ULTRASOUND IN WRIST AND HAND SPORT INJURIES

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Hand and wrist injuries are common in athletes and can affect articular structures (ligaments, joint surfaces etc), periarticular tendons, muscles and nerves. These injuries can be acute or chronic. Acute injuries follow sudden traumatic events such as falls or joint sprains. Chronic lesions can be the result of local repetitive microtrauma or the sequelae of an acute injury. An accurate patient history and careful clinical examination are essential to obtain an early diagnosis. This allows prompt and proper treatment, assisting the athlete to return to sport without significant complication or delay. Nevertheless, an imaging modality is usually obtained to confirm the clinical suspicion, assess the extent of tissue damage and help choose between surgical or conservative treatment.

Ultrasound (US) is a cheap, non-invasive and dynamic modality that allows accurate evaluation of the para-articular soft tissues of the wrist and hand. It is readily available and patient friendly. However, it requires an experienced physician with high quality equipment and accurate knowledge of normal anatomy and anatomic variants and ability to correlate with clinical data[1–3].

Before starting the US examination, physicians should carefully review the request form, as well as obtain a brief history and perform a basic physical examination in order to help target the region of interest. Standard radiographs obtained before the US examination are helpful since the radiographs allow a panoramic evaluation of the bone and joint structures that are not evaluated as effectively with US. The two imaging modalities are complementary and work well in daily practice when an immediate or prompt imaging assessment is needed.

Modern US equipment with broadband electronic transducers working at 10 to 17 MHz is necessary for accurate study of the superficial soft tissues of the wrist and hand. Hockey stick transducers are particularly helpful since their small size allows dynamic examination during movement of joints and tendons. Colour Doppler is always performed to detect signs of local inflammation or to judge the flow of internal vessels. Also, evaluation of the contralateral limb can be performed if needed, for comparison.

This article briefly presents the US appearance of the most frequent sport injuries of the hand and wrist.

TENDON DISORDERS

Tendinopathies

There are a variety of tendinopathies that can affect the wrist and hand of an athlete.

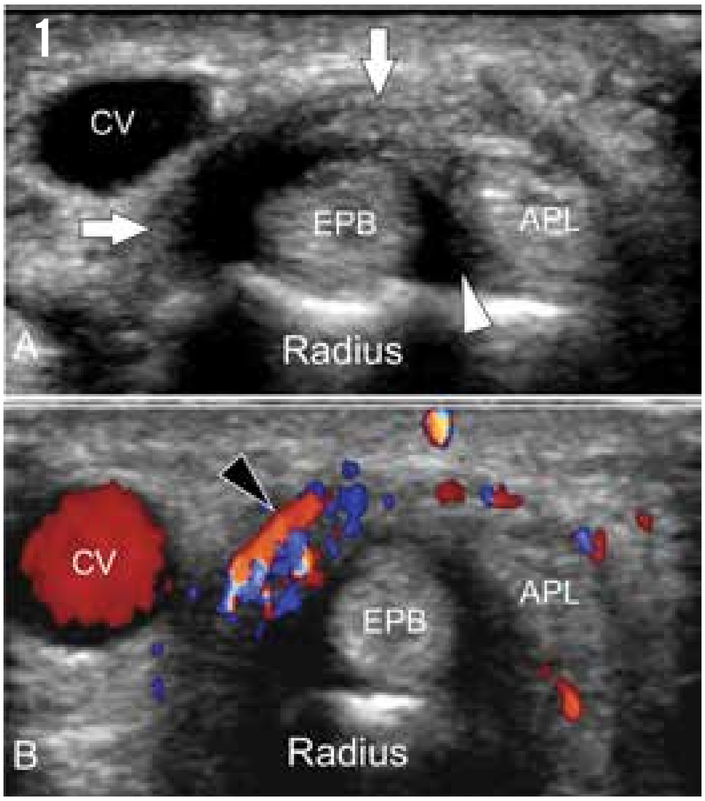


Figure 1: De Quervain tenosynovitis. (A) Axial grey-scale and (B) colour Doppler US obtained over the first extensor compartment. Images show hypoechoic and irregular thickening of the retinaculum of the first extensor compartment (arrows) surrounding the extensor pollicis brevis tendon (EPB). The retinaculum of the abductor pollicis longus tendon (APL) is normal. Note a septum divisum (white arrowhead) separating the two tendons. In (B) colour Doppler shows evident hyperaemic changes inside the pathologic retinaculum (black arrowhead). CV=cephalic vein.

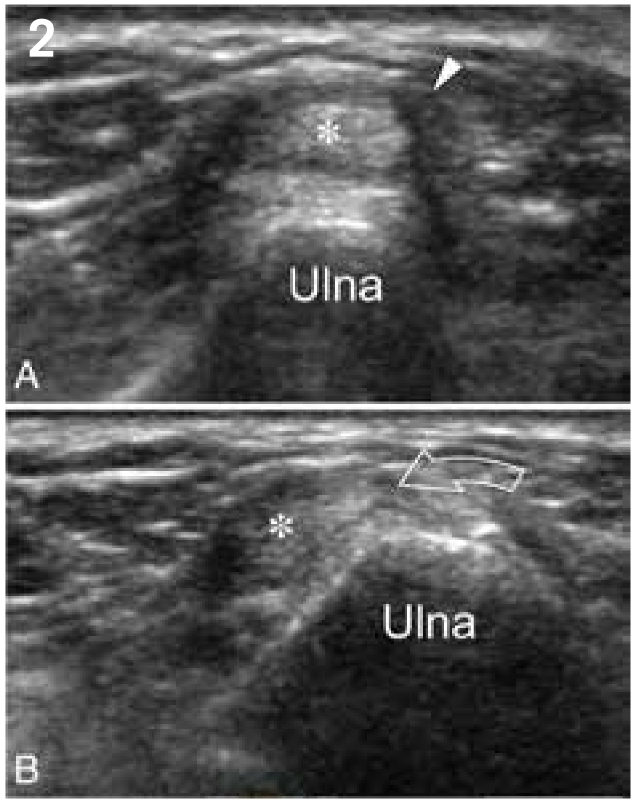


Figure 2: Instability of the extensor carpi ulnaris tendon. (A) Axial grey-scale sonograms obtained over the ulnar head in pronation and (B) forced supination. In (A) the tendon (asterisk) is normally located and appears surrounded by a thick and hypoechoic retinaculum suggesting a tear. In (B) the tendon appears dislocated medially (arrow).

They are usually the result of repetitive micro trauma. Depending on the nature and type of sport, the injuries can affect the extensor or flexor tendons.

De Quervain tenosynovitis is a frequent tendinopathy affecting the tendons of the first extensor compartment of the wrist (extensor pollicis brevis and abductor pollicis longus tendon). It is seen mainly in sports that require repetitive forceful grasping coupled with ulnar deviation (golf, fly fishing, squash and badminton). US shows the pathologic changes affecting the retinaculum and tendons (Figure 1). The retinaculum, which usually presents as a thin hyperechoic band, appears hypoechoic and swollen. The presence of a septum divisum (a vertical septum dividing the compartment in two distinct fibro-osseous tunnels and facilitating tenosynovitis) can be easily detected by US. The tendons can appear swollen and hypoechoic. In acute cases, the tendon sheath is thickened and can contain fluid (tensosynovitis). Colour Doppler can show hyperaemia of the retinaculum, tendons and synovial sheath. In addition to providing diagnostic information, US can be used to guide needle placement into a tendon sheath if a steroid-anaesthetic injection is needed. US guidance is especially useful in the presence of a septum divisum, in which case the injection must be directed only inside the affected tunnel.

