INTERPRETATIONS

Interpretation of wrist and hand radiographs

Introduction

Wrist and hand injuries account for approximately 15% of casualty department attendances. Recognition of injuries in this area is important as apparently minor injuries can result in significant loss of function. Early detection and appropriate management usually results in full recovery of normal function.

Adult anatomy

The adult wrist consists of eight carpal bones arranged in proximal (scaphoid, lunate, triquetrum and pisiform) and distal (trapezium, trapezoid, capitate and hamate) rows. These form three articulations: the radiocarpal, carpocarpal and carpometacarpal joints. The distal radius articulates with the lunate and scaphoid and is supported by strong radiocarpal and intercarpal ligaments. The distal radioulnar joint includes the triangular fibrocartilage that allows pronation and supination at the wrist. The carpocarpal and carpometacarpal joints are supported by strong ligaments. As in the foot the first three metacarpals articulate with their own carpal bone – trapezium, trapezoid and capitate – while the fourth and fifth metacarpals share the hamate.

The metacarpal and phalanges articulate via synovial joints. There are strong radial and ulna collateral ligaments that prevent sideway movements at the metacarpophalangeal (MCP) and proximal interphalangeal joints. The capsule of the interphalangeal and MCP joints is thickened on the volar (palmar) aspect and forms a dense fibrous structure called the volar plate that attaches to the adjacent phalanx. Each finger has two flexor tendons and one extensor tendon that inserts into the base of the phalanges.

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

Correspondence to: Dr CJ Harvey

Developmental anatomy

The carpal bones begin to ossify from 1–2 years of age onwards and are all present by 5–6 years of age. The scaphoid and trapezoid are the last ones to ossify. The primary ossification centres for the metacarpals and phalanges are already present at birth. Secondary ossification centres (epiphyses) appear for the base of the first metacarpal, heads of the other metacarpals and bases of the phalanges at about 2–3 years of age. Fusion of the growth plates occurs at 17 years of age. Biological skeletal age can be ascertained from left hand and wrist films up until puberty.

Interpretation of wrist and hand radiographs

Technical factors

Wrist

Posteroanterior (PA) view: This should include the distal radius and ulna as well as radiocarpal joint, carpometacarpal joints and metacarpal bases.

Lateral view: This is mainly used to assess radiocarpal alignment and identifying carpal dislocations.

Scaphoid views: These will be discussed in more detail below.

Hand

The optimal radiographic projection will depend upon detailed clinical information. PA and oblique views of the entire hand are indicated for injuries to the metacarpals or phalanges. PA and lateral views of individual digit or thumb injuries are recommended.

Systematic radiological assessment

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

Film quality

On wrist films the radius and ulna should be superimposed to avoid spurious diagnosis of dislocation of the distal ulna. Similarly on the PA wrist view there should be no overlap of the distal radius and ulna as a result of rotation.

Bone and joint alignment

The metacarpal bases, radius, lunate and capitate articulate with each other lying in a straight line on the lateral view of the wrist. The joint spaces should be parallel and uniform in width (1–2 mm). On the PA wrist three parallel arcs may be drawn joining the articular margins of the carpal bones. The first arc consists of proximal articular margins of the scaphoid, lunate and triquetrum, the second by joining the distal articular margins of the proximal carpal row and the third by joining the proximal articular margins of the capitate and hamate (*Figure 1*). Disruption of these parallel lines indicates subluxation or dislocation of the carpal bones. On hand films the phalanges and metacarpals of each finger and thumb should be normally aligned on both views (*Figure 1*).

