

Musculoskeletal Radiograph Interpretation – Specific Approach by Joint/Area

The [generic approach to musculoskeletal radiograph interpretation](#) is covered separately. This is sufficient for most single bone radiographs. However, radiographs of many joints/areas require a specific approach to interpretation or have specific signs which need to be looked for within the *ABCS approach* – these are outlined here.

Facial bones

- Identify **zygoma** (*stool*) and look for fractures of its **4 legs**:
 - Zygomatic arch – if you imagine the zygoma as an elephant's head, this leg looks like an its trunk on a radiograph
 - Frontal process of zygoma
 - Orbital floor
 - Lateral wall of maxillary antrum
- Soft tissue signs** indicating a fracture (working downwards)
 - Black eyebrow sign – black eyebrow like shadow across top of orbit (air in orbit from sinus, usually due to orbital blow-out fracture)
 - Teardrop sign – dark shadow at the top of the maxillary antrum (soft tissue herniation of orbital contents from orbital blow-out fracture)
 - Fluid level – in maxillary antrum (blood from fracture)



Common pathology

- Nasal bone fracture: commonly due to punch injury; may not be seen on radiographs and X-rays are not performed to specifically look for it as it does not change management; look up the patient's nose to exclude a septal haematoma!
- Mandible fracture: commonly due to punch injury; use an OPG X-ray to look for it, not a facial bone X-ray
- Zygomatic arch fracture
- Orbital floor fracture
- 'Tripod' fracture: fractures of all 4 'legs' of the zygoma due to major trauma – should really be called a quadripod fracture

Cervical spine

Lateral view (**ABCS**)...

- Adequacy:** Need to see skull base and C7/T1 disc space (if not, get *swimmer's view*)

Alignment

- Alignment arcs** (look for smooth curves)
 - Anterior vertebral body line
 - Posterior vertebral body line
 - Spinolaminar line (anterior edges of spinous processes)
 - Posterior spinous line (posterior edges of spinous processes)

Bones

- Peg** of C2 sticking up
 - Should be smooth and flat
 - Atlanto-axial space should be <5mm in adults or <3mm in children (the space in front of the peg, before the posterior part of C1 tubercle)
- Harris ring** of C2 integrity (formed by: body of C2 anteriorly and posteriorly, and borders of the pedicles superiorly and inferiorly)
- Trace** around each vertebral body to look for fractures

Cartilage

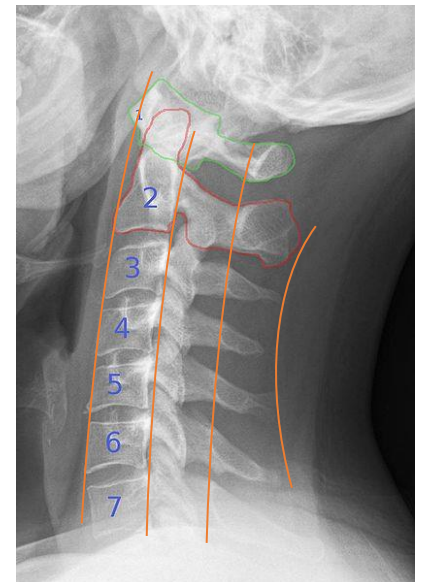
- Equal **gaps** between vertebral bodies

Soft tissues

- Anterior **para-spinal soft tissue** width (line in front of vertebral bodies)
 - C1-4 = < a third vertebral body width
 - C5-7 = < whole vertebral body width

AP view...

- Spinous processes**
 - Alignment in straight line (may need to go down middle of bifid processes)
 - Distance apart



PEG view...