On the posterolateral side of the wrist, tendinopathy of the extensor carpi ulnaris (ECU) tendon mostly affects rowers or tennis players. This can lead to local chronic pain and dysfunction, affecting the athlete's performance. Clinical findings may seldom mimic disorders of the distal radioulnar joint or the triangular fibrocartilage complex. In such instance, suspected triangular fibrocartilage complex injuries are better evaluated with CT/MR-arthrography, while US allows adequate assessment of the ECU and its retinaculum.

US can easily determine the presence of ECU tendinopathy and/or tenosynovitis. In tendinopathy, the examination allows the visualisation of anomalies of the internal fibrillar pattern (hypoechogenicity and internal clefts) and changes in tendon size. The tendon can show hypervascular changes due to internal neovascularisation. In tenosynovitis, US shows thickening of the synovial sheath, usually associated with local hypervascularisation and a frequently associated effusion.

Tendinopathy can follow retinacular tears and consequent ECU instability which would occur during prono-supination of the forearm (Figure 2). Instability is typically

> ***Ultrasound is a cheap, non-invasive and dynamic modality that allows accurate evaluation of the para-articular soft tissues of the wrist and hand***

seen in tennis when the player realises a powerful pronation from a supinated position. The diagnosis relies on the patient history and physical examination ('snap' is felt or heard over the caput ulnae during pronosupination). In difficult cases, US can detect the pathologic appearance of the retinaculum and assess for tendon instability. Retinacular tears will appear as a hypoechoic focal disruption in the retinatculum. This allows the ECU to dislocate anteriorly. Dynamic ultrasound performed with pronation-supination movements will allow detection of ECU instability. Intrasubstance longitudinal split tears of the deep face of the tendon are commonly seen in instability and appear as hypoechoic clefts in the normal hyperechoic tendon.

Tears

'Jersey finger' refers to a traumatic avulsion of the distal insertion of the flexor digitorum profundus (FDP) tendon most frequently affecting the ring finger. It is most commonly observed in rugby when a player grabs another player's jersey during a tackle. It is caused by an active flexion of the distal interphalangeal joint and a concomitant powerful passive extension. As a result of the opposing forces, the tendon pulls out and is retracted proximally. Leddy and Parker's classification takes into account the degree of retraction of the FDP, the affection of the vincula and the presence of a bone fragment[4]. In type I the tendon is retracted to the palm and in type II to the level of the proximal interphalangeal joint. In Type IIIA a bone fragment avulses and becomes caught at the entrance to the fourth annular pulley or the flexor digitorum superficialis chiasm. Type IIIB is characterised by a distal phalanx fracture combined with avulsion of the FDP from the fractured bone.

US clearly shows the relation between the avulsed hyperechoic fragment and the retracted FDP tendon (Figure 3). The size and location of the fragment as well as its relationship with the annular pulleys can be assessed. The empty distal tendon sheath and the irregular appearance of the base of the distal phalanx are also evident.

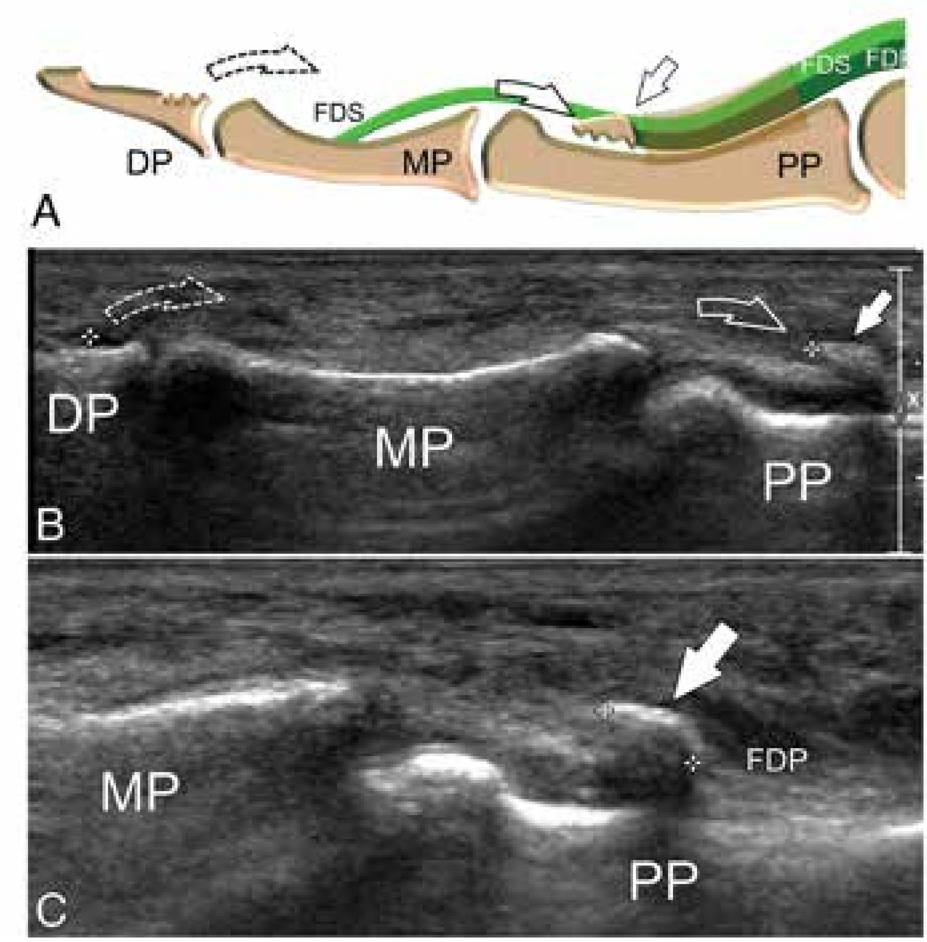


Figure 3: Jersey finger. (A) Schematic drawing and (B) sagittal US obtained over the palmar aspect of the fourth digit. In (A) is depicted the bony avulsion (dotted curved arrow) of the flexor digitorum profundus tendon (FDP). The avulsed fragment (arrow) is retracted (curved arrow) at the distal end of the A2 pulley. (B, C) corresponding US image. PP, MP, DP=proximal, middle and distal phalanges, FDS=flexor digitorum superficialis tendon.

