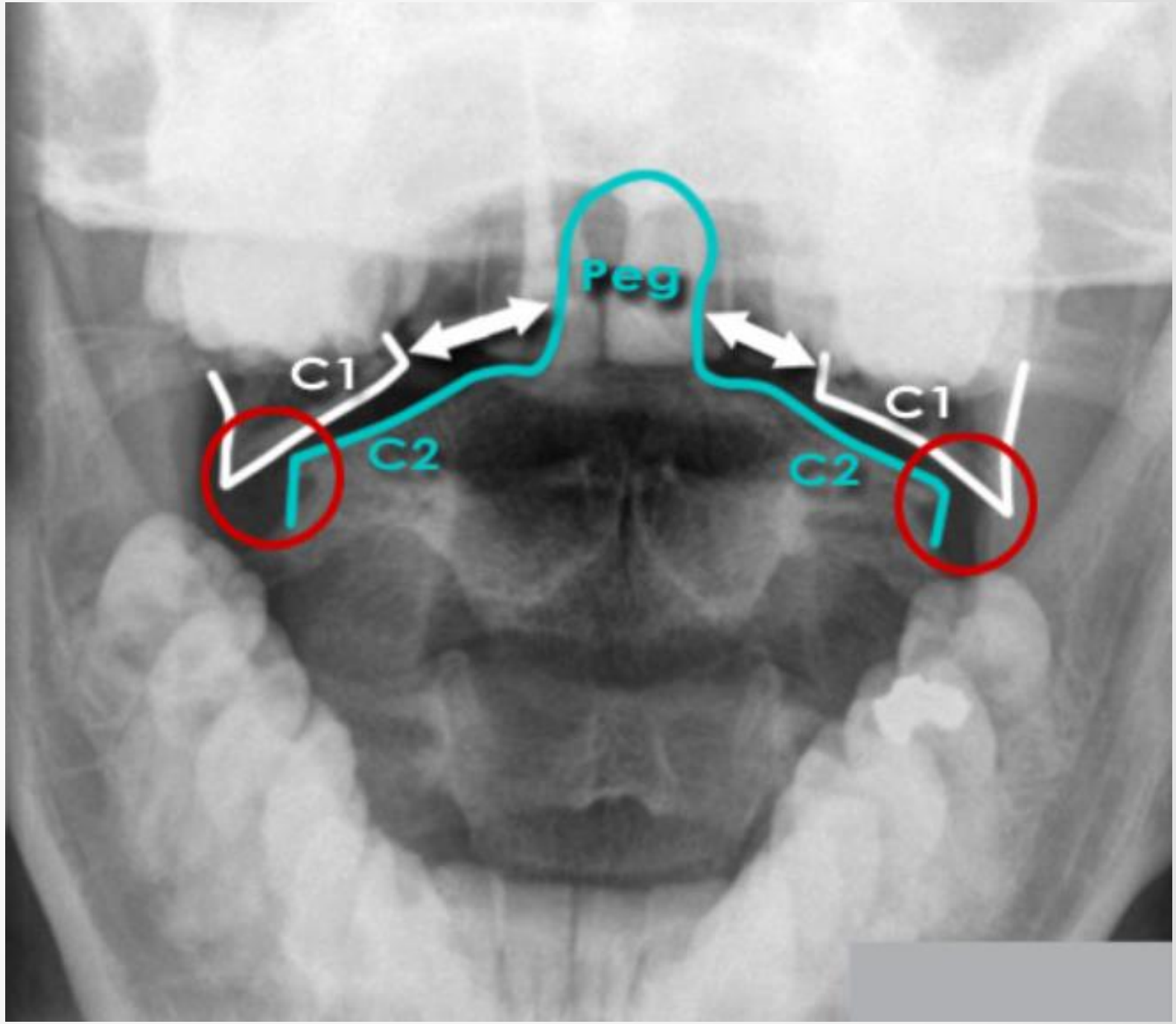
C-spine normal anatomy - ' Swimmer's' view

- Oblique image with the humeral heads projected away from the C-spine
- The cervico-thoracic junction can be seen
- Check alignment by carefully matching the corners of each adjacent vertebral body - anteriorly and posteriorly



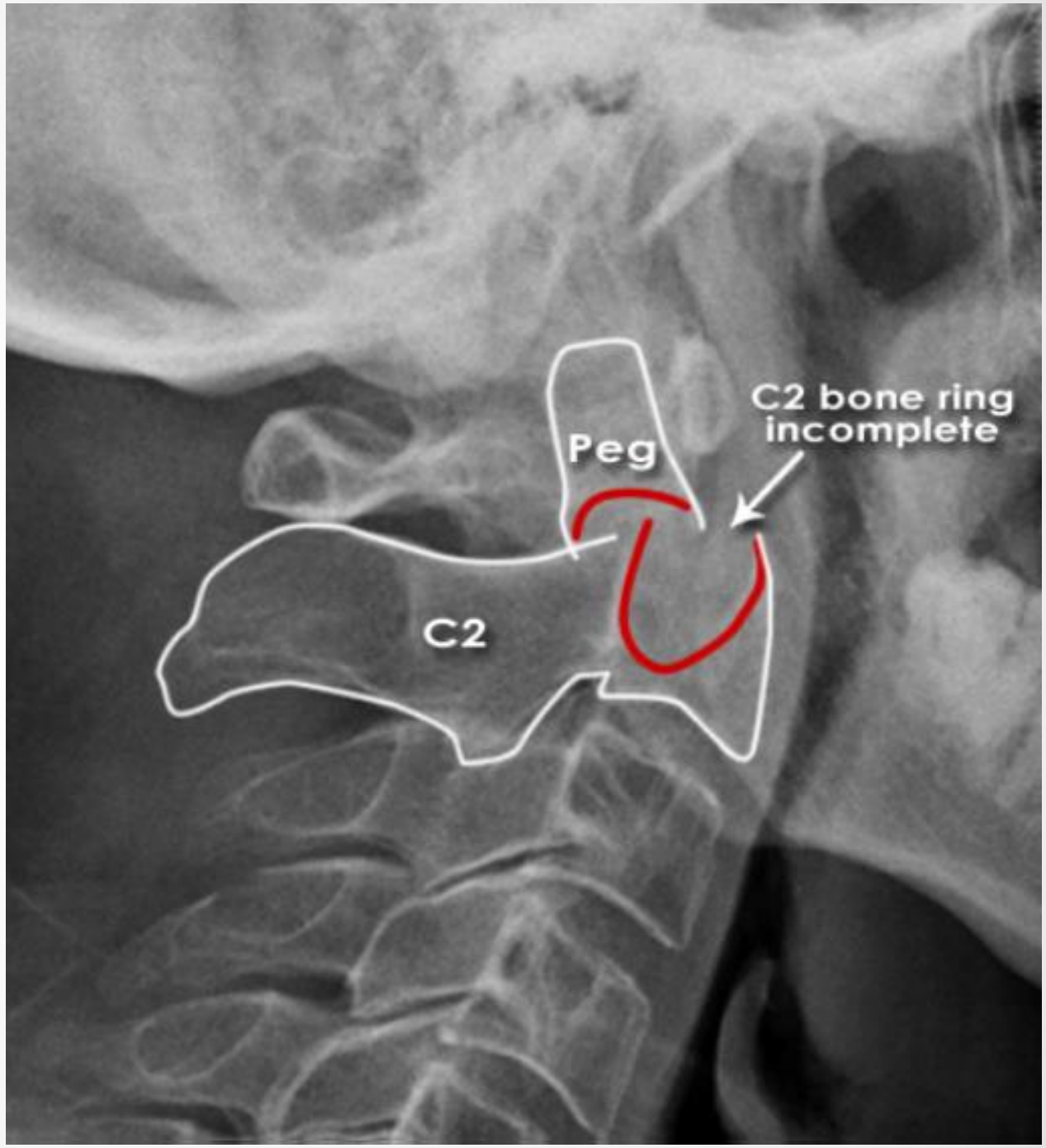
C1 'Jefferson' fracture - Open mouth view

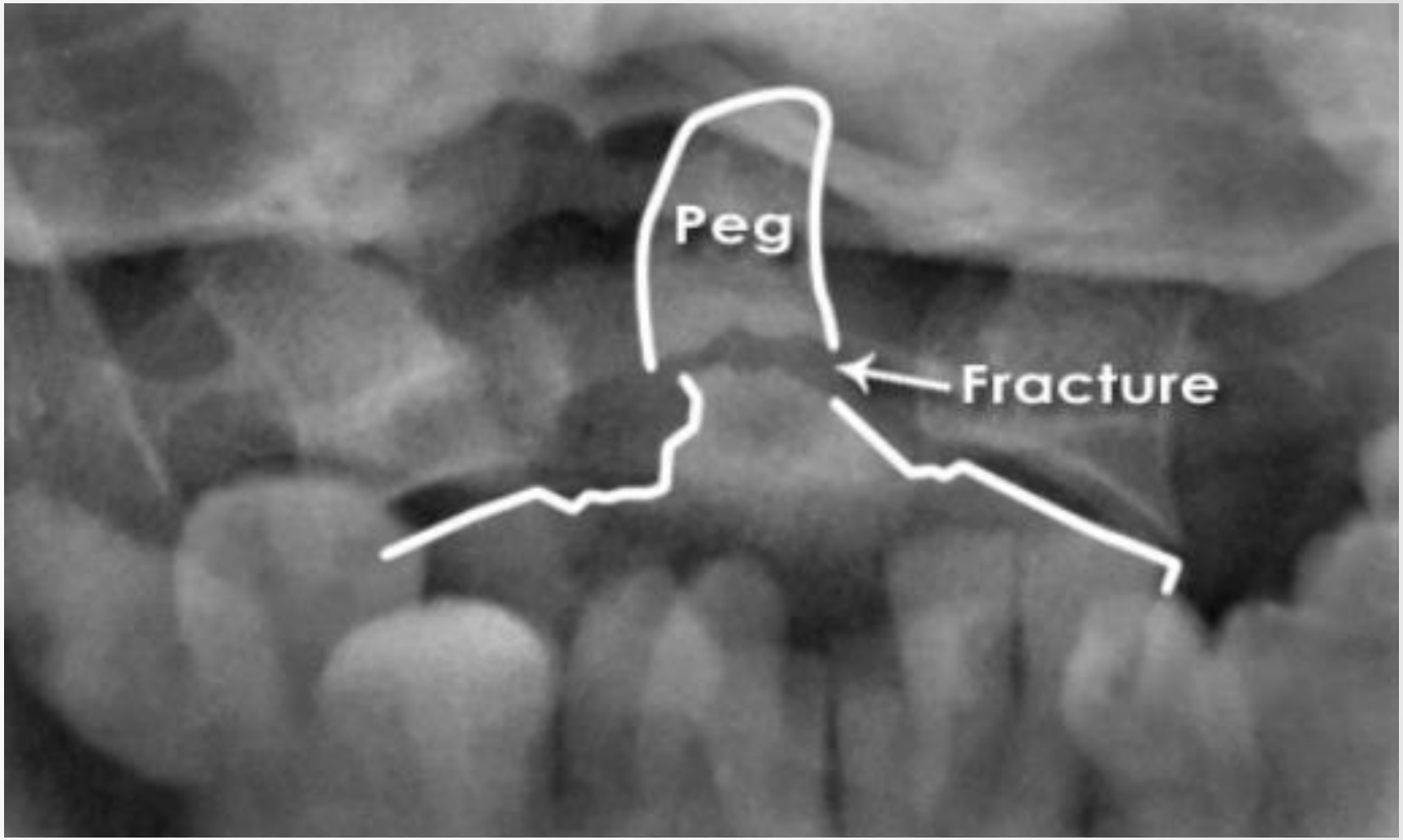
- The space between the odontoid peg of C2 and the lateral masses of C1 is widened on both sides (**arrows**)
- The lateral masses of C1 are both laterally displaced and no longer align with the lateral masses of C2 (**red rings**)



C2 odontoid peg fracture - Lateral view

- The C2 bone 'ring' is incomplete due to a fracture
- The odontoid peg is displaced posteriorly





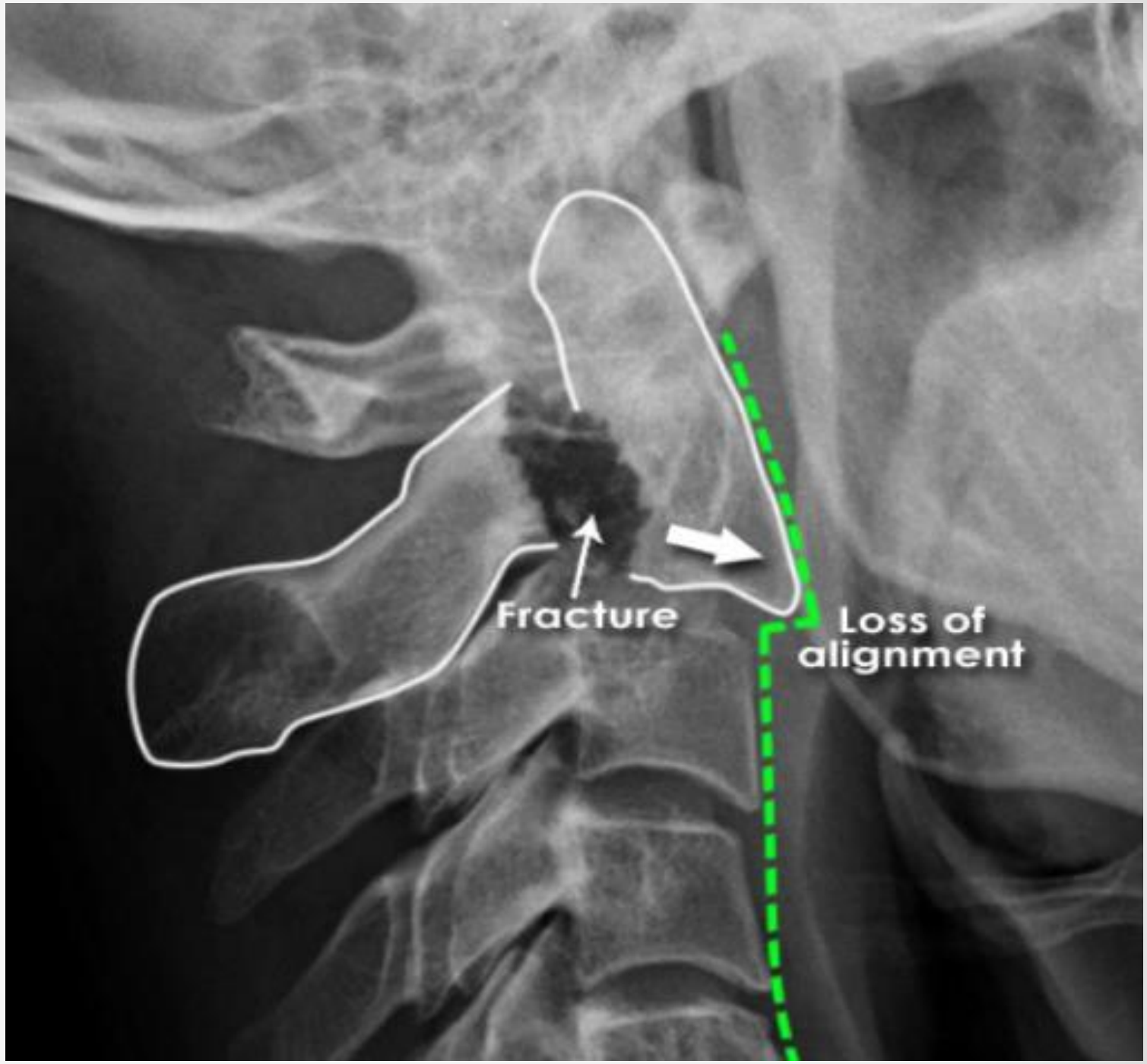
C2 odontoid peg fracture - Open mouth view

- Displaced fracture of the odontoid peg
- It is uncommon to see such an obvious fracture on the open mouth view - many fractures of the odontoid peg are more readily seen on the lateral view

C2 'hangman' fracture - Lateral view

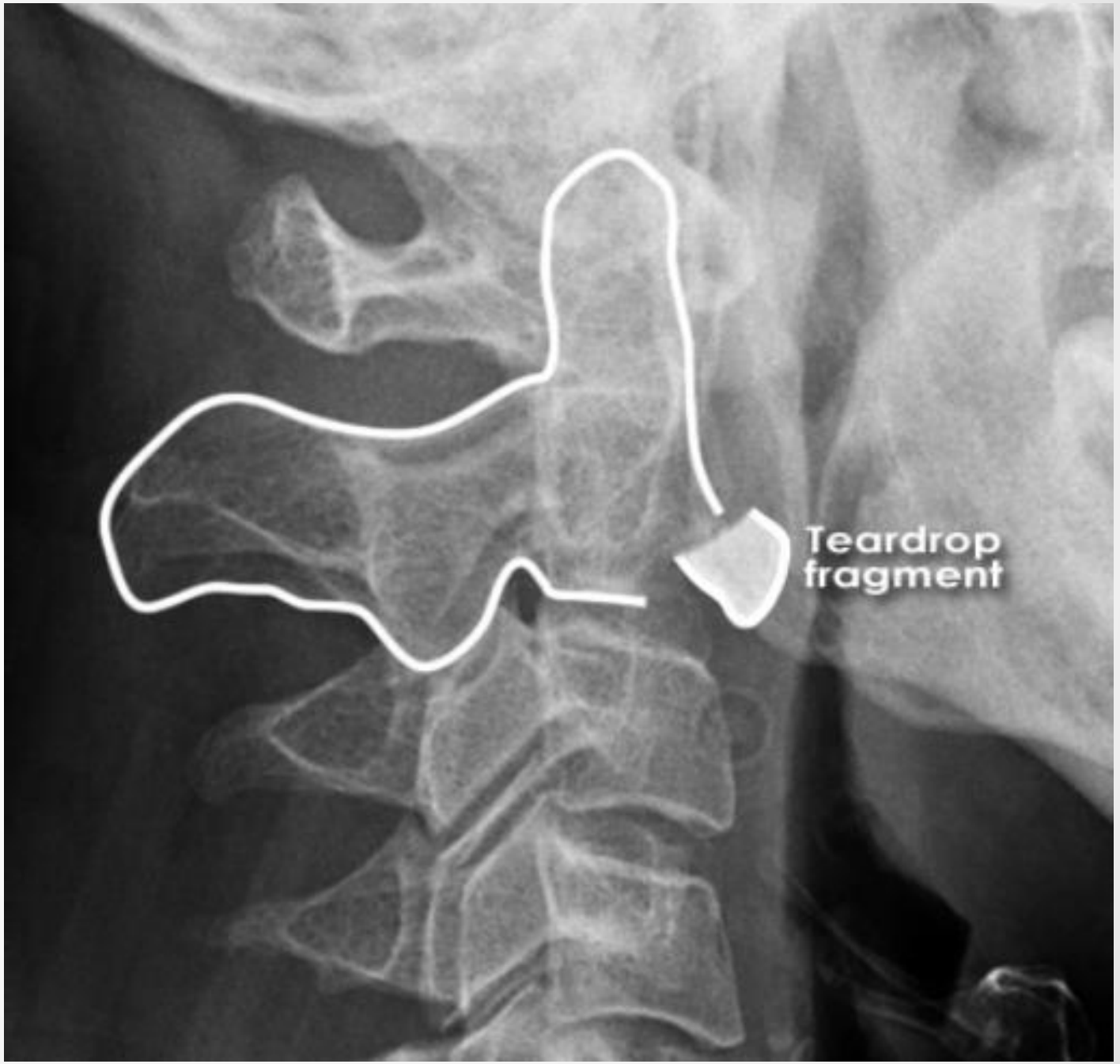
- Loss of alignment at C2/C3 with anterior displacement of C2 (**large arrow**)
- Following the cortical outline of C2 (**white line**) reveals discontinuity due to a fracture

results from a high force hyperextension injury. The fracture involves the pedicles of C2 and often results in anterior displacement of the body and peg of C2.



'Extension teardrop' fracture - Lateral view

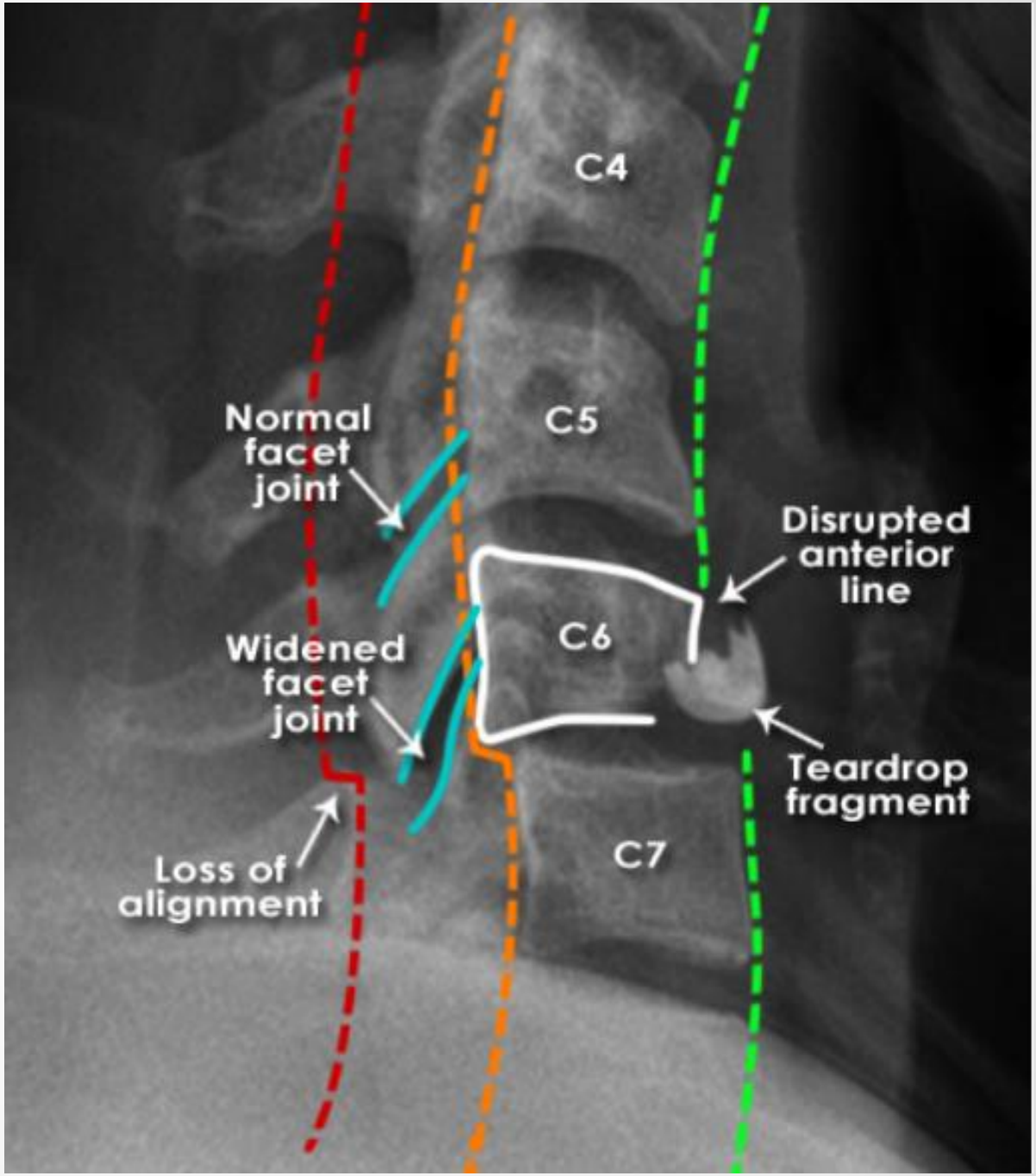
- A fracture fragment is seen at the anterior/inferior corner of C2 resembling a 'teardrop'



Hyperextension may result in avulsion of the anterior corner of a vertebral body - most commonly C2.

'Flexion teardrop' fracture - Lateral view

- Following the outline of the vertebral bodies shows an anterior - inferior C6 vertebral corner 'teardrop' fracture fragment
- The facet joint of C6/C7 is widened - compare with level above



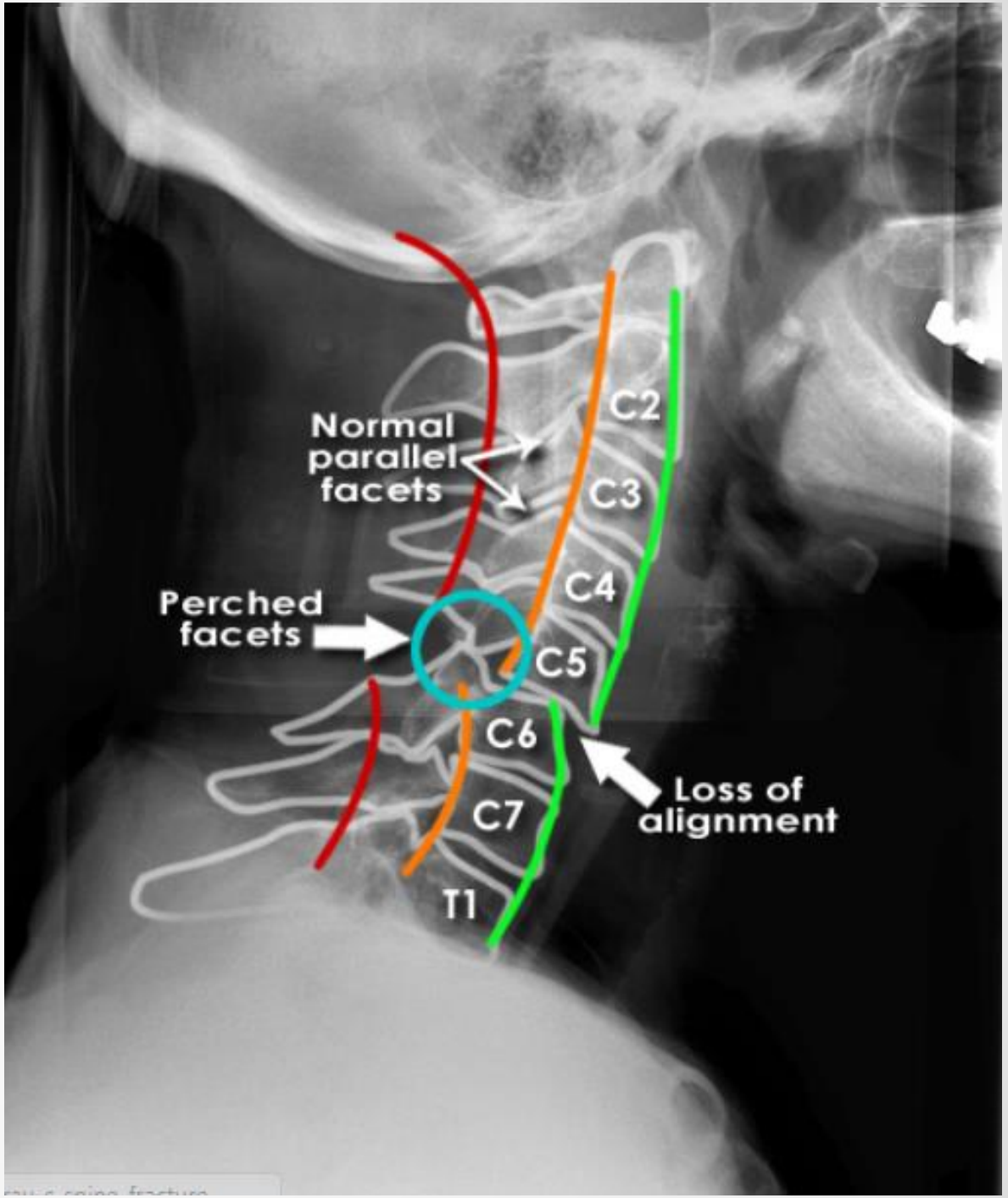
This fracture may occur at any level between C3 and C7. It is a highly unstable injury with a high incidence of associated spinal cord injury.