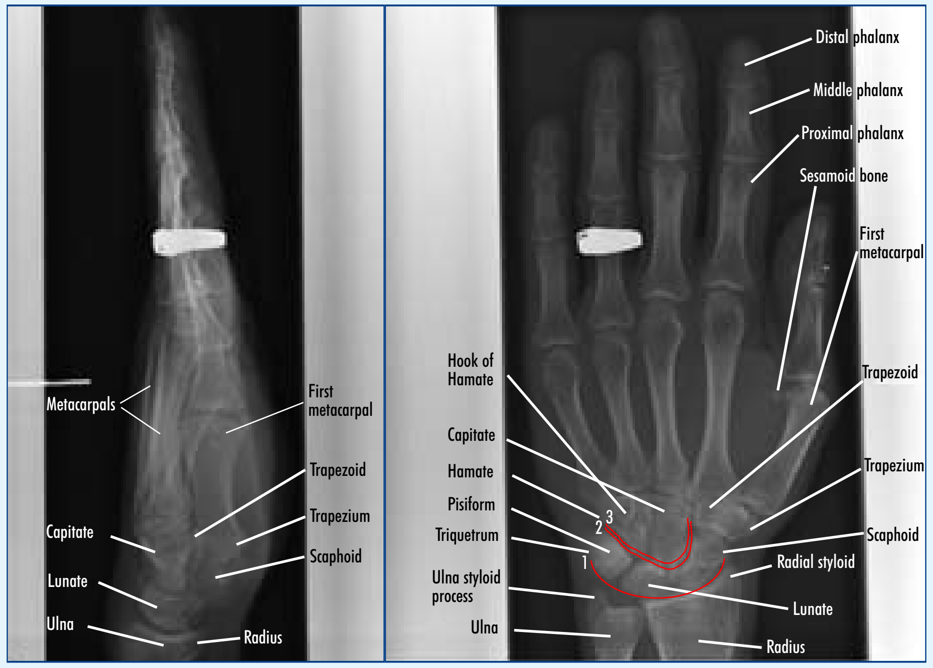

Figure 1. Normal posteroanterior and lateral radiographs of the wrist and hand. Superimposed red arcs (numbered 1, 2 and 3) defining normal carpal bone anatomy.

Table 1. Common errors

Wrong patient and/or date. Side marker on film erroneously applied
Mistaking sesamoid bones/accessory ossicles for fractures. Sesamoid bones/accessory ossicles have well corticated smooth rounded margins. Consult a book if unsure (Keats and Anderson, 2001)
Mistaking soft tissue creases as fractures. If a line extends beyond the cortical margin it is not a fracture. Also do not confuse a vascular groove for a fracture
Poor radiography may mask injuries: Dislocations, avulsion fractures of the volar plate and fractures extending to the articular surfaces may be missed on poorly positioned lateral views. Avulsion fractures affecting the collateral ligaments may be missed on poorly positioned posterioanterior views, therefore repeat the film if it is of poor quality.
Closure of the distal radial epiphysis may leave a dense line that should not be diagnosed as an impacted fracture

Bone margins

The cortical margins of all the bones should be inspected on two views to exclude a fracture. Also check bone density and trabecular pattern. Sclerotic bands may be the only sign of an impacted fracture. Vascular channels need to be distinguished from fractures. Vascular channels are often seen in the distal shaft of the phalanges and appear as thin, radiolucent lines that run obliquely from the external proximal surface entering the medullary canal distally.

There are numerous accessory ossicles or sesamoid bones around the wrist and hand. These occupy classic positions and have well corticated margins as opposed to the irregular edges of fracture fragments.

Soft tissues

Use a bright light to look for soft tissue swelling as this may be the only indicator of injury. Note foreign bodies.

Rigorous radiological assessment may help to avoid common interpretative errors encountered in casualty (*Table 1*).

Wrist injuries

Most wrist injuries are caused by a fall on the outstretched hand in which the force is transmitted across the scaphoid waist and carpocarpal joint.

Distal radial fractures

Colles' fracture

This is a fracture of the distal radius with dorsal displacement of the distal fragment producing a 'dinner fork deformity' on the lateral view (*Figure 2*). It may be associated with a fracture of the ulnar styloid process and scaphoid.

Smith's fracture

This is also known as a 'reverse Colles' fracture' in which there is anterior displacement of the distal fracture fragment.