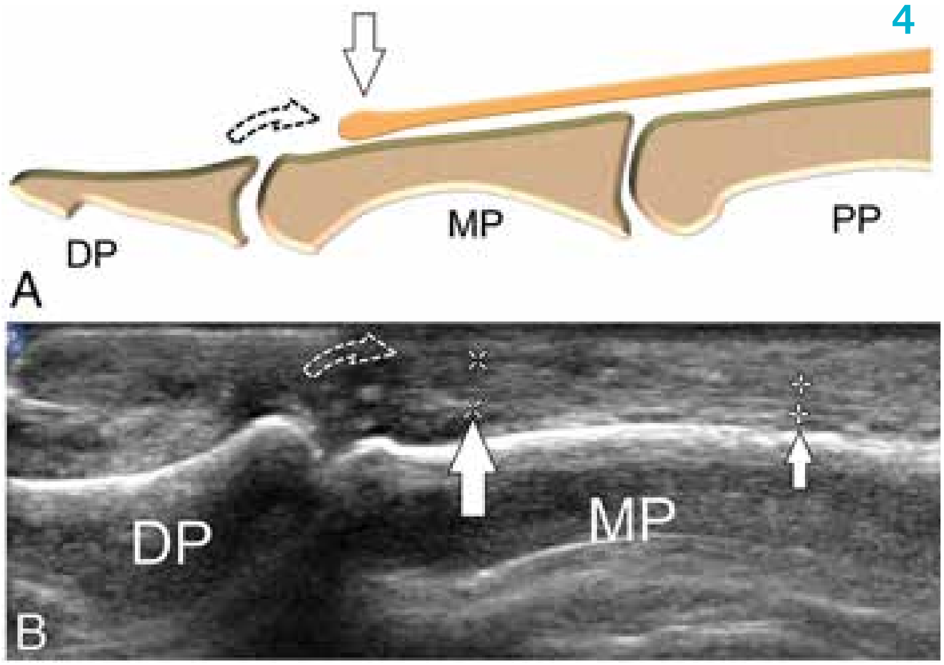


Figure 4: Mallet finger. (A) Schematic drawing and (B) sagittal US obtained over the dorsal aspect of the third digit. In (A) is depicted the avulsion (dotted curved arrow) of the extensor digitorum tendon (arrow) from the base of the distal phalanx (DP). (B) Corresponding US image. Note the swelling and hypoechoic appearance of the distal tendon (large arrow) compared with the normal proximal tendon (small arrow). MP=middle phalanx.

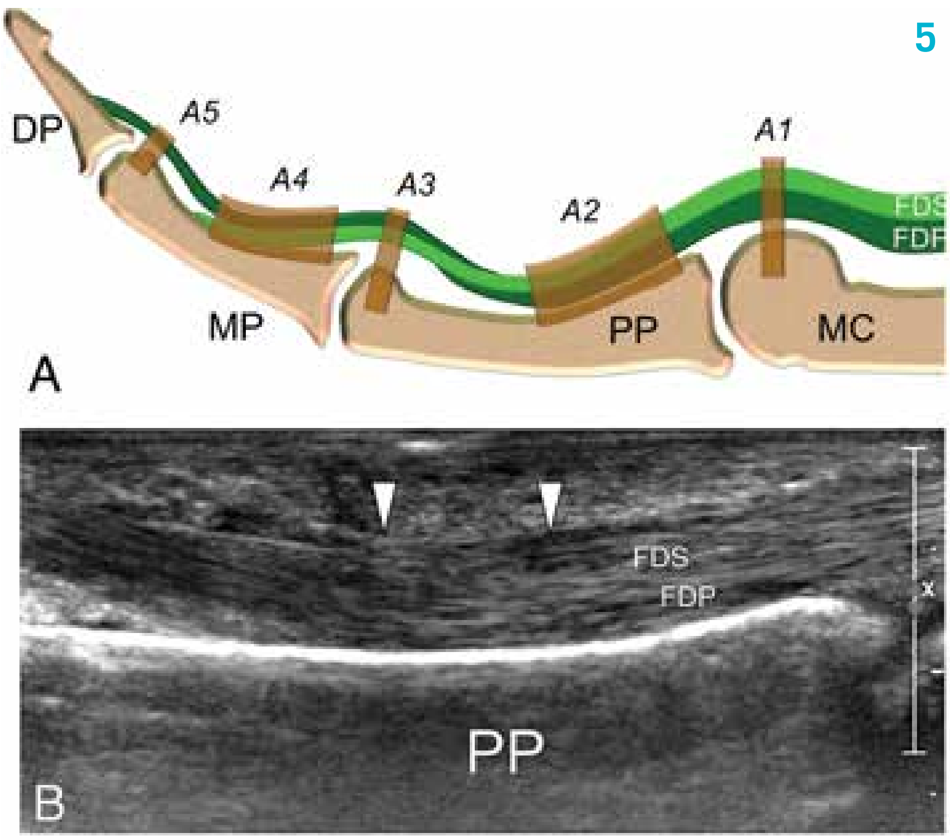


Figure 5: Normal anatomy and US anatomy of the annular pulleys. (A) Schematic drawing and (B) sagittal US obtained over the palmar aspect of the proximal phalanx (PP) of the third digit. In (A) note the five annular pulleys (A1-A5) and their relation with the flexor digitorum superficialis (FDS) and profundus (FDP) tendon. In (B) the tendons show a normal fibrillar pattern. They run on the anterior aspect of the proximal phalanx. The A2 pulley (arrowheads) appears as a thin hyperechoic line. MC=metacarpal, MP, DP=middle and distal phalanx.

'Mallet finger' refers to distal avulsion of the extensor digitorum tendon frequently seen in softball, baseball, basketball or in football receivers. When associated with a bony avulsion US is not useful since radiographs allow the diagnosis and can evaluate the size and displacement of the bone fragment. In absence of bone avulsion US can confirm the diagnosis and, more importantly, assess the entity of the proximal retraction of the tendon stump (Figure 4).

PULLEY DISORDERS

'Climber's finger' refers to a variety of digital lesions due to local stress from climbing activities affecting the joints and the digital annular pulleys (AP)[5]. Annular pulleys are thin fibrous ligaments that retain the flexor tendons against the phalanges during finger flexion (Figure 5)[6]. Acute annular pulley injuries are frequently observed in rock climbers who are accustomed to holding their body weight with one hand. These injuries are the consequence of a brutal extension force on the flexor tendon with the finger in an arched position. Often, the pulleys have been weakened by repetitive strains or overuse. Nearly 3/4 of pulley ruptures occur at the A2 pulley and in nearly 2/3 of cases they affect the ring finger. If not adequately treated, annular pulley tears can result in flexion contracture and weakening of mechanical properties.

US allows an accurate assessment of the number and extent of pulleys injured and also help in deciding between conservative or surgical treatment.