- **Outline bones** and check **gaps**
 - Peg
 - C2 attached
 - C1's lateral masses and their alignment with the peg and C2's lateral masses

Common pathology (working downwards)

C1

- Jefferson fracture: multiple fractures at different points in C1 ring due to a compressing vertical force
- Rupture of transverse ligament of C1 causing C2 subluxation: revealed by asymmetry of gaps between peg and C1's lateral masses on peg view, and increased atlanto-axial space on lateral view

C2

- Base of peg fracture
- Hangman's fracture: fractures of both pedicles of C2 due to hyperextension injury e.g. hanging or head striking dashboard in RTA

C3-7

- Spinous process fracture
- Vertebral body compression fracture
- Burst fracture: comminution of a vertebral body due to vertical compression force
- Extension teardrop fracture: avulsion of anteroinferior vertebral body corner due to sudden pull of anterior longitudinal ligament during forced extension
- Flexion teardrop fracture: compression anterior vertebral body with anteroinferior vertebral body fragment detachment due to extreme flexion and axial loading
- Anterior subluxation: disruption of alignment arcs due to flexion-rotation injury
- Unilateral facet joint dislocation: difficult to see – spinous processes may not be aligned on AP view and may be subluxation on lateral view

Note, up to 10% of fractures may not be visible on C-spine radiographs. If you are still clinically very suspicious of a fracture, consider CT

Thoracic and lumbar spine

Lateral view (**ABCS**)...

Alignment

- **Alignment arcs** (look for smooth curves)
 1. Anterior vertebral body line
 2. Posterior vertebral body line

Bones

- **Trace** around each vertebral body to look for fractures
- Loss of vertebral height/wedging

Cartilage

- **Gaps** between vertebral bodies (disc spaces gradually increase, except for L5/S1 which is slightly smaller)

Soft tissues

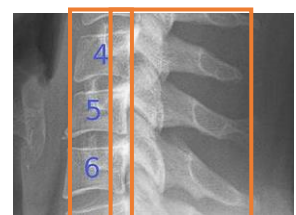
- Anterior **para-spinal soft tissue** width (line in front of vertebral bodies)

AP view...

- **Alignment** of spinous processes and lateral sides of vertebral bodies (arcs)
- **Pedicles** – check for equal distances between
- **Transverse processes** – look for fractures
- **Paraspinal soft tissue** lines in thoracic spine (bulging may be paraspinal haematoma due to a fracture)

Spine stability

- When an injury is detected, it must be classified as stable or unstable
- The spine is formed by '3 columns' – if 2 or more are disrupted, the injury is **unstable**
 - Anterior column = anterior longitudinal ligament, anterior part of annulus, anterior two thirds of vertebral body
 - Middle column = posterior longitudinal ligament, posterior part of annulus, posterior margin of vertebral body
 - Posterior column = facet joints, pedicles, posterior ligaments



Common pathology

- Osteoporotic compression fracture: most common by far; may be clinically silent
- Wedge compression fracture: compression of anterior portion of vertebral body due to flexion injury

- Transverse process fractures: caused by rotation or extreme lateral bending
- Burst fracture: comminution of a vertebral body due to vertical compression force e.g. landing on feet from high fall
- Fracture-dislocation injury: a vertebral fracture with subluxation/dislocation of the vertebra
- Chance fracture: anterior vertebral body compression with transverse fracture of the body, fracture of the posterior part of the body and fracture of the posterior elements of the vertebra (e.g. spinous process) due to violent forward flexion shearing injury e.g. RTA

Shoulder

AP view...

- Alignment
 - **Glenohumeral joint**
 - Humeral head should articulate with glenoid
 - Superior border of humeral head should have a walking stick appearance (lost in posterior dislocation – looks like a *lightbulb*)
 - **Acromioclavicular joint** – inferior cortices of clavicle should align with acromion process
 - **Coracoclavicular joint** – distance between coracoid and clavicle should be <1.3cm
- Bones – outline all bones to look for fractures
 - **Humerus** head and neck
 - **Glenoid** margin
 - **Clavicle**
 - Body or neck of **scapula**

Apical oblique view...

- Alignment of humeral head and glenoid (glenoid looks like a triangle, the centre of which should be immediately adjacent to centre of humeral head)
- Look for fractures of humeral head/neck and glenoid margin

Scapula Y view (lateral)...

