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The hand and wrist

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The 'hand' lies distal to the carpometacarpal (CMC) joints and provides fine control, with movement relying on a relatively simple arrangement of bones, tendons and ligaments. By contrast, the 'wrist', acting as a link between the hand and the forearm, is much more anatomically, functionally and radiographically complex.

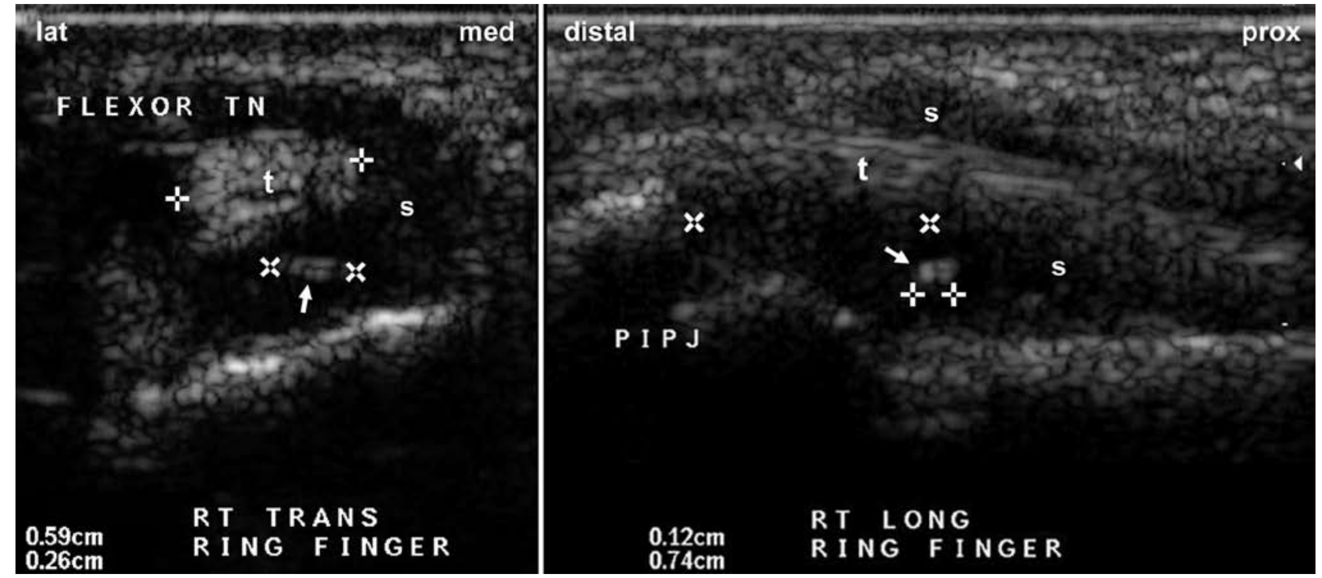
Biomechanically, the wrist transfers forces from either the forearm to the hand (as in throwing) or the hand to the forearm (as occurs in swimming). To achieve efficient transfer of force, the wrist must be able to remain stable while under load during movement or in a fixed position.

The hand and wrist are particularly susceptible to injury due to their exposed position and their key role in many activities. Up to 9% of all sports injuries involve the hand and wrist (Lee and Montgomery 2002). Sports involving ball handling, gymnastics and fighting are the leading causes of injury. Sport is the most common cause of phalangeal fractures in 10- to 39-year-olds and produces 43% of all injuries in 10- to 19-year-olds (Snead and Rettig 2001).

In the past, sporting injuries of the hand and wrist were often casually and sometimes poorly managed. Injured fingers were frequently strapped to the neighbouring finger and painful wrists were supported with strapping to enable the athlete to continue playing or competing. It was not uncommon for strapping to be reapplied for months, with little attention paid to the nature of the underlying injury. An immediate or early return to sport was the clear priority.

However, experience has taught us that this relaxed approach to hand and wrist injuries can result in significant deformities and disabilities, many of which can be avoided with appropriate management at the time of the injury. The prompt restoration of stability and function is now recognised as essential to achieving an optimal treatment outcome. Imaging plays an important role in this process, contributing to a fast and accurate diagnosis.

A basic set of conventional radiographs is often all that is required to assess the hand. However, the wrist frequently needs further work up, with either special views or the use of additional imaging methods. Ultrasound has become an extremely valuable diagnostic tool used to assess foreign bodies (see Fig. 2.1), abnormalities of tendons and ligaments, soft-tissue masses such as ganglia, some vascular injuries, and synovitic processes affecting small joints (Read et al. 1996). Targeted high-resolution CT examination can further characterise bone lesions, including subtle or radiographically occult fractures and dislocations. MRI has an important role in the diagnosis of bone marrow changes, the triangular fibrocartilage complex (TFCC)



▲ **Fig. 2.1** Ultrasound has become an extremely valuable diagnostic tool. In this case, transverse and long-axis views of the ring finger flexor digitorum superficialis-flexor digitorum profundus (FDS-FDP) tendon complex (t) demonstrate a surrounding collar of hypoechoic flexor tenosynovitis (s) secondary to a wooden splinter (arrow) lying within the tendon sheath at the level of the proximal phalangeal neck.

and intrinsic ligament injuries, tendon pathology, synovitis, cartilage abnormalities, neural entrapment and impingement syndromes. Nuclear bone scans also provide a method of finding occult fractures and demonstrating marrow changes.