In complete tears, US shows palmar subluxation of the flexor tendons that are no longer held against the anterior aspect of the phalanges (Figure 6)[7]. Longitudinal sonograms are more helpful in assessing the bowstringing of the tendons and in detecting which pulley is torn. Partial tears appear as thickened and hypoechoic pulleys without subluxation of the flexor tendons. US will show bowstringing of the tendon in patients when a complete tear is present. During dynamic examination obtained with resisted flexion, the gap between the displaced tendons and the phalanges increases in proportion to the number of disrupted pulleys. In complete tears, a

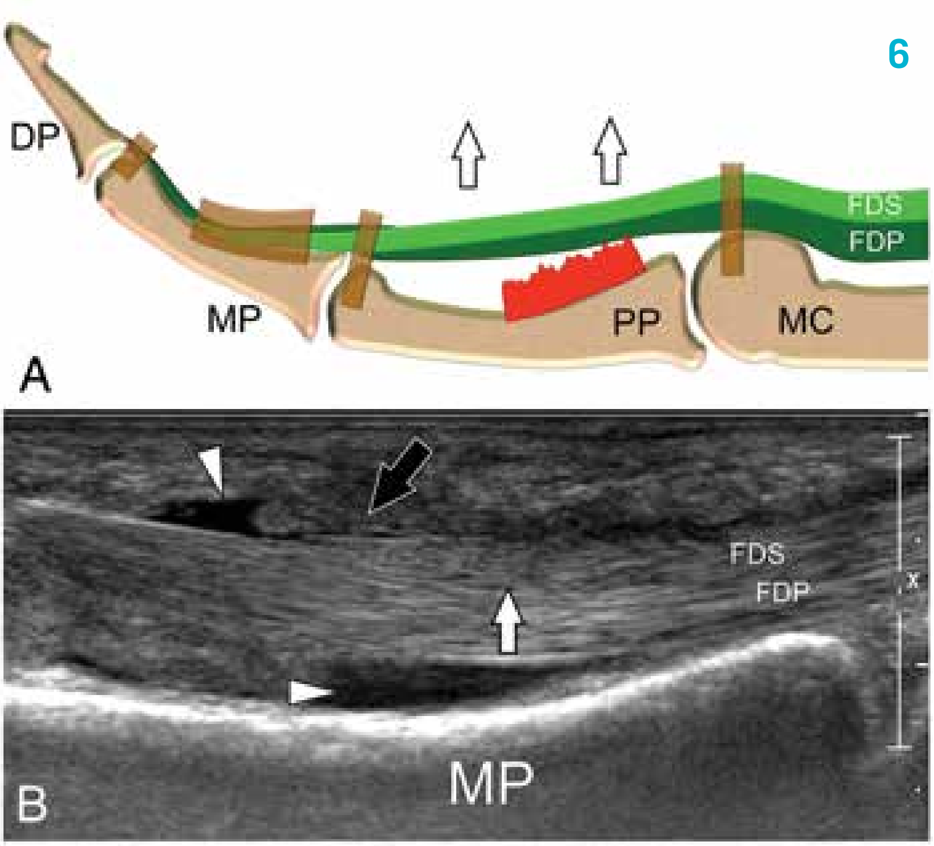
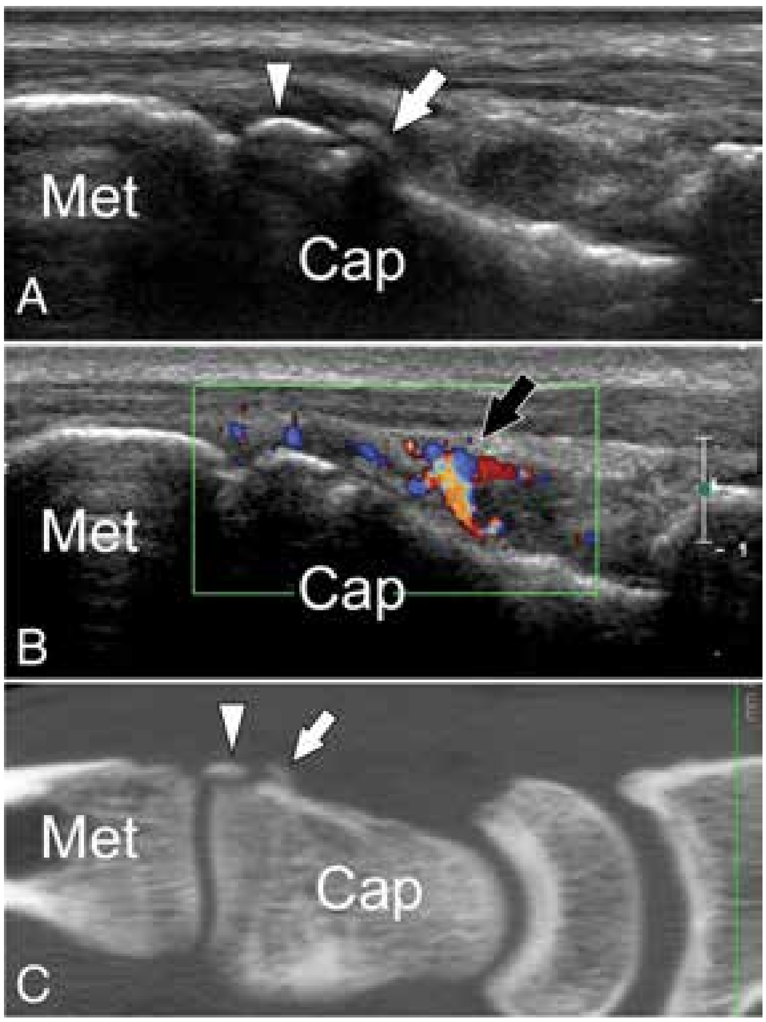


Figure 6: Acute complete tears of A2 pulleys. (A) Schematic drawing and (B) sagittal US obtained over the palmar aspect of the proximal phalanx (PP) of the fourth digit. In (A) note the A2 tear and the subsequent palmar dislocation (arrows) of the flexor digitorum superficialis (FDS) and profundus (FDP) tendons. In (B) the A2 pulley (black arrow) is thickened and hypoechoic. Note the palmar bowstringing of the tendons (white arrow). The tendon sheath contains a fluid collection (arrowheads).

Figure 7 (Below): Bone trauma. Capitate fracture. (A) Sagittal US (B) and colour Doppler US obtained over the dorsal aspect of the wrist in a patient that sustained a local trauma. US was obtained to rule-out a dorsal ganglion. (C) reformatted sagittal CT image of the wrist. US images show a cortical avulsion (arrowhead) of the distal capitate (Cap) Note the adjacent calcified callus (arrow). Note how the calcified callus is less echogenic then the fragment. In (B) colour Doppler shows the hyperaemia of the periosteum and adjacent soft tissues. CT confirms the US findings. Met=first metacarpal.



hypoechoic fluid collection located inside the tendon sheath reflects tenosynovitis.

BONE TRAUMA

Although US cannot adequately evaluate the osseous structures, scanning of the bones surfaces must always be performed since this can reveal local discontinuity related to fractures. Some fractures detected at US can be difficult to see on standard radiographs because of the superposition of other bony structures. Due to its tomographic capabilities, US can detect a variety of infra-radiological fractures such as those affecting the scaphoid, the dorsal face of the triquetrum (avulsion) or other carpal bones (Figure 7). In addition to the cortical break, US can show a subperiosteal collection (haematoma) and oedema in the adjacent soft tissues. Colour Doppler will show increased local vascularity.

