High-resolution ultrasound of the hand and wrist

Poster No.: C-2286
Congress: ECR 2010
Type: Educational Exhibit
Topic: Musculoskeletal
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Keywords: ultrasound, wrist, hand
DOI: 10.1594/ecr2010/C-2286

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Learning objectives

1. Review the clinically relevant anatomy and US appearances of tendons, ligaments and nerves of the wrist and hand.
2. Diagnose extensor and flexor tendon abnormalities, retinacula-related disorders, ligament injuries and compressive or traumatic neuropathies of the median, ulnar and radial nerves.
3. Examine rheumatologic disorders and space-occupying lesions of the wrist and hand.

Background

Normal Anatomy and Scanning Technique
The wrist is traversed by a series of twelve extensor and twelve flexor tendons, most of which are invested by a synovial sheath, and by three nerves, the median, ulnar and the sensory branch of the radial nerve. **Extensor tendons**
- They pass through a series of osteofibrous tunnels composed of depressions in the surface of the radius and ulna that are covered by the extensor retinaculum. From the deep surface of the retinaculum, vertical fibrous bands insert into the bone, dividing the extensor tunnel into six compartments numbered from radial (I) to ulnar (VI). *(Fig. 1) on page 4.*
- US images are first obtained at the distal radius to identify the Lister tubercle, the landmark that separates the 2nd and 3rd compartments. Then the probe is swept proximally and distally along the axis of the tendon or directed radially or ulnarly to change the compartment to be examined.
- **Pitfall:** Depending on probe positioning, the normal extensor retinaculum surrounding the tendons may assume a hypoechoic appearance from anisotropy. This should not be misinterpreted as tenosynovitis.

In the fingers, the extensor tendons become broad and flat, like an aponeurotic expansion, that covers the dorsal aspect of the metacarpophalangeal joint (MCPJ) and proximal phalanx and narrows distally (extensor hood). Each tendon has three slips: one central which runs in the midline to insert onto the middle phalanx and two lateral which pass on each side of the central to insert on the distal phalanx. Over the metacarpal head, the extensor tendon complex is stabilized by a retinaculum, which is known as the sagittal band. *When examining the dorsal wrist, transverse planes are best to depict and correctly identify the extensor tendons. Longitudinal images may be helpful to assess tendon gliding and check the distal tendon insertions dynamically.*
**Flexor tendons**
• Flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) tendons have a common synovial sheath. Flexor pollicis longus (FPL) crosses the tunnel enveloped by a separate sheath.
• After exiting the carpal tunnel, they diverge to reach the respective fingers.
• At the base of the proximal phalanx, the FDS tendon divides into two slips which pass on each side of the FDP tendon. More distally, the FDS slips cross dorsal to the FDP and insert into the shaft of the middle phalanx, whereas the FDP continues its straight course to reach the base of the distal phalanx.
• FPL tendon traverses the thenar eminence between the superficial and deep bellies of the flexor pollicis brevis muscle. It then enters the thumb passing in between the sesamoids to insert at the base of the distal phalanx.

(Fig 2) on page 5

In each finger, flexor tendons are invested by a single synovial sheath and are stabilized by a fibrous envelope consisting of a complex system of annular pulleys and cruciform bands (Fig 3) on page 6.
• The primary flexors of the wrist, the flexor carpi radialis (FCR) and the flexor carpi ulnaris (FCU), travel outside the carpal tunnel.
• The FCR is invested by an own synovial sheath which inserts on the 2nd metacarpal after coursing in close relationship with the scapho-trapezio-trapezoid (triscaphe) joint.
• The FCU is not invested by a synovial sheath and courses on the ulnar side of the wrist to insert into the pisiform, the hook of the hamate and the fifth metacarpal.
• Finally, the palmaris longus (PL) tendon is a thin tendon which passes midline and superficial to the transverse carpal ligament.