Bilateral perched facets - Lateral view

- (Same patient as image below)
- Loss of alignment of all three lines at C5/C6 with 'perching' of the C5 facet on the C6 facet (**ring**)
- No fracture is visible
- The pre-vertebral soft tissue is widened due to a haematoma

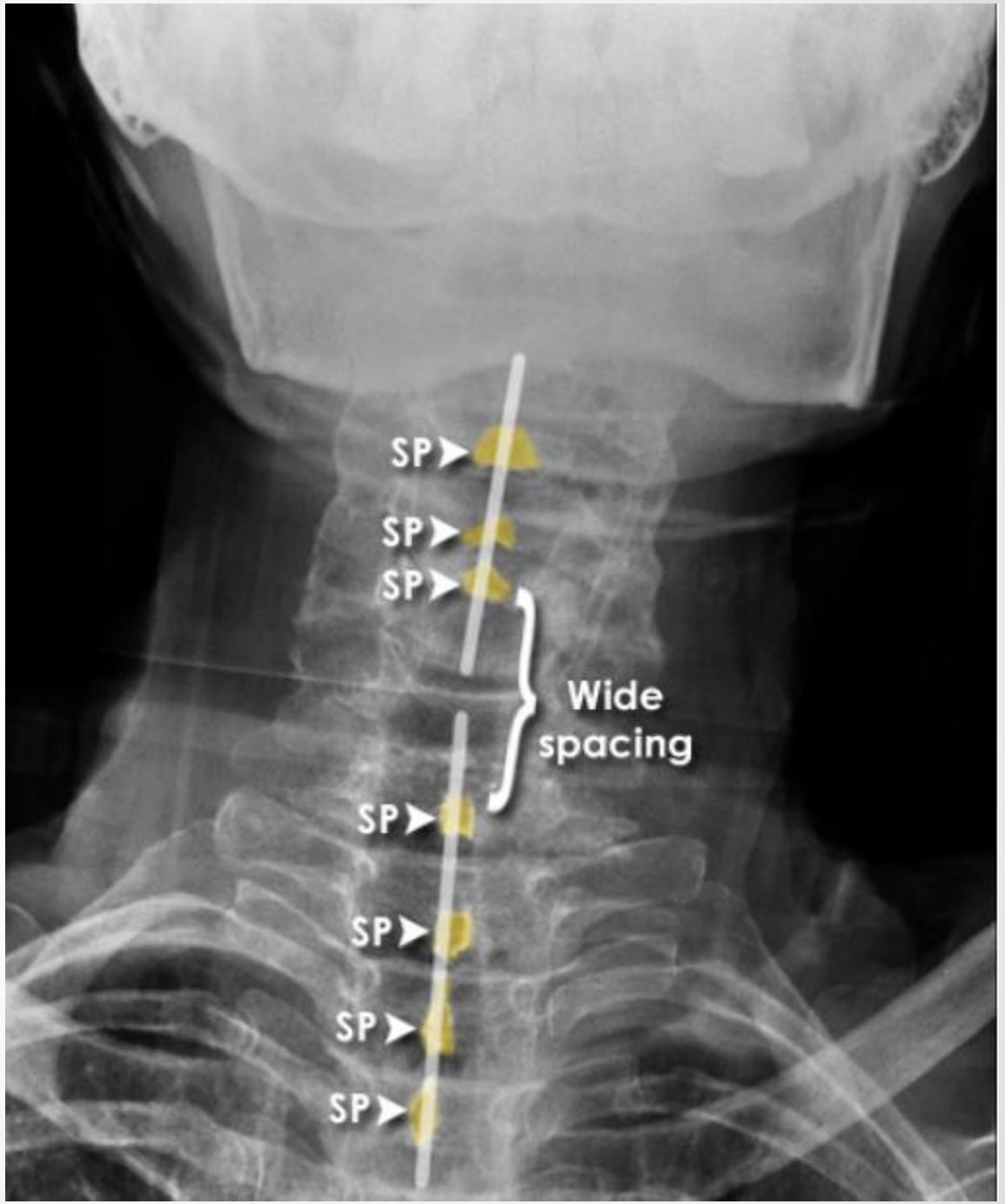
Note

- The spinal canal lies between the posterior (**Orange**) and spinolaminar (**Red**) lines
- Derangement of the spinal canal due to this injury results in a high incidence of spinal cord injury



Bilateral perched facets - AP view

- (Same patient as image above)
- There is widening of space between the C5 and C6 spinous processes (**SP**) with loss of normal alignment
- Again no fracture is demonstrated

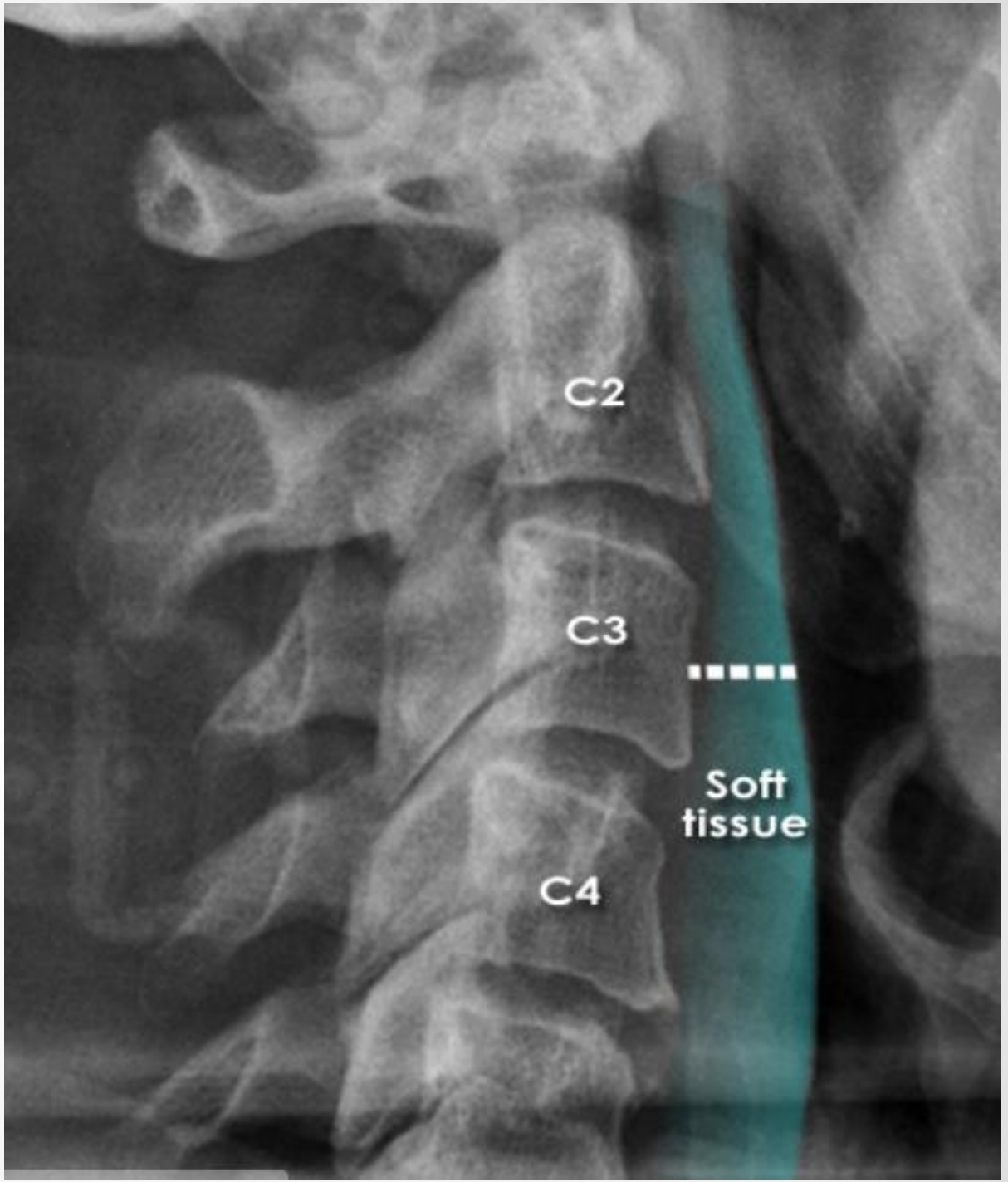


Pre-vertebral soft tissue

- At the level of C3 the pre-vertebral soft tissue is thickened - (>1/3rd the width of the vertebral body)
- This soft tissue swelling is the only visible sign of injury
- CT showed a fracture at C4 not visible on the plain X-ray

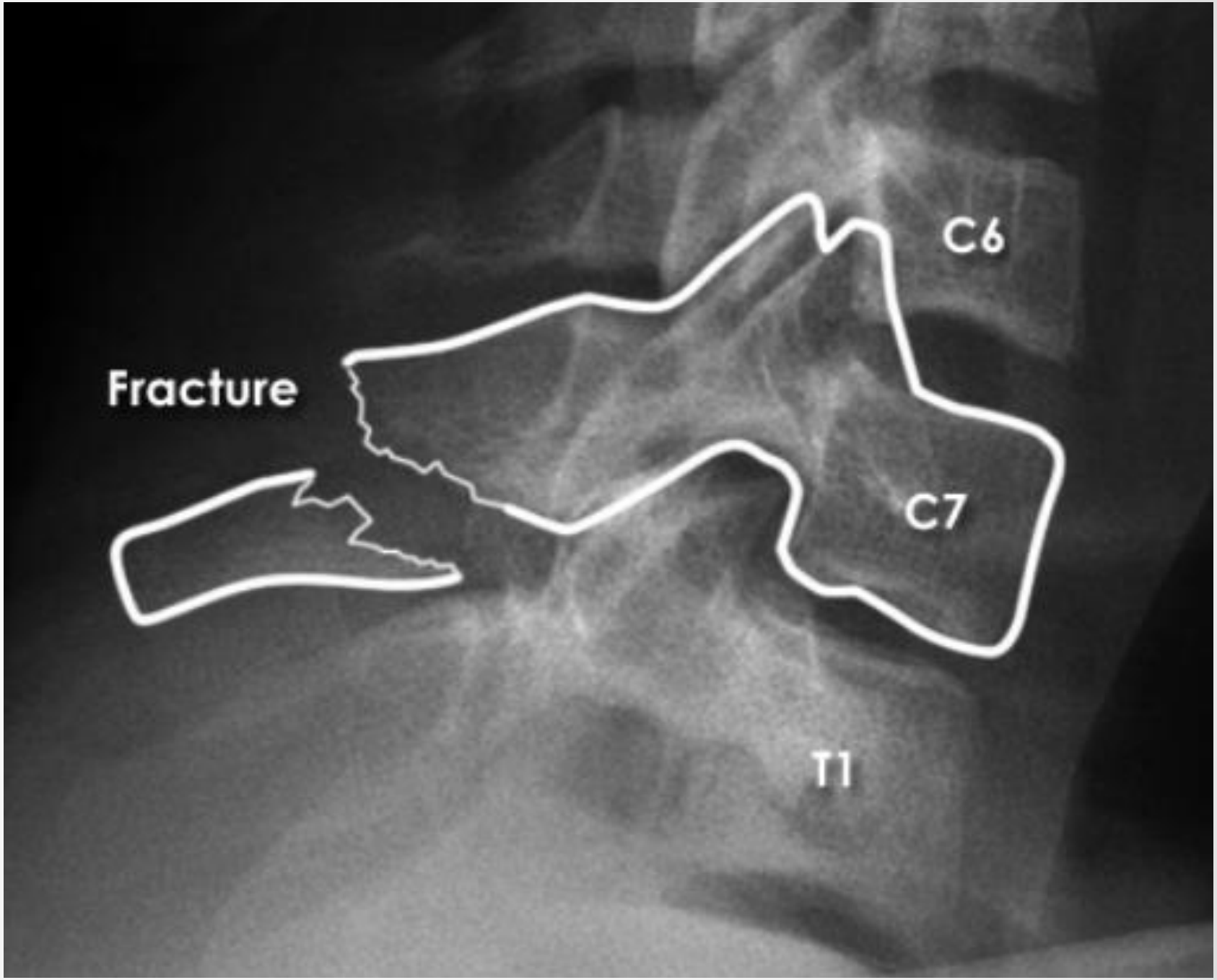
Note

- Not all C-spine fractures are accompanied by pre-vertebral haematoma
- Lack of pre-vertebral soft tissue thickening should **NOT** be taken as reassuring



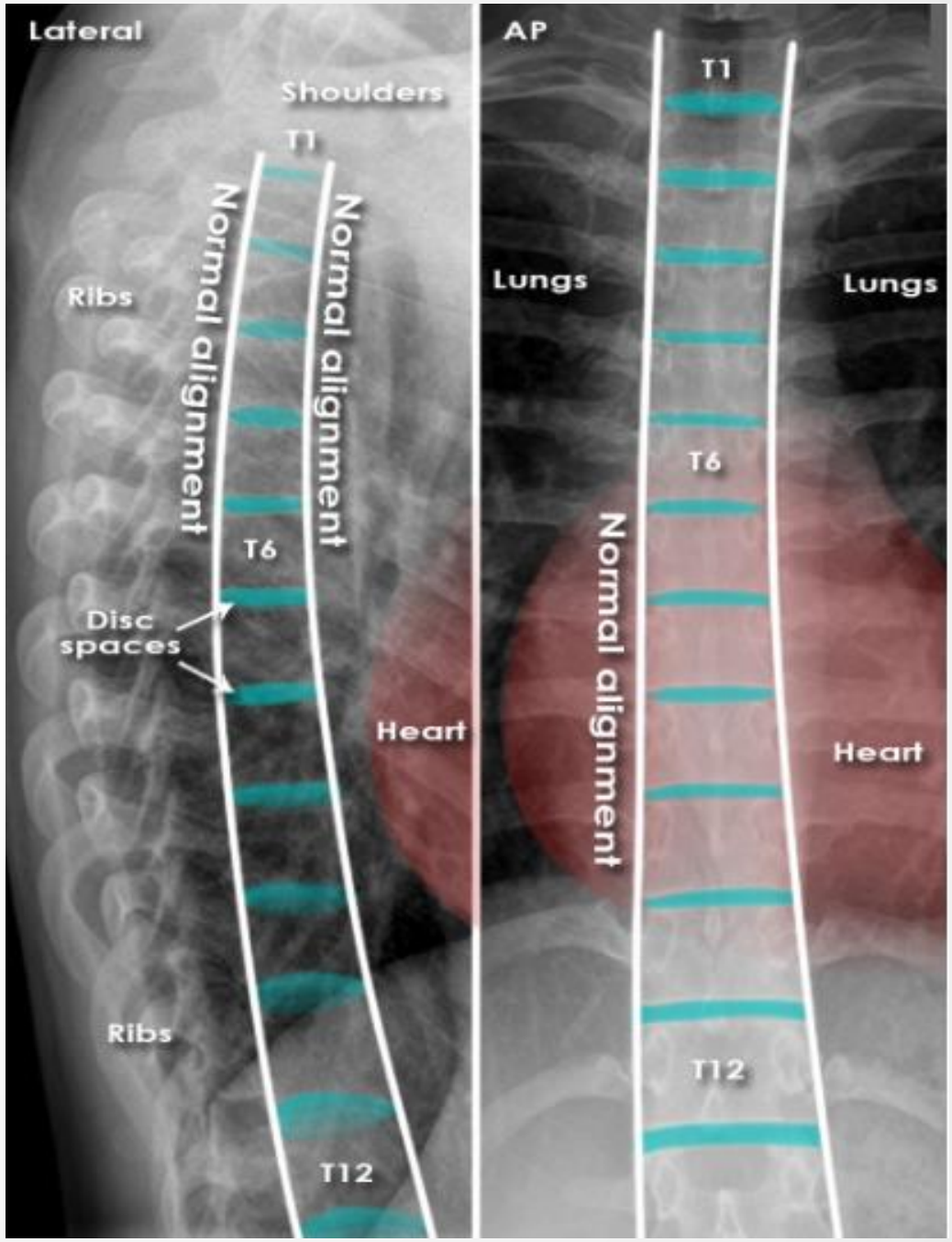
Spinous process 'clay-shoveller's' fracture

These avulsion injuries are traditionally known as 'clay-shoveller's' fractures due to the mechanism of repeated forceful flexion associated with shovelling.



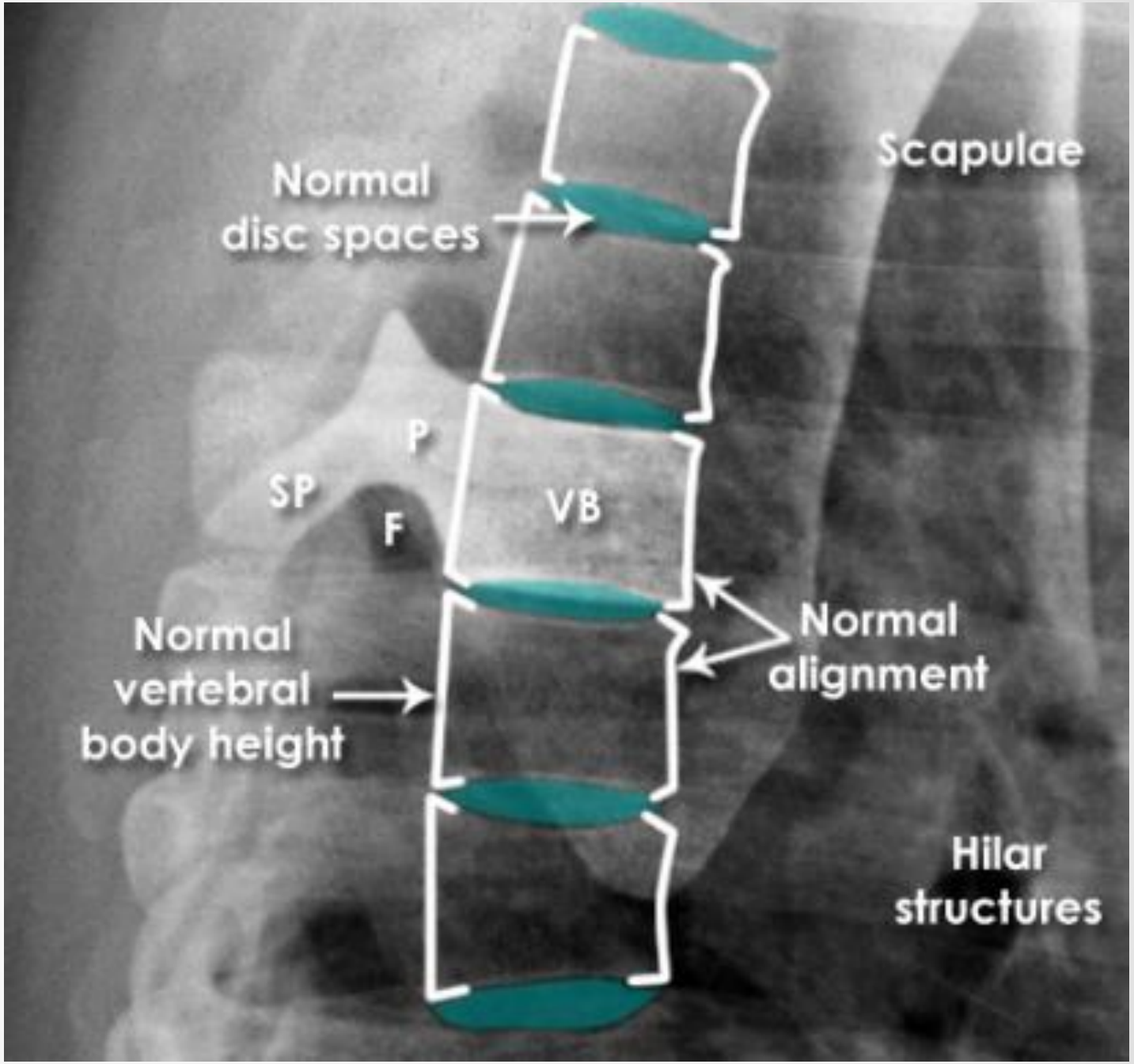
Thoracic spine systematic approach - Lateral and AP

- **Coverage** - The whole spine is visible on both views
- **Alignment** - Follow the corners of the vertebral bodies from one level to the next
- **Bones** - The vertebral bodies should gradually increase in size from top to bottom
- **Spacing** - Disc spaces gradually increase from superior to inferior - **Note**: Due to magnification and spine curvature the vertebral bodies and discs at the edges of the image can appear larger than those in the centre of the image
- **Soft tissues** - Check the paravertebral line (see AP image below)
- **Edge of image** - Check the other structures visible



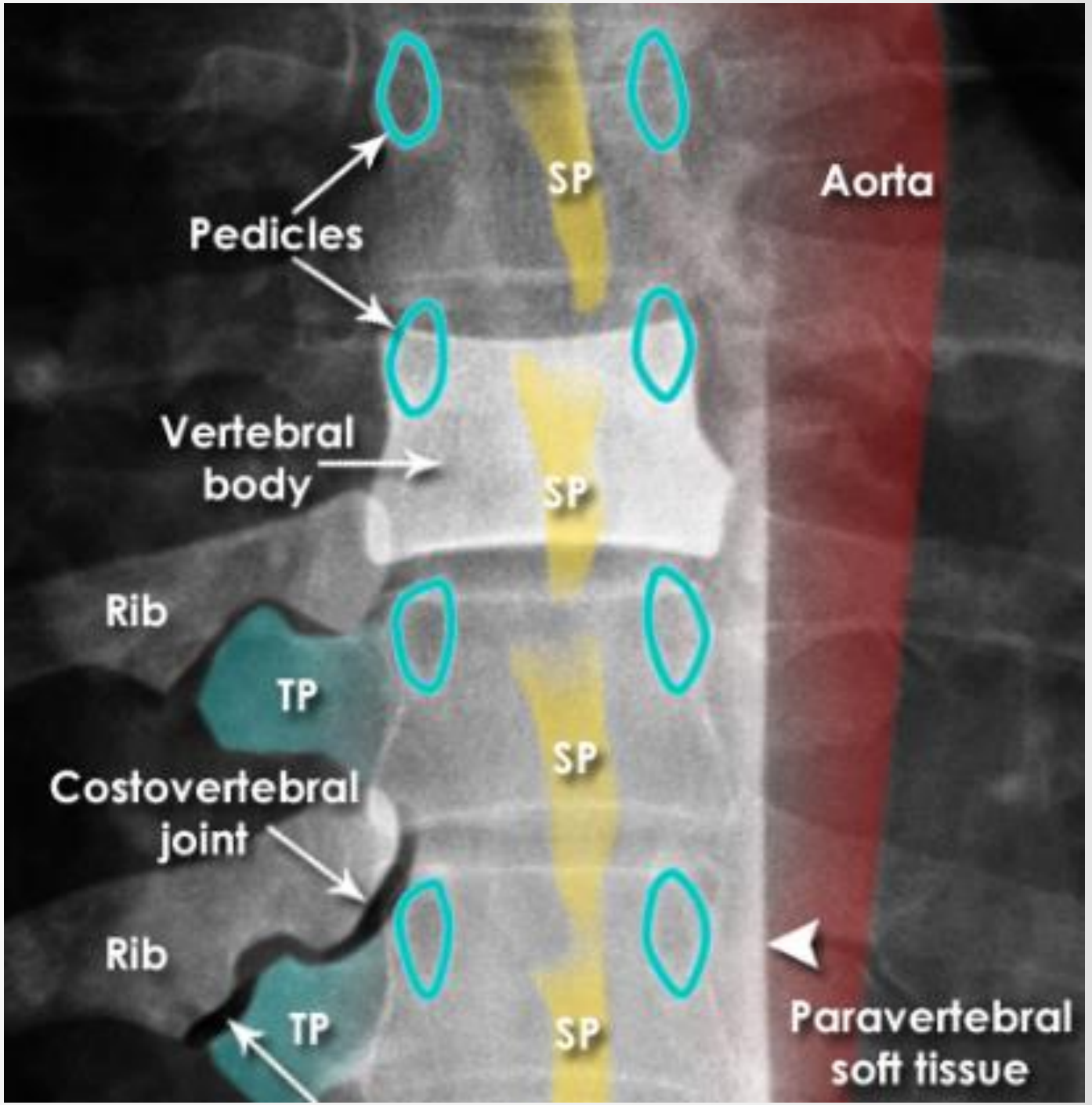
T-spine normal anatomy - Lateral (detail)

- **Alignment** - Vertebral body alignment is assessed by carefully matching the anterior and posterior corners of the vertebral bodies with the adjacent vertebra
- **Bones** - Gradual increase in vertebral body height from superior to inferior
- **Spacing** - Disc spaces gradually increase in height from superior to inferior
- **VB** = Vertebral body
- **P** = Pedicle
- **SP** = Spinous process (ribs overlying)
- **F** = Foramen - spinal nerve root exit



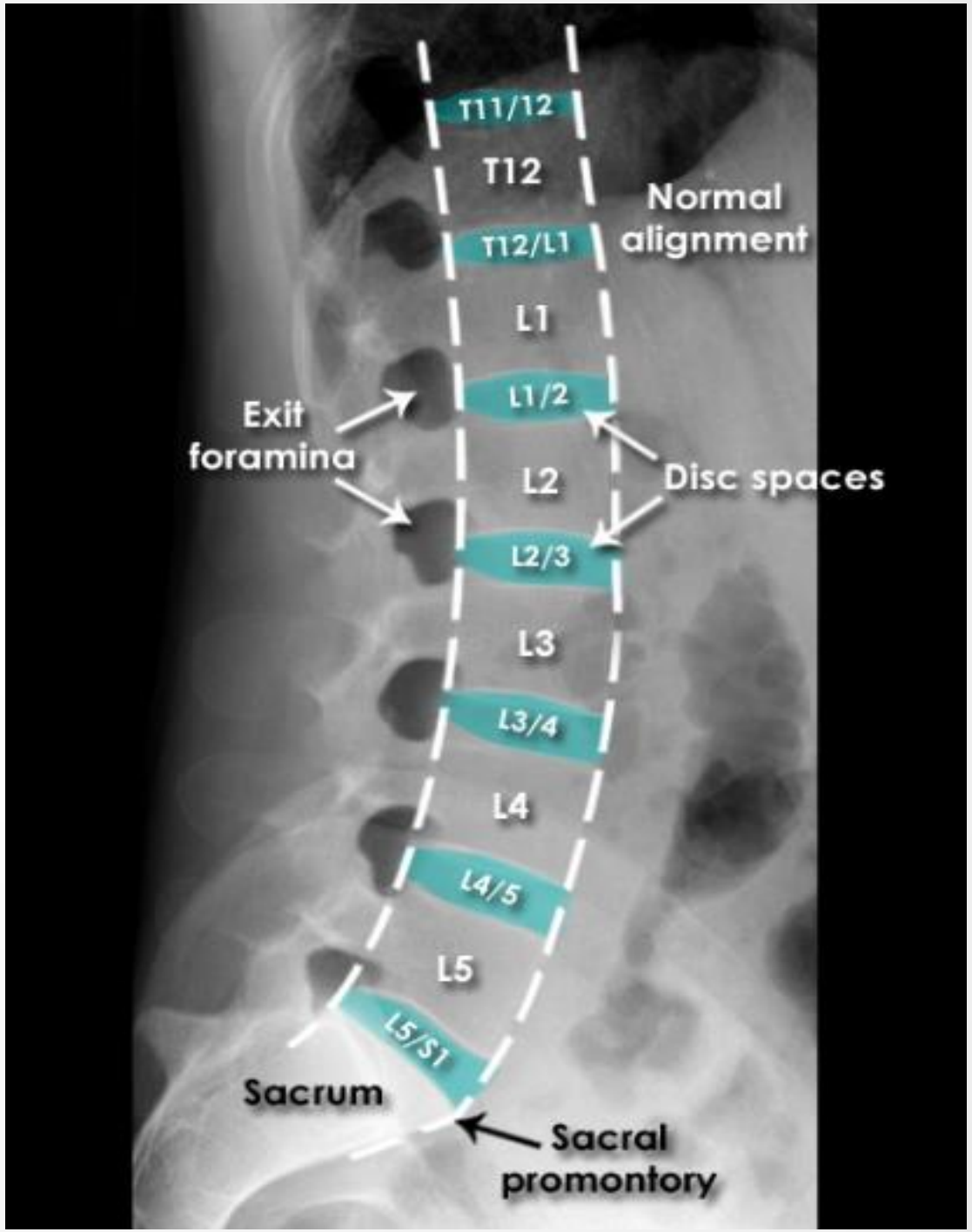
T-spine normal anatomy - AP (detail)

- **Alignment** - The vertebral bodies and spinous processes (**SP**) are aligned
- **Bones** - The vertebral bodies and pedicles are intact
- Other visible bony structures include the transverse processes (**TP**), ribs, and the costovertebral and costotransverse joints
- **Spacing** - Each disc space is of equal height when comparing left with right. The pedicles gradually become wider apart from superior to inferior
- **Soft tissue** - Note the normal paravertebral soft tissue which forms a straight line on the left - distinct from the aorta