In determining which of these tests might be useful, the sports physician must, as always, be guided by a thorough history and physical examination. In particular, the history often holds the key to understanding the precise mechanism of the injury, and this information alone will usually suggest the probable diagnosis. It will also assist the radiologist in the selection of the most appropriate imaging protocol and direct the search for relevant imaging findings, which can sometimes be remarkably subtle and otherwise overlooked. Many bone and soft-tissue injuries occur in characteristic patterns. Consequently, an understanding of the mechanism of injury through an appropriate history is considered to be an essential component of radiological interpretation.

Imaging of the hand

As noted above, plain films play a major role in assessing injuries of the hand. A plain film series includes two standard radiographic views: a posteroanterior (PA) view and an oblique view. A PA view (see Fig. 2.2) should be obtained with the forearm resting prone on the table with the hand, elbow and shoulder in the same horizontal plane. This position is known as 'zero rotation' (see page 58). The fingers are slightly separated and the primary beam is centred on the head of the third metacarpal. It is possible to tell whether an examination has been obtained in the PA or anteroposterior (AP) position. When the image has been obtained in the PA position, the ulnar styloid process is positioned at the medial edge of the distal ulna, whereas if the examination is taken in the supine or AP position, the ulnar styloid process is projected more laterally or over the centre of

▲ **Fig. 2.2** A PA view of the hand provides a comprehensive overview of bone, joints and soft-tissue anatomy.

the distal ulna. An oblique view (see Fig. 2.3) is obtained by raising the radial side of the hand by resting the hand on a 45° sponge. As with the PA view, the fingers are slightly separated and the primary beam is centred on the head of the third metacarpal.

There are additional plain film views of the hand that may be helpful with certain particular clinical presentations (see Table 2.1). These views help to image specific anatomical structures that need to be examined given the injury that is clinically suspected.

Table 2.1 Additional plain film views of the hand

Additional plain film views of the hand are used in the following clinical situations:

- thumb injury
- possible ligamentous injury at the first metacarpophalangeal joint
- a suspected finger injury
- if a metacarpal fracture has been demonstrated on the routine films
- injury to the medial carpometacarpal joints
- a suspected intra-articular fracture of a metacarpal head.

▶ **Fig. 2.3(a)** An oblique view adds a further dimension to radiographic assessment of the hand, without creating the confusion that would result from the superimposition of structures in a lateral projection.
▼ **(b)** This athlete has fractures of metacarpals three and four, which are difficult to see on the PA view. The fractures are well demonstrated when the hand is viewed obliquely. There is also evidence of old injury at the radial aspect of the bases of the second and third proximal phalanges.

Specific views of the thumb (see Fig. 2.4) should be requested whenever there is clinical suspicion of a thumb injury. The anatomical plane of the thumb differs from that of the remainder of the hand and the thumb is therefore inadequately demonstrated on routine hand views.

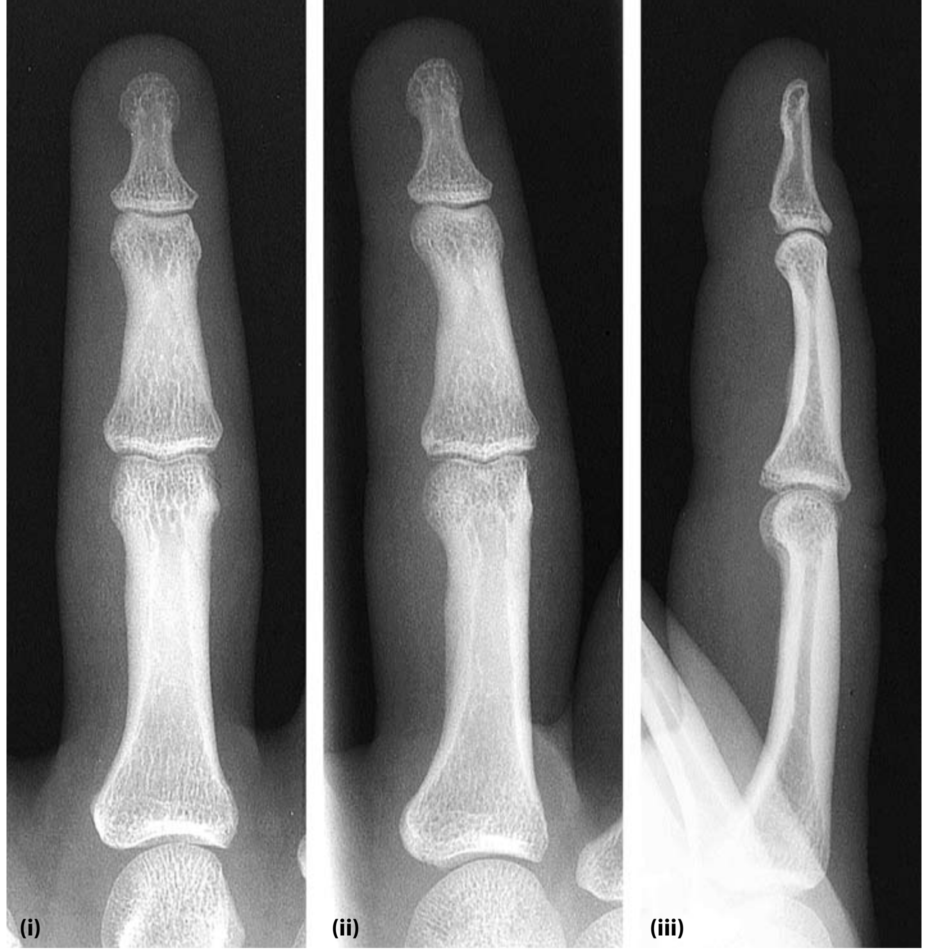
A true lateral view is particularly important to allow adequate assessment of the first CMC joint, the first metacarpophalangeal (MCP) joint and the interphalangeal joint of the thumb. To obtain an AP view of the thumb, the hand is internally rotated until the dorsum of the thumb lies flat on the cassette. An oblique view is obtained by rotating the thumb to a position midway between an AP and a lateral view. All views are centred on the first MCP joint.