Intrinsic ligaments of the wrist
• The two most important are the scapholunate (SLL) and lunotriquetral (LTL) ligaments.
• On transverse planes, the SLL is depicted as a compact echogenic fibrillary band between the lunate and the scaphoid, just distal to the Lister tubercle.
• SLL is fundamental to carpal stability, and its assessment with US is useful if a normal ligament is identified. Its non-visualization on dorsal scans does not necessarily indicate a complete tear as its ventral part might be intact.
• Dynamic scanning obtained during ulnar and radial deviation of the wrist can show instability of the scapho-lunate articulation and increase the confidence that the non-detectable SLL is torn.
• LTL can be located by shifting the probe slightly to the ulnar side. Its US appearance is similar to that of the SLL.
• The triangular fibrocartilage complex (TFC) or radioulnar disk is attached by its apex to a depression between the styloid process and the head of
the ulna; and by its thin base to the prominent edge of the radius. At US, it appears as a homogeneously echogenic inverted triangular structure deep to the ECU tendon.

Nerves
- Three nerves cross the wrist: the median (MN), the ulnar (UN) and the superficial cutaneous branch of the radial (RN). In the wrist, the UN is accompanied by the ulnar artery (UA) and the MN gives off a secondary sensory nerve, the palmar cutaneous branch (PCBMN).
- In the distal forearm, the MN courses in the hyperechoic fascial plane between the FDS and FDP. As the MN approaches the wrist, it shifts radially and then moves superficial passing alongside the lateral margin of the FDS to align itself in the midline before entering the carpal tunnel.
- On short-axis planes, the MN has an oval cross-section at the proximal tunnel and becomes more flattened as it progresses distally to the level of the hamate hook. Throughout the carpal tunnel, it is covered by a localized thickening of the antecubital fascia known as the transverse carpal ligament or the flexor retinaculum.
- Two methods are used to measure the CSAMN: the indirect method, based on calculation of the nerve diameters by calipers and application of the ellipse formula (LL diameter x AP diameter x p/4) and the direct method, based on manual tracing and automated calculation of the area.
- The US beam should be always directed perpendicular to the long-axis of the MN, even when the nerve assumes an oblique course from surface to depth. Optimal probe orientation can be defined dynamically by tilting the probe over the nerve or inducing slight changes in the carpal position.
- The UN crosses the wrist passing through the Guyon tunnel. This small tunnel lies in a more superficial and medial location then the carpal tunnel. It is bounded by the pisiform (medially), the transverse carpal ligament (floor) and the palmar carpal ligament (roof).
- The UN bifurcates within the tunnel into two terminal divisions, the superficial (sensory) branch and the deep (motor) branch, the latter supplying most of the intrinsic muscles of the hand.
- Distal to the Guyon tunnel, the sensory branch has a straight course while the motor branch reflects across the palm to end at the first interosseous space.
- On the radial aspect of the distal forearm, the superficial cutaneous branch of the RN pierces the fascia between the tendons of the ECRL and the brachioradialis to move into the subcutaneous tissue. Then, it overlies the anatomical snuff-box traversing the extensor tendons of the first compartment in close relationship with the cephalic vein.