- Alignment of humeral head and glenoid (humeral head should be in the centre of the glenoid which is in the middle of the Y shape formed by the scapula's blade + acromium + coracoid)
Note: on this lateral view, anterior is towards the ribs and posterior is away from the ribs

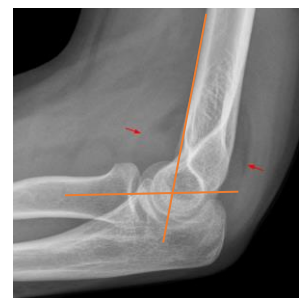
Common pathology

- Anterior dislocation of glenohumeral joint: seen on AP view as humeral head lying directly below coracoid process; associated fractures:
 - Hill-Sachs lesion – compression fracture of posterolateral aspect of humeral head
 - Bankart lesion – anterior lip of glenoid breaks off
 - Avulsion fracture of supraspinatus origin
 - Humeral head fracture e.g. greater tuberosity
- Posterior dislocation of glenohumeral joint (rare, but often occurs during epileptic fit): humeral head looks like lightbulb on AP view (loss of walking stick appearance); seen clearly on apical oblique and scapula Y views where humeral head is posterior to glenoid
- Fracture of greater tuberosity of humerus
- Proximal humeral fracture
- Clavicle fracture: occur due to fall on shoulder or out-stretched hand or direct trauma
- Acromioclavicular joint dislocation/subluxation

Elbow

Lateral view...

- Alignment
 - **Radiocapitellar line** (can also view on AP view) – line in the centre of the long axis of the proximal 2-3cm of radius should transect the capitellum circle (if not, there is dislocation of radial head)
 - **Anterior humeral line** (in children to rule out subtle supracondylar fracture) – should transect the capitellum circle, with at least one third of the circle anterior to the line
- **Elbow fat pads** (seen as dark streaks closely related to anterior and posterior part distal humerus)
 - Presence
 - Anterior – can be normal
 - Posterior – abnormal because the fat is usually hidden in the olecranon fossa, presence indicates a fracture
 - Displacement – indicates a fracture (see example in image)



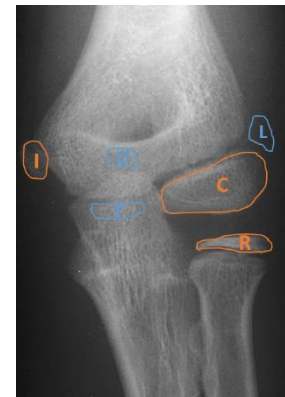
Lateral and AP views...

- **Bones** – trace all bones looking for fractures (look closely at radial head and neck cortex)

Ossification centres in children

Accumulate in sequence below (**CRITOL**) – check they are normal and appear by dates below

- **C**apitellum 2y (part of humerus that articulates with radius)
- **R**adial head 4y
- **I**nternal (medial) epicondyle 6y
- **T**rochlea 8y (part of humerus that articulates with ulna)
- **O**lecranon 10y
- **L**ateral epicondyle 12y



Common pathology

- Fracture of head or neck of radius (most adults)
- Olecranon fracture
- Monteggia: fracture of ulna + dislocation of radial head (don't confuse with Galeazzi below)
- In children
 - Supracondylar fracture (most children): assess using anterior humeral line; high risk of vascular damage
 - Avulsion of epicondyles

Wrist and distal forearm

PA view...

- Alignment
 - **Radial articular surface** should lie distal to ulna
 - **Scapho-lunate distance** should be <2mm wide (increased if ligamentous injury – causes chronic wrist pain)
- **Bones** – trace all bones looking for fractures (look closely at radial articular surface, ulna styloid process, scaphoid, and any cortical angulation or bulges in children)

Lateral view...

- Alignment
 - Normal **apple-in-cup** (on saucer) alignment of radius, lunate and capitate (image below)
 - **Palmar tilt** of radial articular surface should be 2-20° (may be impacted fracture if not)
- Bones – specifically:
 - **Dorsal cortex of distal radius**
 - **Bone fragment** posterior to carpal bones (triquetral fracture)