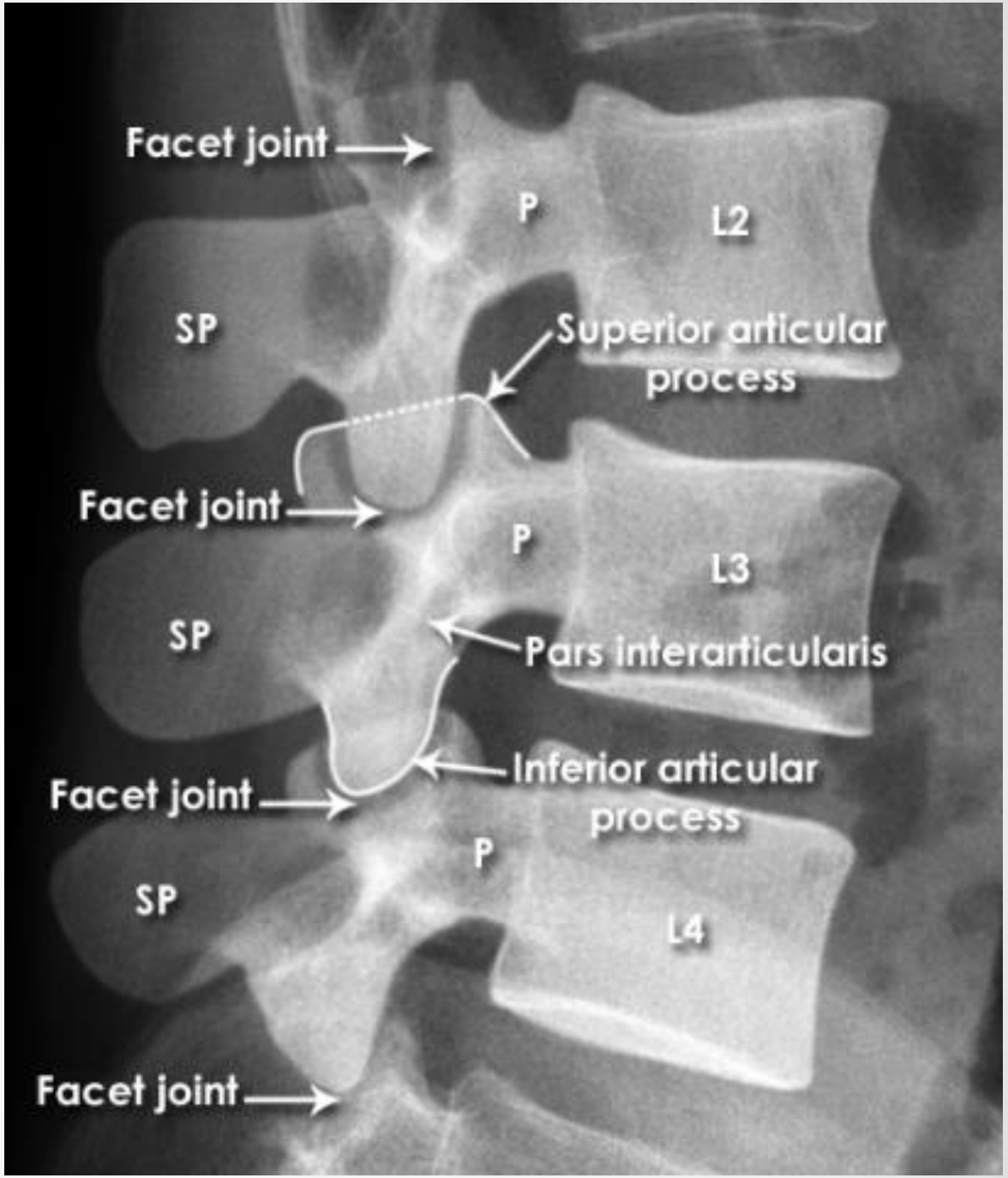
L-spine systematic approach - Lateral

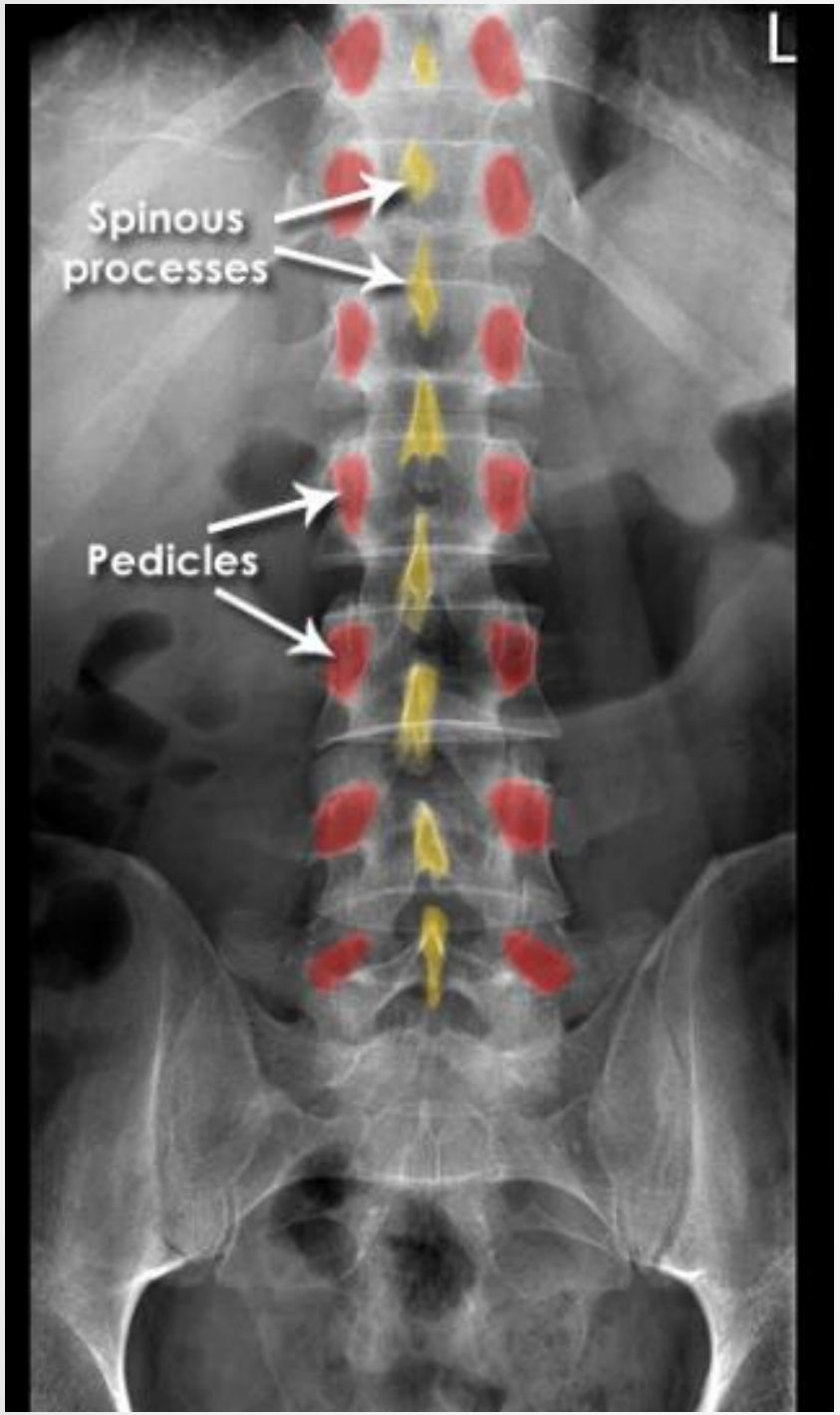
- **Coverage** - The whole L-spine should be visible on both views
- **Alignment** - Follow the corners of the vertebral bodies from one level to the next (**dotted lines**)
- **Bones** - Follow the cortical outline of each bone
- **Spacing** - Disc spaces gradually increase in height from superior to inferior - **Note**: The L5/S1 space is normally slightly narrower than L4/L5

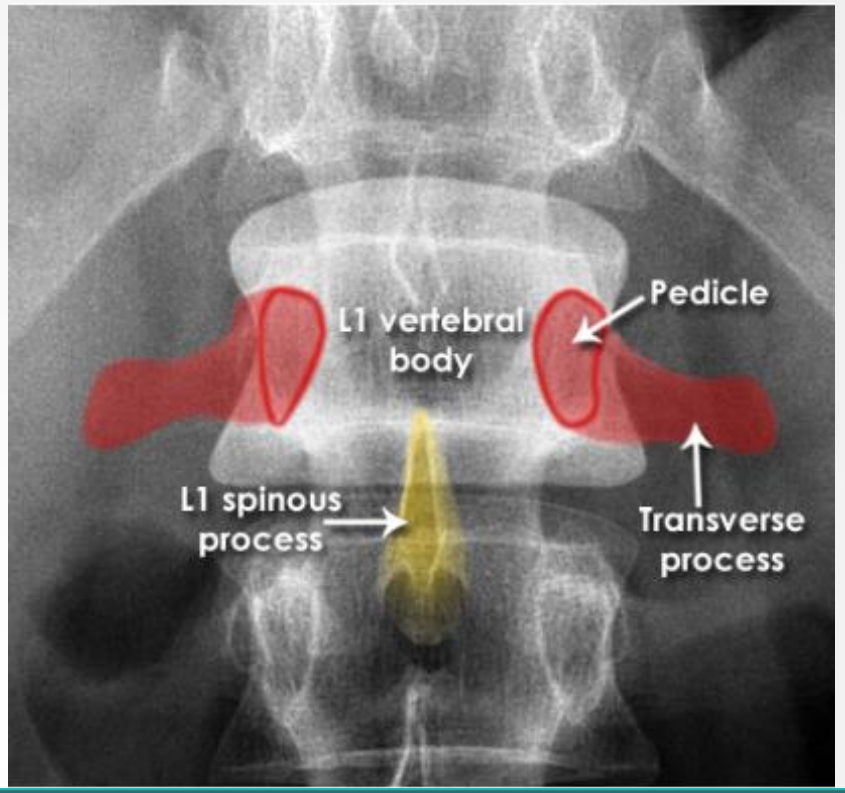


L-spine normal anatomy - Lateral (detail)

- Check the cortical outline of each vertebra
- The facet joints comprise the inferior and superior articular processes of each adjacent level
- The pars interarticularis literally means 'part between the joints'
- **P** = Pedicle
- **SP** = Spinous process





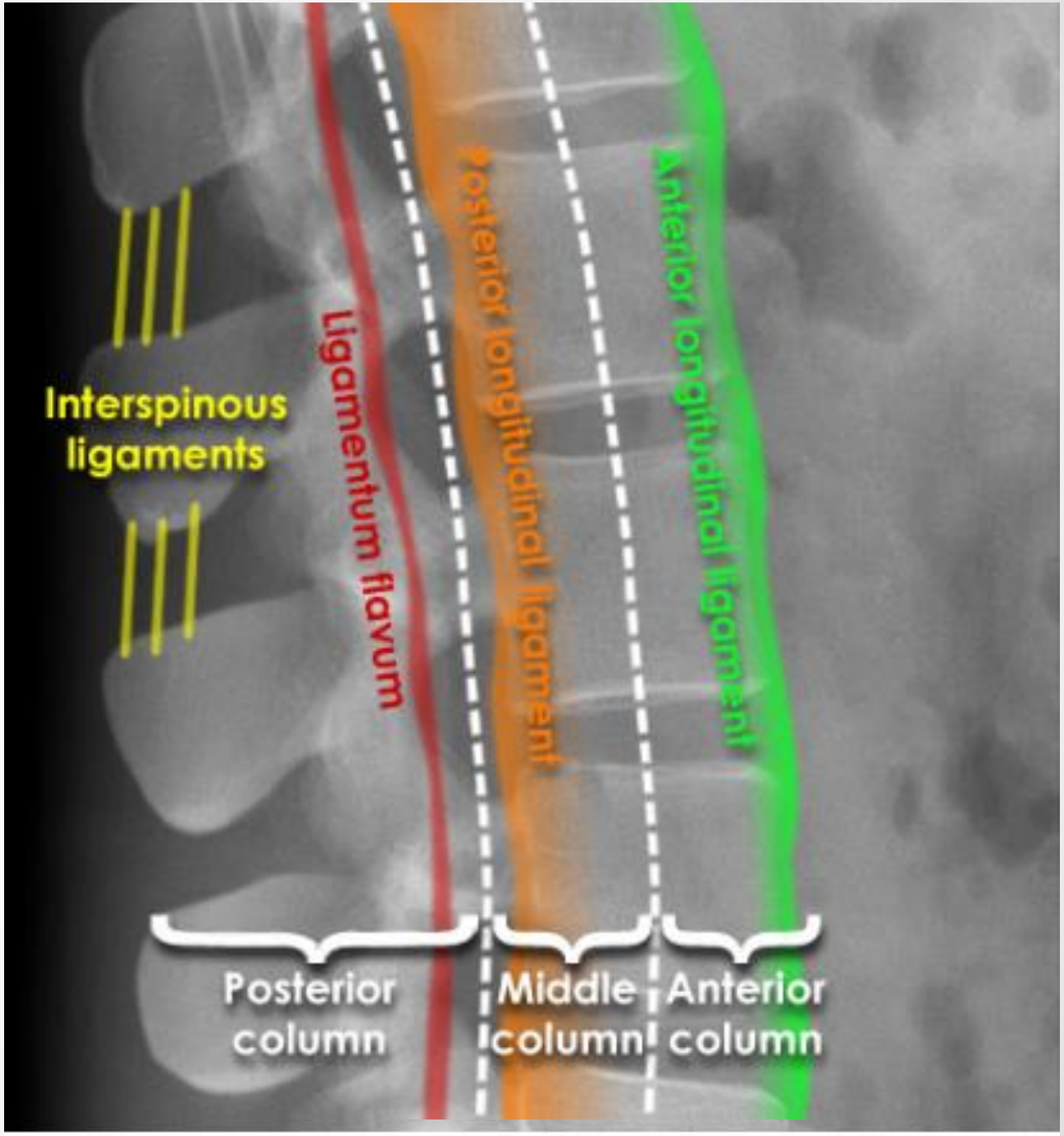


L-spine systematic approach - Normal AP

- **Alignment** - The vertebral bodies and spinous processes are aligned
- **Bones** - The vertebral bodies and pedicles are intact
- **Spacing** - Gradually increasing disc height from superior to inferior. The pedicles gradually become wider apart from superior to inferior - **Note**: The lower discs are angled away from the viewer and so are less easily assessed on this view

Three column model - Anatomy

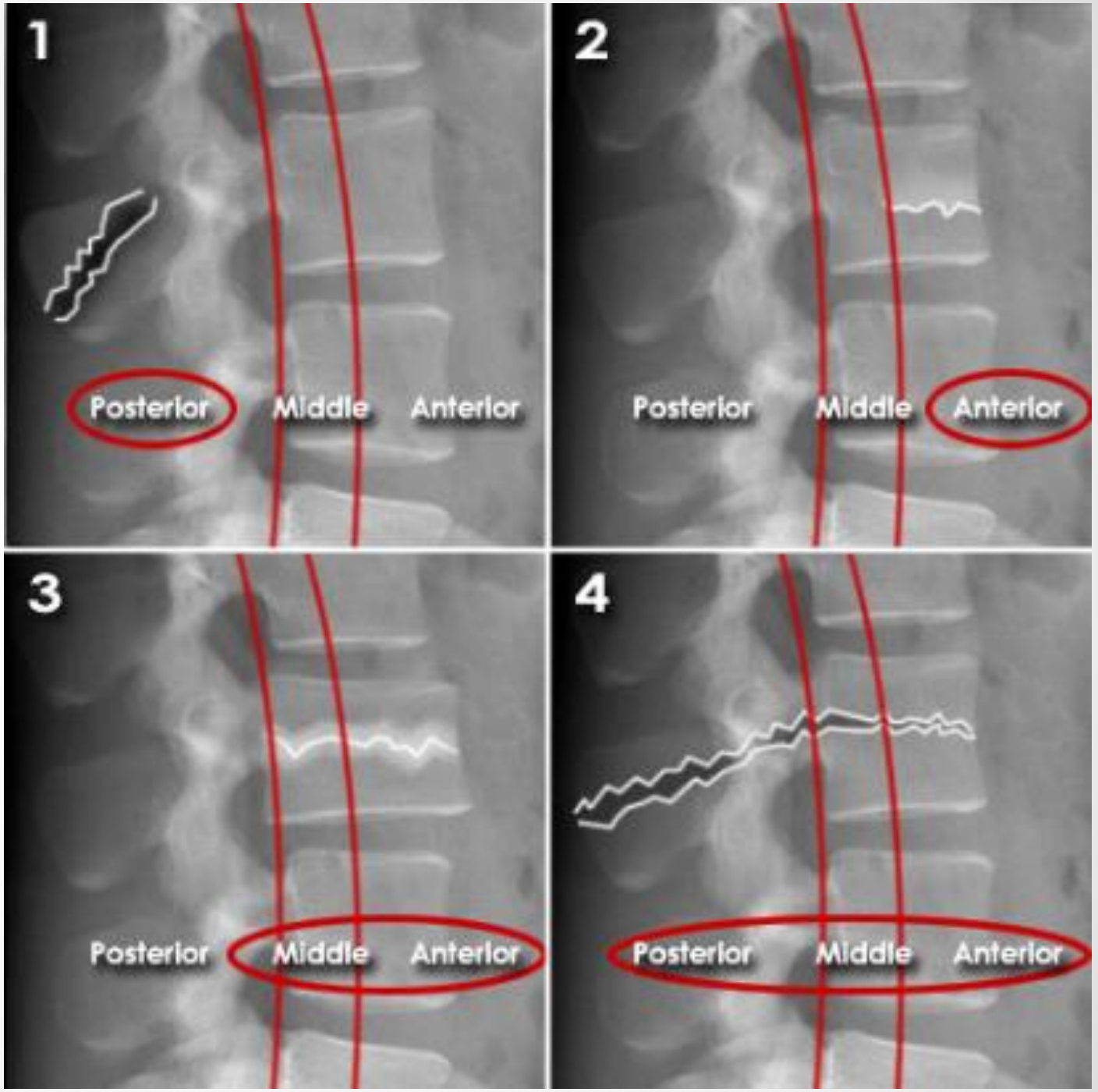
- **Anterior column** = Anterior half of the vertebral bodies and soft tissues
- **Middle column** = Posterior half of the vertebral bodies and soft tissues
- **Posterior column** = Posterior elements and soft soft tissues



Three column model - Fracture simulation

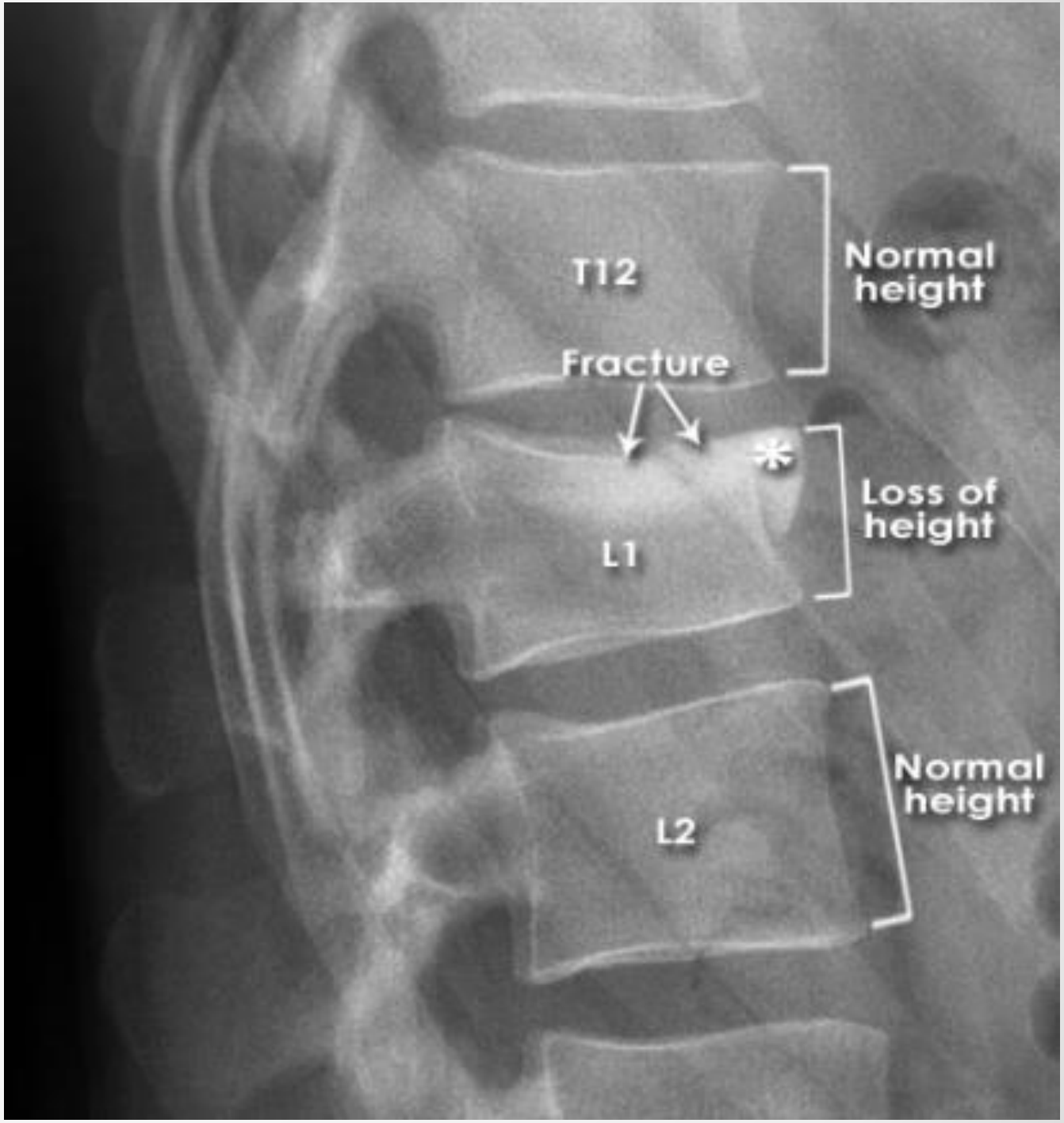
- Injuries 1 and 2 affect one column only and are considered 'stable'
- **1** - Spinous process injury
- **2** - Anterior compression injury

- Injuries 3 and 4 affect two or more columns and are considered 'unstable'
- **3** - 'Burst' fracture
- **4** - Flexion-distraction fracture - 'Chance' type injury



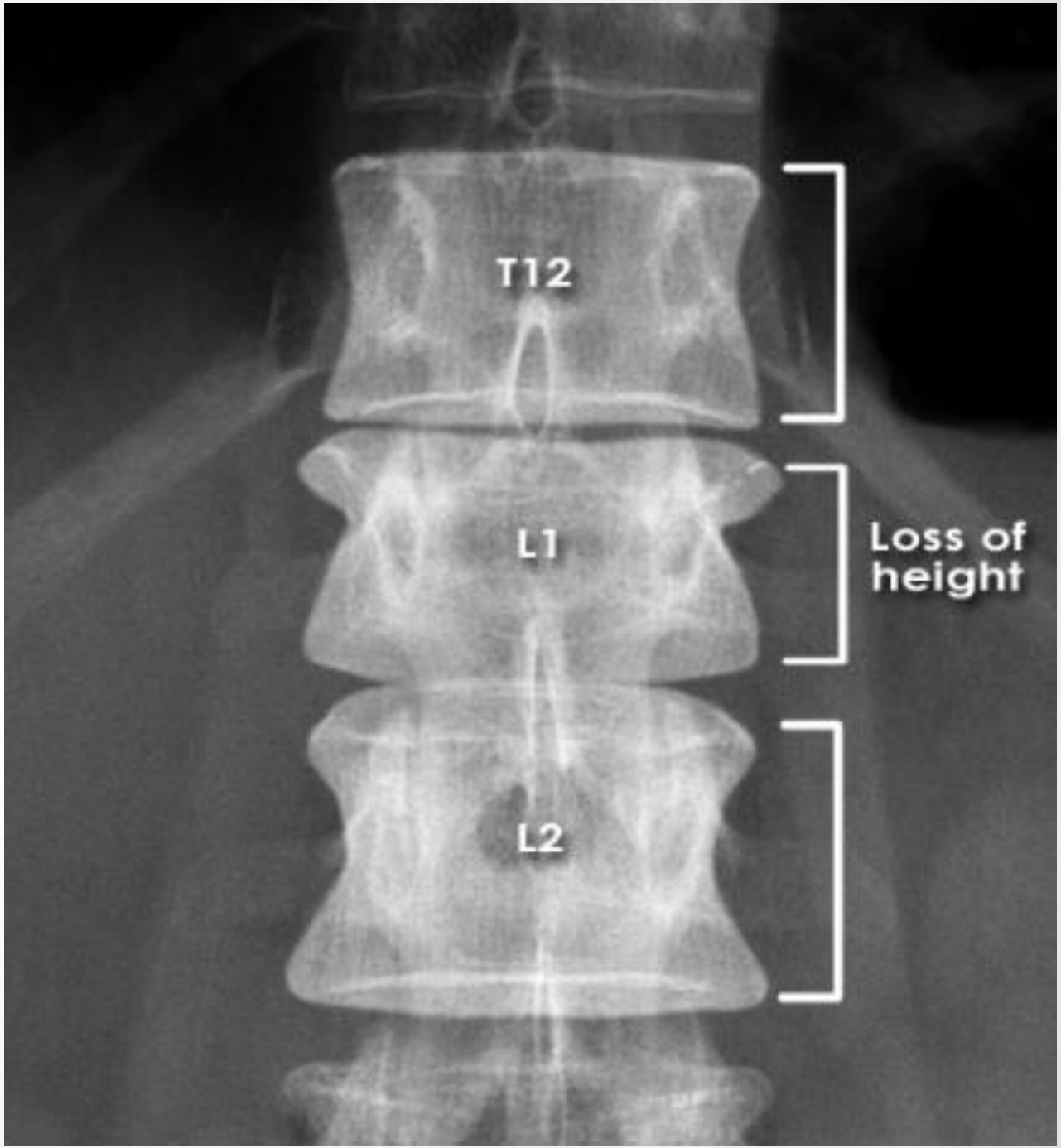
Anterior compression injury - L-spine - Lateral

- (Same patient as image below)
- A poorly defined dense (**white**) fracture line is visible with a detached fracture fragment (**asterisk**)
- L1 has lost height anteriorly and there is disruption of the anterior column only



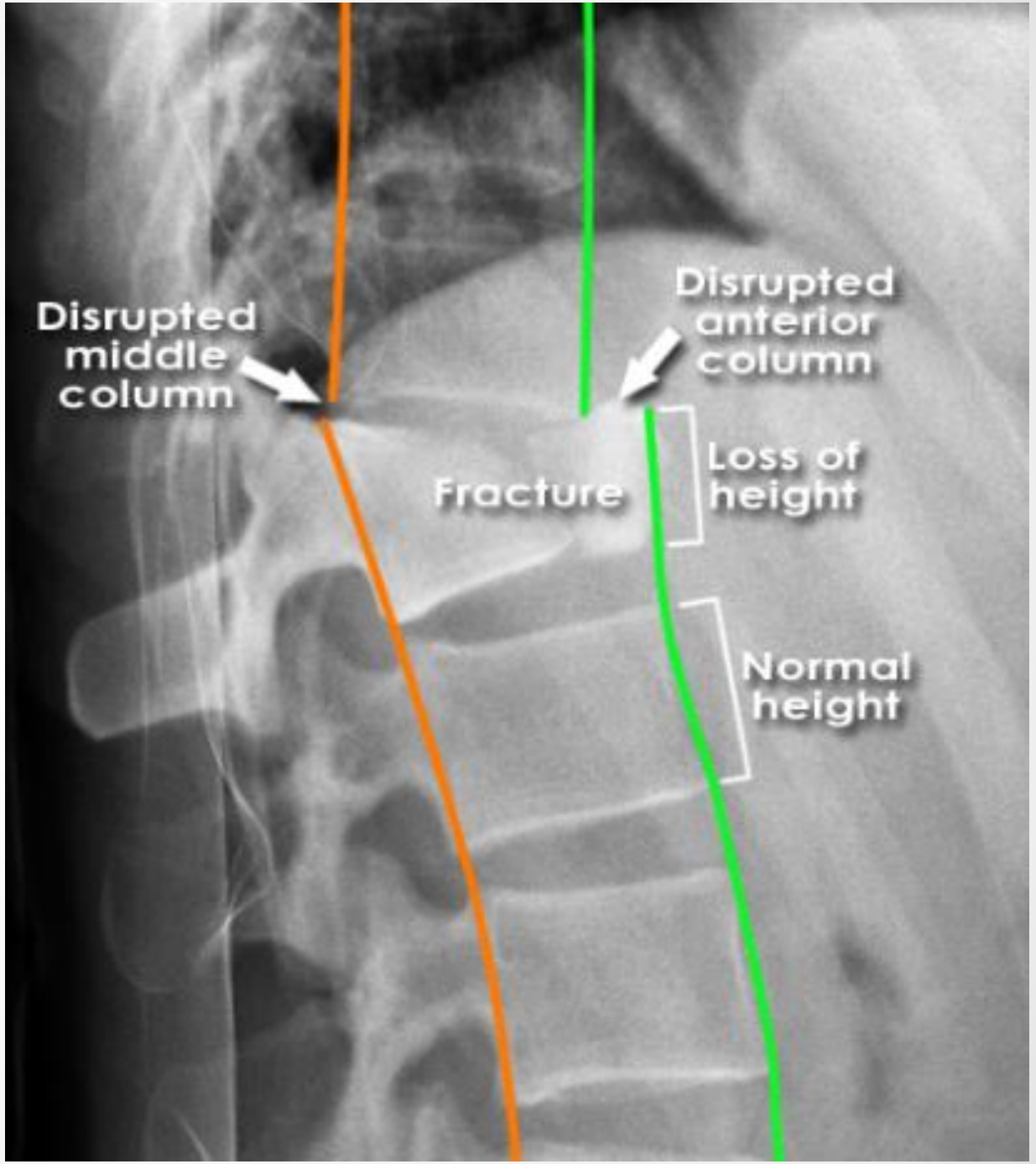
Anterior compression injury - L-spine - AP

- (Same patient as image above)
- Loss of vertebral body height can be seen but the fracture is not visible on this view



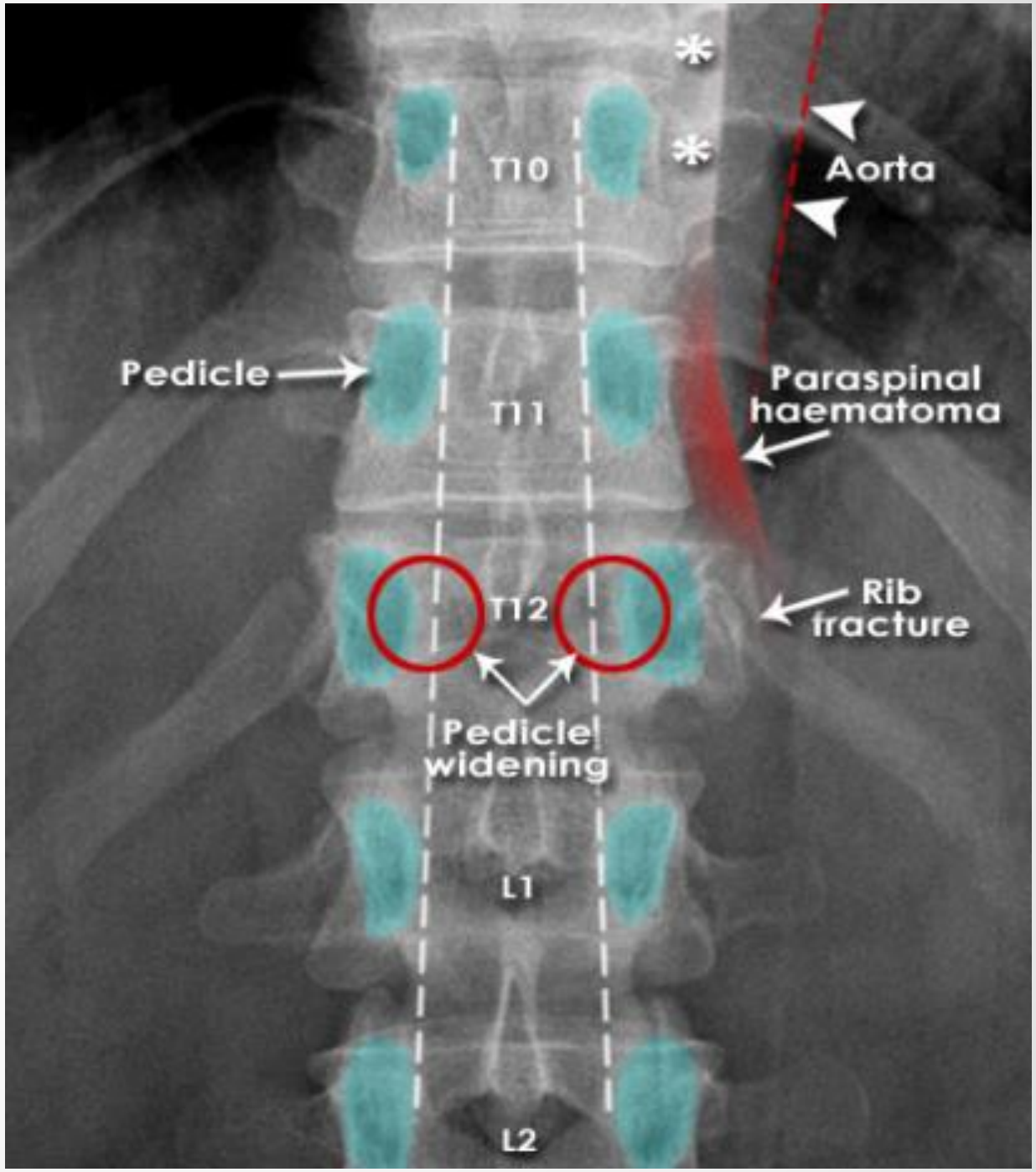
Thoracolumbar 'Burst' fracture - Lateral