'Hook of the hamate' fractures can result from direct trauma (fall) or follow chronic stress as can be seen in golfers or tennis players. US can detect these fractures that can be missed on standard radiographs. A peculiar technique of examination is needed and consists in scanning the hook over its cubital face in the axial plane[8]. US shows an irregular interruption of the bony cortex (Figure 8). Pressure can be applied

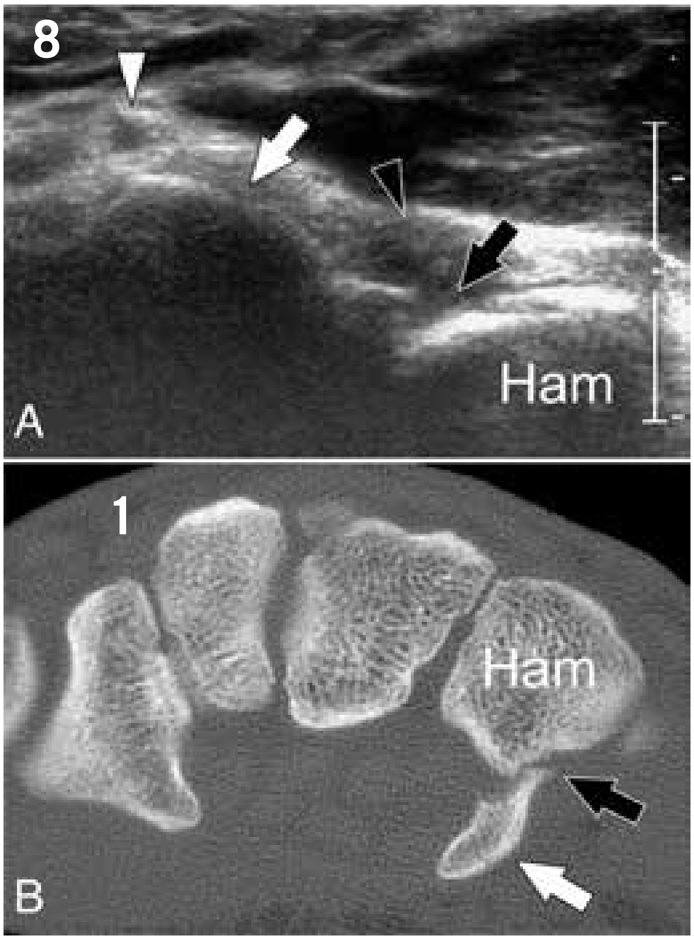


Figure 8: Bone trauma. Fracture of the hook of the hamate. (A) Axial US obtained over the medial aspect of the wrist. (B) Corresponding axial CT image of the wrist. US was obtained to rule-out chronic tendinitis in a tennis player. US shows a focal interruption (black arrow) of the hyperechoic cortex of the ulnar face of the hamate located at the base of the hook (white arrow). Note the sharp borders of the fracture surfaces and the associated local fluid effusion (black arrowhead). The white arrowhead points to the deep branch of the ulnar nerve. Local compression through the transducer was painful. CT confirms non-healing of a fracture of the base of the hook of the hamate. Ham=hamatum.

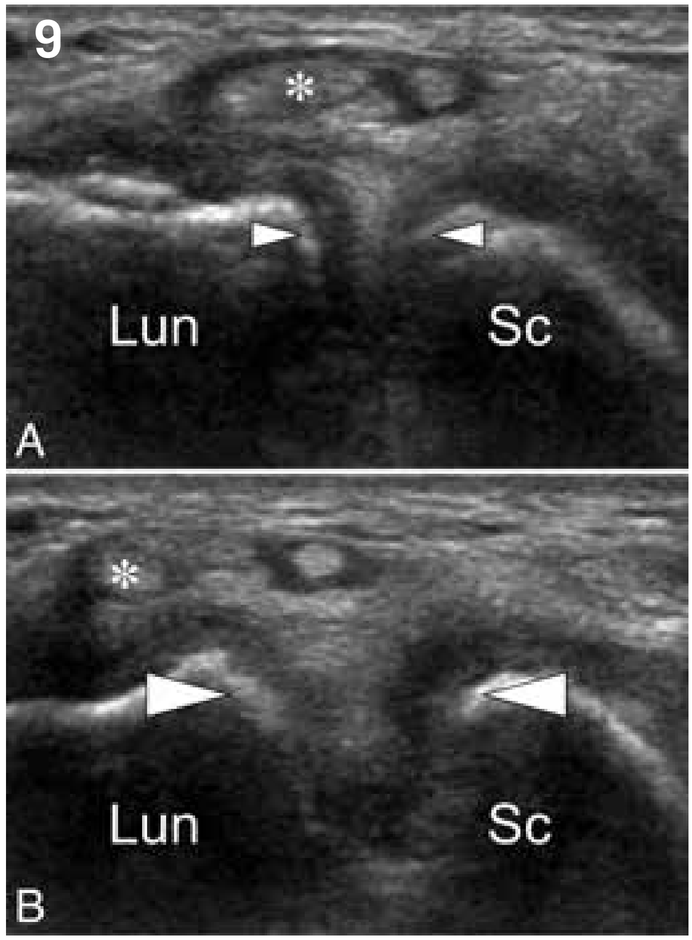


Figure 9: Ligament trauma. Tear of the scapho-lunate ligament. (A) Axial US images obtained in neutral position and (B) in ulnar deviation over the dorsal aspect of the proximal row of the carpal bones. In (A) the distance (small arrowheads) between the scaphoid (Sc) and the lunate (Lun) is normal. Nevertheless the dorsal band of the scapho-lunate ligament is barely visible. The extensor tendons of the fourth compartment are normal (asterisk). In (B) dynamic US examination, realised during ulnar deviation of the wrist, shows a definite widening of the scapho-lunate space confirming a complete tear of the dorsal band of the scapho-lunate ligament.

with the transducer over the fractured hook and will reproduce the patient's pain. US can also detect irregularity of the flexor tendon of the small fingers secondary to chronic impingement over the sharp borders of the fracture. Failed fusion of the ossification centre of the hook is not infrequent and appears as a small accessory ossicle (os hamuli proprium) located palmar to the body of the hamatum. The US appearance can mimic a hook fracture. Nevertheless a definite diagnosis can be made by demonstrating the well-defined, smooth border of the ossicle.

JOINT DISORDERS

Scapho-lunate ligament

Tears of the scapho-lunate ligament are frequent in sports-related injuries of the wrist and if not recognised can lead to dorsal instability of the wrist and in turn to a scapho-lunate advance collapse wrist. MRI, MR/CT-arthrography are the best modalities to assess scapho-lunate ligament tears and carpal instability. Although evaluation of the palmar and middle portion of the ligament can be difficult to see on US, it can accurately show the dorsal band and tears can appear as swelling and hypoechoic appearance of the torn ligament. Dynamic examination of the scapho-lunate joint obtained by axial dorsal sonograms performed in radial and ulnar deviation of the hand can show widening of the scapho-lunate interval thus confirming the diagnosis (Figure 9). Further imaging must be obtained if surgical treatment is required.