When a ligamentous injury at the first MCP joint is suspected, stress views may be helpful to assess the integrity of the ulnar and radial collateral ligaments. The radiographic technique, indications and contraindications for stress views are discussed on page 39.

All finger injuries require specific finger views (see Fig. 2.5(a)(i)–(iii) overleaf). A finger series includes a PA view (i), an oblique view (ii) and a true lateral view (iii). A technically good lateral projection is critical to the assessment of fracture-dislocation injuries. In acquiring the images, the finger should lie fully extended against the cassette with the primary beam centred on the proximal interphalangeal joint. Good collimation enhances detail. A lateral view of all fingers can be obtained by fanning and separating the fingers, as in Fig. 2.5(b).

When a metacarpal fracture has been demonstrated on the routine hand views, a slightly off-lateral view of the hand may be useful to help assess displacement, angulation or shortening at the metacarpal fracture site (see Fig. 2.6).

▲ **Fig. 2.4** A thumb series includes AP **(a)**, oblique **(b)** and lateral **(c)** views. Specific thumb views are essential when there has been a thumb injury, demonstrating the relevant anatomy in true AP, oblique and lateral projections. Note the recent fracture of the distal phalanx and an old injury to the anterior aspect of the base of the proximal phalanx, which has the appearance of an old volar plate avulsion.



▶ **Fig. 2.5(a)** A finger series includes a PA view **(i)**, an oblique view **(ii)** and a true lateral view **(iii)**. There is minor soft-tissue swelling centred on the proximal interphalangeal joint but no bone injury is seen.

▼ **(b)** A lateral view of all fingers is possible using a single exposure, by fanning the fingers and resting them in the lateral position on a stepped foam wedge.

▼ **Fig. 2.6** When a metacarpal fracture is present, this slightly off-lateral view may be helpful to allow assessment of the angulation and shortening at the fracture site.

A reversed oblique view (see Fig. 2.7) is a useful additional view to demonstrate injury at the base of the fourth and fifth metacarpals and the adjacent carpals and medial CMC joints. The technique is discussed on page 45.

If an intra-articular fracture of a metacarpal head is suspected, Brewerton's view (Anderson 2000) is a valuable additional view (see Fig. 2.8). This view brings the majority of the articular surfaces of the MCP joints into profile and enables identification of small articular fractures. The radiographic technique to acquire this view is discussed on page 43.

▶ **Fig. 2.7** This reversed oblique view shows an incomplete undisplaced fracture at the base of the fifth metacarpal (arrow) and enables examination of the hamate as well as the fourth and fifth CMC joints.

▲ **Fig. 2.8** Brewerton's view shows a large proportion of the articular surfaces of the MCP joints and is particularly valuable when an intra-articular fracture is suspected. This examination is normal.

Hand injuries

Hand injuries may involve bone, joints, tendons, ligaments and other soft tissues.

Bone and joint injuries

Finger injuries

Phalangeal fractures

Residual deformities following a phalangeal fracture may interfere with normal function. Consequently, all suspected phalangeal fractures require imaging, since particular fractures need orthopaedic assessment. If deviation (see Fig. 2.9 overleaf) or rotation (see Fig. 2.10) of the distal fracture fragment has occurred and is left unreduced, fingers may cross when a fist is made. This would interfere with normal hand function. Other fractures, such as condylar fractures, are intrinsically unstable and usually require fixation (see Fig. 2.11).

▲ **Fig. 2.9** If deviation such as this is uncorrected, overlapping of the fingers will result when the fingers are flexed.

▼ **Fig. 2.10** There is a fracture of the middle phalanx with considerable rotation of the distal fragment. If this rotation is uncorrected, the fingers may overlap when a fist is formed.