Images for this section:
Fig. 1. Extensor tendons. A Schematic drawing of the six compartments of the extensor tendons (I-VI). The compartments are numbered with roman numerals encircled in grey from radial to ulnar. The extensor tendons are: the abductor pollicis longus (APL), the extensor pollicis brevis (EPB), the extensor carpi radialis longus (ECRL), the extensor carpi radialis brevis (ECRB), the extensor pollicis longus (EPL), the extensor digitorum communis (EDC), the extensor indicis proprius (EIP), the extensor digiti minimi (EDM) and the extensor carpi ulnaris (ECU). Arrow, Lister tubercle; asterisk, DRUJ. B Cadaveric view over the dorsal wrist shows the EPL tendon running alongside the Lister tubercle (arrow). Distal to it, this tendon deflects toward the thumb crossing over the ECRB and ECRL. Asterisk indicates the ulnar head.
**Fig. 2. Flexor tendons.** A carpal tunnel at its distal level. The transverse carpal ligament (hollow arrowheads) inserts on the tubercle (white arrow) of the trapezium and the hook (asterisk) of the hamate. Nine tendons cross the carpal tunnel, including four from the flexor digitorum superficialis (FDS), four from the flexor digitorum profundus (FDP) and the tendon of the flexor pollicis longus (2). The flexor carpi radialis (1) travels outside the tunnel, in close proximity to the trapezium. The median nerve (hollow arrow) lies radially in the carpal tunnel, immediately deep to the transverse carpal ligament. At the hamate level, the ulnar nerve is already divided into superficial sensory (black arrowhead) and deep motor (black arrow) branches. PL, palmaris longus tendon. B Corresponding cadaveric slice of the distal carpal tunnel. The tunnel is delimited by carpal bones and a fibrous roof formed by the transverse carpal ligament (arrowheads) that inserts on the tubercle (white arrow) of trapezium and the hook (asterisk) of the hamate. The flexor digitorum tendons from the FDS and FDP are bundled up in the tunnel. Relative to them, the FCR (1) and the FPL (2) assume a more radial position.
Fig. 3. **Annular pulley system. A** Schematic drawing shows the positions of the five annular pulleys. The A1-, A3- and A5-pulleys lie over the heads of the metacarpal, proximal phalanx and distal phalanx, whereas the A2- and A4-pulleys attach to the shaft of the proximal and middle phalanx respectively. **B** Cadaveric dissection of the flexor tendons at the level of the proximal phalanx illustrates the two slips of the FDS tendon passing on each side of the FDP. They are firmly restrained again the bone by the A2-pulley.

Fig. 3: .
Imaging findings OR Procedure details

**Extensor tendon tears**

- They usually occur in the fingers and cause typical deformities (e.g. "mallet finger" and "boutonnière deformity") that are easily diagnosed at physical examination.
- On the other hand, identification of extensor tendon ruptures in the wrist may not be straightforward clinically and US can be invaluable.
- The most frequent extensor tendon tear in the hand is the Extensor Pollicis Longus (EPL), that produces loss of extension at the IPJ of the thumb and inability to grip with the other fingers.
- Apart from spontaneous ruptures in patients with rheumatoid arthritis, on local or systemic steroids therapy and or sports/work related repetitive stress, EPL rupture may be due to injury and wrist fractures, impingement by orthopaedic devices (e.g. Kirschner-wire fixation, volar plating) or stab wounds (Fig. 4) on page 17.
- In the presence of an EPL tear, the US pattern shows a gap between tendon ends occupied by a continuous or discontinuous hypoechoic interval due to debris or frayed residual fibers. The tendon ends may appear as stump-like structures or, following elongation trauma, are tapered.
- The intact extensor retinaculum in non-displaced radial fractures may cause a decreased compliance to raised compartmental pressure in the osteofibrous tunnel delimited by the Lister tubercle and predispose to tendon rupture. A vascular watershed vasculature in the tendon at the Lister tubercle level may specifically increase tendon vulnerability in this area.
- In secondary EPL tears that occur following volar plate fixation, US may incidentally show the tips of the screws perforating the dorsal radial cortex of the radius and causing the tendon rupture (Fig. 5) on page 17.
- In patients with EPL rupture, the status of the EIP should be evaluated as it may be used as a graft. Then, US can also confirm tears of tendons that cannot be easily assessed clinically, such as the EIP, ECRB and ECRL.

**Flexor tendon injuries**

- They are less frequent than extensor tears and their rupture usually follows a penetrating injury or in association with systemic disorders or therapy with steroids or quinolones.
- Accurate localisation helps to plan the surgical approach (Fig. 6) on page 19 and US is particularly helpful in locating the two ends of the ruptured tendon as they may be retracted a considerable distance from the site of the tear.
- In addition, in the presence of jersey finger, US are useful to confirm the traumatic FDP tendon avulsion from the distal phalanx and to show if the tendon is attached to an avulsed bone fragment.
Many factors influence recovery following flexor tendon tears, the most important of which is location of injury, according to the following classification:

1. -zone-1, distal to the FDS insertion;
2. -zone-2, from the A1-pulley to zone-1;
3. -zone-3: from the distal edge of the flexor retinaculum to the A1-pulley;
4. -zone-4, within the carpal tunnel;
5. -zone-5, proximal to the carpal tunnel.

