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Grand Rounds

Interpretation Of Radiographs Performed For Investigation Of Upper Limb Injury

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Musculoskeletal trauma is one of the common reasons for attendance to Accident & Emergency and/or primary care. Appendicular radiographs, with the chest radiograph, constitute the commonest plain radiographic investigations the population undergo. Diagnosis is often straightforward, but certain patterns of injury may be more complex and elude detection. Reliance on a single investigation, and particularly a single view, at one time point without proper clinicoradiological correlation and follow-up can have detrimental consequences.

A fracture can be defined as a 'break in the continuity of a bone' and is included in the International Classification of Disease (ICD-10) under M84 as 'Disorders of continuity of bone'[1].

Fig 1. Buckle Fracture.
No fracture is visible in the dorsopalmar (DP) view but a buckle fracture is seen at the radial dorsal cortex (*) on the lateral (LAT) view underlining the importance of imaging in two planes.

The purpose of this paper is to review common fracture patterns of the upper limb. 'Overlooks' or 'don't miss' cases that are detected by radiologists subsequently will be highlighted and discussed. Conventionally the upper limb is divided into 'parts' by the three major joints of wrist, elbow and shoulder and imaging should be tailored around clinical findings and appropriate application of this principle will also be discussed.

THE WRIST AND HAND

Many fracture complexes are described in this region. The patient's age as well as the mechanism of injury are important considerations in the fracture pattern. Children's bones are soft and may not have ossified, so incomplete fractures (where only one cortex breaks) are common. Fig 1 demonstrates one type of incomplete fracture (the other type being a greenstick fracture) and illustrates an important radiological principle: always image in two planes. Typically, the two planes are at right angles to each other and are known as 'orthogonal' planes.

Fig 2. Colles Fracture.
Distal nonarticular radial fracture with dorsal angulation & displacement of the distal radius (←) with soft tissue injury and commonly associated ulnar styloid fracture (*).

It would be remiss not to include the familiar Colles' fracture (Fig 2a), named after the Irish surgeon Abraham Colles who described it in 1814. (Abraham Colles, 1773–1843)[2]. This classically occurs after a fall on an outstretched hand and is the most common fracture of the forearm.

In addition, several other eponymous distal radius-ulnar fractures are described. The classic descriptions are outlined in Table 1 and Fig 3 although depending on the severity of the injury classical patterns are not always seen.

The scaphoid fracture is important, not least because of the medico legal implications if it is missed. There is a high risk of malunion and avascular necrosis of the proximal pole due

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Table 1

Eponymous Fractures of Distal Radius9

Eponymous Name	**Fracture of Distal Radius**	**Intra-articular**	**Angulation**	**Displacement**
Colles Fracture (Fig2)	Transverse	No	Dorsal	Dorsal
Smith Fracture (Fig3a)	Transverse	No	Palmar	Palmar
Barton Fracture (Fig3b)	Dorsal	Yes	N/A	+/- Dorsal
Chauffeur Fracture	Lateral (Radial Styloid)	Yes	N/A	+/- Lateral

Fig 3. Other Eponymous Wrist Fractures.
(a)Smith ('reverse Colles') with palmar angulation (line).
(b) Barton (dorsal oblique intra-articular) fracture of the distal radius (←)[9].

to the bone's distal blood supply. With an appropriate clinical history, a standard 3 or 4 view radiograph series should be performed to ensure full visualisation of the carpal bones (Fig 4). This however may not reveal an undisplaced scaphoid fracture initially[3].

Non-scaphoid carpal fractures are seen less frequently than scaphoid fractures and form only 10-30% of carpal fractures4,8 It is important to consider an occult fracture (up to 16%3,4), dislocation and/or ligamentous disruption

Fig 4. Proximal pole scaphoid fracture (←) & concurrent triquetral fracture (*) .

Common practice in suspected scaphoid injury is to immobilise in cast and perform repeat radiographs after 10 to 14 days[6]. This approach is however debated and it is becoming more common to perform secondary investigations such as Magnetic Resonance Imaging (MRI), Isotope Bone Scan or Computed Tomography (CT), each with their own benefits, limitations and sensitivities[5,6].

when clinical signs or symptoms are present but there is no visible bony injury on radiographs (clinical-radiological disassociation).

In the hand, a common fracture is the Boxer's fracture

Fig 5. Hand Injuries.
(a) A Boxer's fracture in the 5th metacarpal.
(b) A Bennett fracture which is an intra-articular fracture-dislocation at the base of the metacarpal of the thumb (1st).
The dashed line represents the site of MCP-UCL of the thumb involved in Skier's thumb (not present).

Fig 6. Finger Injuries.
(a) A common example is the volar plate avulsion injury at the base of the middle phalanx.
(b.c) In the absence of bony injury one must consider the less common ligamentous rupture. Always check for joint subluxation or dislocation: less obvious on the DP but clear on lateral projection.