Ulnar collateral ligament of the thumb MCP joint

Valgus stress to the thumb metacarpal phalangeal (MCP) joints are very common in skiers following a fall but can be also

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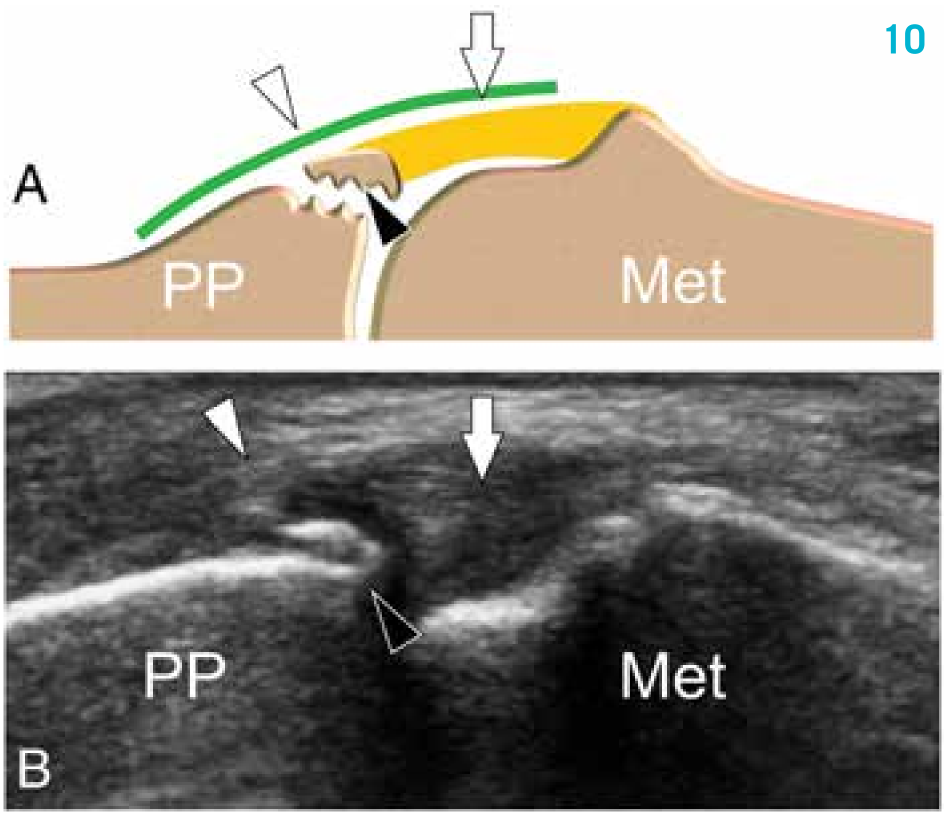

Figure 10 (Left): Ligament trauma. Tear of the ulnar collateral ligament (UCL) of the thumb joint. Bone avulsion. (A) Schematic drawing and (B) coronal US obtained over the ulnar aspect of the MCP joint of the thumb. Note the bone fragment (black arrowhead) due to an osseous avulsion at the distal insertion of the UCL. The ligament (arrow) is irregular and hypoechoic. The aponeurosis of the adductor pollicis brevis muscle is normal (white arrowhead). MCP=metacarpal phalangeal, Met=first metacarpal, PP=proximal phalanx.

Figure 11(Below): Ligament trauma. Tear of the ulnar collateral ligament (UCL) of the thumb MCP joint. Full thickness tear. (A) Schematic drawing and (B) coronal US obtained over the ulnar aspect of the MCP joint of the thumb. Note the hypoechoic tear (black arrowhead) located in the middle third of the ligament. The cranial and distal stumps (arrows) are normally hyperechoic. The aponeurosis of the adductor pollicis brevis muscle is normal (white arrowhead). MCP=metacarpal phalangeal, Met=first metacarpal, PP=proximal phalanx.

Ultrasound and standard radiographs work well in daily practice when an immediate or prompt imaging assessment is needed

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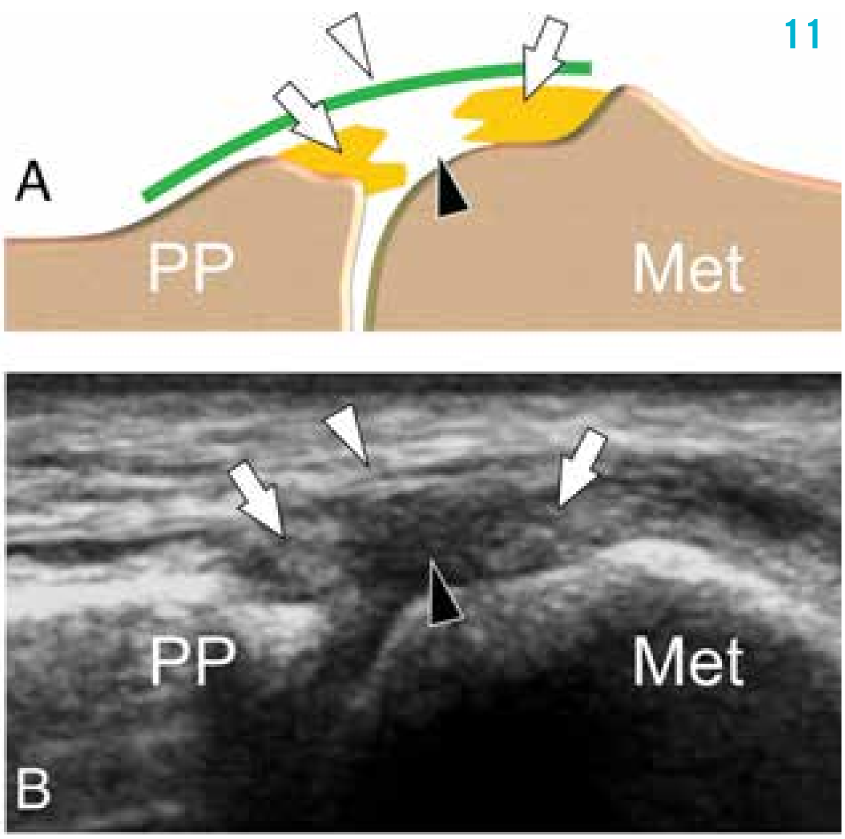