Common pathology

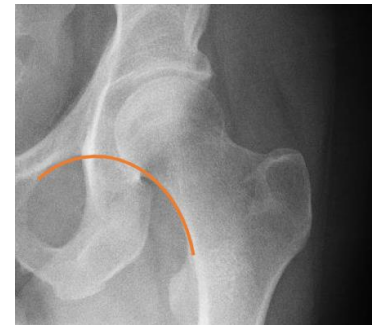
- Distal radius fracture
 - Colles' fracture: distal radius fracture with dorsal angulation
 - Smith's fracture: distal radius fracture with volar angulation
 - Barton's fracture: intra-articular distal radius fracture
- Scaphoid fracture: scaphoid views should be requested if suspected (clinical signs: 1. anatomical snuffbox tenderness, 2. scaphoid tubercle tenderness, 3. thumb telescoping tenderness) – however, fractures are often not visible on X-rays until 10 days, so if clinically suspicious treat and re-X-ray in 10 days; scaphoid fractures are important because of the retrograde blood supply and risk of avascular necrosis
- Triquetral fracture: bone fragment posterior to carpal bones indicated triquetral avulsion fracture
- Ulna styloid fracture: displacement indicates distal radio-ulna joint disruption
- Lunate dislocation: cup (lunate) of the apple-in-cup dislocates anteriorly leaving other bones in place
- Perilunate dislocation: cup (lunate) is in line but the apple (capitate) and all other carpals are displaced posteriorly
- Greenstick fracture (in children): revealed by slight angulation of bone cortex
- Torus fracture (in children): revealed by slight bulge of bone cortex
- Distal radius growth plate fracture in children
- Galeazzi: fracture of radius + dislocation of distal ulna (**GFR = Galeazzi Fractured Radius** – don't confuse with Monteggia above)



Pelvis and hip

AP view...

- Alignment
 - **Shenton's line** – smooth imaginary curve joining curve of inferomedial neck of femur and curve of inferior border of superior pubic ramus (disruption indicates a neck of femur fracture)
 - **Femoral head** alignment with acetabulum (can dislocate any way inc medially)
 - **Symphysis pubis** – width should be <5mm and superior pubic rami bones should align
 - **Sacro-iliac joint** widths should be equal
- Bones
 - **Proximal femur(s)**
 - **Acetabulum** (look through the femoral head)
 - **Large ring** – trace inner and outer parts of pelvic ring
 - **2 small rings** – trace obturator foramen and outer pubic/ischial bones
 - **Sacral foramina** (compare sides)



Lateral hip...

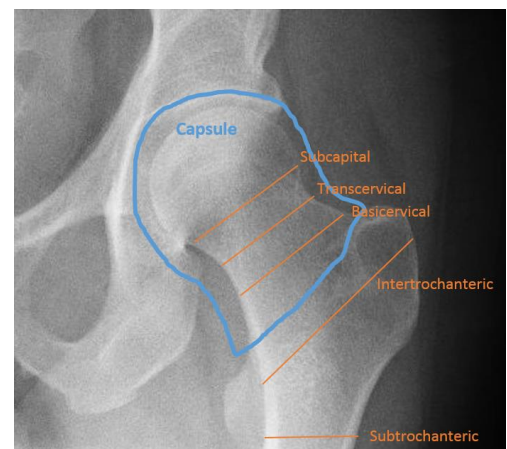
- Specifically check
 - **Neck of femur**
 - **Trochanteric region**

Synchondroses and apophyses in children/adolescents

- Check they are the same on each side
- **Synchondroses** are the cartilaginous connections between the ischial and pubic bones in children before they fuse
- **Apophyses** are small secondary bones (connected to main bones via growth plates) to which muscles attach. This makes them prone to avulsion. Most are seen on radiographs between 13-15 years of age, after which they begin to fuse (takes ~ 5 years)
 - Iliac crest (abdominal muscles)
 - ASIS (sartorius/tensor fasciae latae)
 - AIIS (rectus femoris)
 - Ischial tuberosity (hamstrings)
 - Greater trochanter (gluteus muscles)
 - Lesser trochanter (iliopsoas)