(Fig 5a). This angulated fracture of the distal metacarpal commonly occurs at the metacarpal of the little finger but can occur in any. The base of the thumb is at increased risk of bony-ligamentous injury due to its exposed position and complex articulation. Examples include a Skier's thumb (rupture of the medial/ulnar collateral ligament of the metacarpal-phalangeal joint (MCP-UCL) of the thumb +/- bony avulsion) or Bennett fracture (Fig5b).

Fig 7. Radial Head Fracture.
In the adult this is the commonest site of elbow injury while in children the developing distal humerus (supracondylar fracture) is the most frequent site[7,8].

The digits themselves, particularly the distal phalanges, are especially vulnerable to direct trauma. Each bone and joint, visible on the radiograph, must be carefully evaluated for any penetrating, crush or avulsion associated injury (Fig 6).

THE FOREARM AND ELBOW

Proximal to the wrist the bony elbow structures require careful assessment not just for cortical integrity (Fig 7) but anatomical alignment (Fig 8) and secondary 'soft tissue' signs. Specifically the presence of an effusion on true lateral (Fig 8) is often critical in the detection algorithm of bony injury.

Fig 8. Supra-condylar fracture.
Radial line intersects (R) capitellum in all views. Anterior humeral line (AH) should intersect capitellum anterior to its posterior third.

In children developing ossification centres can provide additional challenges for the radiologist. The centres ossify in a predicable order with age and the 'C.R.I.T.O.L.' mnemonic may be utilised to correlate the sequence of ossification with radiographic findings (ie first **C**apitellum <**R**adius <**I**nternal epicondyle <**T**rochlea <**O**lecranon <**L**ateral epicondyle last)[7].

Fig 9. Forearm Fractures- not always isolated.
(a) Monteggia described an ulnar fracture & radial head dislocation
(b) Galeazzi described a mid radial shaft fracture & dislocation of distal radioulnar joint[9].

Injury to any long bone in apparent isolation should prompt clinical assessment of both proximal and distal joints with radiographs undertaken, in two planes to include these joints. Examples of such joint involvement would include the Monteggia and Galeazzi fracture-dislocation patterns (Fig 9)

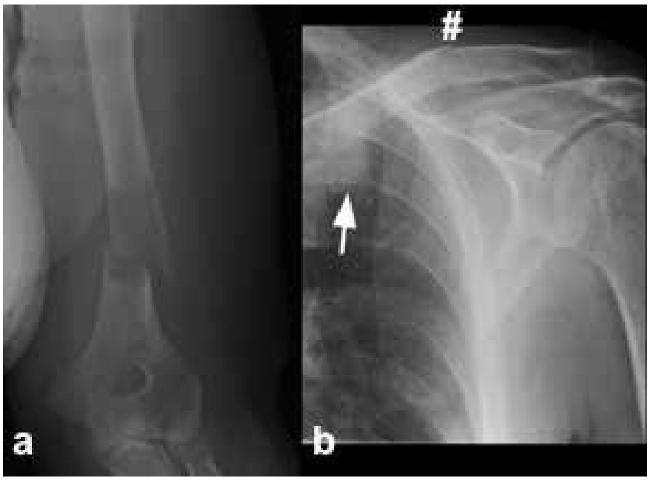

Fig 10. Pathological Fracture
(a) A humeral fracture occurring with minimal trauma reveals a underlying lucency subsequently confirmed to be one of multiple skeletal metastases.
(b) In a different patient investigation of a clavicular fracture (#) reveals a coincidental apical lung tumour (←).

HUMERUS AND SHOULDER

The diaphysis of the humerus is less commonly injured than its peri-articular portions except in severe trauma8. A fracture in the absence of a history of a suitable energy mechanism should raise the possibility of an insufficiency or pathological fracture. Examples of said underlying processes are osteoporosis or metastasis respectively (Fig10a). This

Fig 11. Proximal Humeral Fracture.
Anteroposterior (AP) and Axial (AX) views._
There is a simple (i.e. consisting of only two fragments) fracture (←) at the 'surgical neck' of humerus. The fracture is less easily seen on the axial view but satisfactory gleno-humeral alignment is readily assessed.

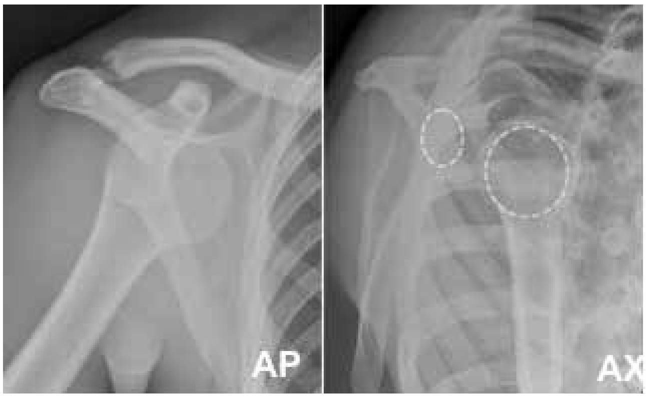

Fig 12. Anterior-Inferior Shoulder Dislocation.
On anteroposterior (AP) views the humeral head overlaps the glenoid.
On axial (AX) views the humeral head (large circle) is seen to lie anterior and inferior in relation to the glenoid (small circle).