- (Same patient as image below)
- Both the anterior and middle columns are disrupted
- Injury has resulted in increased kyphosis
- A large vertebral body fragment is displaced anteriorly



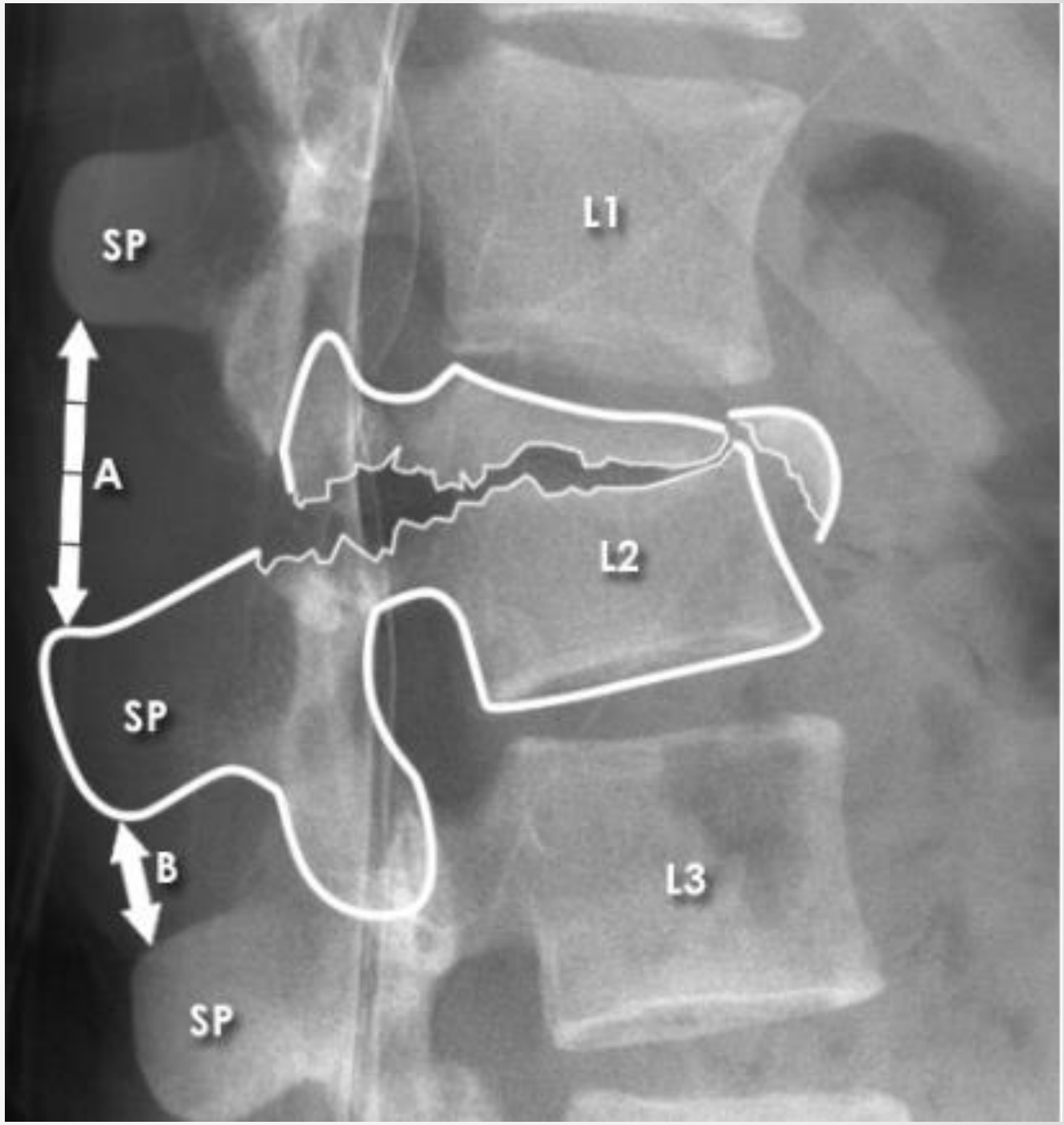
Thoracolumbar 'Burst' fracture - AP

- (Same patient as image above)
- The T12 vertebral body has lost height and the adjacent rib is fractured
- The interpedicular width should increase gradually from superior to inferior (**white dotted lines**)
- At the level of the fracture there is sudden widening of the interpedicular width - **Note**: This sign is not always visible in burst fractures
- The normal paravertebral soft tissues (**asterisks**) is widened by a paraspinal haematoma at the level of the fracture



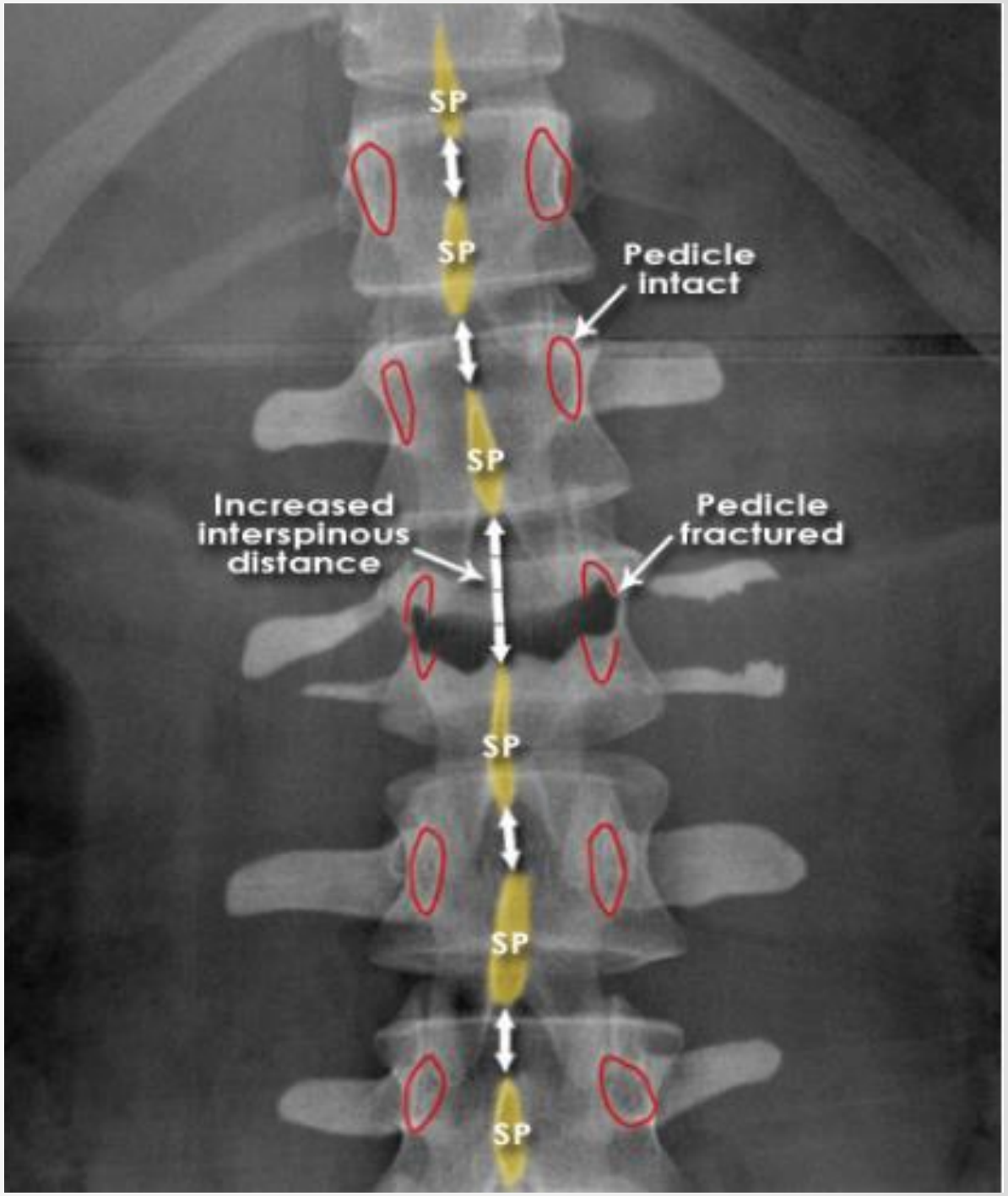
Flexion-distraction / 'Chance' fracture - Lateral

- All three columns are disrupted
- **A** = Widened spinous processes (**SP**) indicating disruption of the interspinous ligaments at the level of the fracture
- **B** = Normal interspinous distance



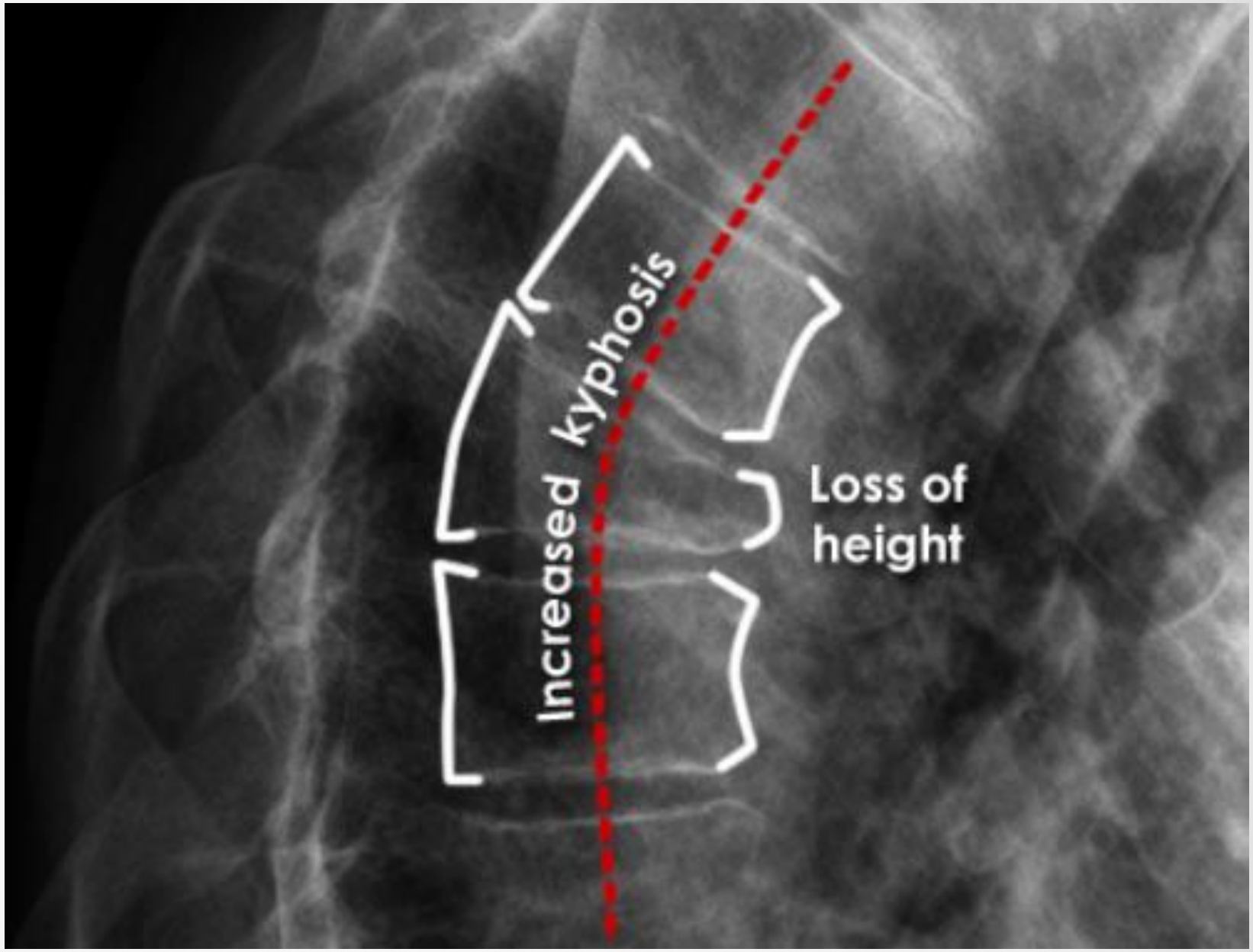
Flexion-distraction / 'Chance' fracture - AP

- The interspinous distance is increased at the level of the fracture
- In this case the pedicles and transverse processes have been split horizontally



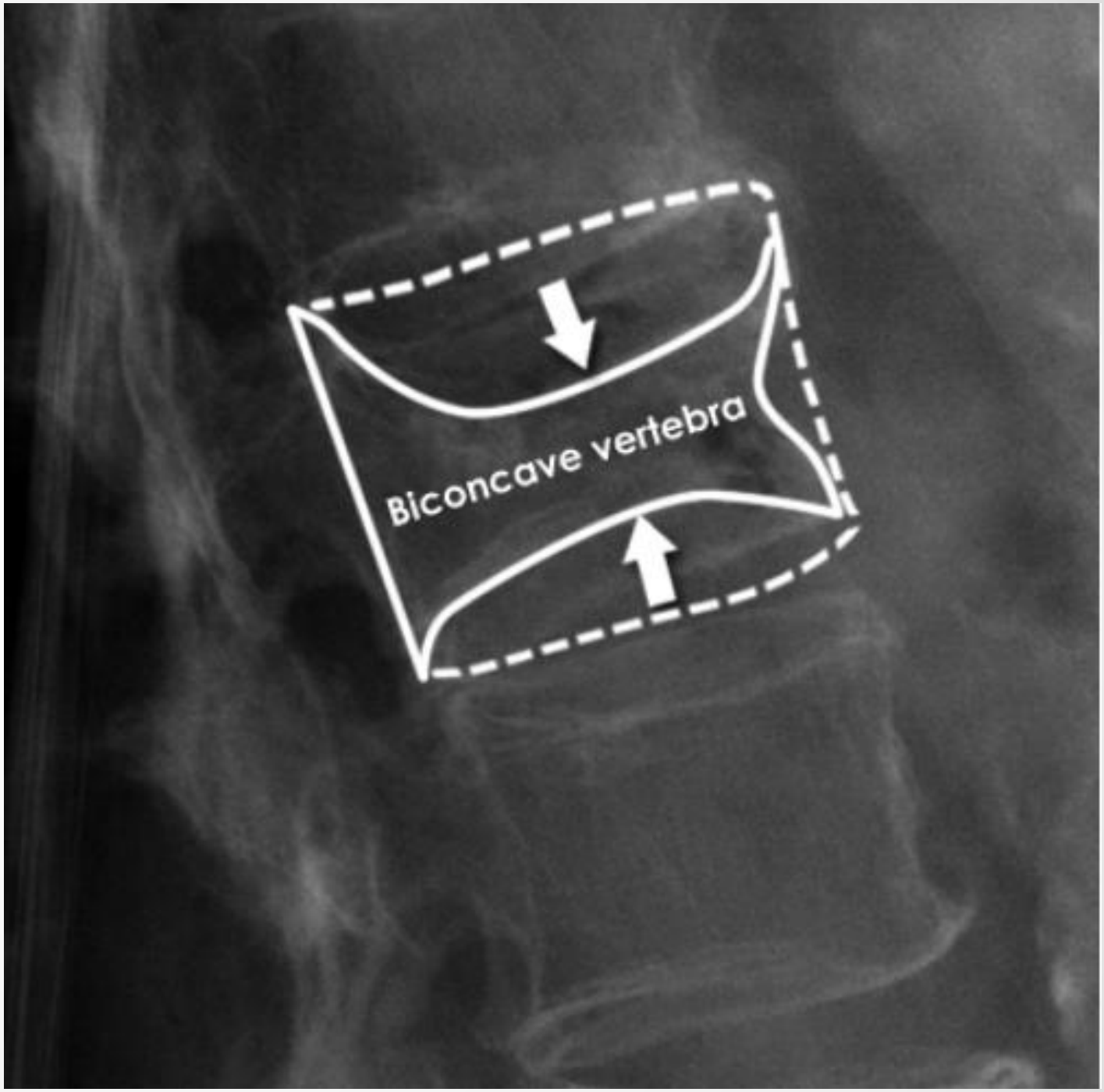
Thoracic spine - 'Wedge' compression fracture

- Note the low density (blackness) of the vertebral bodies
- The vertebral body has lost height anteriorly
- Kyphosis is increased



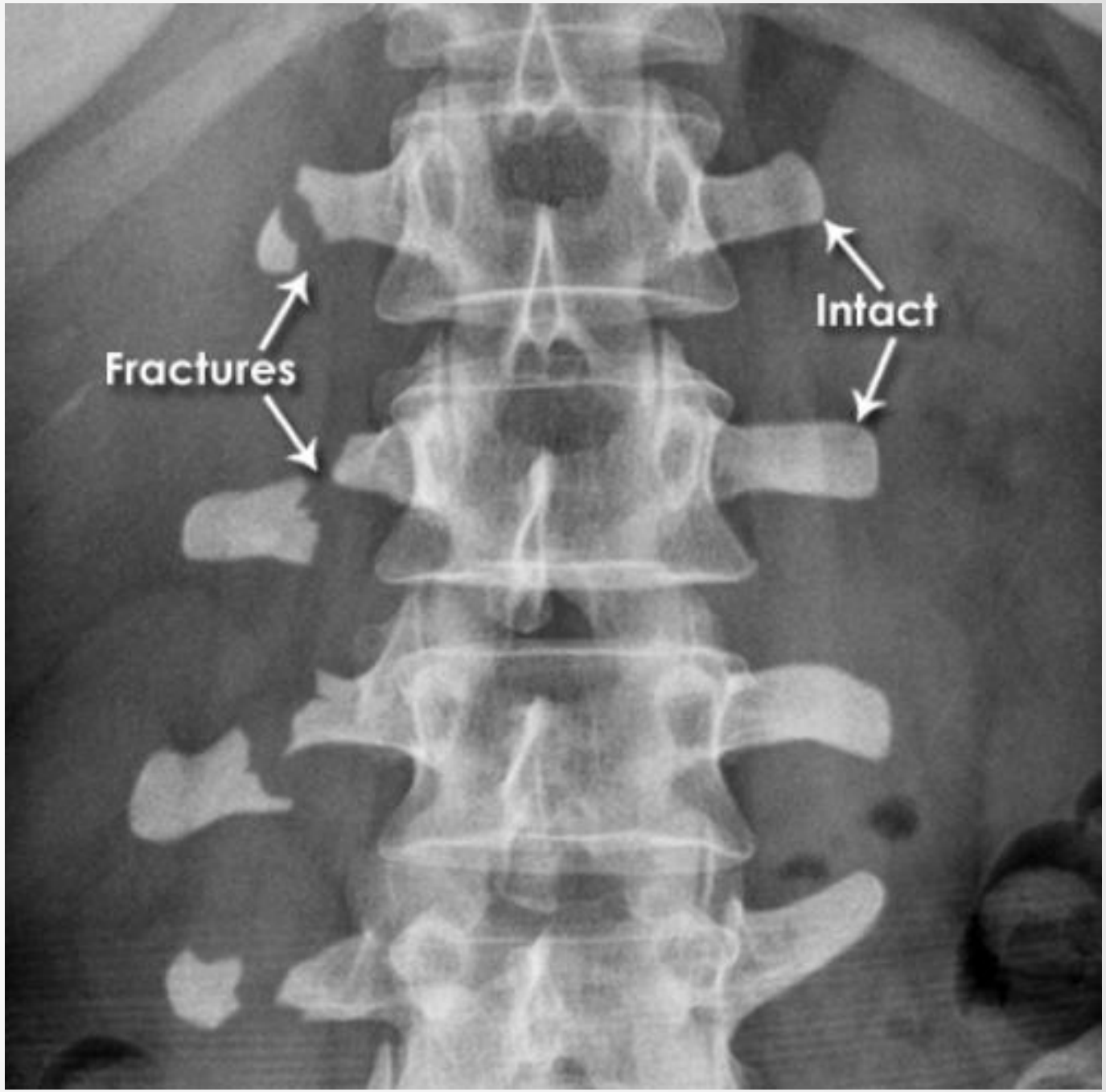
Lumbar spine - Biconcave fracture

- Note the low density (blackness) of the vertebral bodies
- Compression injuries of both the superior and inferior endplates of the vertebral body have resulted in a biconcave appearance
- The vertebral body has also lost height anteriorly - compare to level below (superimposed dotted line)



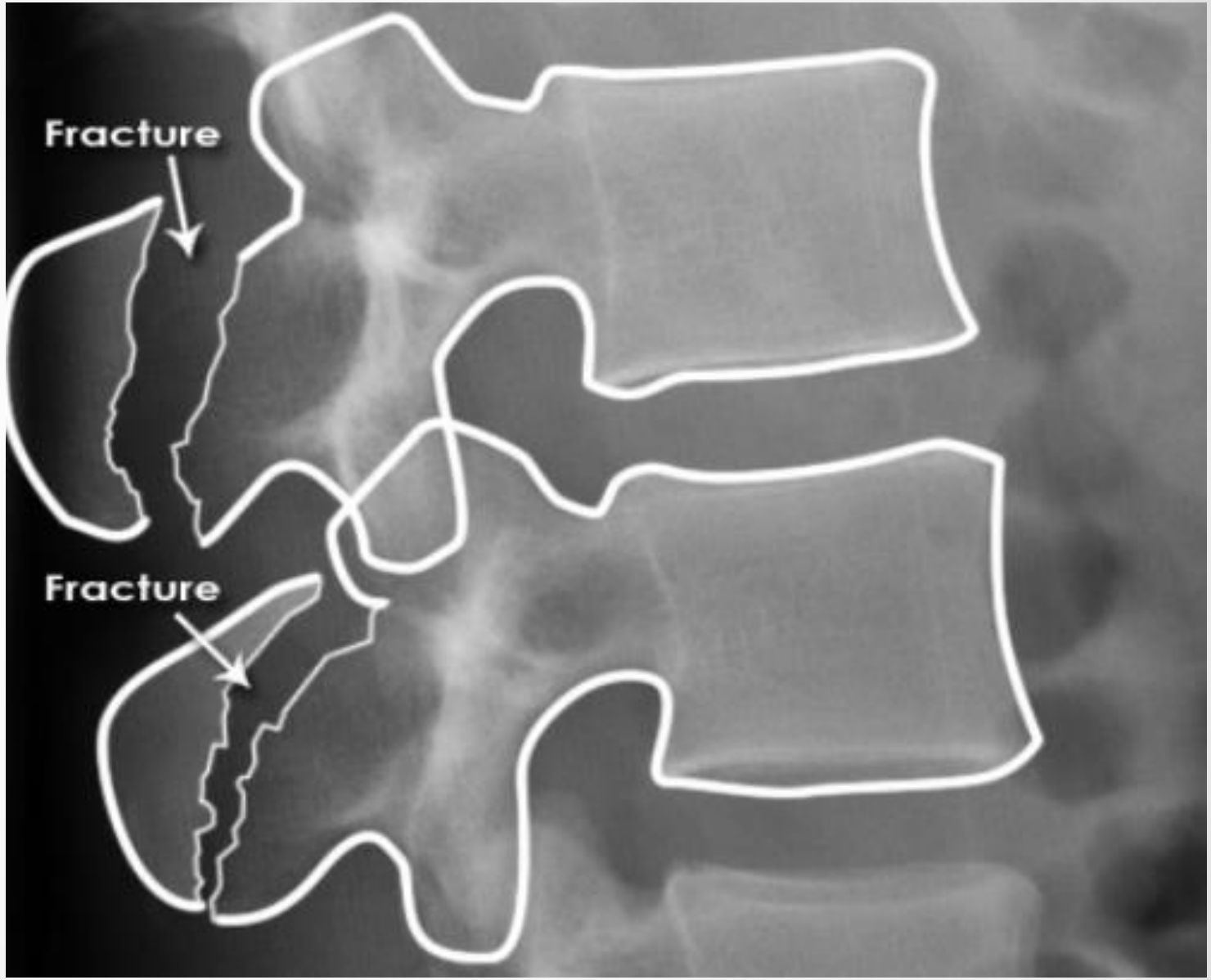
Transverse process fracture - Lumbar spine AP