Common pathology

- Neck of femur fracture: elderly patient after fall; may be a white line (impacted) or black line (displaced); classified as per image; management:
 - Intracapsular (risk of avascular necrosis)
 - Displaced >60y → *THR* if active and with-it, *hemiarthroplasty* if not
 - <60y or undisplaced → try *cannulated screws*
 - Extracapsular
 - Intertrochanteric → *dynamic hip screw* or *gamma nail*
 - Subtrochanteric → *intra-medullary nail*
- Pubic rami fracture: elderly patient after fall
- Acetabular fracture: in major trauma or femoral head dislocation; bone fragments may be seen
- Avulsion fractures: bone at sites of tendon insertion can be ripped off occur during sports injuries
- Femoral head dislocation: occurs commonly after total hip replacement and in major trauma
- Children and adolescents with hip pain
 - Perthe's disease: 5-10 years; signified by increased density and decrease in size of epiphysis
 - Slipped upper femoral epiphysis (SUFE): 10-15 years; seen best on lateral radiograph
 - Femoral and iliac apophyseal avulsions: occur due to sudden muscle contraction in adolescence (most are ASIS/AIIS/ischial tuberosity)



Knee

AP view...

- Alignment
 - **Vertical lines** drawn from the most medial and lateral parts of the femoral epicondyles should have <5mm of the adjacent tibial condyles outside (if more, may be tibial plateau fracture)
- Bones
 - **Femur** – especially the condylar surfaces

- **Tibia** – look closely at each tibial plateau (should be very smooth), their subchondral bone and the intercondylar eminence
- **Fibula** – head and neck
- **Patella** – look through femur
- Bone fragments anywhere

Lateral view...

- **Patella position** – the distance from the patella to the tibial tubercle should be the length of the patella itself \pm 20% (may be increased in patella tendon rupture)
- **Articular surfaces** and the femur and patella, and for any bone fragments
- **Suprapatella bursa** (seen as longitudinal dark shadow superior to the patella, between prefemoral fat and suprapatellar fat)
 - AP width – should be <5mm wide (called the 'suprapatellar strip' if normal, indicates joint effusion if increased)
 - Fat-fluid level in suprapatella bursa (indicates intra-articular fracture because the fat is from bone marrow)

In children, also look for

- Growth plates of femur, tibia, fibula – look for epiphyseal fracture
- Cortex of femur and tibia for any cortical angulation (greenstick fracture) or bulges (torus fracture)
- Femoral condylar surfaces – look for osteochondral lesion or fracture

Common pathology

- Tibial plateau fracture: may be subtle; commonly seen as lateral tibial plateau depression following traumatic compression by lateral femoral condyle; can be classified using *Schatzker classification*
- Patella body fracture: caused by direct blow
- Neck of fibula fracture: ensure the common peroneal nerve function is tested
- Patella dislocation: usually dislocates laterally
- Patella tendon rupture: high patella
- ACL/PCL avulsion fractures: look for bone fragments from the tibial intercondylar eminence within the joint
- Segond fracture: avulsion of a fragment from the lateral tibial condyle by the lateral collateral ligament
- Stress fracture of tibia: appears as sclerotic band

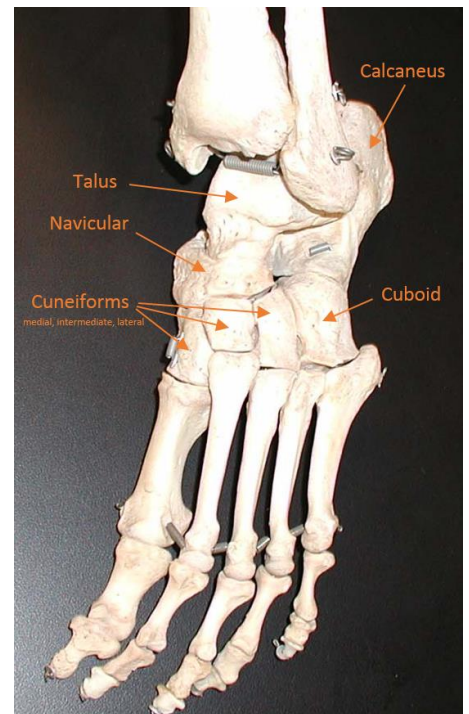
Ankle (& hindfoot)

AP mortice...

- Alignment
 - **Tibia and fibula** (increased distance indicates tibiofibular interosseous membrane rupture)
 - Should overlap distally
 - Distance between them should be <6mm (measured 1cm proximally to lateral tibial articular surface)
 - **Tibiotalar joint** width <4mm
- Bones
 - **Talus** dome and medial and lateral tubercles
 - **Malleoli**
 - **Growth plates** (in children)

Lateral view...