Barton's fracture

This is a fracture of the dorsal aspect of the radius that extends to the wrist joint. A 'reverse Barton's fracture' occurs on the volar aspect and also extends to the articular surface. Fractures that involve the articular surface carry a poorer prognosis as a result of the increased incidence of articular cartilage damage and therefore premature osteoarthritis.

Figure 2. Colles' fracture posteroanterior and lateral view) showing a typical dorsal displacement of the distal radial fracture fragment ('dinner fork deformity') on the lateral view.

Chauffeur's fracture

This is a fracture of the radial styloid process.

Galeazzi fracture (distal radial fracture associated with a dorsal dislocation of the distal radioulnar joint) was covered in the previous article on the elbow (Allen et al, 2005).

Carpal fractures

The scaphoid is the most commonly fractured carpal bone (90%). Clinically a fracture is suggested by anatomical snuff-box tenderness. A scaphoid film series consists of a PA, lateral and two obliques. If no fracture is seen but is still strongly suspected clinically a follow-up film in 10–14 days is mandatory by which time the fracture may be seen as a lucent or dense line. In fact patients in whom a scaphoid series has been performed should have follow-up films whether or not a fracture has been demonstrated.

Scaphoid fractures may also be demonstrated by magnetic resonance imaging, bone scan or computed tomography. Eighty per cent of scaphoid fractures are across the waist. Since the blood supply to the proximal pole enters via the distal pole there is a risk of non-union and avascular necrosis if the patient is incorrectly managed (*Figure 3*).

Figure 3. Scaphoid series with non-union of a scaphoid waist fracture complicated by avascular necrosis of the proximal pole (seen as a sclerotic fragment).


Figure 4. Triquetral fracture best seen on the lateral view as a bony fragment dorsal to the carpal bones (arrow). On the posteroanterior view the fracture cannot be visualized. This case illustrates the importance of imaging trauma cases in two planes to avoid missing bony injuries.

Triquetral fractures are the second commonest carpal bone fracture. It is recognized as a fragment of bone seen posterior to the carpal bones on the lateral view (*Figure 4*).


Figure 5. Lunate dislocation with Monteggio fracture (fracture of the ulna with dislocation of the radial head).


Figure 6. Perilunate dislocation. On the lateral view there is dorsal dislocation of the distal carpal row. The lunate bone articulates normally with the radius although there is some rotation, giving it a triangular appearance on the posteroanterior (PA) film. Also there is loss of the normal joint space between the proximal and distal carpal rows on the PA view indicative of dislocation.

Carpal dislocations

Lunate dislocation

In this type the lunate bone dislocates anteriorly. It is best diagnosed on the lateral view and is recognized by the abnormal anterior site of the lunate while the radius articulates erroneously with the capitate (*Figure 5*). On the PA view the lunate has a triangular shape rather than its normal quadrilateral shape and there is loss of joint space between the scaphoid and lunate.

Perilunate dislocation

In this type the lunate remains correctly sited and the rest of the carpus dislocated dorsally (*Figure 6*). Again it is best diagnosed on the lateral view and is often associated with a scaphoid fracture (trans-scapho-perilunate dislocation).


Figure 7. There is widening of the scapholunate joint space (arrow) indicative of rupture of the scapholunate ligament (Terry Thomas sign).

Carpal subluxations

Ligamentous rupture will result in widening (≥ 2 mm) of the intercarpal joints. A well recognized example is the scapholunate ligament rupture (rotatory dislocation of the scaphoid) seen on the PA view as widening of the scapholunate joint (Terry Thomas sign) (*Figure 7*).

Child trauma

The wrist is a common site of trauma in children. Epiphyseal, metaphyseal and greenstick injuries (*Figure 8*) should be looked for. The epiphysis, epiphyseal plate and metaphysis is involved in up to 15% of fractures of the long bones in children. The epiphyseal plate is weaker than the adjacent ligaments and tendons and so is commonly involved in injuries (*Figure 9*). The complication of premature epiphyseal fusion may lead to angulation deformities (if part of the growth plate is involved) or limb shortening.