- Multiple fractures of the transverse processes are seen on one side



Spinous process fracture - Lumbar spine - Lateral

- Only 1 column is visibly injured but further imaging should be considered



Types of Fractures

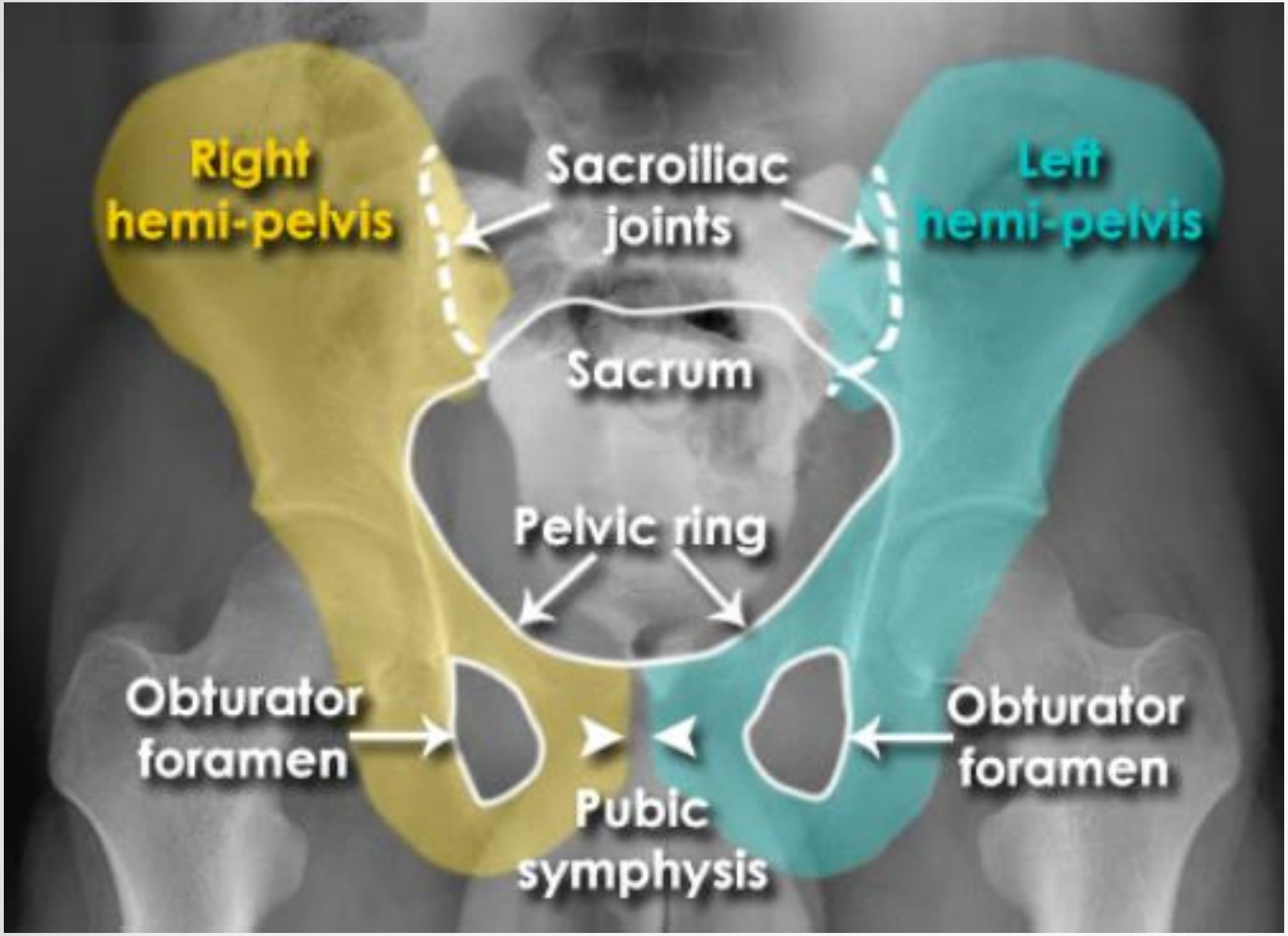
01 Skull

02 spine

03 Sacrum & pelvis

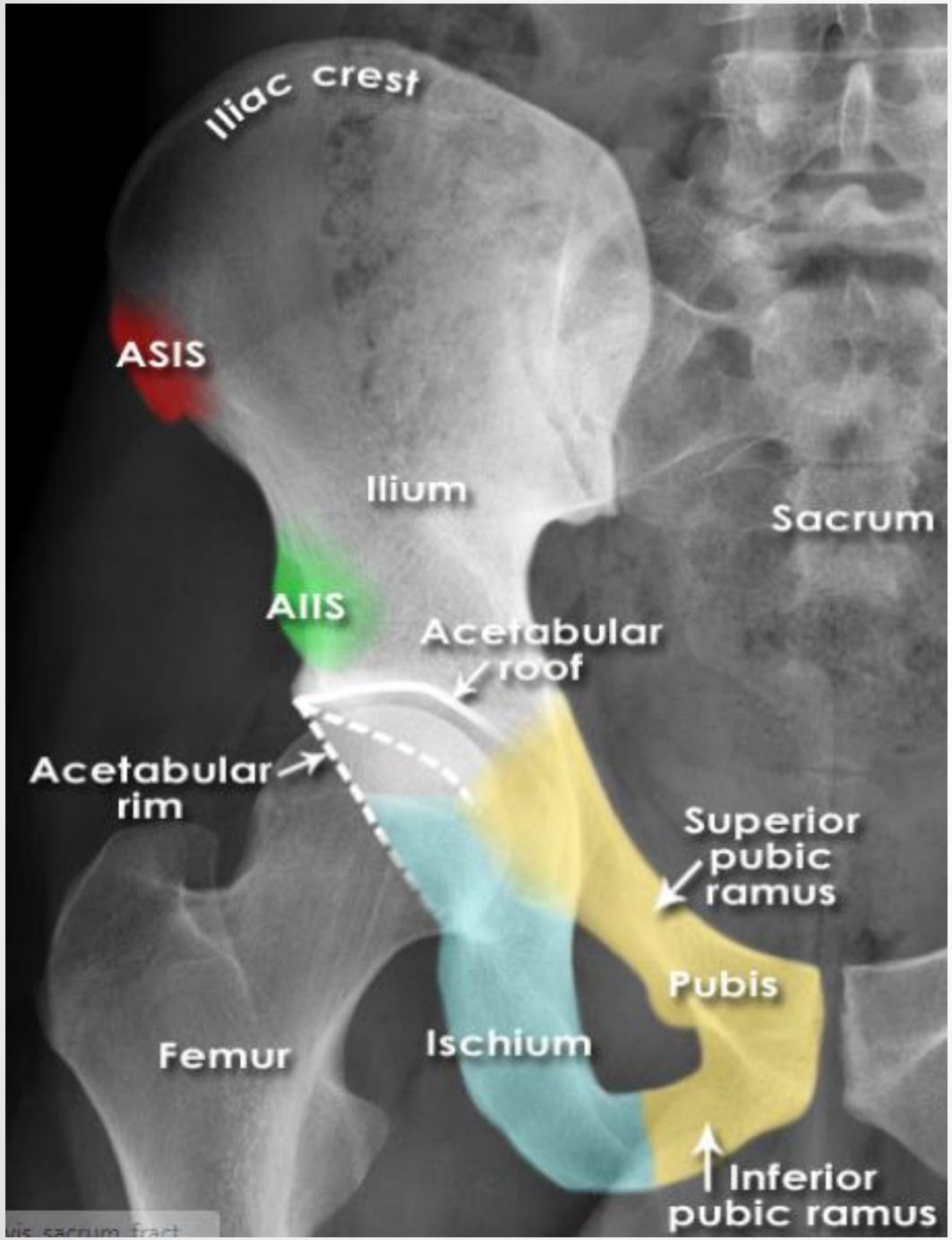
04 Sternum & ribs

05 Face



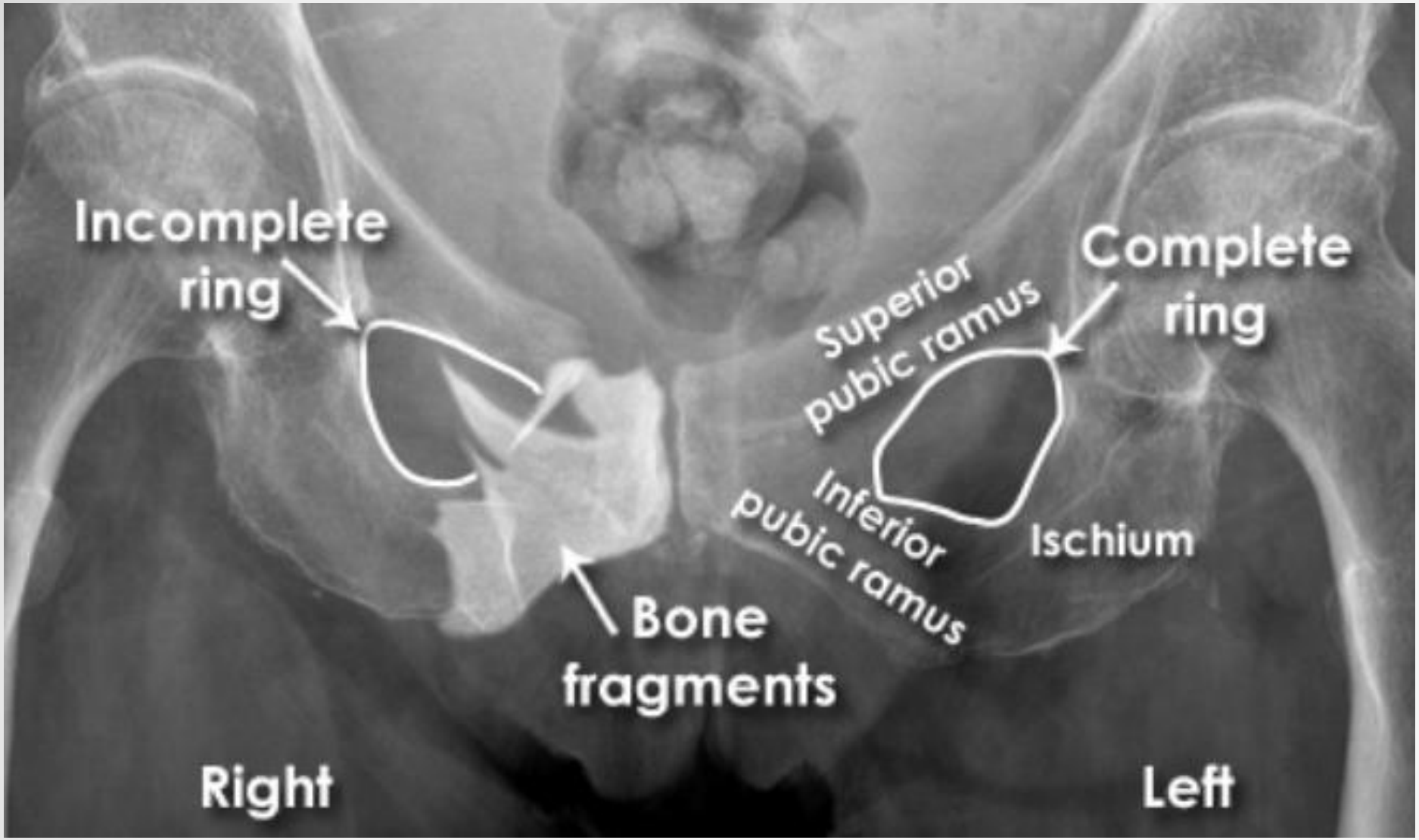
Pelvis anatomy - Normal AP

- The 2 hemi-pelvis bones and the sacrum form a bone ring bound posteriorly by the sacroiliac joints and anteriorly by the pubic symphysis
- Each obturator foramen is also formed by a ring of bone



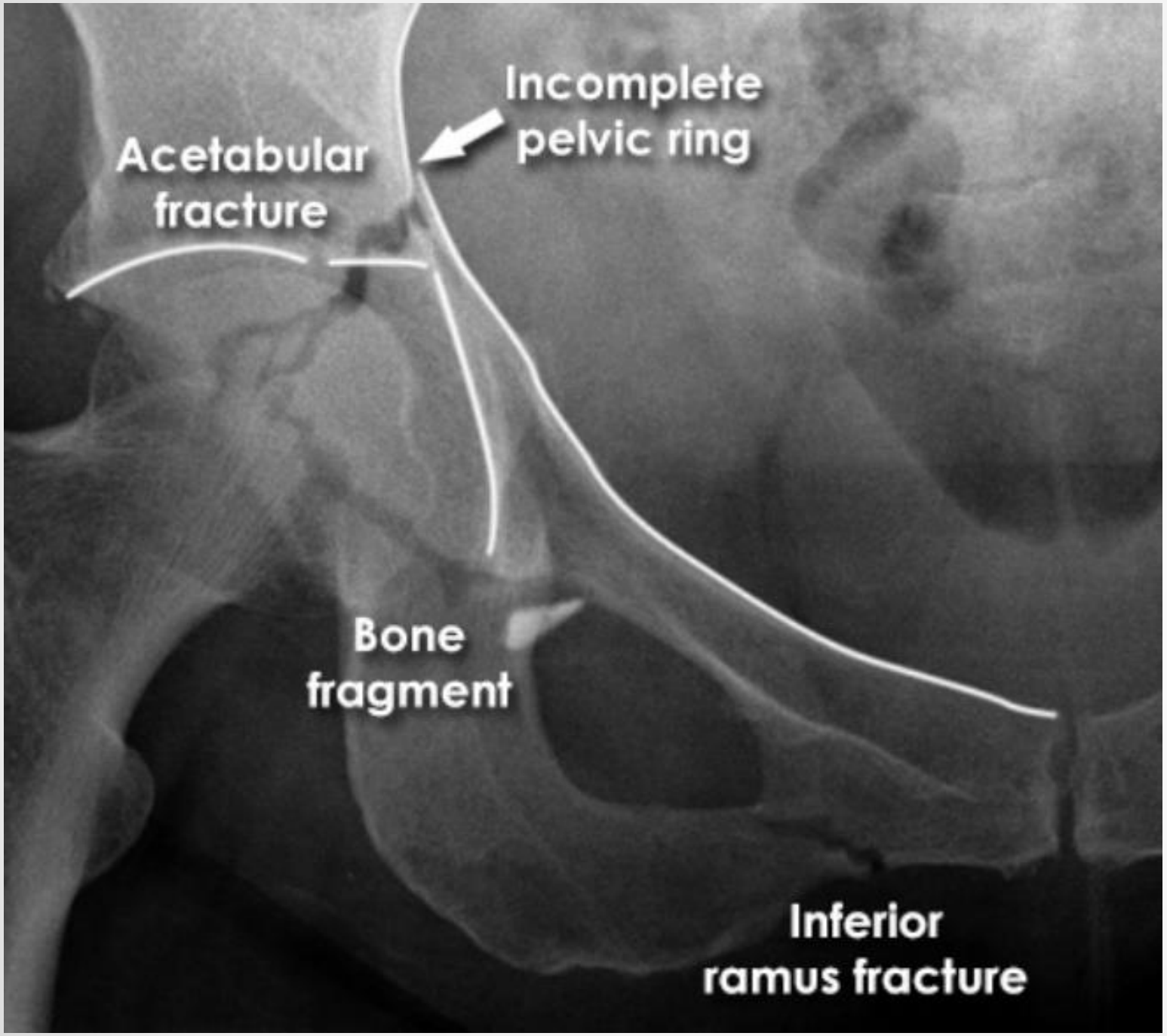
Hemi-pelvis anatomy - Normal AP

- Each hemi-pelvis bone comprises 3 bones - the ilium (**white**), pubis (**orange**) and ischium (**blue**)
- The 3 bones fuse to form the acetabulum - the pelvic portion of the hip joint
- **ASIS** = Anterior Superior Iliac Spine = attachment site for sartorius muscle
- **AIIS** = Anterior Inferior Iliac Spine = attachment site for rectus femoris muscle



Pubic ramus fracture

- The obturator ring is incomplete on the right
- A fracture passes through the superior and inferior pubic rami
- Compare with the normal left side

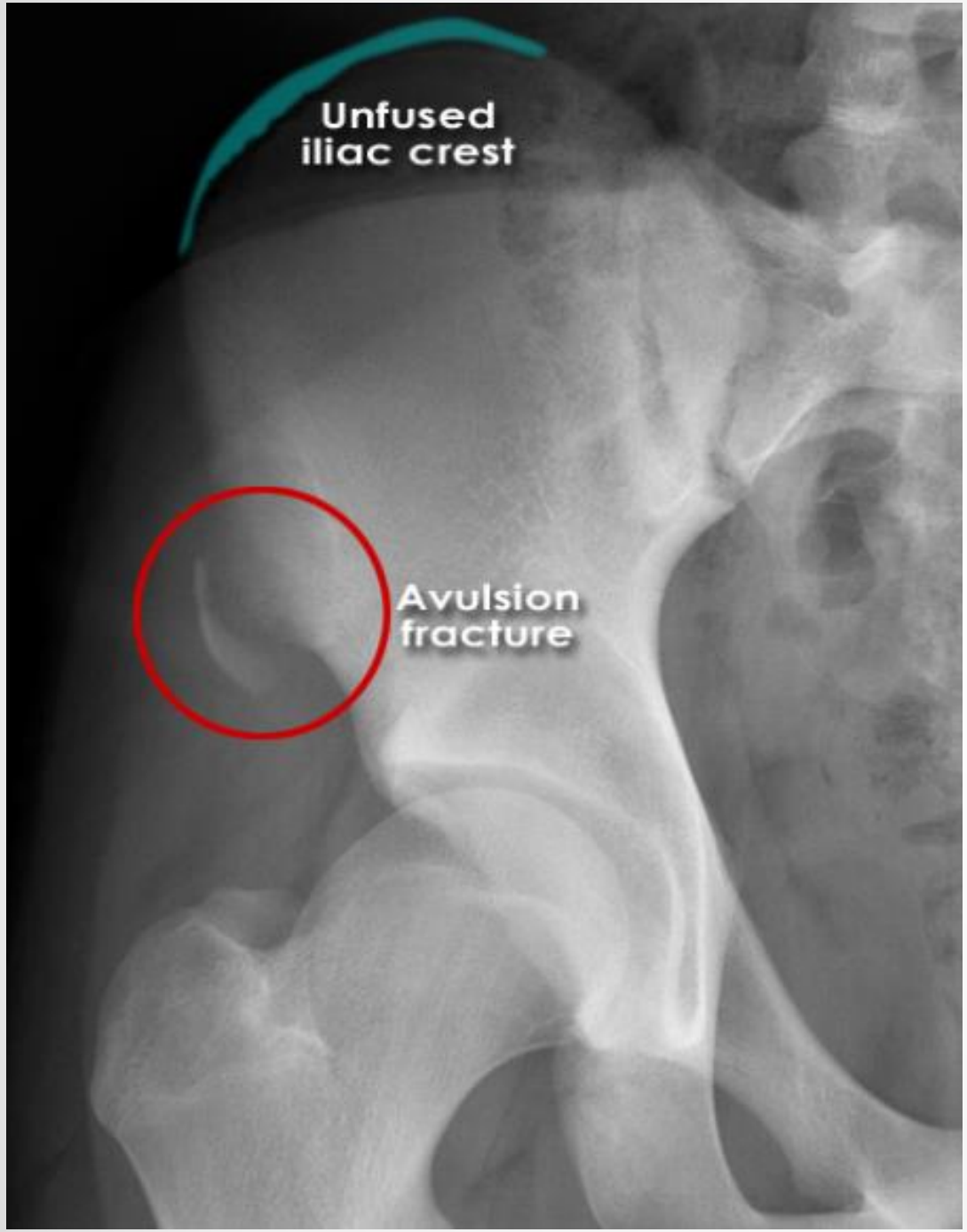


Acetabular fracture

- A tiny step in the cortical edge of the pelvic ring reveals a fracture which passes into the acetabulum
- The fracture passes to the obturator ring and then through the inferior pubic ramus

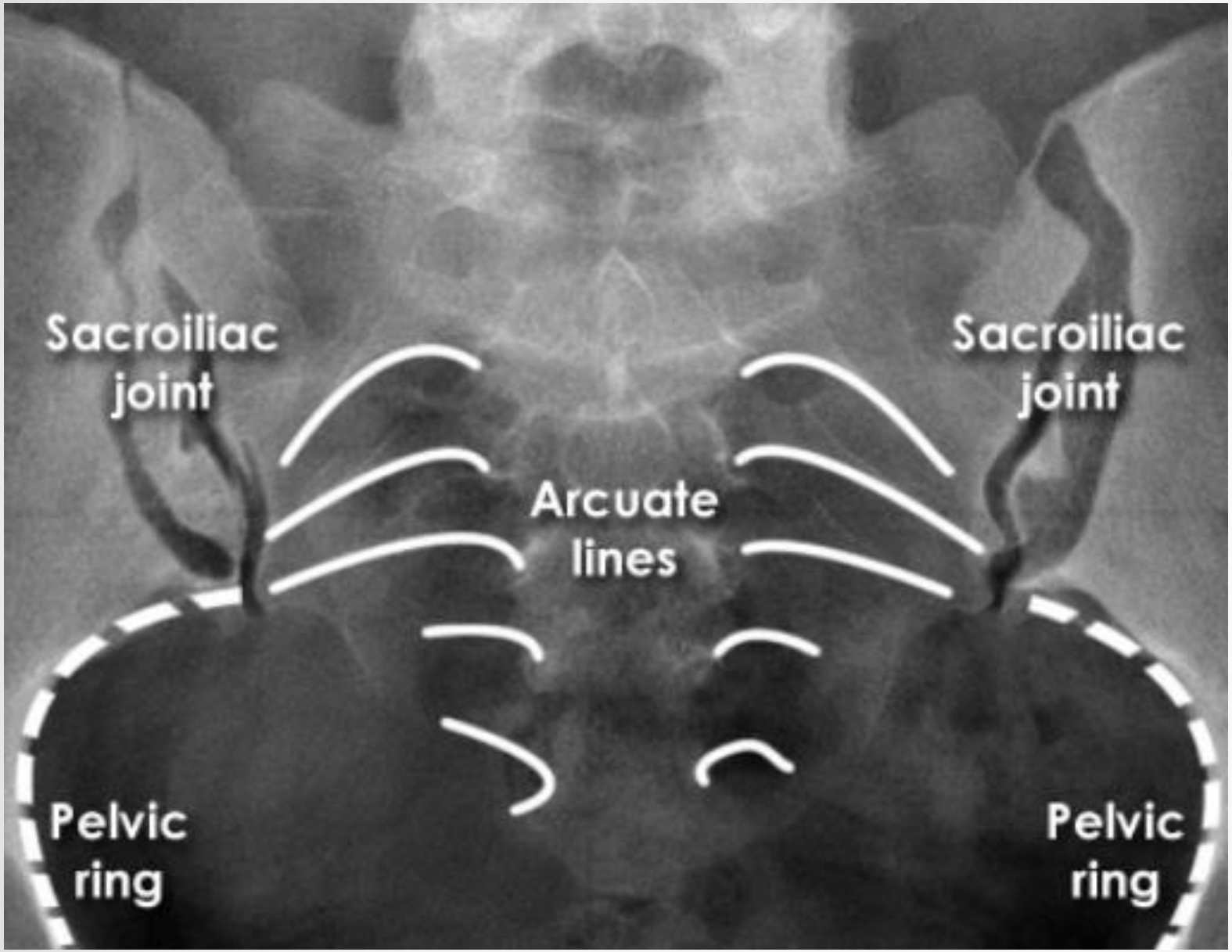
Pelvis diastasis

- Both the pubic symphysis and the right sacroiliac joint are widened
- There is complete separation of the right hemi-pelvis from the axial skeleton



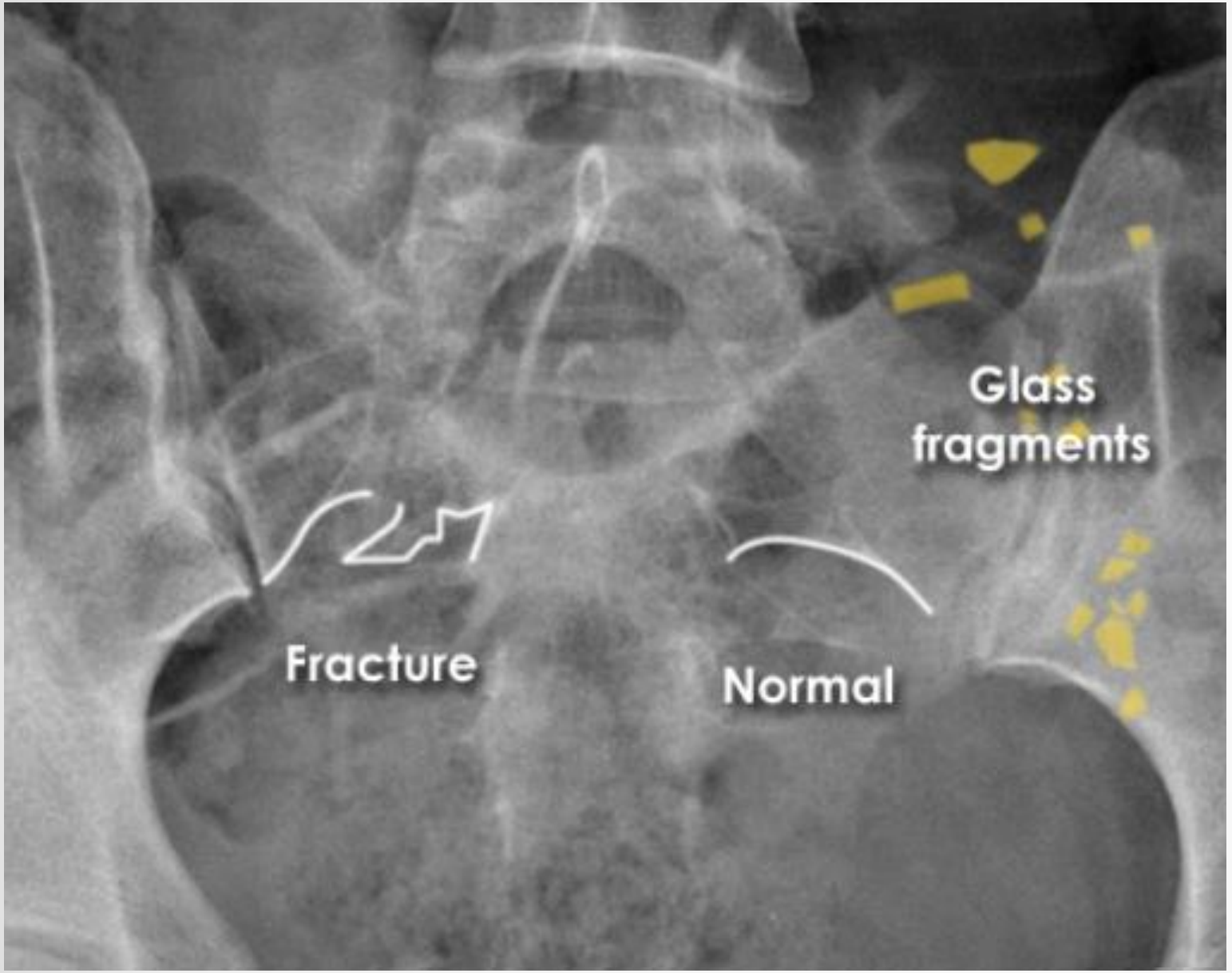
ASIS avulsion fracture

- A small fragment of bone has detached from the pelvis
- All or part of the sartorius tendon origin will be attached to the bone fragment
- Note the normal appearance of the unfused iliac crest apophysis in this male teenager



Pelvis anatomy - Sacrum - Normal AP

- The sacrum and the iliac bones overlap to form the sacroiliac joints
- The arcuate lines of the sacrum are the roofs of the sacral exit foramina which carry the sacral nerve roots



Sacral fracture- AP pelvis

- Loss of the smooth arcuate lines is a sign of sacral fracture

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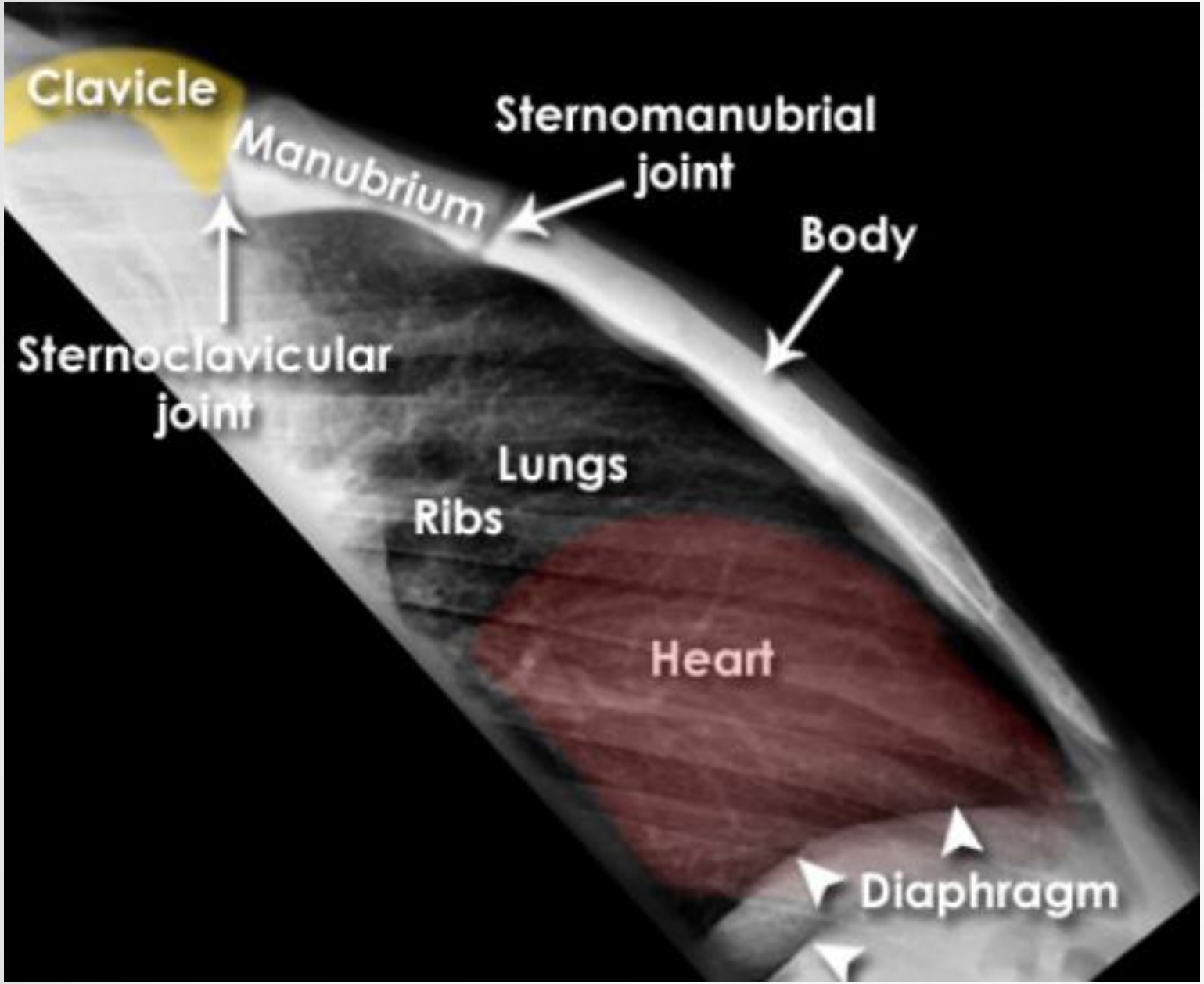
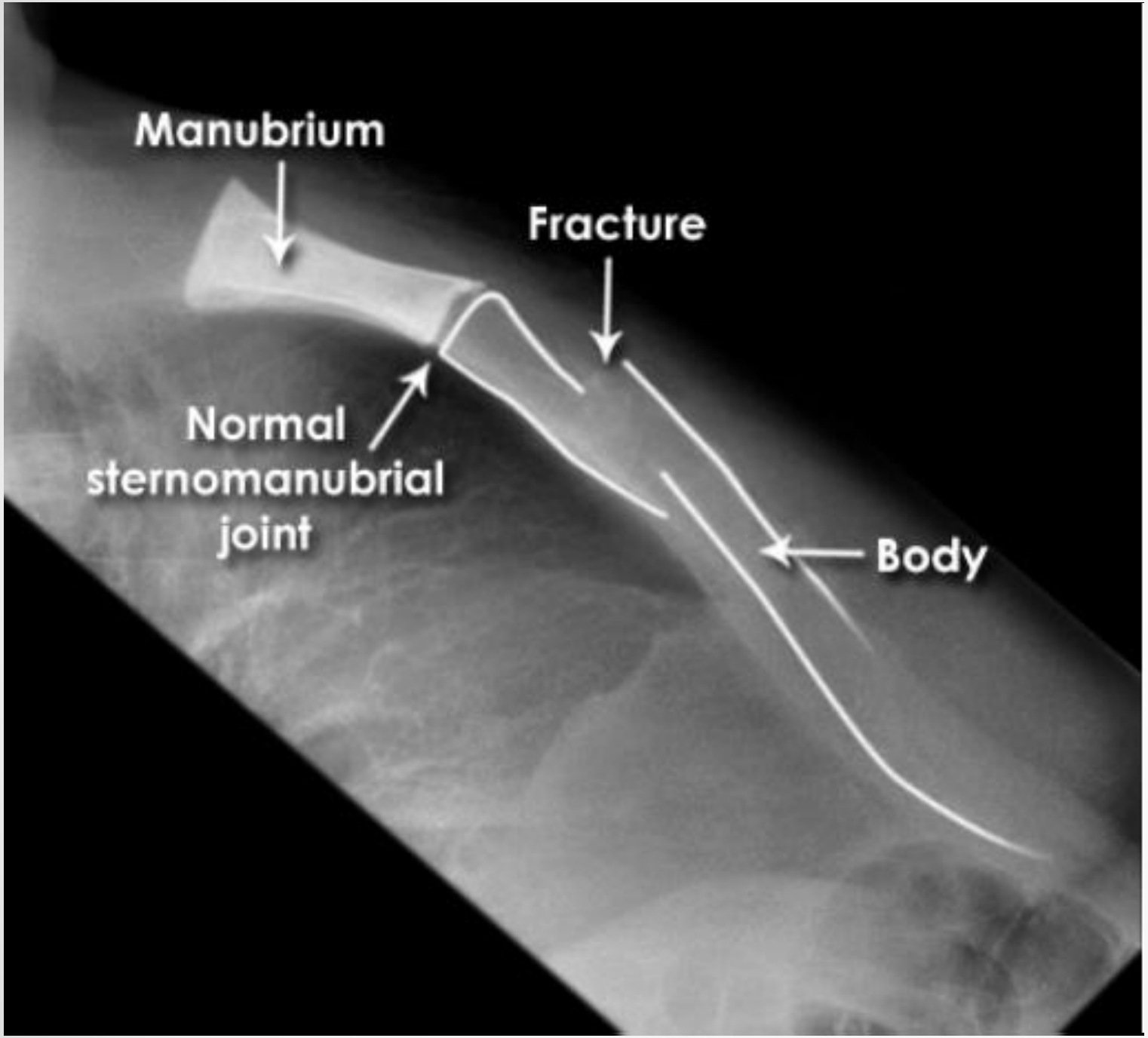