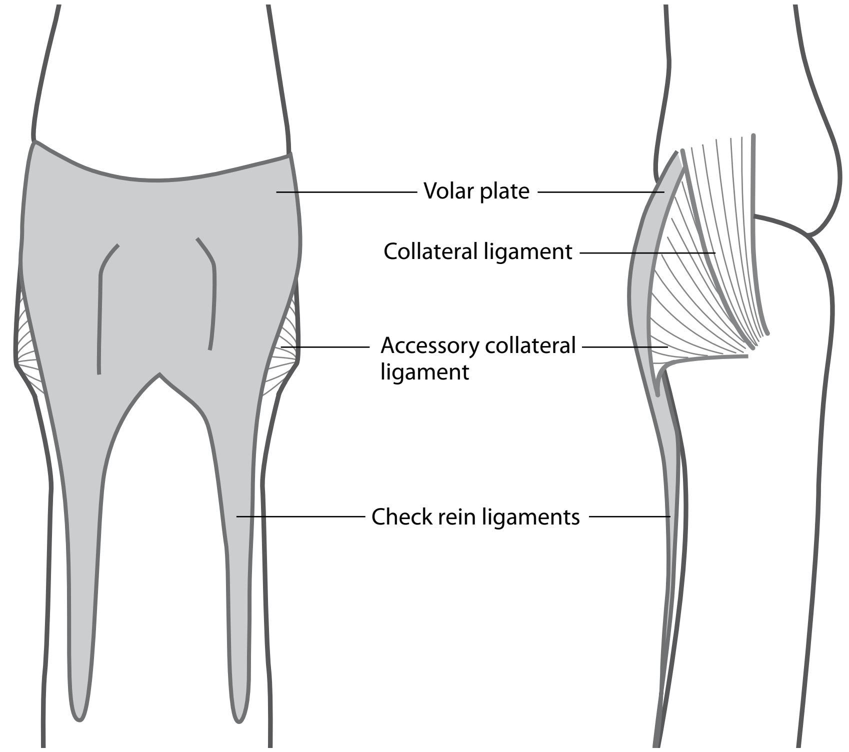
▲ **Fig. 2.11** Uni- or bicondylar fractures **(a)** are usually unstable and require fixation **(b)**. Note that the distal screw has broken at surgery and the head of the screw has been removed.

Interphalangeal joint injuries

Interphalangeal joints are hinge joints (see Fig. 2.12) capable only of flexion and extension. The capsular ligament is reinforced on both sides by the collateral and accessory collateral ligaments. The volar plate protects the palmar aspect of the joint and acts as a constraint against hyperextension. The accessory collateral ligaments fuse with the lateral margins of the volar plate, increasing stability. The volar plate is membranous proximally and fibrocartilagenous distally. Joint injuries are often the result of an axial force, a so-called 'jamming' injury, forced hyperextension or violent deviation forces. Injury to the volar plates is a common injury and the radial collateral ligament is the ligament most injured. Direct trauma also occurs frequently, usually resulting from a fall, fighting or a stomping injury.

Volar plate injuries

Injury to the volar plate results from hyperextension and may occur with or without a characteristic associated phalangeal avulsion fracture. A volar plate injury without a fracture is an extraordinarily common occurrence in sports involving ball handling and is a source of discomfort every time the finger is 'jammed'. The athlete characteristically presents with soft-tissue swelling and tenderness centred on the injured joint (see Fig. 2.13). If an avulsion fracture is present, this will occur at the distal attachment of the plate, with proximal retraction of the bone fragment. The fragment avulsed is often tiny, and careful inspection of the anterior recess of the painful joint is warranted (see Fig. 2.14). When a large fragment is avulsed,



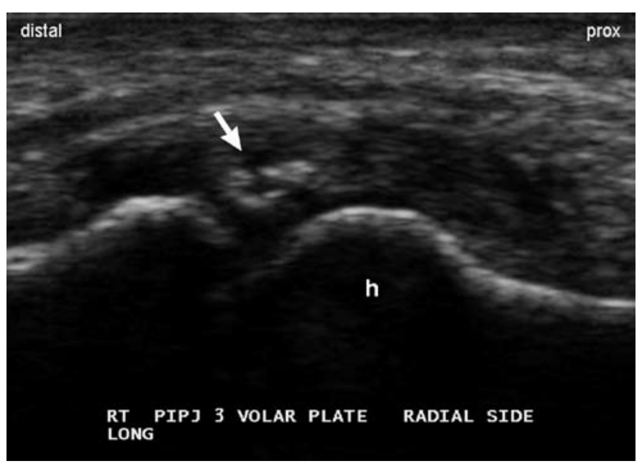
▲ **Fig. 2.12** This line drawing depicts an interphalangeal joint showing ligaments and volar plate