The Salter–Harris classification of epiphyseal injuries should be known and applied (*Table 2*). A greenstick fracture is seen as a break in one cortex with bending of the other, associated with angulation (*Figure 8*). A torus fracture is seen as buckling of both cortices without angulaton (*Figure 10*).

Figure 8. Posteroanterior and lateral views of the forearm showing a greenstick fracture of the radius with angulation (red arrow) and a torus fracture of the ulna (arrow).

Hand injuries

Thumb injuries

Bennett's fracture

This is a fracture of the base of the first metacarpal extending into the carpometacarpal joint with dislocation at the carpometacarpal joint (*Figure 11*). The metacarpal is pulled dorsally and medially by the abductor pollicis longus muscle which inserts into its base. Since it is an unstable fracture referral to a hand surgeon is suggested as it may require open reduction and internal fixation.

Figure 9. Salter–Harris type II fracture of the base of the proximal phalanx of the thumb (arrow).


Figure 10. Torus fracture of the distal radius seen as buckling of the radial cortex (arrow).

Gamekeeper's or skier's thumb

This is as a result of a rupture or sprain of the ulnar collateral ligament at the first MCP joint secondary to forceful abduction of the thumb. Occasionally it may be associated with an avulsion fracture. Radiographs may be normal or only show soft tissue swelling. A stress view may demonstrate instability of the joint. A complete tear of the ligament requires surgical repair.

Metacarpal and phalangeal fractures

Most fractures involve the mid shaft of the metacarpal or phalanx and are stable only requiring strapping (*Figure 12*).


Figure 11. Bennett's fracture. There is a fracture of the base of the first metacarpal (arrow) with dislocation of the metacarpal as a result of pull of the abductor pollicis longus muscle.

Certain fractures require referral to a hand surgeon:

- Avulsion fractures of a bone fragment from the base of a phalanx
- A spiral fracture of the shaft with rotation of the fragments as internal fixation may be required
- Extension of the fracture to a joint surface.

Figure 12. Oblique fractures of the third and fourth metacarpal shafts. Note that there is no extension of the fracture to the articular surface.

Figure 13. Subtle fracture of the neck of the fifth metacarpal with some volar augulation (arrow), best seen on the oblique view.

Table 2. Salter–Harris classification

Type I	Separation of the epiphysis with the fracture confined to the growth plate (6%). Examples include apophyseal avulsion and slipped capital femoral epiphysis. This has a good prognosis regardless of site
Type II	Fracture through the growth plate extending through the metaphysis (75%). This type of fracture is usually seen at the distal radius. It has a good prognosis but may result in minimal shortening
Type III	Fracture through the growth plate extending through the epiphysis (8%) and into the joint space. The prognosis is fair
Type IV	Fracture extending from the articular surface of the epiphysis (i.e. involving the joint space) through the growth plate and metaphysis (10%). There is an increased likelihood of deformity and angulation
Type V	Compression of the growth plate (1%). The prognosis is poor with growth impairment very common
The prognosis is worse in the lower limb independent of Salter–Harris type	

Boxer's fracture

This is a fracture of the neck of the fifth metacarpal and is usually associated with volar angulation of the head (*Figure 13*).

Avulsion fractures

These are fragments of bone avulsed at the insertion of collateral ligaments (medial or lateral avulsion), volar plate (palmar avulsion) (*Figure 14*) or extensor tendons (dorsal avulsion).

These injuries may appear trivial but may cause significant hand dysfunction if missed.

Mallet injury

This is caused by rupture or avulsion of the extensor tendon from the terminal phalanx. A bone fragment is only present in approximately 25%. Clinical examination reveals a flexion deformity of the terminal phalanx that cannot be extended. Management of a closed mallet injury is by splintage in a mallet splint.