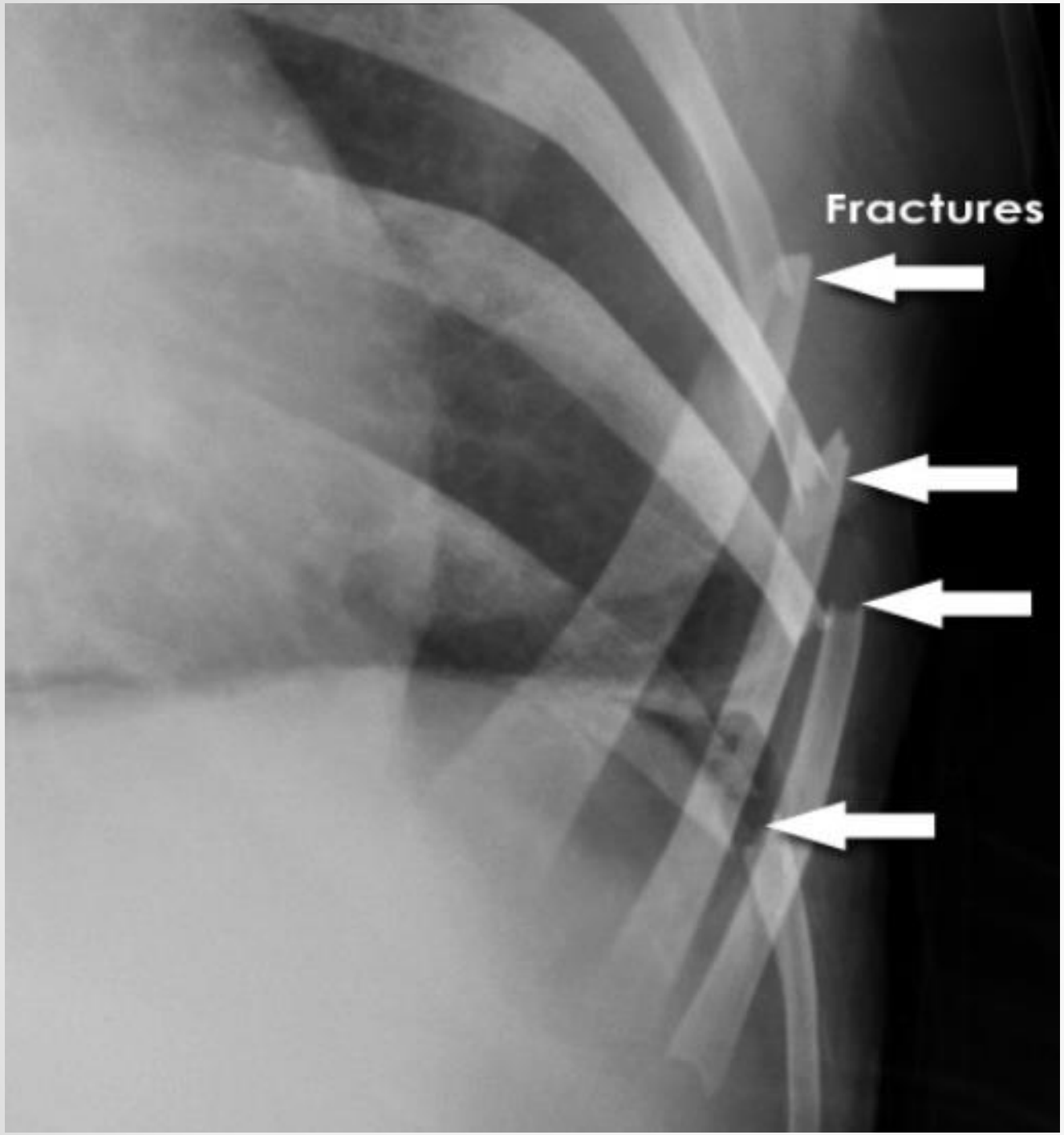
Sternum - Normal - Lateral

- Note the normal sternomanubrial joint which should not be mistaken for a fracture



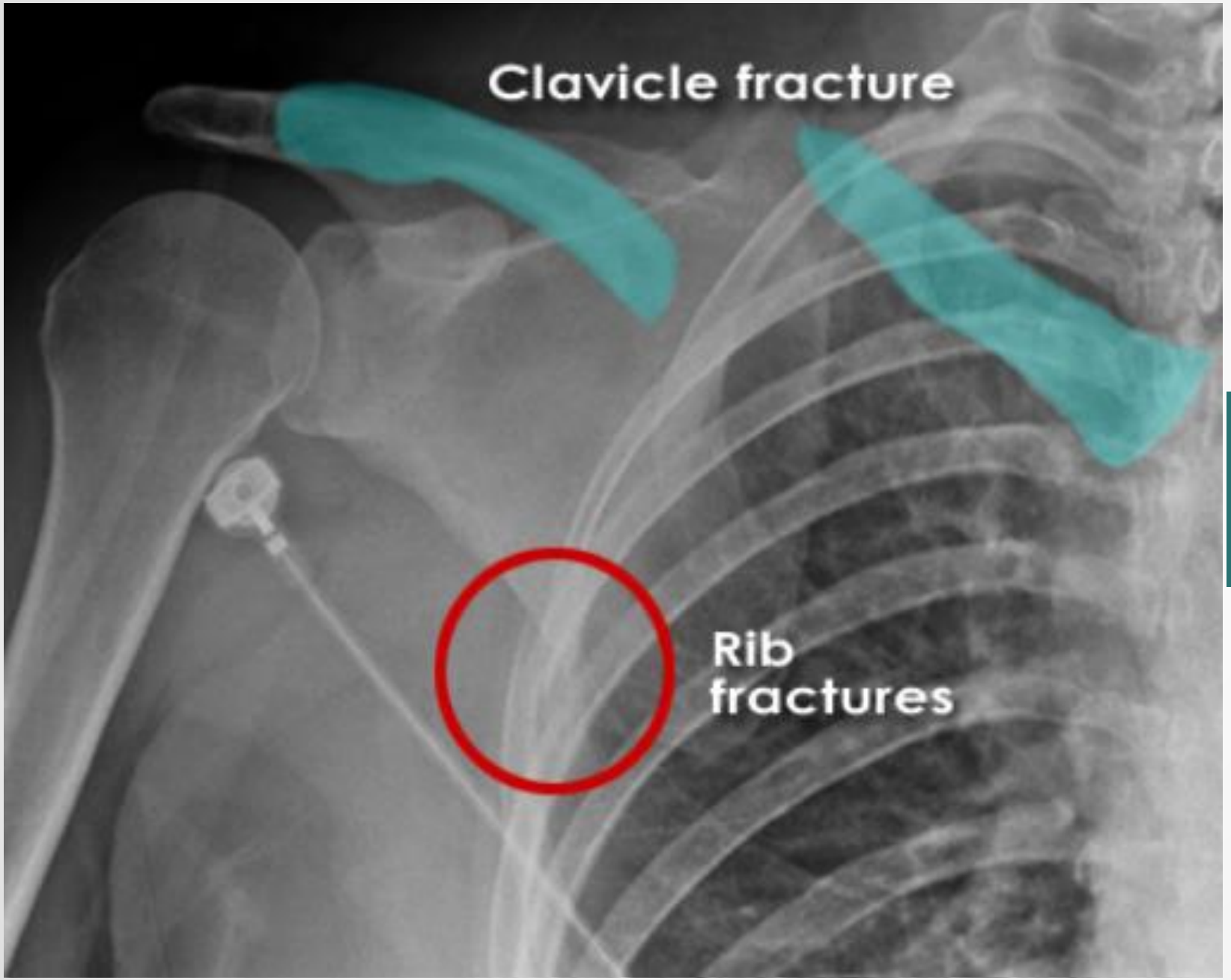
Sternal fracture - Lateral

- A step in the cortex of the sternum indicates a fracture



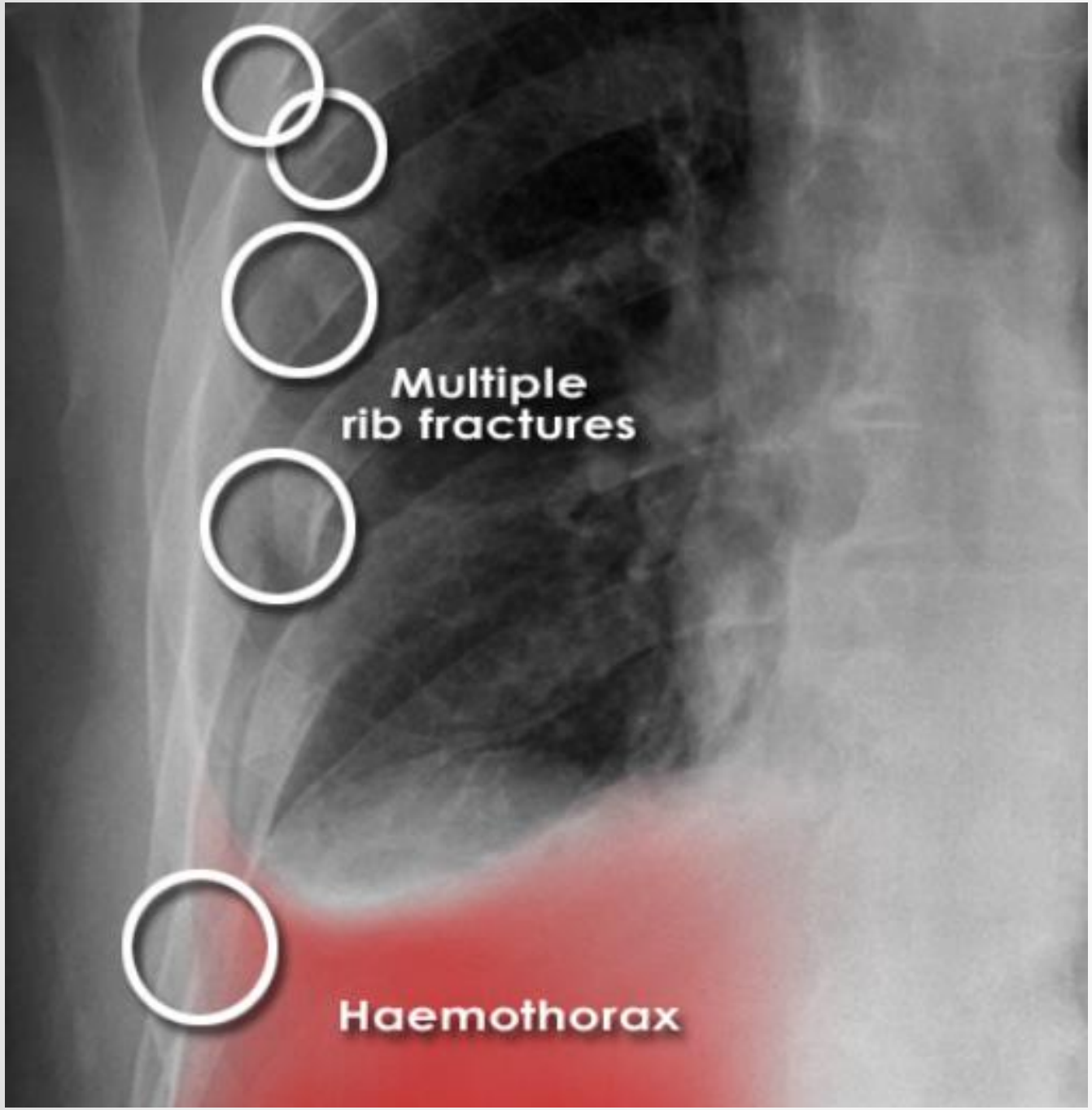
Rib fractures - Chest X-ray (detail)

- Multiple displaced lower left rib fractures are visible



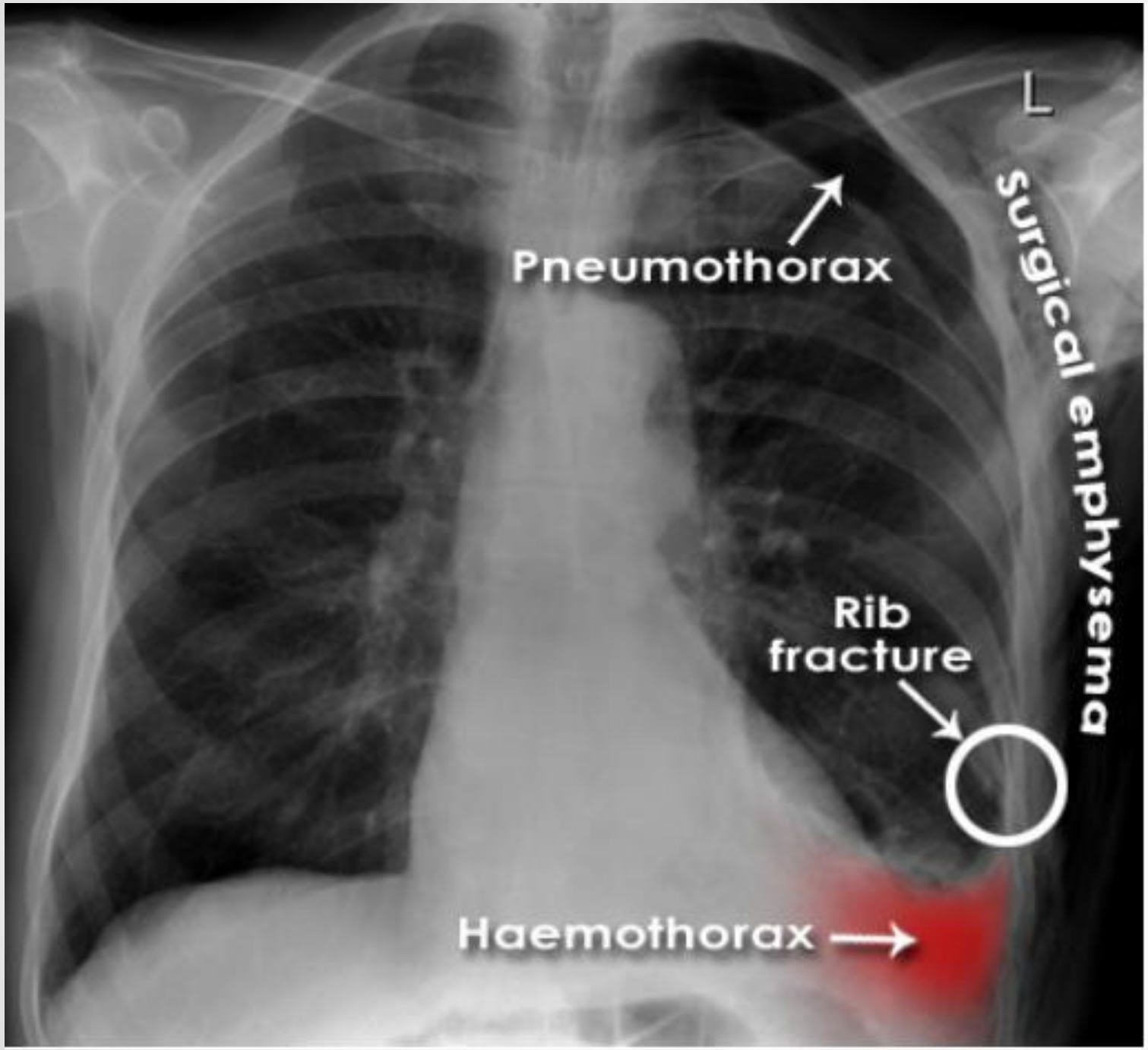
Subtle rib fracture - Shoulder X-ray

- The clavicle fracture is obvious
- A subtle rib fracture is also seen
- Note: Always check for a second injury



Rib fractures with haemothorax - Chest X-ray

- Multiple rib fractures are accompanied by a small pleural effusion - likely a haemothorax



Rib fracture with pneumothorax - Chest X-ray

- A minimally displaced rib fracture is visible
- This fracture is complicated by a haemothorax and a pneumothorax with surgical emphysema

Types of Fractures

01 Skull

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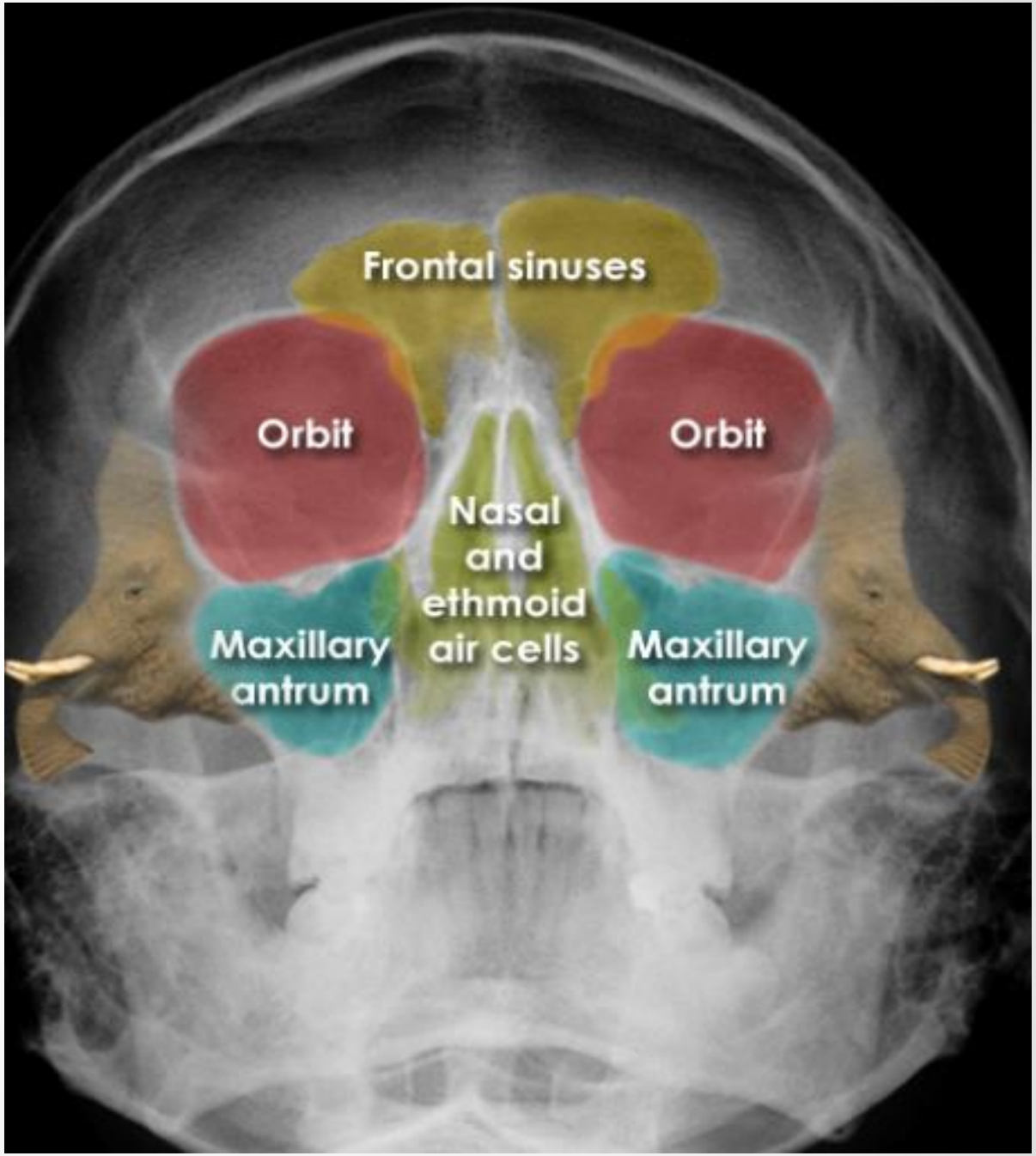
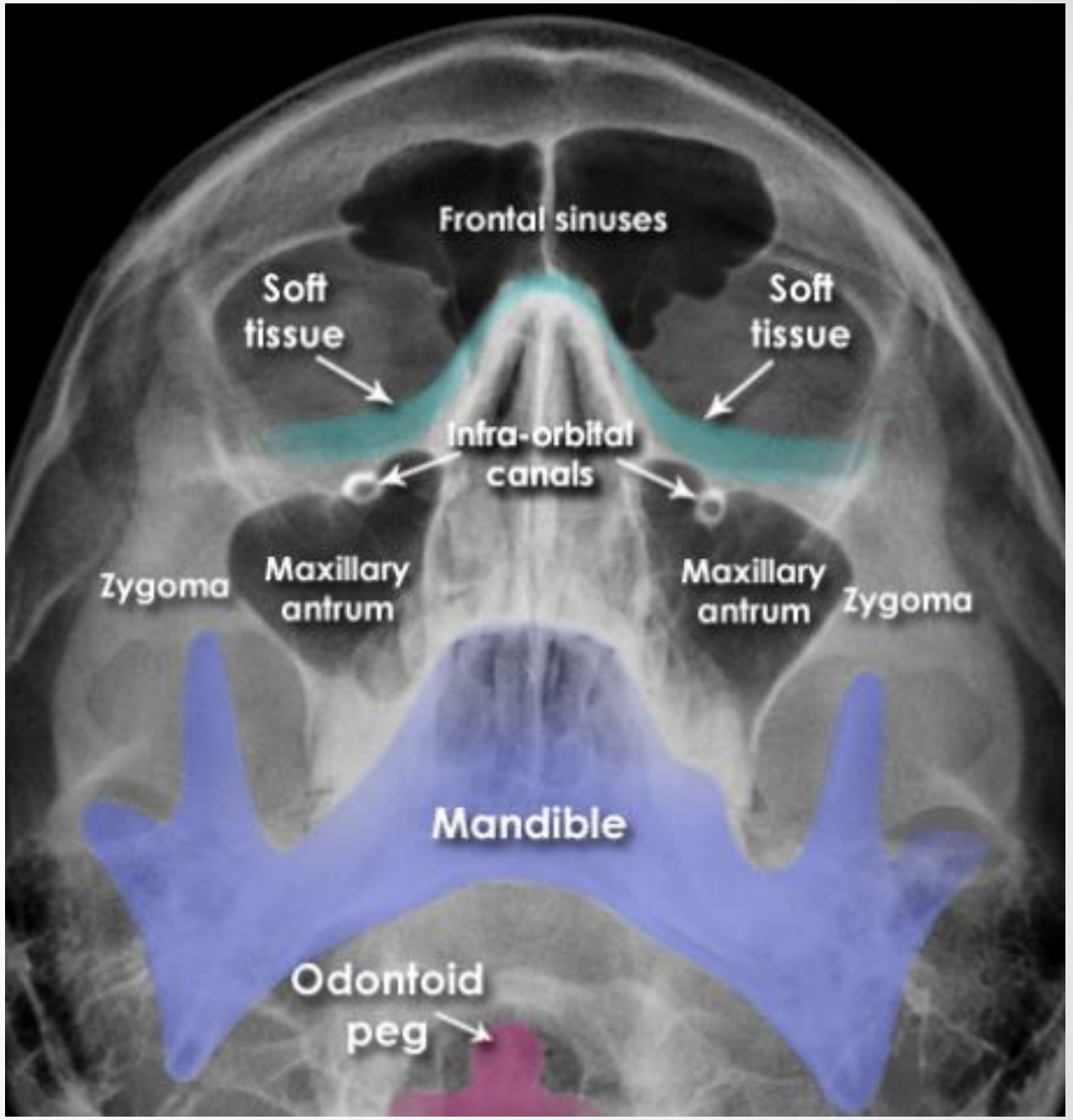
Occipito-Mental (OM) view - Normal

- This view is acquired with the patient looking slightly upwards
- Each zygoma and zygomatic arch resembles the head and trunk of an elephant
- The blacker areas are the orbits and paranasal sinuses - frontal, nasal/ethmoid, and maxillary
- The frontal sinuses are highly variable in appearance



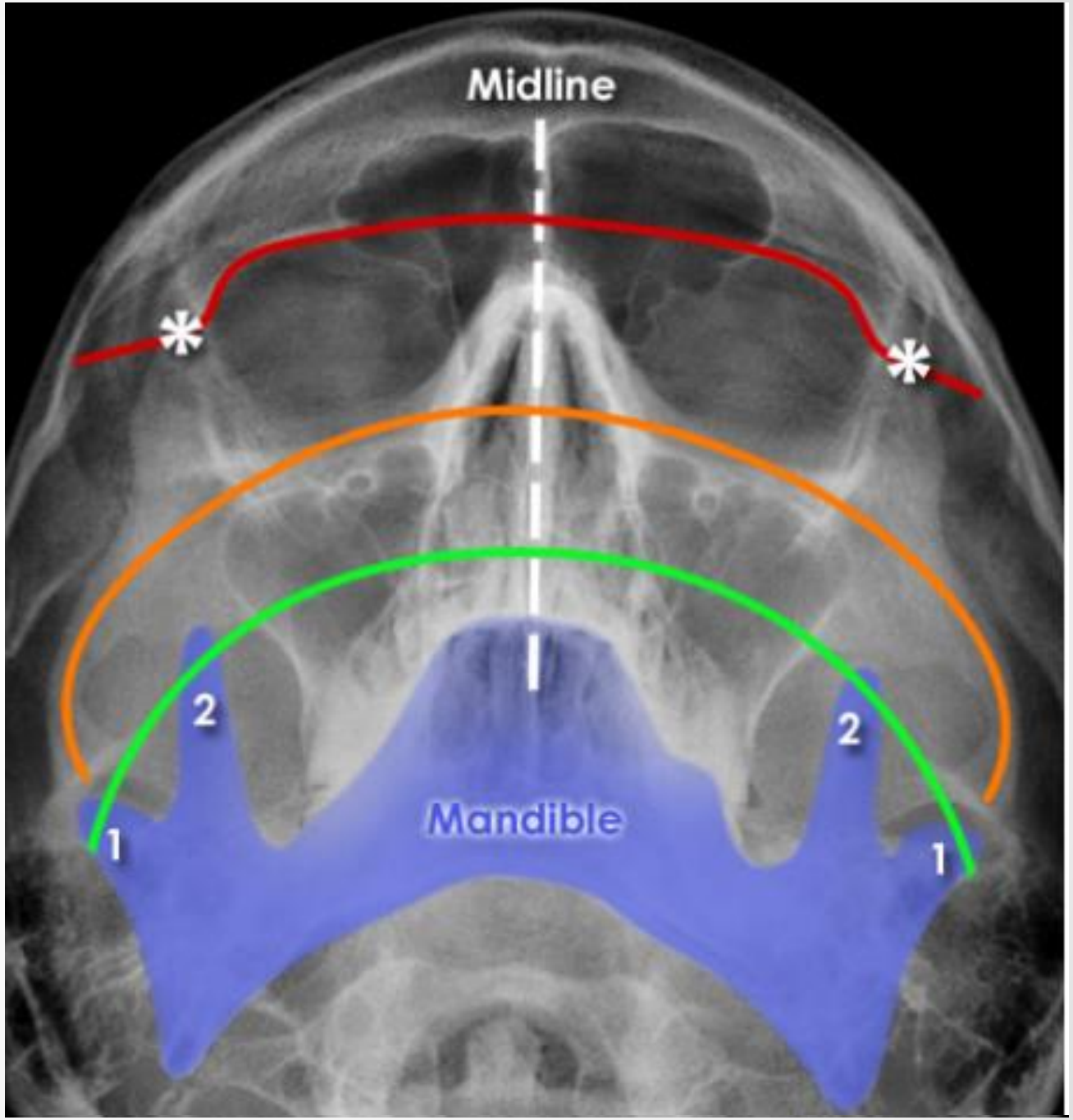
Occipito-Mental (OM30) view - Normal

- This view is acquired at 30° from horizontal with the patient in the same position as for the OM view
- Each infra-orbital canal is part of the floor of the orbit - these carry the maxillary division of the trigeminal nerve which can be injured as the result of fracture
- Note that each maxillary antrum is clear (black)
- Other visible structures include the mandible and the odontoid peg



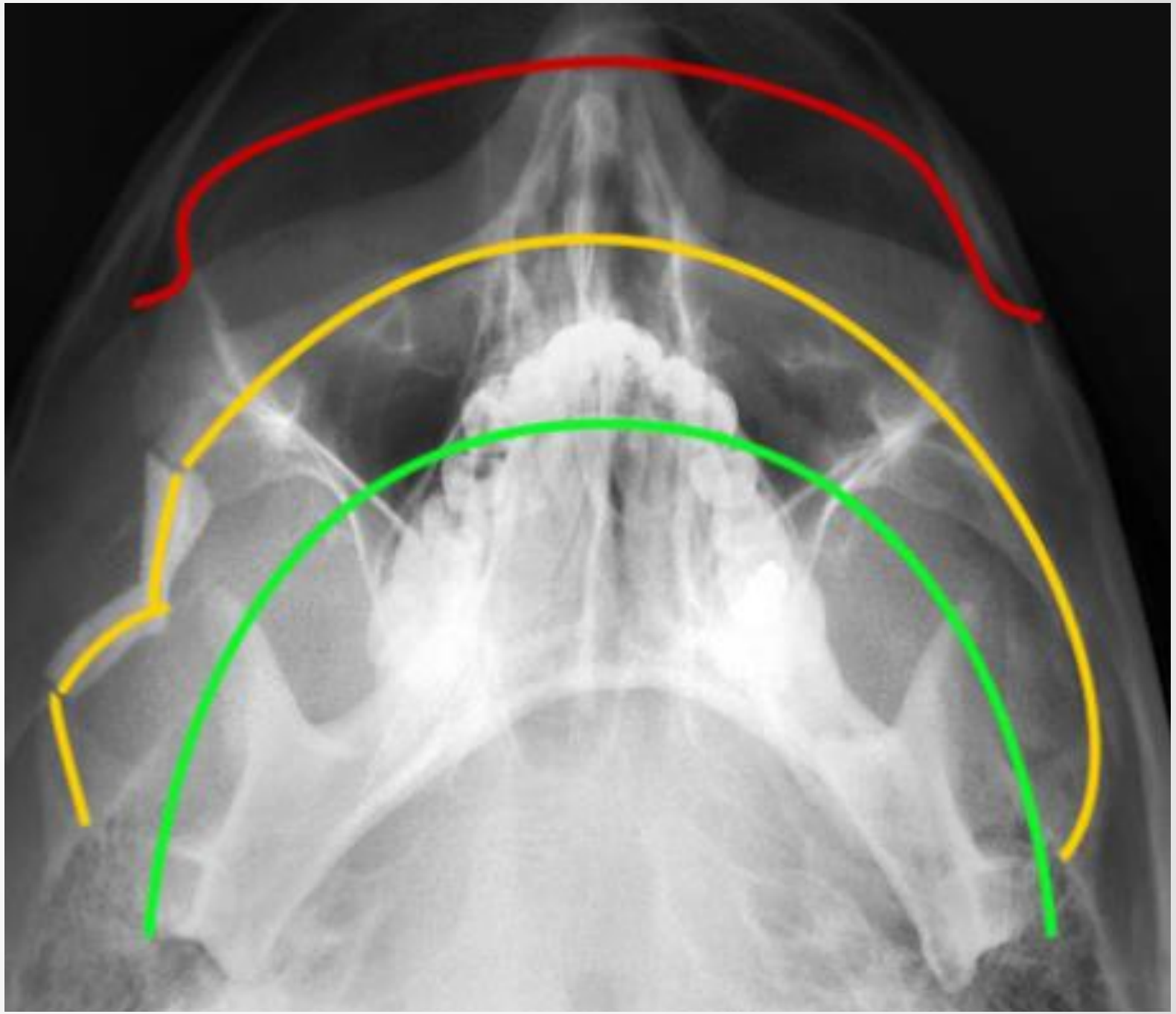
McGrigor-Campbell lines

- The ' McGrigor-Campbell lines' are visible on OM and OM30 views and can act as anatomical references to assess the facial bones for injury
- Upper line - (**Red**) passes through the zygomatico-frontal sutures (asterisks) and across the upper edge of the orbits
- Middle line - (**Orange**) follows the zygomatic arch (elephant's trunk), crosses the zygomatic bone and follows the inferior orbital margins to the opposite side
- Lower line - (**Green**) passes through the condyle (**1**) and coronoid process (**2**) of the mandible and through the lateral and medial walls of the maxillary antra on each side
- Midline - used to assess symmetry