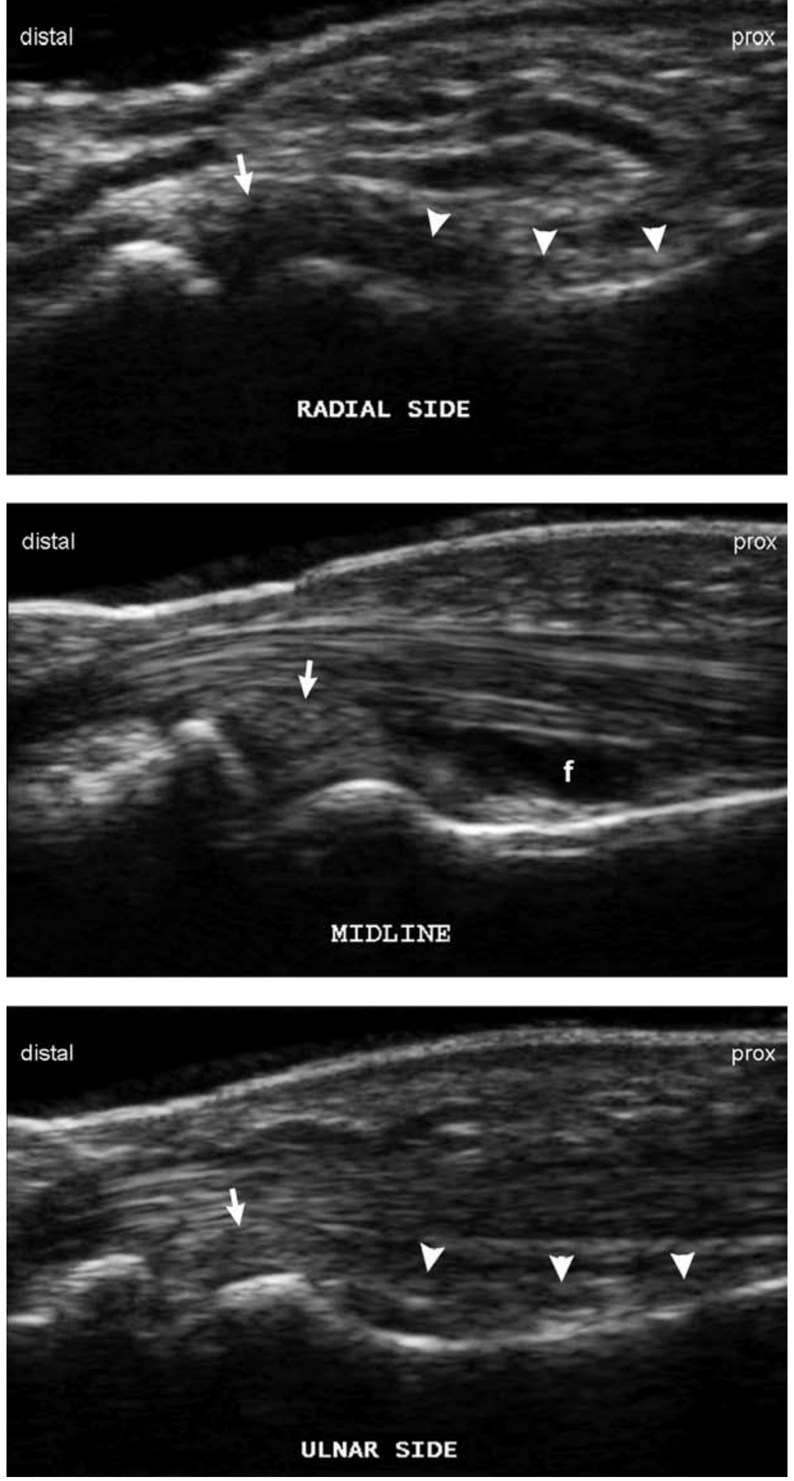
▲ **Fig. 2.13** This is the typical appearance of a volar plate injury without a fracture. A fusiform soft-tissue swelling is seen, centred on the injured joint.

◀ **Fig. 2.14** When traction by the volar plate separates a bony fragment, it is usually tiny and is often identified only after careful inspection of the anterior aspect of the injured interphalangeal joint. These tiny fragments are often best seen in the oblique view (arrow).

dorsal subluxation may occur (see Fig. 2.15). If 30–40% of the articular surface is separated, instability can be anticipated and fixation is usually considered (Palmer 1998). Occasionally a volar plate injury is suspected clinically but the plain films are normal. In such circumstances, the volar plate can be imaged by ultrasound (see Figs 2.16 and 2.17) or MRI (see Figs 2.18 and 2.19).

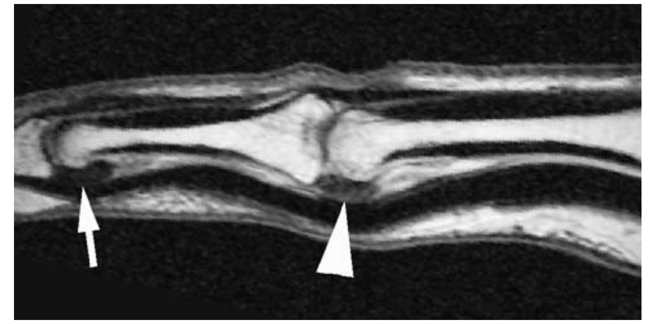
▲ **Fig. 2.15** A hyperextension injury has avulsed a large fragment from the volar aspect of the middle phalanx, which involves about 50% of the articular surface. This has resulted in instability and dorsal subluxation of the proximal interphalangeal (PIP) joint.



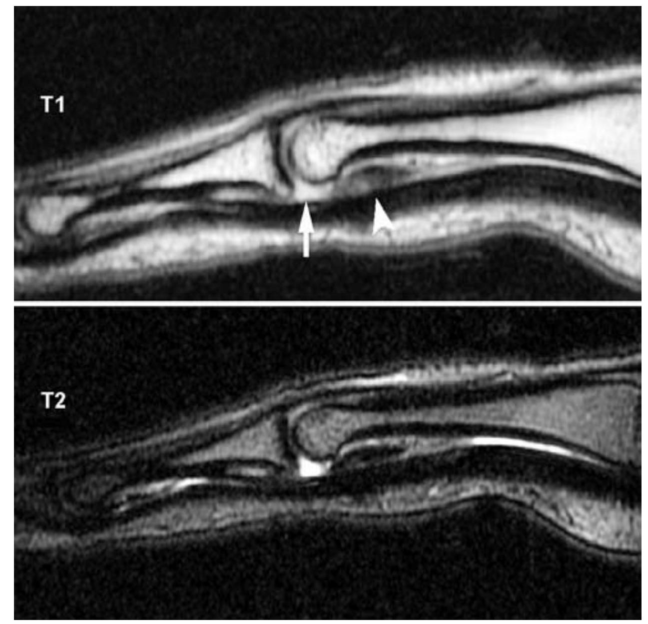


▲ **Fig. 2.16** A normal volar plate is demonstrated by ultrasound. Long-axis ultrasound images show the volar plate (arrows) of the PIP joint and its attachment to the proximal phalangeal neck via the check-rein ligaments (arrowheads). The check-rein ligaments are taut in finger extension but folded and lax in finger flexion. Note fluid (f) within the volar recess of the PIP joint between the check-rein ligaments.