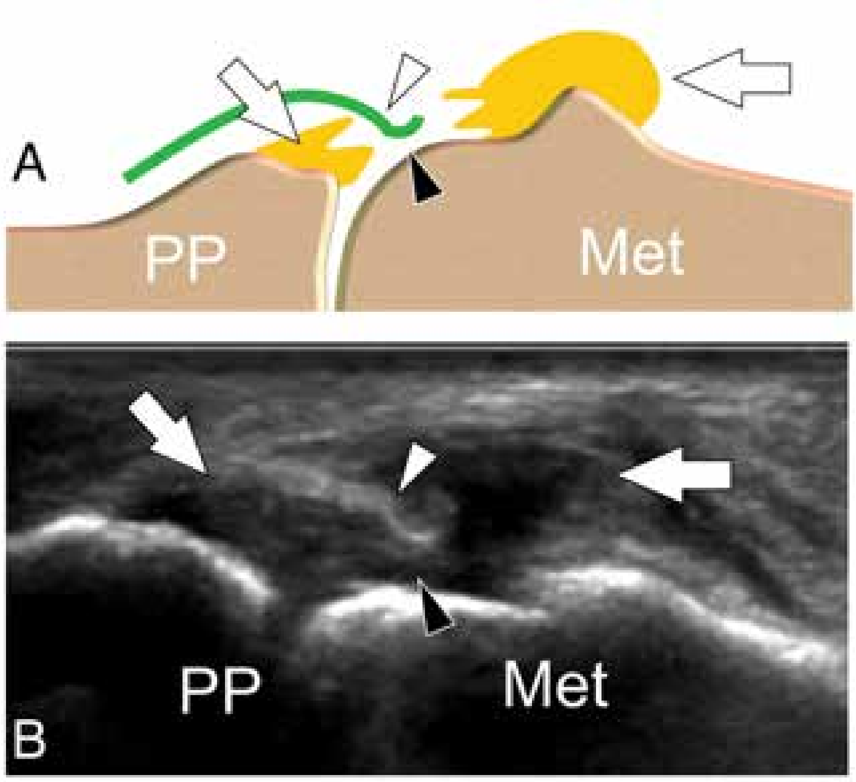


Figure 12: Ligament trauma. Tear of the ulnar collateral ligament (UCL) of the thumb MCP joint. Full thickness tear with Stener lesion. (A) Schematic drawing and (B) coronal US obtained over the ulnar aspect of the MCP joint of the thumb. Note interposition of the aponeurosis of the adductor pollicis brevis muscle (white arrowhead) between the two ligaments' stumps (arrows). MCP=metacarpal phalangeal, Met=first metacarpal, PP=proximal phalanx.

observed in other sports such as judo. These forces can result in injury to the ulnar collateral ligament (UCL). In complete tears, instability of the joint can affect the strength of prehension and if untreated can lead to chronic instability, degenerative joint disease and pain, limiting movement. US can accurately assess tears of the UCL (92% sensitive for UCL ruptures and a positive predictive value of 99%[9]). It can detect bony avulsion, usually located at the distal attachment of the ligament (Figure 10) and can help to distinguish between partial and complete tears (Figure 11)[10]. In partial tears the ligament is swollen, irregular and hypoechoic. Full-thickness tears are visualised on US as complete discontinuity of the ligament fibres. Tears frequently affect the distal part of the ligament, although injury can also occur in the middle third. Local hypervascular changes on colour Doppler are frequent in acute cases. Partial and complete tears are usually treated by splinting and non-steroidal anti-inflammatories because of the possibility of fibrous healing. A Stener lesion refers to interposition of the aponeurosis of adductor pollicis muscle between the ruptured UCL and its insertion at the base of the proximal phalanx (Figure 12). This prevents healing and is a well-recognised indication for surgical repair in athletes. US can accurately assess the presence of a Stener lesion. US shows the proximal irregular and swollen ligament end retracted proximally at the level of the distal metaphysis of the metacarpal. The retracted ligament is separated from the distal and smaller stump by the thin hyperechoic aponeurosis. Passive flexion of the interphalangeal joint during US examination helps in detecting the aponeurosis, which moves simultaneously with the extensor pollicis longus tendon.

Palmar plate and collateral ligaments tears

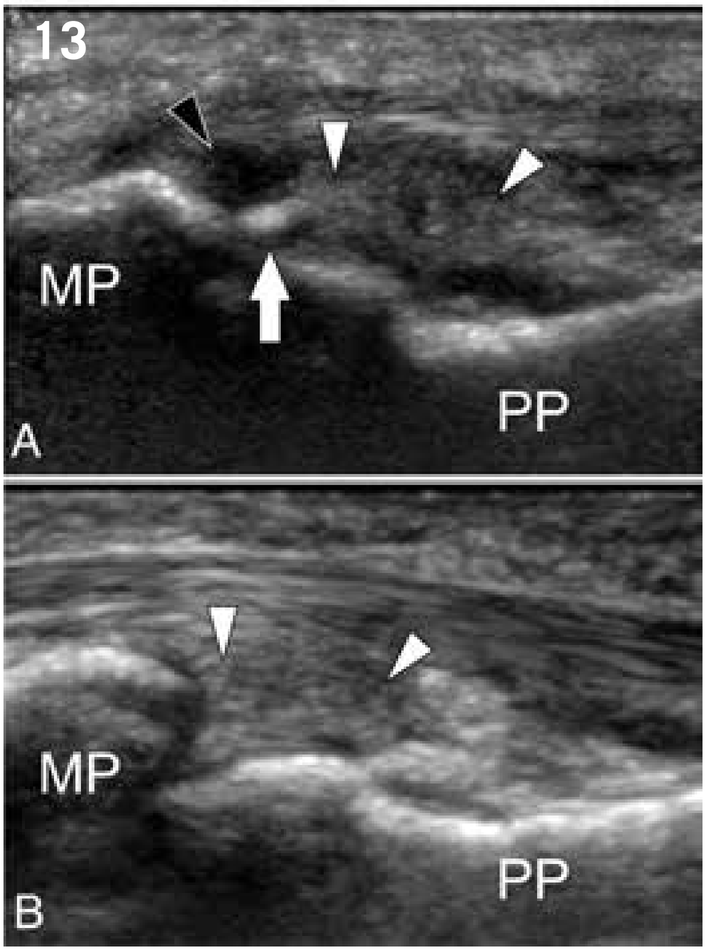
Palmar plate (PP) and collateral ligament (CL) injuries of the proximal interphalangeal joint are common injuries in ball sports and mostly follow a hyperextension sprain[11]. Although these injuries can be well-assessed by clinical evaluation and standard radiographs, US can also accurately depict these lesions. The PP and CL can be seen as hyperechoic structures. The PP is homogeneous, while the CL present has a fibrillar internal pattern. The use of a small footprint transducer allows dynamic examination with passive movement of the affected joint.