The functional outcome of zone-2 injury is poorer and the complication rate, including adhesions, contracture, triggering and pulley failure, is greater than that associated with injury in other zones.

Postoperatively, a repaired tendon usually appears more heterogeneous than normal. The tendon boundaries are often undefined as a result of fibrotic changes and intratendinous sutures may be seen as bright linear echoes with faint reverberation artefact.

Dynamic scanning during finger flexion and extension is a critical mean to assess how the tendon glides and to rule out adhesions.

Passive traction of peritendinous tissues during tendon movement is the main sign indicating adhesions between the parietal and visceral layers of the sheath and the need for further rehabilitation or tenolysis. Discontinuity in the tendon and detection of sutures floating freely in an empty sheath indicates a retear.

Overuse Tendinopathies and Retinacula-related Disorders

Some wrist tendons may be involved by specific overuse or degenerative changes. Among these conditions there the following. **Proximal intersection syndrome.** It is also known as "oarsman's forearm" or "crossover syndrome" and arises on the dorso-radial aspect of the distal forearm, several centimetres proximal to the Lister tubercle. It results from friction between the myotendinous junctions of the APL and EPB with the tendon sheath containing the ECRB and ECRL. This syndrome is typically encountered in activities that involve repetitive flexion and extension movements of the wrist and can be considered a mimicker of de Quervain disease. The limited gliding space between the radius and the extensor fascia of the forearm seems to play a predisposing role. US may identify both fluid surrounding the radial wrist extensors at the crossing point of the tendons of the first compartment and loss of definition between the two compartments. **Distal intersection syndrome.** It is an extensor tendinopathy of the distal forearm involving the crossover the ECRB and ECRL (2nd compartment) and the EPL tendon (3rd compartment) soon after this latter swings beyond the Lister tubercle. It is not associated to relevant occupational or overuse activities. In most cases, the undersurface of the 2nd compartment tendons is initially impinged by bony spurs in osteoarthritis, SLAC wrist or Colles fracture. After ECRB-ECRL sheath distension, the retinaculum of the 3rd compartment is likely to exert a constricting role.
and making the EPL vulnerable. US demonstrates a variable combination of tendinosis and tenosynovitis affecting the 2nd and 3rd compartments and underlying bony spurs impinging on the tendons.

**FCR tendinopathy.** It may be caused by a degenerative osteoarthritis affecting the triscaphe (scapho-trapezio-trapezoid) joint. The FCR tendon lies in close contact with the triscaphe joint capsule and is predisposed to impingement by an osseous ridging created by osteophytes on the ventral aspect of the scaphoid. FCR tendinopathy may occur in isolation, but is most often associated with SLAC (scapho-lunate advanced collapse). US demonstrates a swollen and heterogeneous FCR with tenosynovial fluid, longitudinal splits and thickening of the retinaculum and peritendinous tissues as well as osteophytes encroaching on the distal FCR from the scaphoid (Fig. 7) on page 18. As patients complain of a painful lump and tenderness over the ventral radial aspect of the wrist, the main role of US is to rule out a ventral wrist ganglion and redirect the diagnosis. **FCU tendinopathy** is rare and mainly occurs in the context of calcific tendinitis (calcium hydroxyapatite crystals deposition disease). This self-limiting condition appears to be related to repetitive activities, such as typing. US shows calcific material in a swollen and heterogeneous tendon, proximal to the pisiform (Fig. 8) on page 20. In acute phases, deposits may be semiliquid.