◀ **Fig. 2.17** A subacute tear of the volar plate is demonstrated by ultrasound. This long-axis ultrasound image shows an irregular mixed hypo-hyperechoic cleft (arrow) indicative of a tear involving the volar plate of the middle finger PIP joint to the radial side of the midline. As the clinical management of volar plate tears is rarely altered, note that imaging beyond simple plain x-ray is *not* commonly performed. Proximal phalangeal head = h.



▲ **Fig. 2.18** This sagittal T1-weighted MR image shows normal volar plates at both the distal interphalangeal (DIP) joint (arrow) and PIP joint (arrowhead). Note that intact volar plates are continuous distally with the bases of the distal and middle phalanges, respectively.



▲ **Fig. 2.19** A PIP joint volar plate tear is shown on T1-weighted and corresponding fat-suppressed sagittal T2-weighted MR images. A fluid-filled gap (arrow) indicates separation of the volar plate (arrowhead) from its normal attachment at the base of the middle phalanx.

Diagnostic imaging of phalangeal fractures and interphalangeal joints

Plain films are invariably the only imaging required for fractures of the phalanges and interphalangeal joints, although ultrasound and MRI may be used to image the volar plate. Interphalangeal joint dislocations are almost always dorsal (see Fig. 2.20). Rarely, volar dislocations can occur at the DIP joint when instability is produced by avulsion of a large dorsal fragment by the extensor tendon (see Fig. 2.21). Following a dislocation, post-reduction films are important and may reveal a previously unrecognised avulsed fragment. Occasionally, dislocations may be irreducible due to entrapment of either the joint capsule or the lateral band of the extensor tendon mechanism. Ultrasound or MRI can be valuable to confirm these complications.

▲ **Fig. 2.20** A violent finger hyperextension injury occurred during a rugby game and produced dislocation of both the DIP and PIP joints. There is also a small fragment separated from the epiphysis at the base of the distal phalanx.

▼ **Fig. 2.21** Volar subluxation and dislocation are uncommon but occasionally may be seen at the DIP joint following avulsion of a large fragment by the extensor tendon. In this case, instability has resulted and there is slight volar subluxation. Also note the hyperextension of the PIP joint. This deformity is described as 'mallet deformity' due to the unopposed pull of the extensor mechanism on the middle phalanx (Lee and Montgomery 2002).

Metacarpal fractures and MCP joint injuries

Injury to the first MCP joint

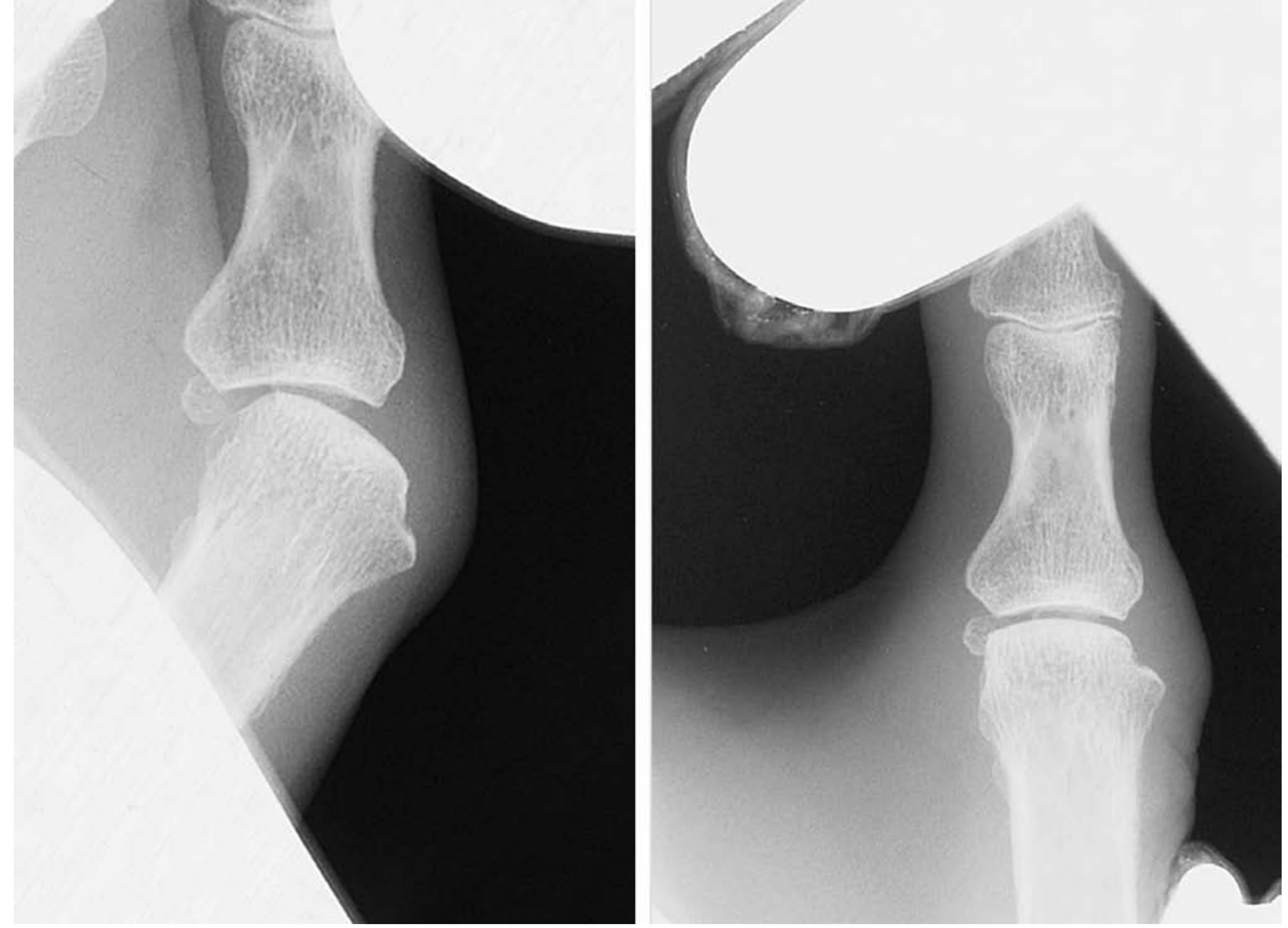
Ligamentous injury occurs at the first MCP joint following a sudden and violent ulnar or radial deviation force applied to the thumb. A radial deviation injury may tear the ulnar collateral ligament (UCL) and produce a so-called 'skier's thumb' or 'gamekeeper's thumb' (Engkvist et al. 1982). An ulnar deviation force may tear the radial collateral ligament. The injury can result in a complete or incomplete tear of the collateral ligament, or in the avulsion of a bone fragment from the ligamentous attachment at the base of the first proximal phalanx. The diagnosis of a collateral ligament tear or an avulsion fracture is important, because instability may result if the injury is overlooked or inadequately managed. Most tears of the ulnar collateral ligament occur at the attachment to the proximal phalanx.