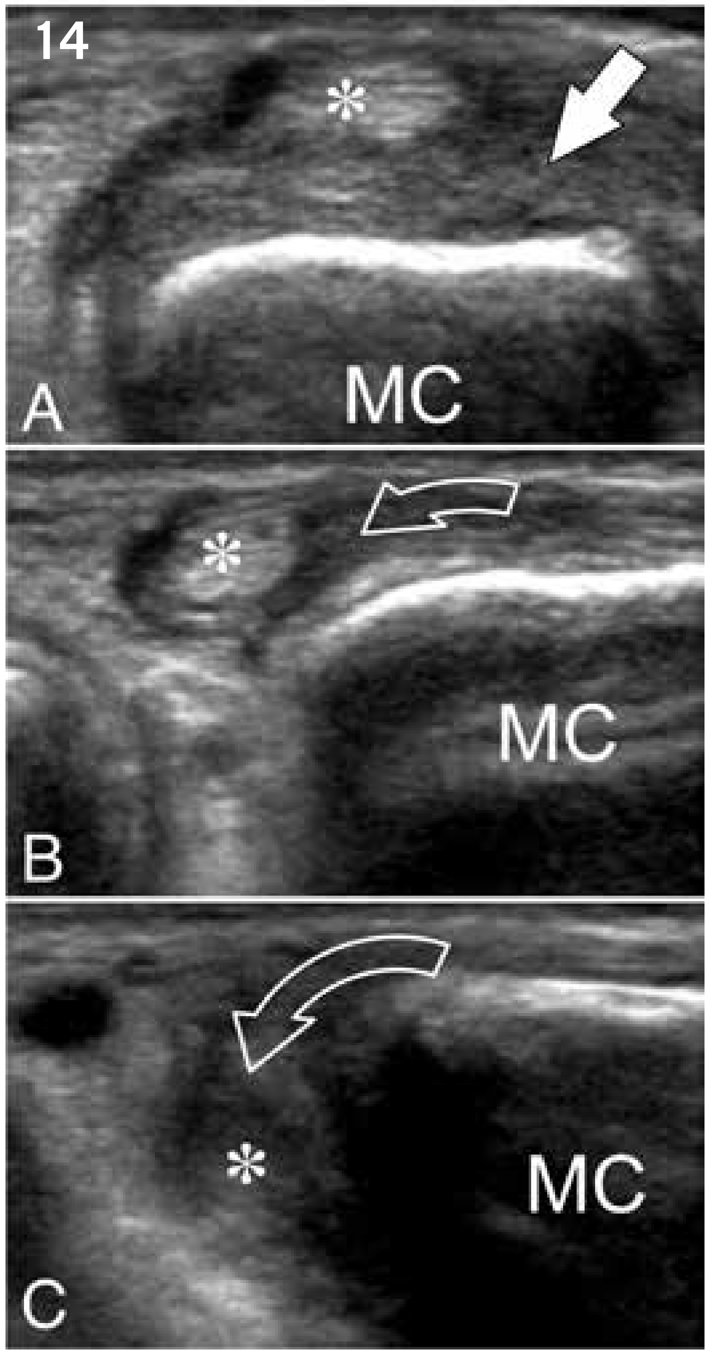
Tears of the plates usually occur at their distal insertion at the volar lip of the middle phalanx (Figure 13). In PP avulsion, US nicely shows the proximally retracted plate that will have a globular appearance. The plate usually lies at the level of the distal metaphysis on the phalanx. The amount of the retraction can be measured by US. When there is an associated cortical bone avulsion, standard radiographs can pick this up but US is more accurate in assessing the fragment size and amount of displacement.

In partial tears the CL is thickened, irregular and hypoechoic and with acute injuries, increased vascular signal at colour Doppler. In complete tears, US can show a local full-thickness gap that can widen when stress is applied to the joint[11].

Boxer's knuckle

At the level of the MCP joints, the extensor tendon is held in position by the sagittal bands (SB) that arise from the transverse intermetacarpal ligaments and volar plate. Sagittal bands allow gliding of the tendon





over the dorsal capsule and prevent their displacement during finger flexion.

The SB can be injured by repetitive local trauma which can occur in sports such as boxing. Rayan and Murray described three types of injuries[12]:

- **Type I:** contusion of the SB without tendon instability.
- **Type II:** tearing of the SB with snapping of the extensor tendon, but without complete dislocation.
- **Type III:** tear of the SB with tendon dislocation into the groove between the metacarpal heads.

The most common lesion is a tear of the radial sagittal band of the fourth digit with ulnar subluxation of the tendon.

Clinically, the subluxation of the extensor tendon that occurs with flexion at the dorsum of the MP joint may mimic a trigger finger. US shows the SB tear as a hypoechoic irregular area and depending on local inflammation may or may not show hyperaemia at colour Doppler. Dynamic US examination is needed to establish a definite diagnosis since the extensor tendon is almost always normally located

Figure 13: Ligament trauma. Tear of the palmar plate. (A) Sagittal US obtained over the palmar aspect of the proximal interphalangeal joint of the injured finger. (B) Corresponding normal US image. In (A) the palmar plate (arrowheads) shows an avulsion of its distal insertion on the base of the middle phalanx (MP). Note the local haematoma (black arrowhead) interposed between the retracted palmar plate and the MP. The arrow points to an associated cortical avulsion. In (B) the palmar plate is normally inserted into the MP base.

Figure 14: Ligament trauma. Boxer's knuckle. (A-C) Axial US obtained over the dorsal aspect of the metacarpophalangeal joint of the fourth finger during progressive finger flexion. In (A), obtained in full extension of the finger, the radial sagittal band (arrow) appears irregular and hypoechoic due to a tear. The extensor tendon (asterisk) is normally located over the middle third of the metacarpal head (MC). (B, C) During progressive flexion of the finger the tendon dislocates ulnarly (curved arrow) to lie inside the fourth intermetacarpal space.

in extension. During progressive flexion the tendon is seen displacing ulnarly to dislocate between the metacarpal heads with complete flexion (Figure 14).

VESSELS AND NERVE TRAUMA

Biker's hammer

Because of their superficial location and close proximity to the bone, vessels of the hand and wrist are predisposed to injuries. The ulnar artery and its branches are most commonly affected at the level of Guyon's canal. This particularly occurs with cyclers where the artery and its branches can be squeezed between the hook of the hamate and the handlebar of the bike.

The damage follows prolonged local grip pressures. Repeated microtrauma may cause intimal thickening with fibrin deposits, thrombosis and possible pseudoaneurysm formations. US shows an increase in the size of the artery with internal thrombosis as a hypoechoic structure filling the lumen. Colour Doppler imaging shows reduced or absent intra-arterial flow (Figure 15).

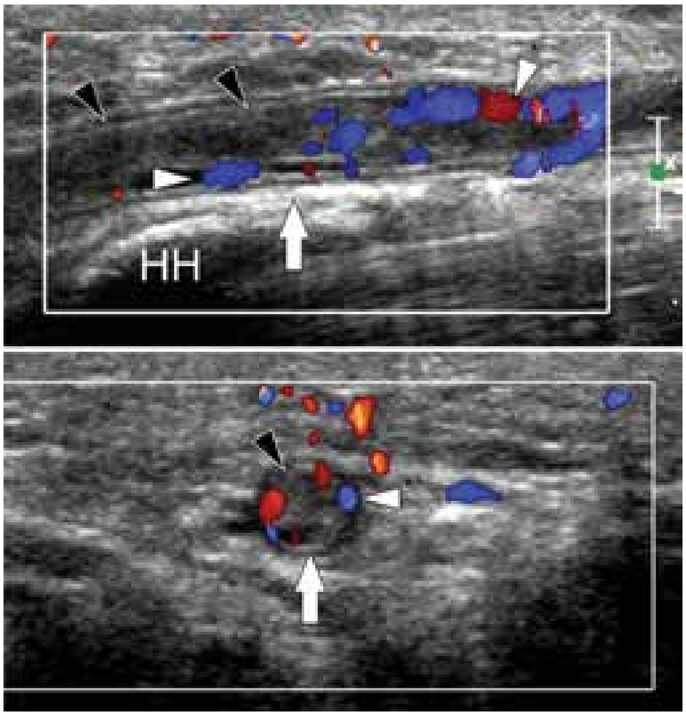


Figure 15: Vessels and nerve trauma. Biker's hammer. (A) Longitudinal and (B) axial colour Doppler US obtained over the palmar aspect of the hypothenar region. Images show a nearly complete thrombosis (black arrowheads) of the superficial branch of the ulnar artery. Some small persistent internal flow signal can be detected (white arrowheads). Note increase in size of the artery and thickening of its wall. HH=hook of the hamate.

CONCLUSION

While patient history is essential in the case of hand and wrist injuries in athletes, imaging modalities operated by experienced physicians is necessary to prevent permanent damage and facilitate a speedy return to play.

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