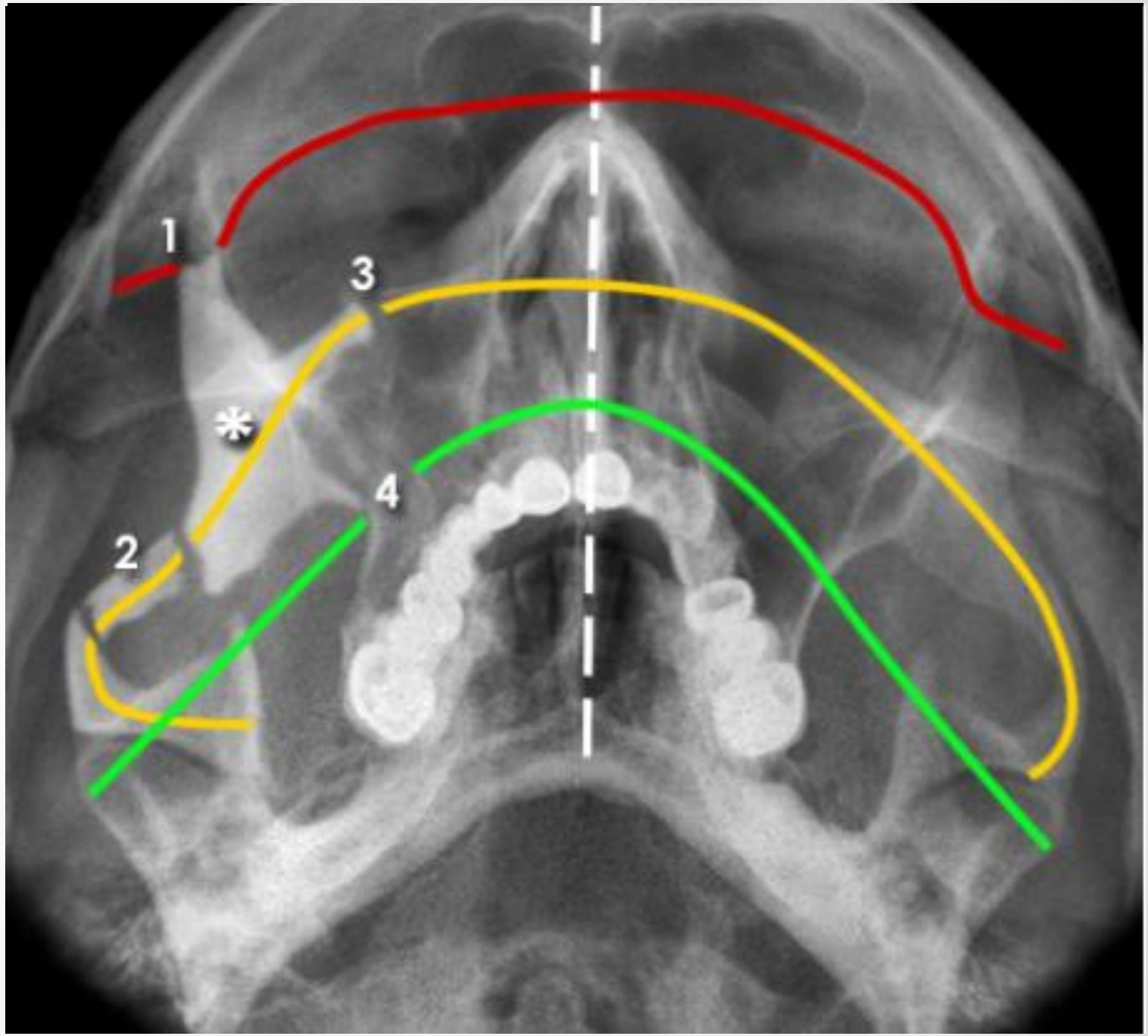
Isolated zygomatic arch fracture

- Disruption of the middle McGrigor-Campbell line is due to a comminuted fracture of the right zygomatic arch
- Following the upper and lower lines shows no fracture



'Tripod' fracture

- **1** - The zygoma (**asterisk**) is separated from the frontal bone at the zygomatico-frontal suture
- **2** - Comminuted fracture of the zygomatic arch
- **3** - Orbital floor fracture
- **4** - Breach of the lateral wall of the maxillary antrum

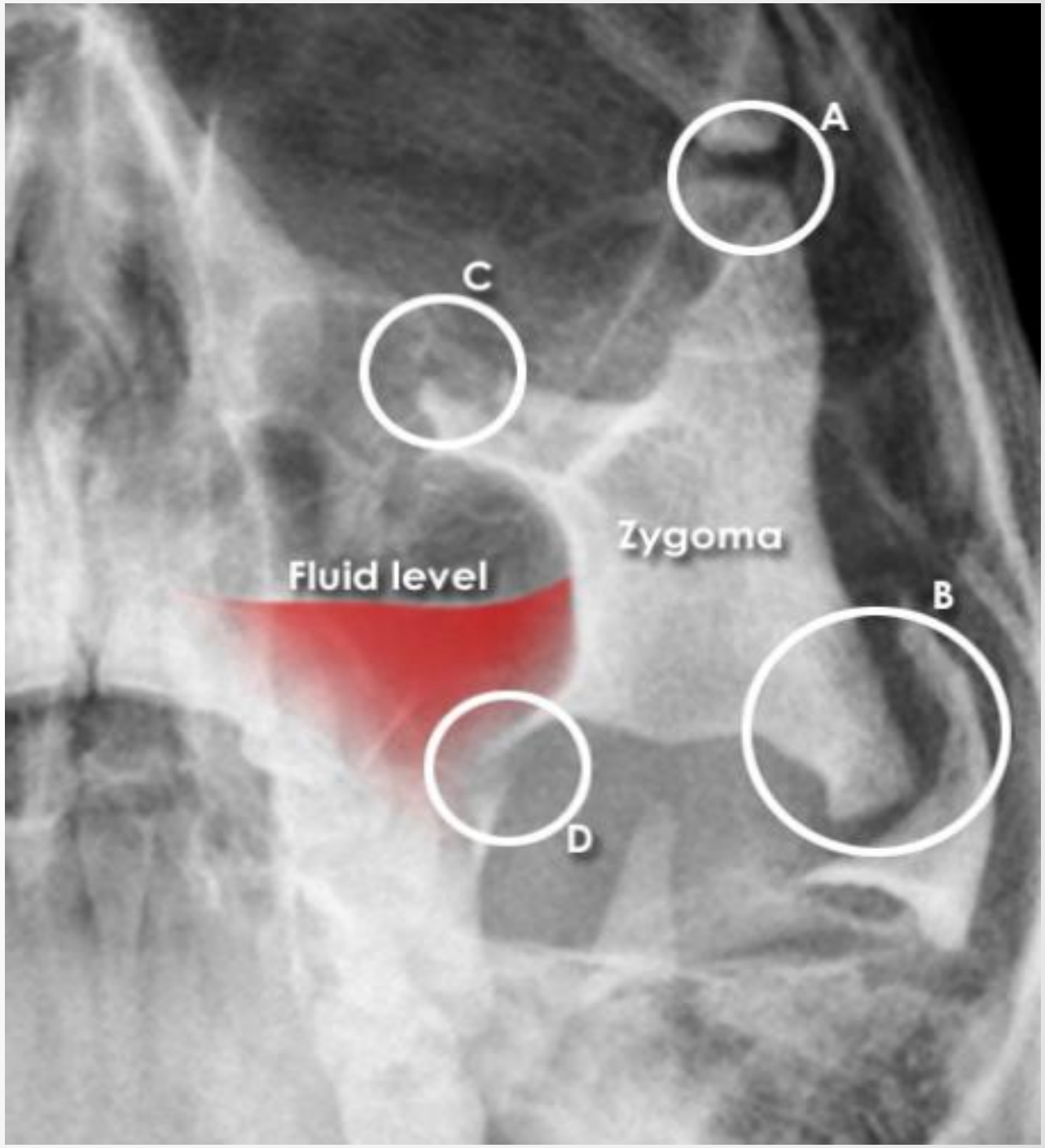


Maxillary antrum fluid level

- A fluid level of blood seen in the maxillary antrum may be the only obvious sign of fracture

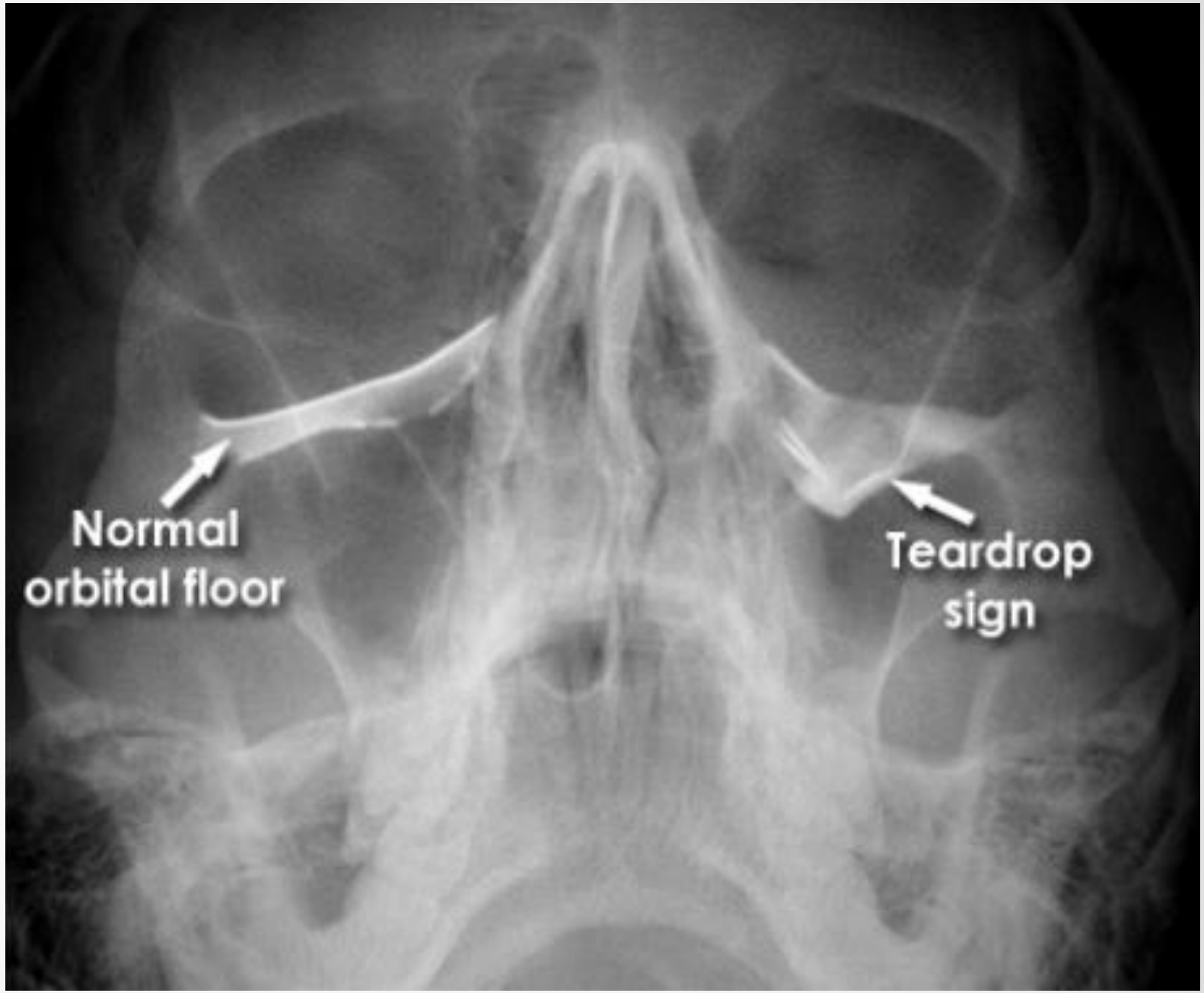
'Tripod' fracture

- **A** - Widened zygomatico-frontal suture
- **B** - Zygomatic arch fracture
- **C** - Orbital floor fracture
- **D** - Lateral maxillary antrum wall fracture



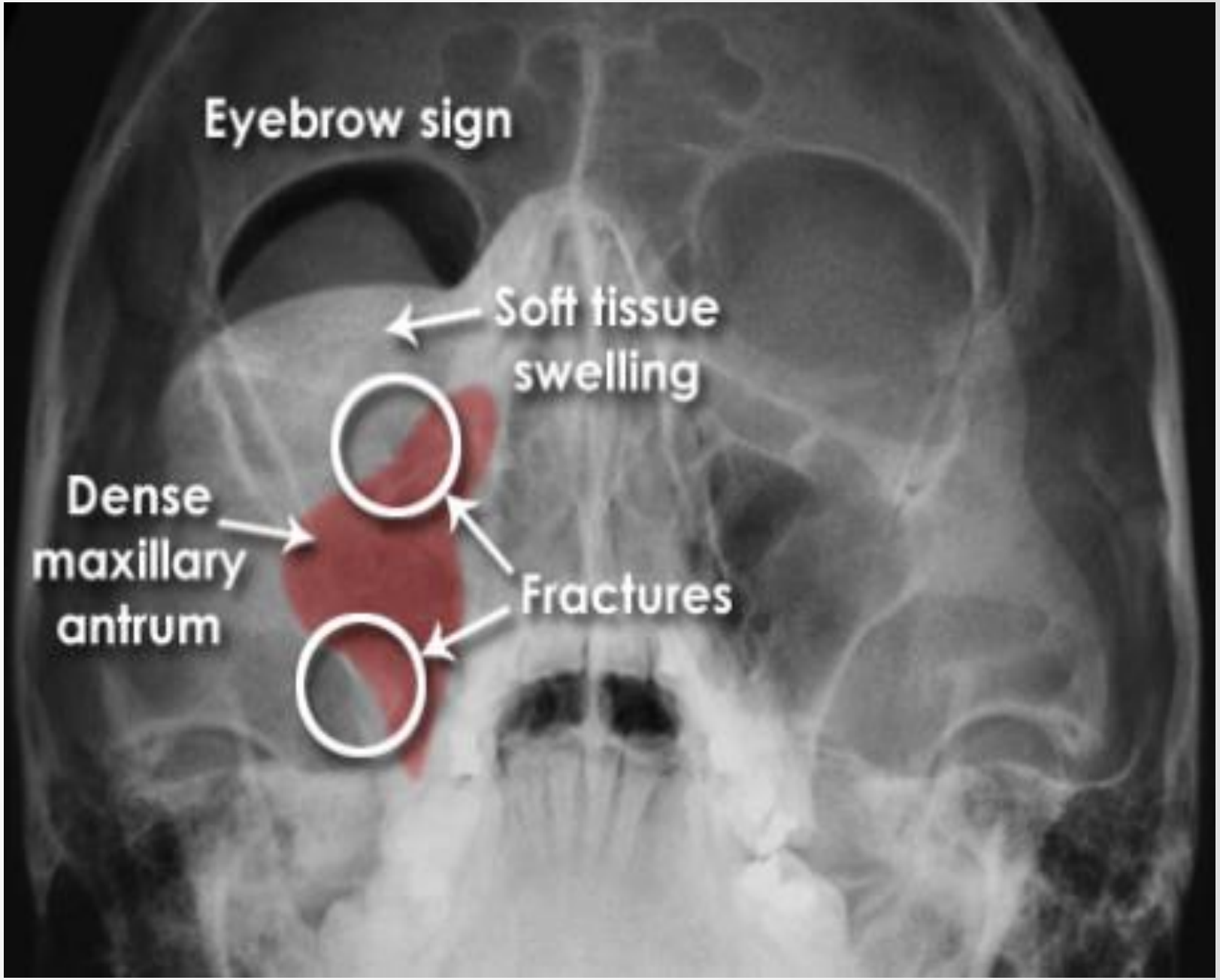
Orbital 'blowout' fracture - Teardrop sign

- On the left a 'teardrop' of soft tissue has herniated from the orbit into the maxillary antrum



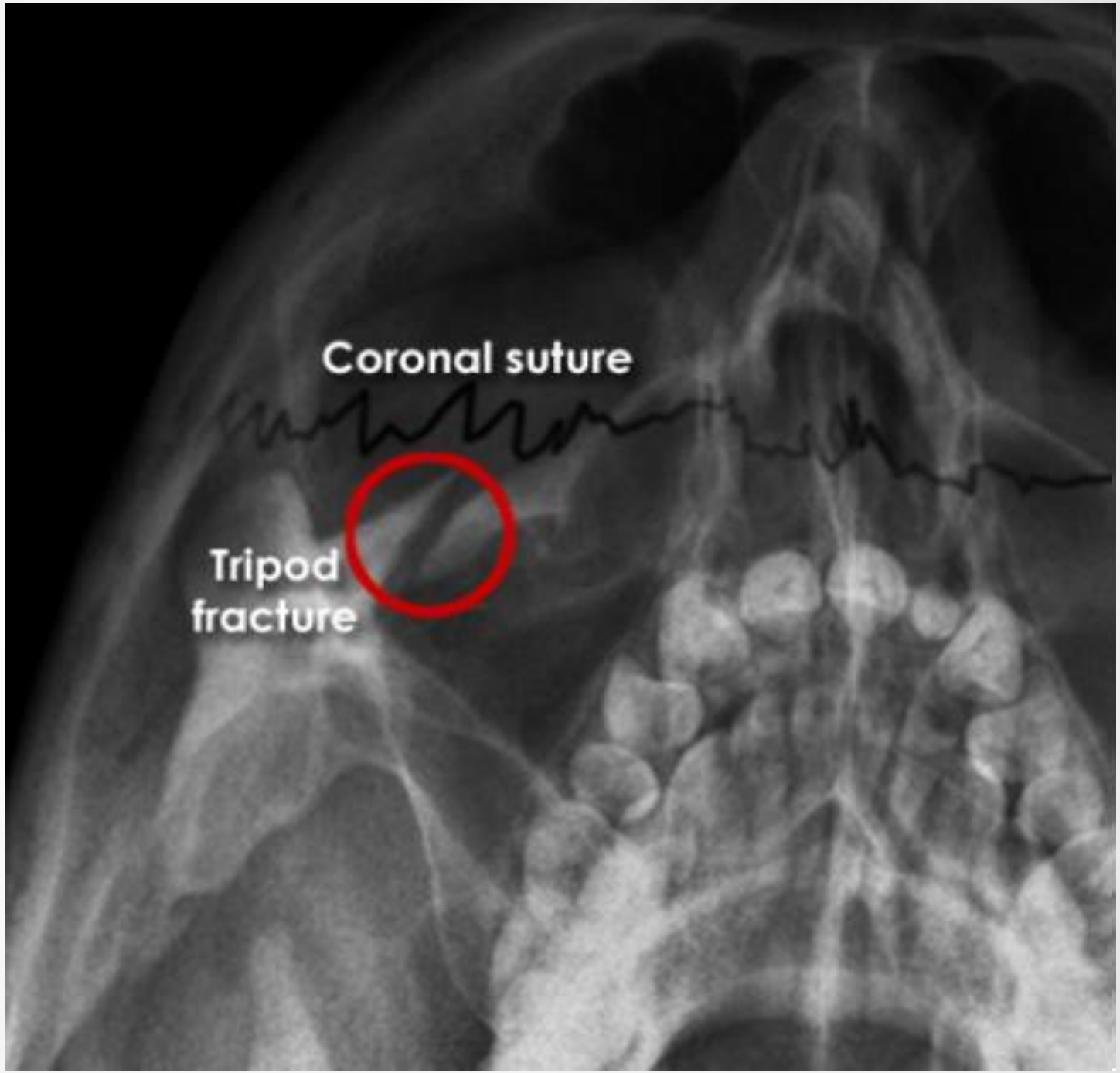
Orbital emphysema - 'Eyebrow' sign

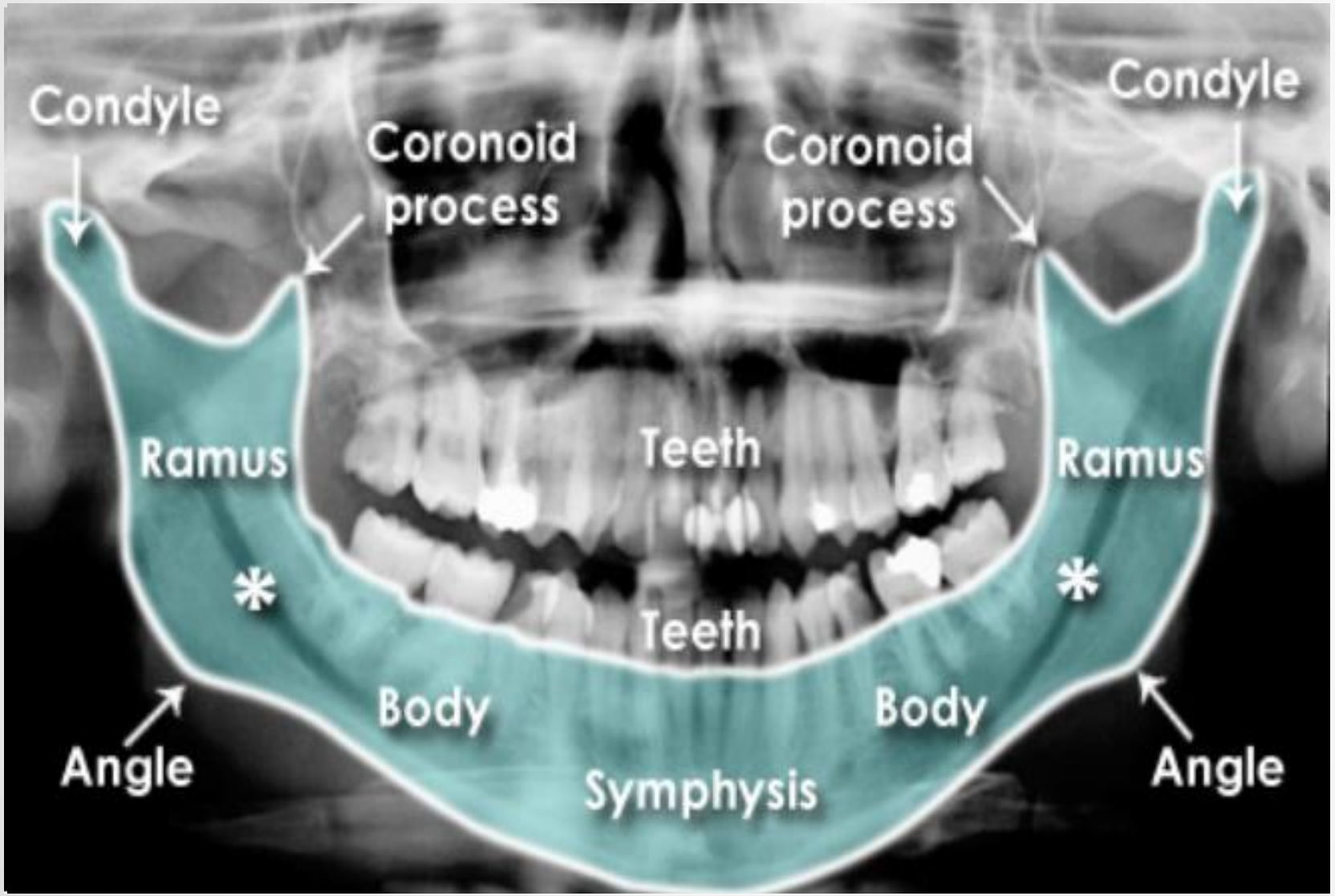
- Fractures are visible of the lateral wall of the maxillary antrum and of the orbital floor
- Air has leaked into the orbit and is seen as an area of comparative low density - the 'eyebrow' sign
- There is also increased soft tissue density due to swelling, and increased density of the maxillary antrum due to blood



Fracture v normal suture

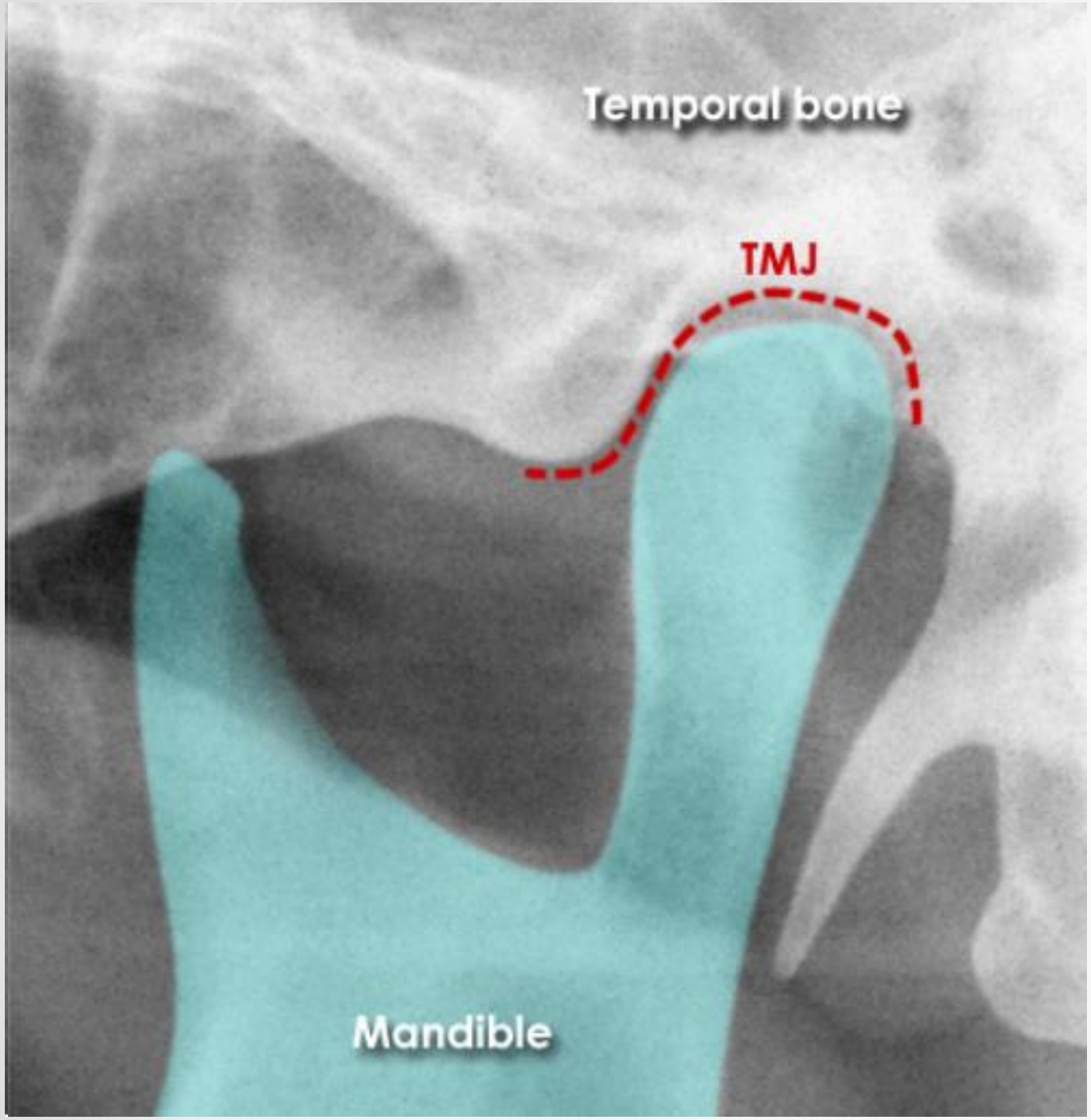
- The eye is drawn to the dark irregular line passing across the orbit which is the normal coronal suture
- A systematic approach reveals a tripod injury with a large fracture of the orbital floor