A stress view may be helpful to assess the integrity of the ulnar or radial collateral ligament when collateral ligament injury is suspected at the first MCP joint (see Fig. 2.22). To stress the UCL, a film of the MCP joint is obtained in the AP position with the joint in 30° of flexion (Lee and Montgomery 2002), while a valgus stress is applied to the MCP joint (see Fig. 2.23). Obviously, to stress the radial collateral ligament, a varus force is used (see Fig. 2.24). The view is abnormal when 30° or more of joint opening is produced on the symptomatic side compared to the normal side (see Fig. 2.25).

▲ Fig. 2.23 In the absence of an avulsed fragment, a view taken while applying a valgus stress to the UCL demonstrates abnormal opening of the medial side of the joint, indicative of a UCL injury.

▼ Fig. 2.22 There is loss of congruency at the first MCP joint suggesting that instability and ligamentous injury may be present. In this case, a stress view may be diagnostic.

▼ Fig. 2.24 Comparative views on stressing the ulnar collateral ligaments of both the symptomatic and asymptomatic sides show a diagnostic discrepancy. The symptomatic joint on the right opens abnormally, 30° more than the asymptomatic joint on the left, confirming rupture of the UCL of the thumb on the right.



▲ Fig. 2.25 Applying a varus stress to the radial collateral ligaments of both the asymptomatic thumb on the right and the symptomatic side on the left allows the diagnosis of a radial collateral ligament rupture on the symptomatic side.

An immediate surgical repair may be required to avoid instability. Conservative management is considered if there is a fracture that involves less than 30% of the articular surface of the base of the proximal phalanx and there is less than 1.5 mm of displacement. It is important to remember that a stress radiograph carries the risk of converting a non-displaced ligament tear or an in-situ avulsion fracture into a Stener lesion. A Stener lesion is present whenever the torn proximal stump of the UCL is displaced superficial to the adductor pollicis aponeurosis. Spontaneous ligament healing with restoration of MCP joint stability cannot then occur (see Fig. 2.26).

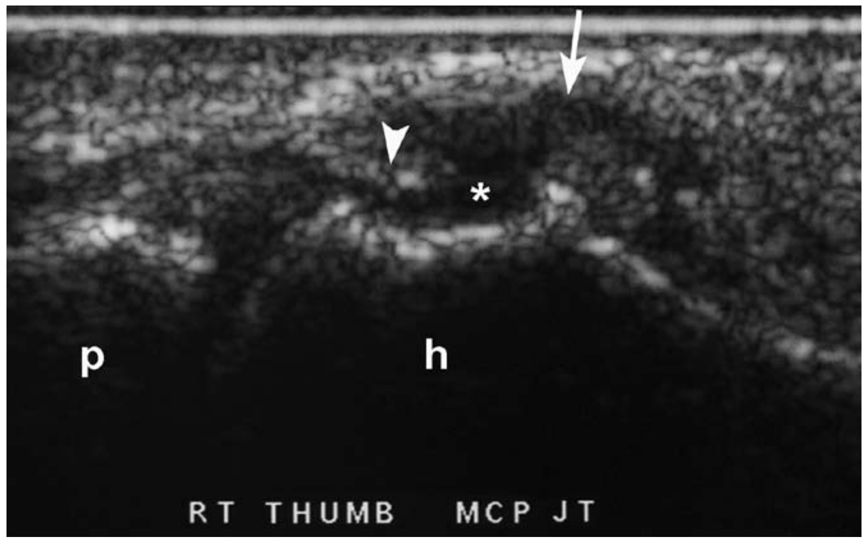
It is therefore inadvisable to perform a stress view if any of the following circumstances apply:

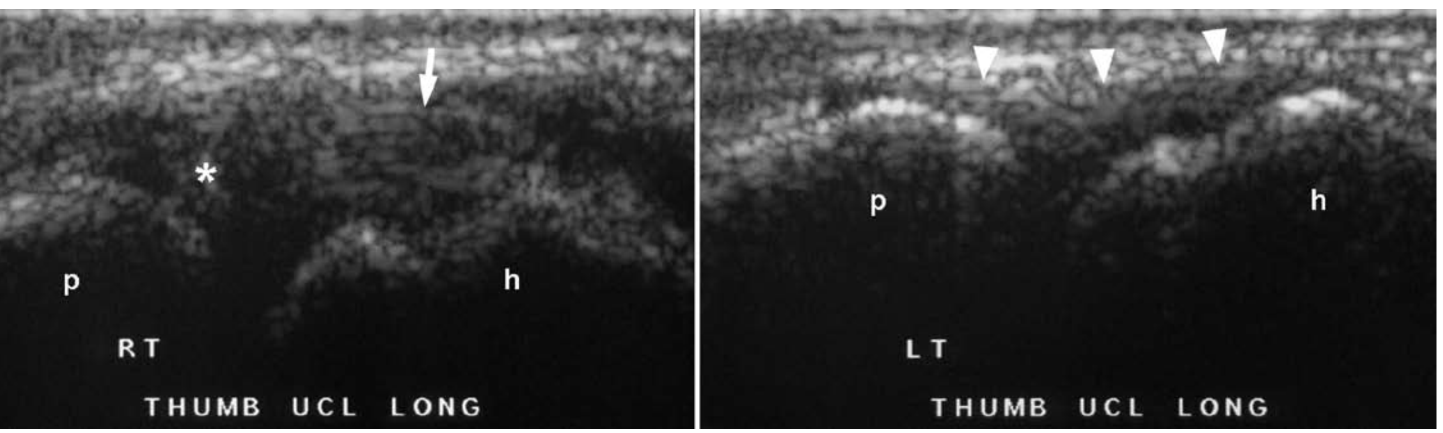
- an avulsion fracture has already been demonstrated on the routine film series (see Fig. 2.27)
- the local policy of surgical management is to explore these injuries regardless of the radiographic findings
- high-quality ultrasound (see Figs 2.28 and 2.29) or MRI (see Fig. 2.30) is available as an alternative method of imaging assessment (O'Callaghan et al. 1994).

▶ Fig. 2.26 It is possible that an energetic stress view such as this may complicate a simple UCL avulsion by converting it into a Stener lesion.

◀ **Fig. 2.27** A small bony fragment can be seen separated by the UCL (arrow). As the diagnosis of an avulsion with displacement is already available, a stress view should not be performed.

▼ **Fig. 2.28** A Stener lesion is demonstrated by ultrasound. A long-axis image of the UCL of the right thumb demonstrates a focal soft-tissue thickening adjacent to the metacarpal head, which represents the displaced proximal ligamentous stump. There is a hypoechoic gap at the usual site of the proximal segment (asterisk). Note the thin echogenic line of inter posed adductor aponeurosis (arrowhead).
Metacarpal head = h. Base of proximal phalanx = p.





▲ **Fig. 2.29** A Stener lesion of the right thumb is demonstrated by ultrasound. The UCL of the *right* thumb MCP joint shows a hypoechoic zone distally that lacks discernible fibres (*), while the proximal portion of the ligament appears to have doubled in thickness (arrow) due to proximal folding and apposition of the torn and displaced distal portion. Arrowheads indicate a normal UCL of the *left* thumb MCP joint for comparison. Metacarpal head = h. Base of proximal phalanx = p.

▶ **Fig. 2.30** MRI demonstrates an undisplaced UCL tear at the thumb MCP joint. This fat-suppressed PD-weighted image shows a hyperintense defect in UCL fibre continuity (arrowhead) at the phalangeal attachment.

Dislocation and subluxation of the MCP joints

Dislocation and subluxation of the MCP joints are hyperextension injuries, with the metacarpal head displaced dorsally (see Figs 2.31 and 2.32). The dislocations are characteristically difficult to reduce due to volar plate entrapment (see Fig. 2.33) or because occasionally the metacarpal head may be pushed through the volar plate or caught between the lumbrical and the long flexor tendon.

▲ **Fig. 2.31** During a game of rugby, a hyperextension force was applied to the thumb, resulting in dislocation of the first MCP joint.

Metacarpal fractures

Metacarpal fractures are a common hand injury, usually resulting from punching (see Fig. 2.34) or direct trauma (see Fig. 2.35). A large percentage of metacarpal fractures result from fighting and football. The most common type is a fracture of the fifth metacarpal neck (see Fig. 2.36): metacarpal fractures represent a third of all

▶ **Fig. 2.33** In an attempt to catch a cricket ball, this young cricketer has dislocated his fourth MCP joint. Joint space widening persists after reduction, suggesting volar plate entrapment within the joint space.

▼ **Fig. 2.32** An excessive hyperextension force to the hand has produced multiple dorsal dislocations of MCP joints two to five, with dorsal displacement of the metacarpal heads.

▼ **Fig. 2.34** Fractures of the fourth and fifth metacarpals have resulted from punching. The medial CMC joints and the hamate may also be injured as a result of this mechanism.