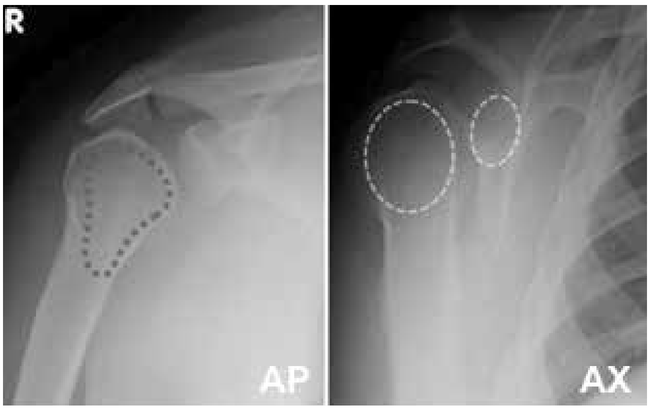

Fig 13. Posterior Shoulder Dislocation.
Axial (AX) view demonstrates the humeral head (large circle) displacement posterior to the glenoid (small circle).
Anteroposterior (AP) view demonstrates internal rotation of the humeral head. This radiological appearance is referred to as the 'light bulb' sign (dark line).

also highlights the importance of reviewing each radiograph for findings outside the 'bony field of view', (Fig 10b).

After the clavicle, the 'surgical' neck of the humerus, just distal to its 'anatomical' head, is the commonest site of fracture in the shoulder region (Fig11) and the third commonest fracture of the extremities[8]. Fractures of the 'anatomical' neck, the articular segment between the tuberosities, in isolation are less common but may seen in complex multi-component injuries [8, 10].

Fig 14. Other shoulder injuries.
(a) **A Bankart lesion:** A fracture of the anterio-inferior glenoid (*) due to anterior dislocation.
(b) **Hill-Sachs deformity:** A subtle impaction fracture of the greater tuberosity (lines) from previous anterior dislocation.
(Note prior surgery ← to a*)

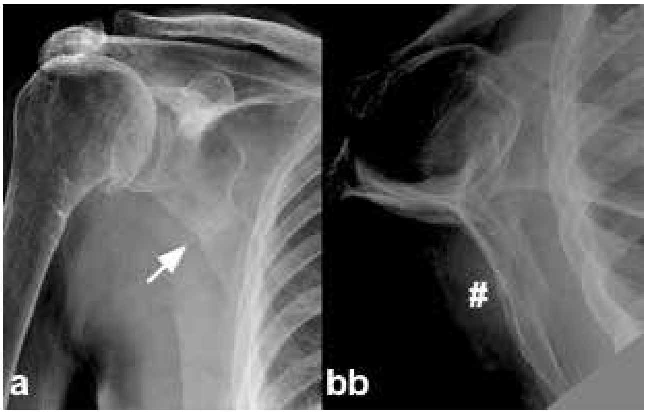

Fig 15 Scapular Fracture
(a) A subtle sclerotic line (←) in the blade of scapula is revealed as a fracture (#) on dedicated views (b).

When interpreting shoulder radiographs, glenohumeral dislocation should also be considered and excluded. The position of the humeral head in relation to the glenoid is assessed on dedicated axial or 'Y' views: an extension of the principle of always reviewing at least two orthogonal views. Anterior-inferior dislocation of the shoulder joint (Fig 12) occurs more frequently than posterior dislocation (Fig 13), each condition presenting with different clinical findings and radiographic appearances[8].

Stabilising soft tissue structures such as the rotator cuff muscles, tendons and ligaments are often injured in combination and need to be considered as they influence management in the short and long term. One must also look for subtle but important injuries especially in the presence of dislocation (or subsequent reduction) such as a Bankart lesion or Hill-Sachs Deformity (Fig14).

A checklist review of review areas such as scapula and ribs should form part of the diagnostic algorithm to ensure subtle or uncommon injuries are not overlooked (Fig 15).

CONCLUSION

Radiographic interpretation is an essential skill for many clinicians but radiologists are there to help and experienced radiographers can often assist. Remember:

1. Image appropriately and provide maximal clinical information.
2. Consider the history, examination and patient age to maximise/optimise clinical-radiological correlation.
3. Always review at least two orthogonal views e.g. AP and Lateral. Review systematically and in its entirety the region imaged.
4. Consider subtle findings such as the presence of acute angles in cortical surfaces; periosteal reaction and sclerosis.
5. Check your review areas.
6. 'Think outside the bone.' Review the soft tissues and consider what other injury may have occurred.
7. Older images are your friend and if no fracture is identified, on the initial view, consider re-imaging after an appropriate interval or undertaking further investigations if symptoms persist (e.g. CT, MRI or Nuclear Medicine studies).

Radiographs are an adjunct to, not a replacement for, clinical assessment and may not always provide a definitive answer.

While I have provided an overview of upper limb radiographic interpretation the principles described above can be applied, generally to the lower limb and to radiographs of the body and axial skeleton.

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