**Trigger finger.** It occurs as a result of fibrosing degeneration, retinacula and annular pulleys may become thickened producing painful gliding, blockage or triggering (a partial blockage that abruptly unblocks) of the underlying tendons. This most often occurs at the level of the A1-pulleys (trigger finger) for the flexor tendons and at the 1st compartment of the extensor tendons (de Quervain disease). Patients with trigger finger usually complain of either blockage or triggering of one or more fingers (the middle finger most commonly) from flexion to extension caused by stenosing tenosynovitis at the level of the A1-pulley, possibly extending distally to involve the flexor sheath between the A1- and A2-pulleys. US allows direct assessment of the "A1-pulley-flexor tendon complex" and can demonstrate a thickened A1-pulley, local swelling of the flexor tendons distal to it, distal tenosynovitis and small cysts at the pulley boundaries related to a fluid-trapping mechanism. In severe cases, dynamic scanning during passive flexion and extension movements of the affected finger can depict difficult tendon gliding underneath the abnormal pulley. Doppler imaging may depict a hypervascular pattern in the A1-pulley and surrounding soft-tissues. It is unclear if thickening of the A1-pulley is initially responsible for the blockage and tendon inflammation or if this thickening is secondary to tendinopathy. Surgical release of the A1-pulley is the treatment of choice. Alternatively, steroid injection into the flexor sheath at the level of the A1-pulley is an effective treatment. However, injection therapy for type-1 diabetic patients is ineffective and surgical release remains the treatment of choice in this subset of patients. US may have value guiding intrasheath steroid injections and assisting percutaneous release of the pulley.

**De Quervain disease.** It is a condition causing pain around the radial styloid associated with movement of the thumb. It is most common in the 30-50 year-old
age group with high prevalence in new mothers (baby wrist) as the motion of picking up the baby can cause irritation of the APL and EPB tendons under the retinaculum of the 1st compartment. Similar to trigger finger disease, the main US signs of de Quervain syndrome include a thickened retinaculum, local fusiform swelling of APL and EPB tendons with tenosynovial fluid distal to the retinaculum and intra- and peritendinous hyperaemia at Doppler imaging (Fig. 9A) on page 23. Dynamic imaging shows difficult gliding of the tendons as they pass under the retinaculum during thumb extension. In severe disease, tendons may form a rounded complex on the short-axis view under a thickened and hypo-anechoic retinaculum and cannot be distinguished from each other. Care should be taken not to confuse the retinaculum (non-compressible and located at the level of the radial styloid) for intrasheath fluid (compressible and usually found distal to the radius). Surgical release may be required when the retinaculum is markedly thickened, whereas mild abnormalities may be treated conservatively.

Occasionally a vertical septum splitting the compartment into two halves (subtunnels) for each of the tendons is recognized. This septum has clinical relevance as de Quervain disease may selectively involve only the dorsal tunnel containing the EPB, and spare the ventral one (Fig.9B) on page 23. As the septum may form a barrier for drug diffusion, the clinician should be informed if this variant is present in order to ensure that steroids are injected into the appropriate half of the compartment or that both tunnels are decompressed at surgery otherwise this variant may influence the post-treatment outcome. The main function of retinacula and annular pulleys is to stabilize the underlying tendons. When these restraining structures tear, a syndrome of tendon instability may occur leading to tendon subluxation or dislocation outside the groove. Depending on the site and applied biomechanical forces, tendon instability may occur during specific joint movements and muscle contraction (transient) or even at rest (permanent). In intermittent instability, dynamic US is an elegant means to demonstrate the tendons as they dislocate and relocate relative to their groove. In the wrist and hand, tendon instability most commonly occurs at the sixth compartment for the ECU, over the dorsal aspect of the metacarpal heads for the extensors (boxer’s knuckle) and on the ventral aspect of the fingers for the flexors (climber’s finger).

**ECU instability.** It typically occurs in professional tennis players following repeated sudden pronation movements from a supinated position (top-spin rotation) that lead to stripping of the ventral attachment of the retinaculum from the ulnar head and subsequent anterior (volar) tendon subluxation or dislocation. The patient usually complains of a painful "snap" over the ulnodorsal aspect of wrist, particularly on forearm rotation. ECU instability is often observed in patients with longstanding rheumatoid arthritis causing hypertrophic ECU tenosynovitis and DRUJ changes. In these circumstances, the pannus plays a causative role in disrupting the retinaculum. The ECU tends to migrate to the volar surface of the ulna behaving as a flexor of the wrist rather than an extensor and permitting dislocation of the distal ulna relative to the radius. Regardless of the cause, US can readily assess the status of the ECU and its position relative to the ulnar groove at rest and during stress test.
**Boxer’s knuckle.** It consists in sagittal band rupture over the dorsal aspect of MIPJs and it is typically encountered in boxers as a result of repetitive direct shocks during matches, but may also occur as a result of trivial trauma. This condition very often involves the long finger and leads to ventral dislocation of the extensor tendon over the ulnar or, less commonly, the radial slope of the metacarpal head during fist clenching. Physical examination is usually enough to establish the diagnosis. However, dynamic US may be helpful to differentiate sagittal band injuries from partial tendon tears, especially when the tendon position cannot be confidently palpated because of overlying soft-tissue swelling or clinical findings are atypical. When the sagittal band is torn, marked dislocation of the extensor tendon is easily visualized during finger flexion by placing the probe in the transverse plane over the metacarpal head. This condition is treated with either splinting in full extension or direct repair of the torn sagittal band and relocation of the central tendon.