Interphalangeal dislocations

Dislocation most commonly affects the proximal interphalangeal joint. Dislocation is best demonstrated on the lateral view (*Figure 15*). Radiographs should be repeated after reduction to look for fractures and check for satisfactory joint alignment. Incongruity may indicate the presence of soft tissue in the joint, e.g. torn volar plate.

Figure 14. Avulsion fracture of the base of the middle phalanx of the index finger at the insertion of the volar plate (arrow).

Figure 15. Volar dislocation at the proximal interphalangeal joint of the fifth finger.

Carpo-metacarpal dislocations

The fourth and fifth joints are most commonly affected and may be associated with a fracture of the base of the metacarpal.

Finger-tip injuries

These injuries are most commonly as a result of a crush fracture (*Figure 16*). Fractures may involve the nail bed or joint space.

Soft tissue injuries

Radiographs may be used to identify radio-opaque foreign (glass and metal) bodies but ultrasound is better for radiolucent objects (wood and plastic). When trying to detect a foreign body a metallic marker should be placed at the site of the injury, tangential to the site of injury. BJHM

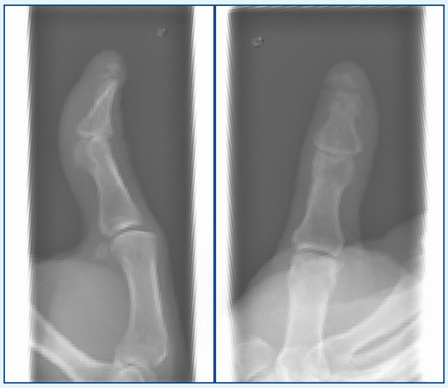

Figure 16. Compound crush fracture of the terminal phalanx complicated by osteomyelitis seen as bony destruction superimposed on a fracture.

Figure 4 *and* Figure 6 *are reproduced with permission from Harvey et al.* Self-Assessment Cases in Surgical Imaging. *Oxford University Press 2005.*
Conflict of interest: none.

Allen SD, Harvey C, O'Regan D (2005) Interpretation of elbow and forearm radiographs. *Br J Hosp Med* **66**(10): M50–M53

Keats TE, Anderson MW, eds (2001) *Atlas of Normal Roentgen Variants That May Stimulate Disease*. 7th edn. Mosby, St Louis

Further reading

Dahnert W (2003) *Radiology Review Manual.* 5th edn. Williams and Wilkins, Lippincott, London

Grainger RG, Allison DJ, Adam A, Dixon AK eds (2001) *Diagnostic Radiology: A Textbook of Medical Imaging*. Vol 1. 4th edn. Churchill-Livingstone, Edinburgh

Nicholson DA, Driscoll PA, eds (2005) *ABC of Emergency Radiology.* 2nd edn. BMJ Publishing Group, Cambridge

Raby N, Berman L, de Lacey G (2005) *Accident and Emergency Radiology. A Survival Guide*. 2nd edn. Saunders, London

KEY POINTS

- Always check the name, age and date.
- Assess film quality.
- Recognition of injuries in the wrist and hand is important as apparently minor injuries can result in significant dysfunction. Early detection and appropriate management usually results in full recovery of normal function.
- Exclude a fracture by examining the cortical contour of every bone on two views. Use a bright light for this. Do not confuse a vascular groove for a fracture.
- If a scaphoid fracture is suspected perform a scaphoid series. Follow-up is mandatory whether or not a fracture has been demonstrated.
- Inspect the lateral view of the wrist for a carpal dislocation or a fracture of the posterior radial cortex.
- Look carefully for subtle greenstick and torus fractures in children.
- Referral to a hand specialist is indicated in fractures that extend to an articular surface, bony avulsions, spiral fractures with rotation, unstable fractures, e.g. Bennett's injury.
- With dislocations look for an associated fracture, e.g. scaphoid fracture in a perilunate dislocation.
- Know the Salter–Harris classification of epiphyseal injuries.