- Alignment
 - **Bohler's angle** of calcaneum – draw a line from highest anterior point to the highest mid-point, then draw a second line from the highest posterior point to the highest mid-point – the acute angle between the lines should be >30° (decreased angle suggests calcaneal fracture)
 - **Talonavicular joint**
- Bones
 - **Tibia**
 - **Fibula**
 - **Talus** – especially neck
 - **Calcaneum**
 - **5th metatarsal base**



Common pathology

- Calcaneus fracture: occurs after fall from height; if suspected, an axial (calcaneal) view should be requested
- Ankle fractures
 - Lateral malleolus fracture – *Weber classification*:
 - Weber A = below ankle joint (syndesmosis intact)
 - Weber B = at ankle joint (syndesmosis intact or partially torn)
 - Weber C = above ankle joint (syndesmosis disrupted)

- Medial malleolus fracture
- Bimalleolar fracture: fracture of lateral malleolus and medial malleolus
- Trimalleolar fracture: fracture of lateral malleolus, medial malleolus and posterior lip of tibia
- Base of 5th metatarsal fracture: forced foot inversion pulls peroneus brevis tendon which avulses base of 5th metatarsal
- Distal tibia growth plate fracture in children
- Tibiofibular interosseous membrane (syndesmosis) tear: revealed by increased distance between the distal tibia and fibula

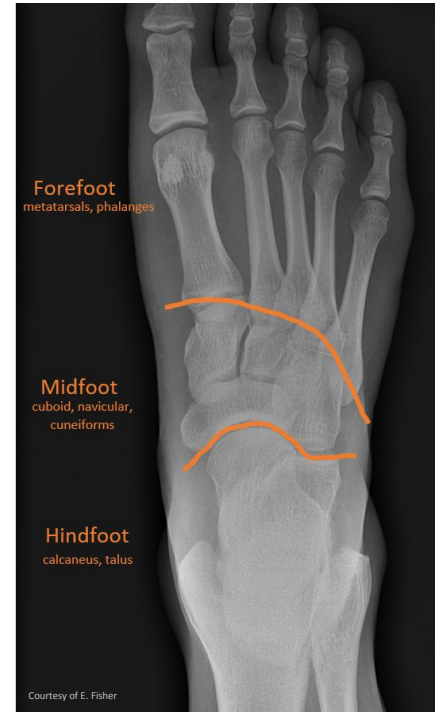
Foot (midfoot and forefoot)

AP view...

- Alignment
 - Lisfranc joint (5 tarsometatarsal joints held by Lisfranc ligament complex)
 - 2nd metatarsal base held in mortice by 3 cuneiforms
 - Medial side of 2nd metatarsal base should align with medial side of intermediate cuneiform
- Bones
 - Metatarsal shafts
 - Phalangeal shafts

Oblique view...

- Alignment
 - Lisfranc joint
 - Medial side of 3rd metatarsal base should align with the lateral cuneiform
 - Hindfoot (calcaneus and talus) articulations with midfoot (cuboid, navicular, cuneiforms)
- Bones
 - Metatarsal shafts
 - Hindfoot bones



Common pathology

- Phalanx fractures
- Metatarsal fractures
- Metatarsal stress fractures
- Base of 5th metatarsal fracture: forced foot inversion pulls peroneus brevis tendon which avulses base of 5th metatarsal
- Lisfranc injury: low impact strain
- Lisfranc subluxation: high impact injury resulting in subluxation at a Lisfranc joint

Salter-Harris grading of growth plate fractures in children

Children's long bones will have growth plates at either end. Fractures can involve these growth plates and are graded by the Salter-Harris classification (**SALTR**):

- Grade I = **S**eparated (fracture straight across growth plate, separating diaphysis from epiphysis)
- Grade II = **A**bove (fracture part across growth plate and part going up into diaphysis)
- Grade III = **b**elow (fracture part across growth plate and part going down into epiphysis)
- Grade IV = **T**hrough (fracture at an angle to growth plate goes right through it)
- Grade V = **R**ammed together (impaction of diaphysis and epiphysis)