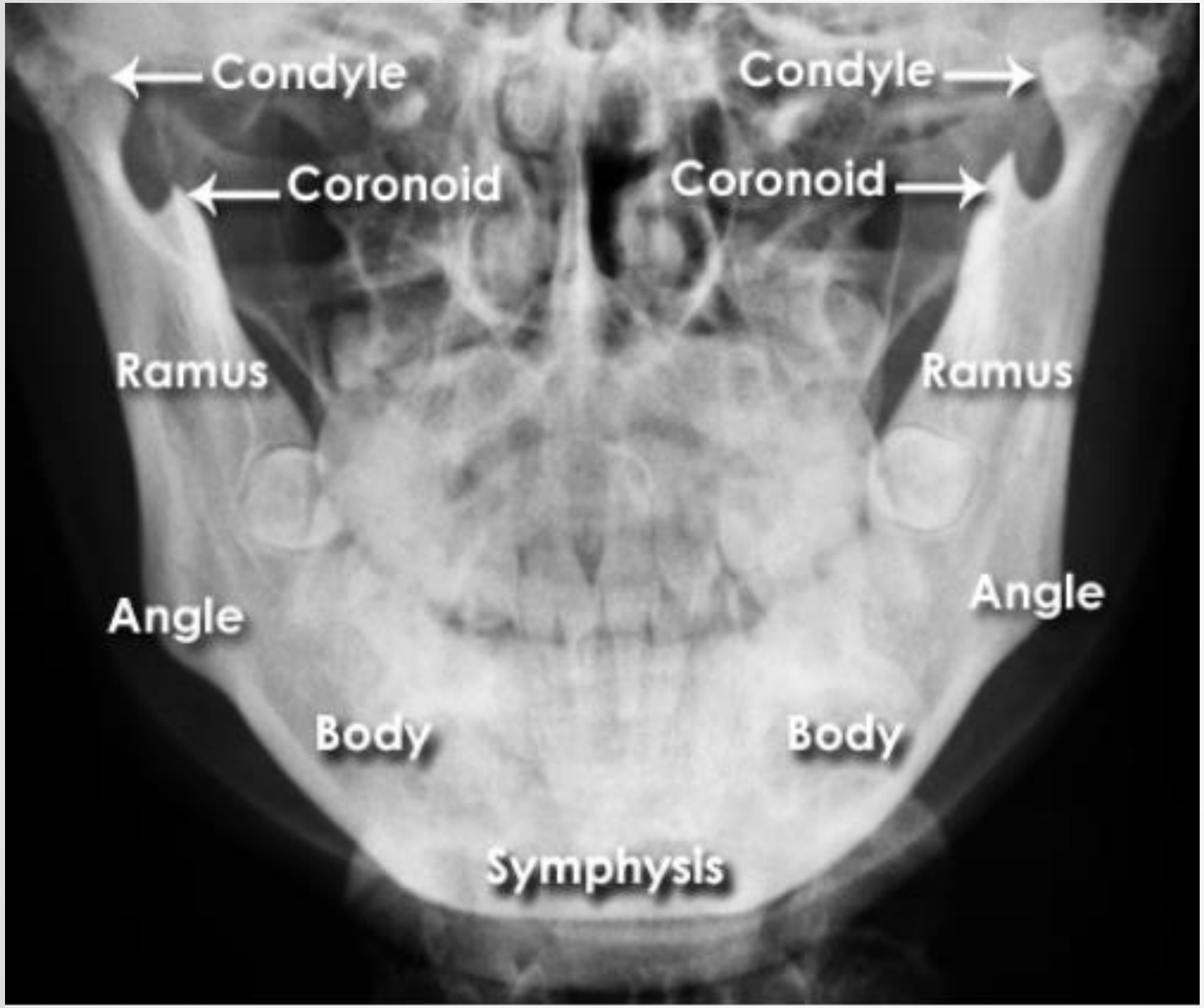
Normal mandible - Orthopantomogram (OPG)

- Follow the cortical edge all the way around the mandible
- Check the temporomandibular joints
- **Asterisks** = Inferior alveolar canal - the course of the inferior alveolar nerve



OPG detail - Normal temporomandibular joint

- The condyle of the mandible meets the glenoid fossa of the temporal bone to form the temporomandibular joint (**TMJ**)

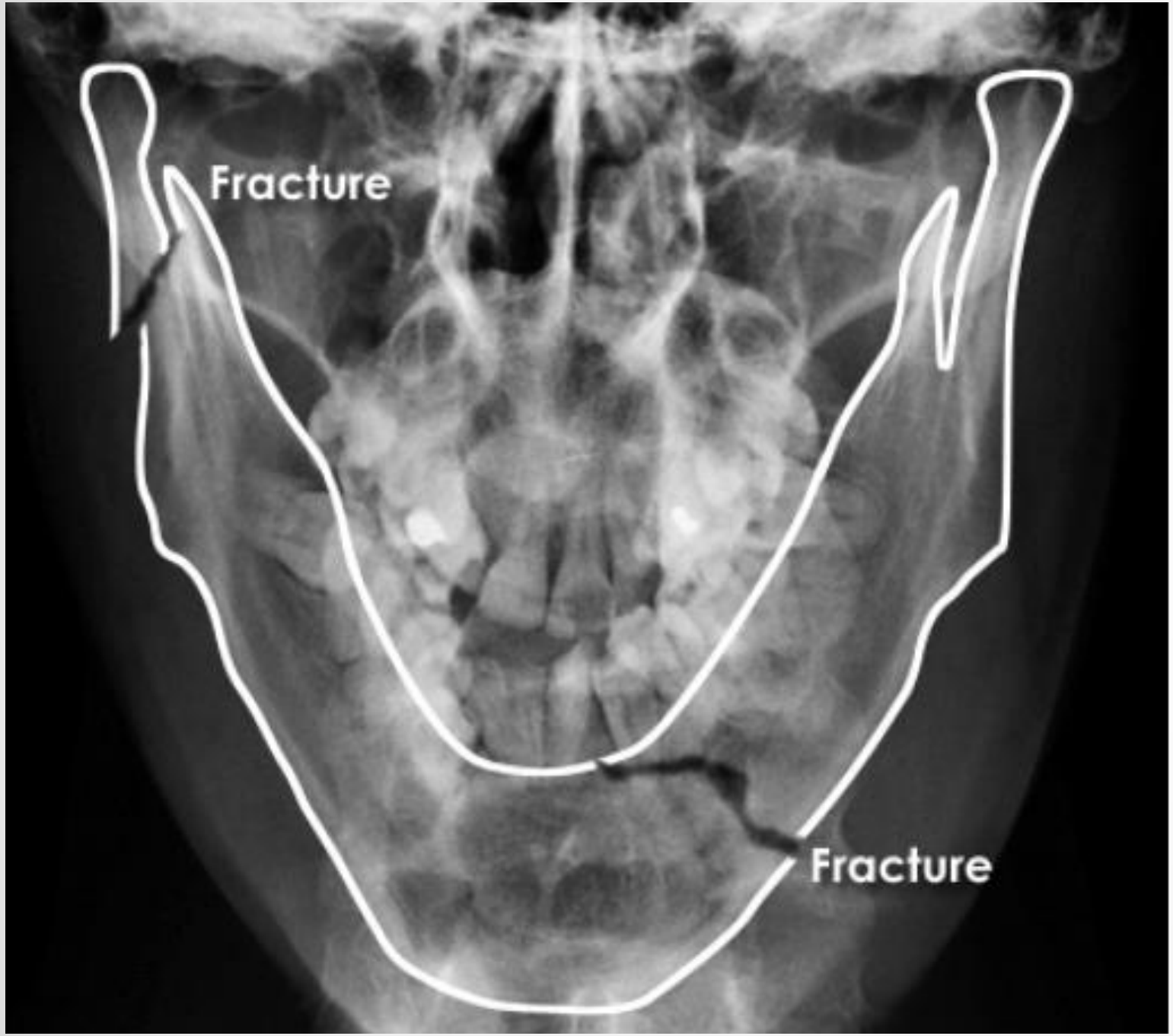


Normal mandible - Mandibular view

- Follow the cortical edge all the way around the mandible

Mandible fracture - OPG

- (Same patient as image below)
- A fracture of the left mandible body is easy to see
- On the right the cortical outline is difficult to follow at the base of the condyle (?) - but no second fracture is readily seen



Mandible fracture - Mandibular view

- (Same patient as image above)
- On this view the right condylar fracture is more easily seen

Topics

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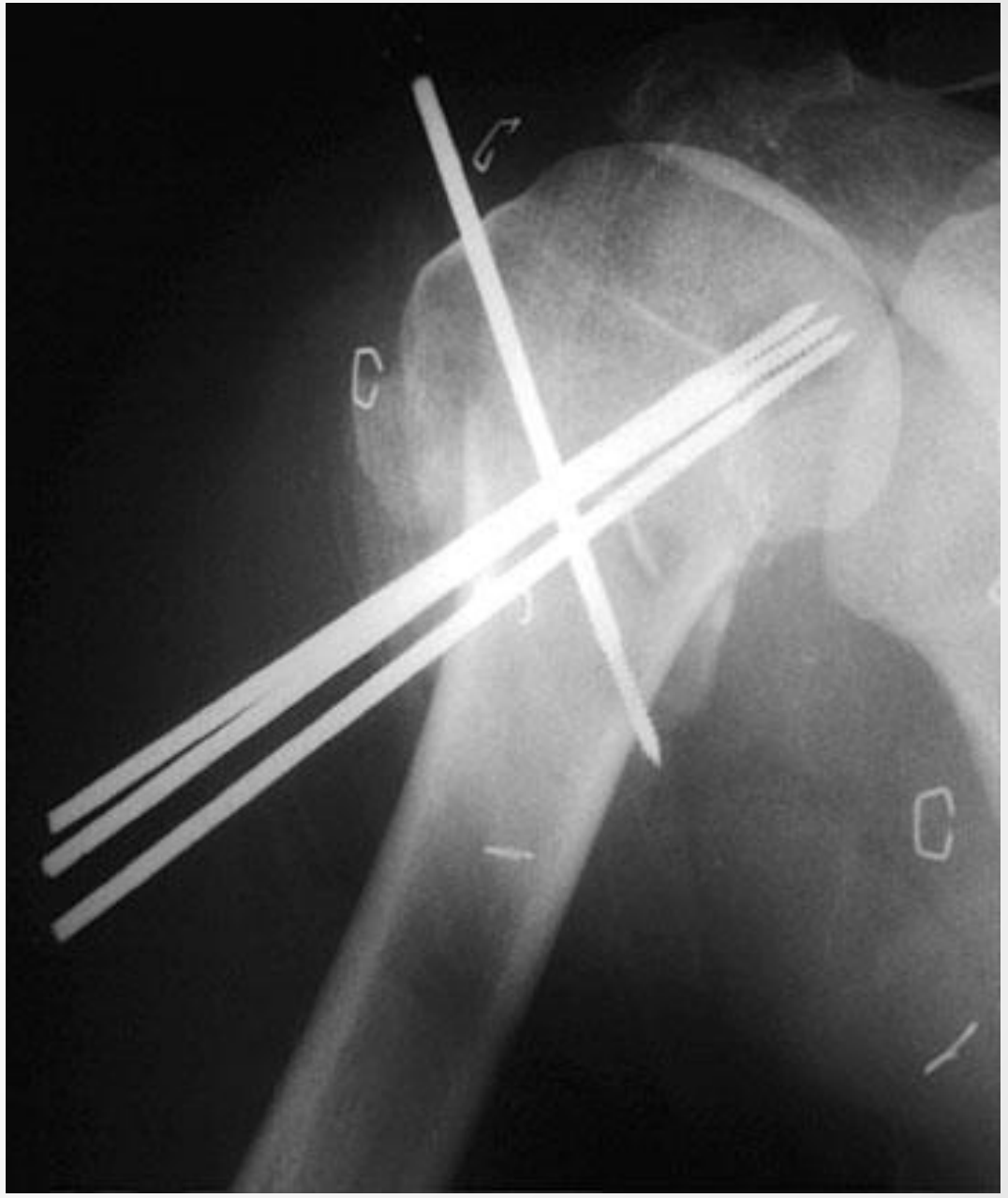
Union and non-union

A comminuted intertrochanteric fracture of the proximal left femur bridged by a dynamic hip screw

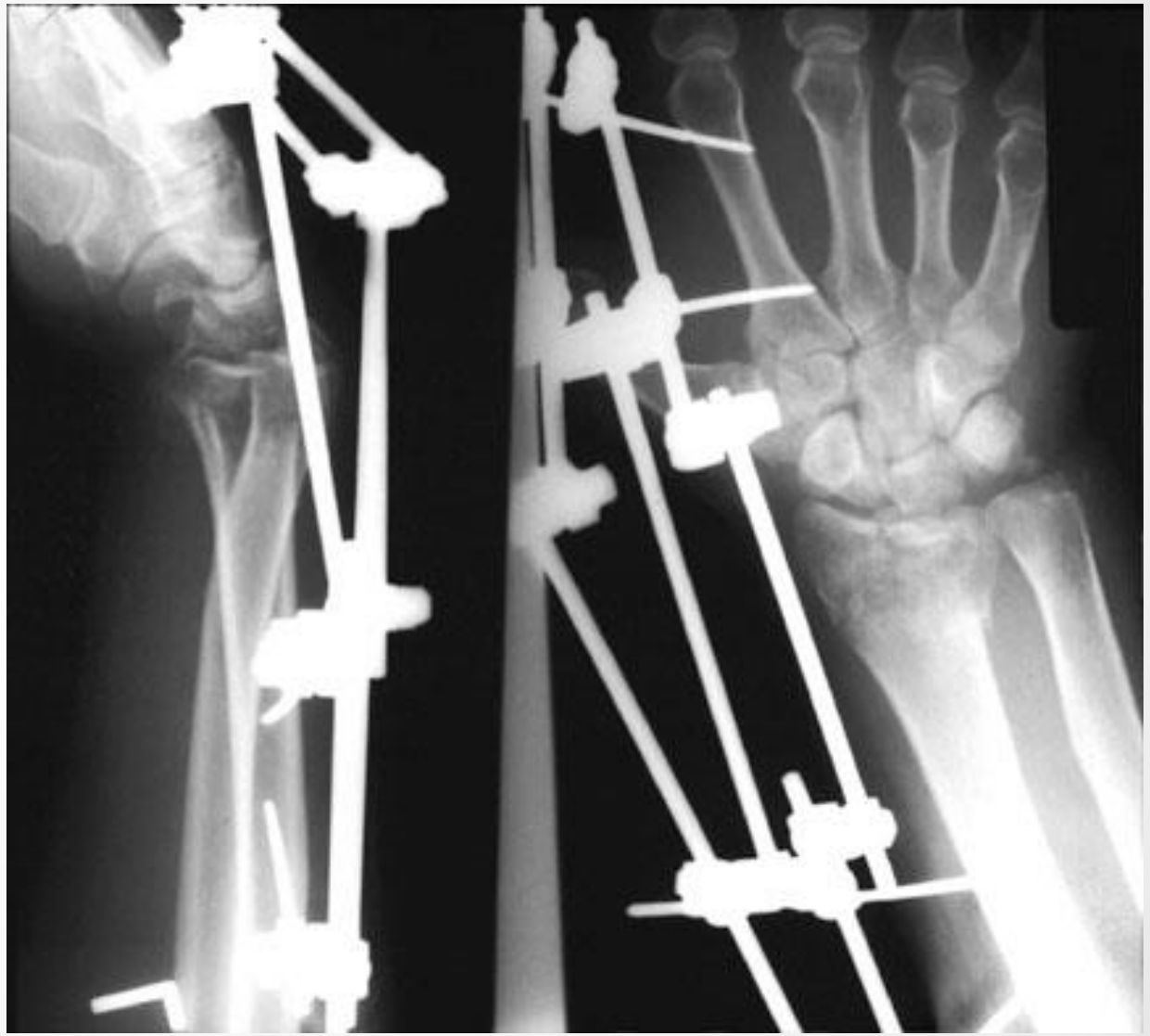
Comminuted fracture of the surgical neck of the humerus bridged by four percutaneous pins



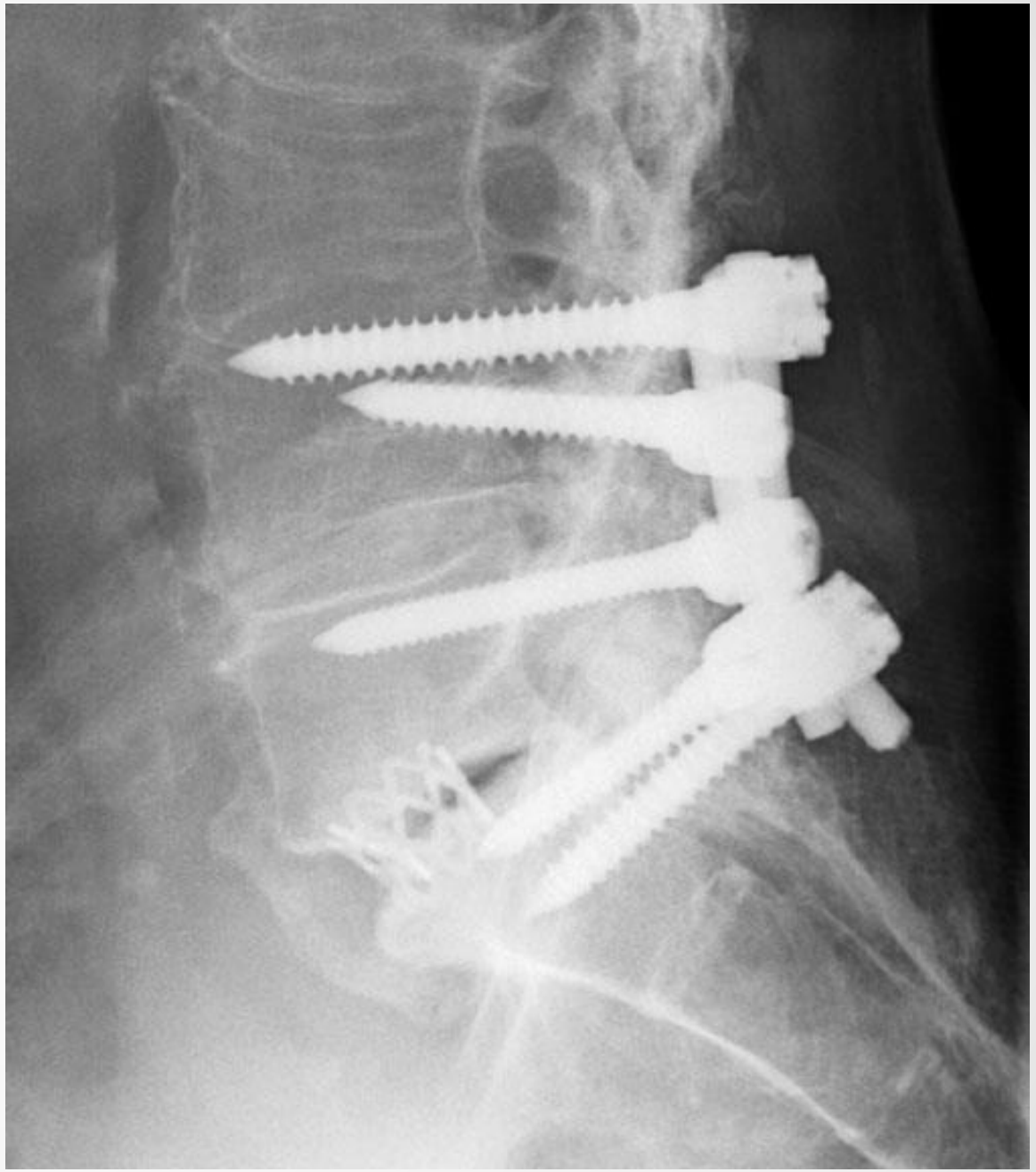
Segmental fracture of the tibia, bridged by an intramedullary nail with a proximal interlocking screw — the distal interlocking screws have been removed

External fixator bridging a tibial fracture

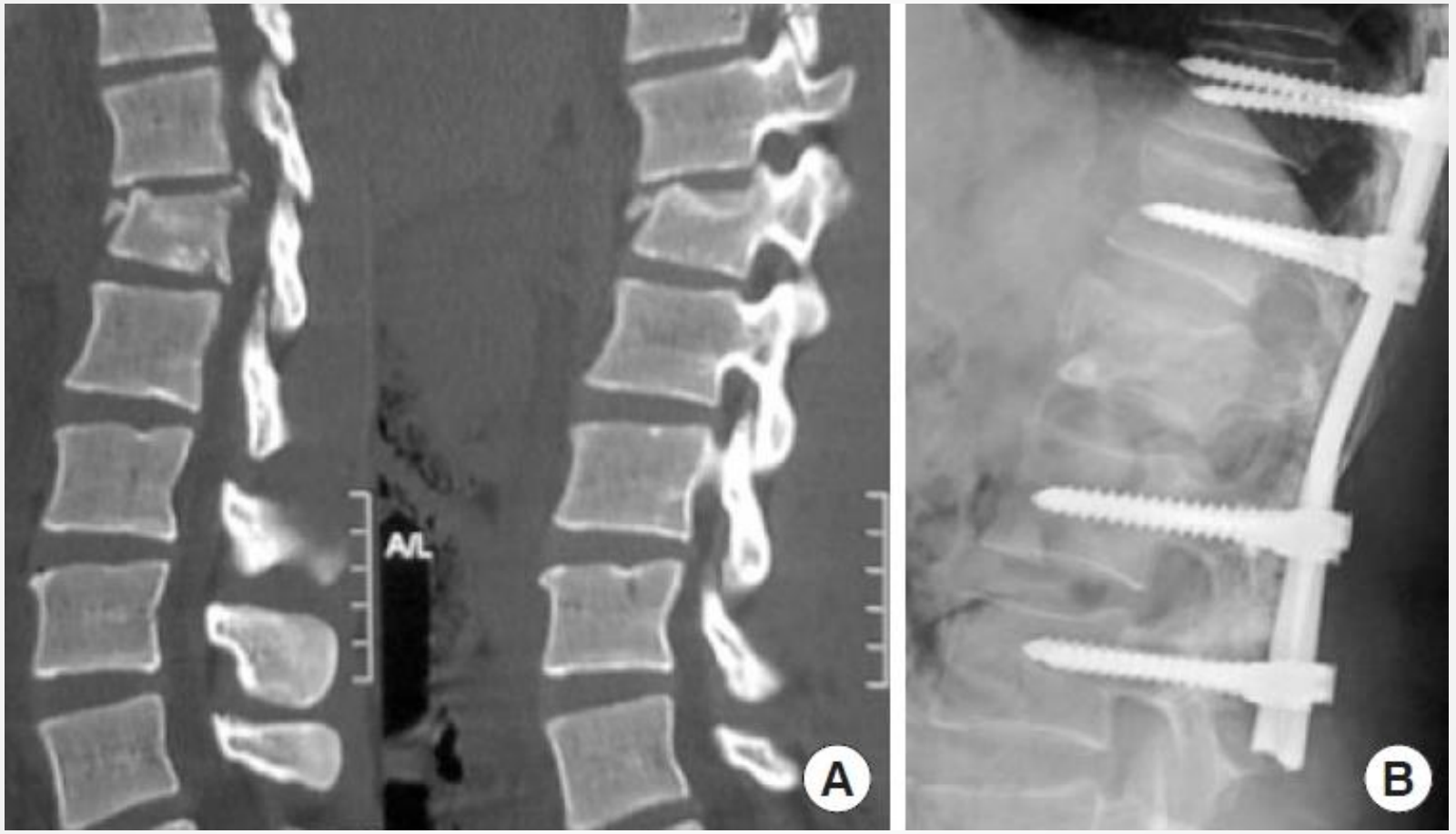
External fixator bridging an unstable distal radial fracture

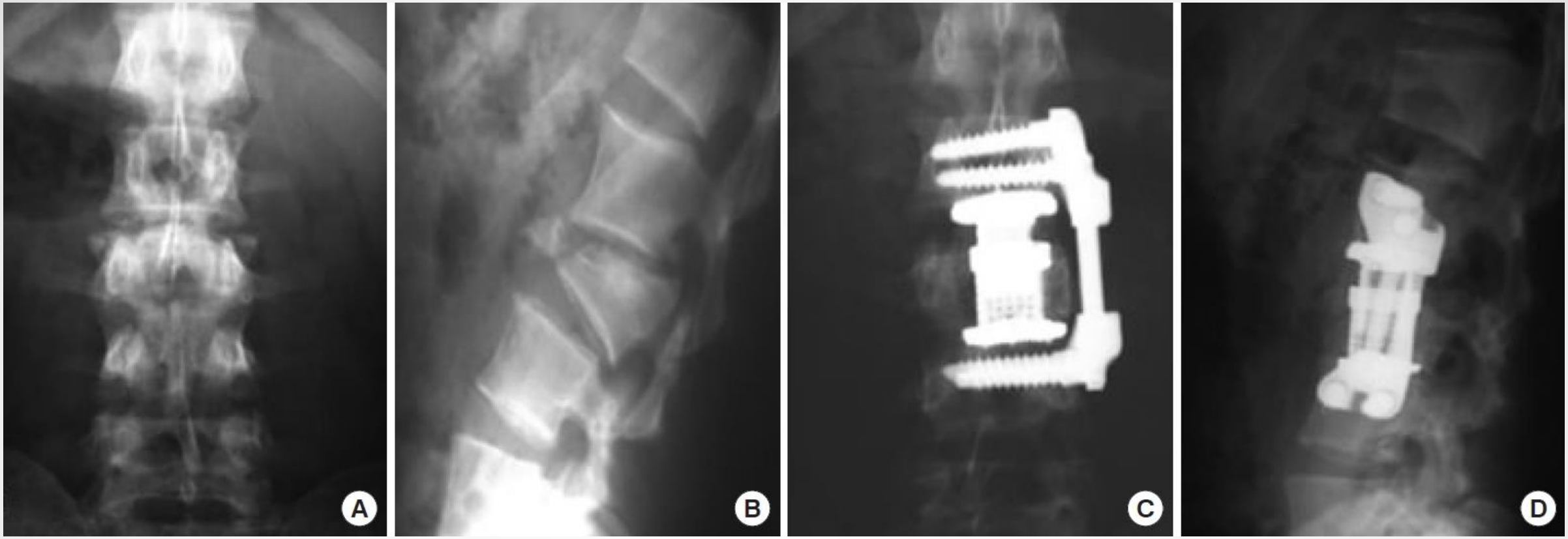


bilateral posterior spinal rods bridging L4, L5 and S1. This patient underwent spinal fusion following a laminectomy done for spinal stenosis. The small metal cage seen in the L5-S1 disk space contains bone graft material which will hopefully promote osseous fusion at this site.



Right acetabular fracture bridged by two reconstruction plates and multiple screws — the extra plate seen laterally is probably a spring plate — also noted is the proximal end of an intramedullary femoral nail


AVL
A
B



(A) L1 burst fracture anteroposterior view. (B) L1 burst fracture lateral view. (C) Anterolateral approach with cage placement anteroposterior view. (D) Anterolateral cage placement lateral view.

Topics

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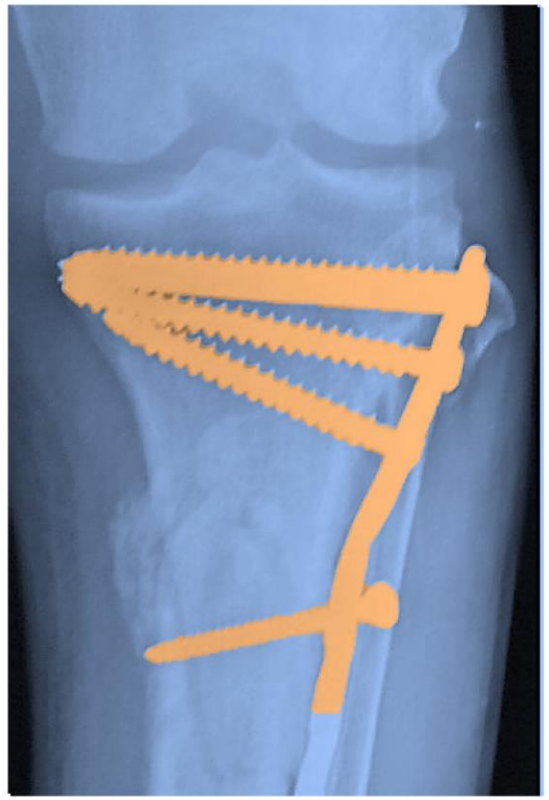
Union and non-union

types of healing

Primary bone healing



Secondary bone healing

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ne … t

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placer … ail or

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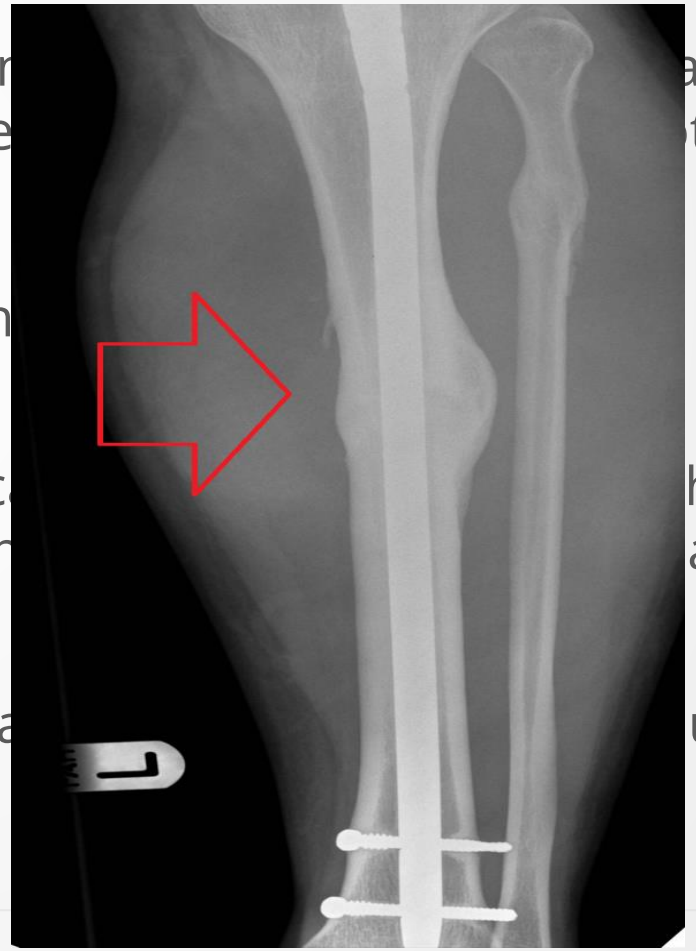

Average healing times of common fractures

Upper Limb:

phalanges: 3 weeks

metacarpals: 4-6 weeks

distal radius: 4-6 weeks

humerus: 6-8 weeks

lower arm: 8-10 weeks

Lower limb:

metatarsals: 6+ weeks

tibia: 10 weeks

femoral neck: 12 weeks

femoral shaft: 12 weeks

Disturbed fracture healing

delayed union

fracture healing takes about twice as long as expected for a specific location

non-union (pseudoarthrosis)

fracture healing does not occur within 6-9 months
common sites: scaphoid bone, femoral neck, tibial shaft

malunion

healing in a non-anatomical position
can be partially compensated for by remodelling of the bone (except for rotational malunion)


a
b
c

Radiographs of a hypertrophic tibial nonunion in a 35-year-old man ten months status after medullary fixation of an open tibial shaft fracture with persistent pain and inability to weight bare. Note abundant callus formation but persistent fracture line.


R


Thank You
for your attention