**Climber’s finger.** Extreme rock-climbers who use fingers-holds (crimp grip, vertical grip) have experience of a tremendous biomechanical overload of their pulley system by the underlying flexor tendons during PIPJ flexion, leading to a various combination of A2-, A3- and A4- pulley tears. In the climber’s finger, US may be particularly helpful to confirm isolated A2- or A4-pulley tears, that may not be easily recognized at physical examination. Dynamic US examination during resisted flexion of the affected finger can depict subluxation of the flexor tendons. Instead of coursing along the concavity of the phalanx in contact with the bone, the tendon lies at a variable distance from the bone *(Fig. 10) on page 22.* The site of maximal volar bowstringing (proximal phalanx for the A2-pulley; middle phalanx for the A4-pulley) usually corresponds to the position of the torn pulley. Scanning planes oriented along the long-axis of the finger are the best to assess these lesions.

**Ligament and Fibrocartilage Disorders**

**Extrinsic and intrinsic wrist ligaments**

- Injuries to the extrinsic (i.e. radiocarpal and ulnocarpal) and intrinsic (i.e. intercarpal) wrist ligaments can lead to chronic wrist pain and carpal instability.
- US is able to identify the dorsal band of the scapholunate (SLL) and lunotriquetral (LTL) ligaments in 97% and 61% of cases.
- US can diagnose SLL and LTL tears by examining the dorsal portion of these ligaments dynamically, with different degrees of ulnar and radial deviation. Ligaments can be considered torn if their fibers are not visualized between the carpal bones and some instability of the scapho-lunate articulation is observed while scanning during ulnar and radial deviation of the wrist. If some irregularity of the ligamentous fibers is observed, the ligament can be considered partially torn/frayed.
• SLL disruption may lead to scapholunate diastasis, palmar flexion of the scaphoid, dorsal flexion of the lunate and proximal repositioning of the capitate, and may progress to degenerative changes at the capitate-lunate and radio-scaphoid joints, the so-called "SLAC" wrist. Although precise measurement of the interosseous distance is difficult to obtain with US due to unclear landmarks for caliper positioning, an increase in the joint width and abnormal mobility of the scaphoid and lunate during ulnar deviation of the wrist are suggestive of a complete tear and should alert the examiner that further imaging is required to confirm the diagnosis (Fig. 11) on page 21. Using tricompartmental wrist arthrography as the reference standard, US results seem more promising for the SLL (100% sensitivity; 92% specificity) than for the LTL (25%-50% sensitivity; 100% specificity).

Triangular fibrocartilage

• The triangular fibrocartilage complex can be evaluated by means of coronal planes through the ECU tendon as an acoustic window. Detection of a definite intrasubstance hypoechoic cleft or defect is the most reliable signs of TFC disk tear on US and 86% sensitivity and 100% specificity has been reported.
• A thinned fibrocartilage may also be associated with a tear.
• However, part of the TFC cannot be evaluated as it is masked by the acoustic shadow from the ulnar styloid and, like other fibrocartilaginous structures, US seems inadequate to distinguish traumatic from degenerative lesions.

Gamekeeper's thumb (or skier's thumb) and Stener lesion

• The gamekeeper's thumb or skier's thumb is the most relevant ligament injury in the fingers. It is the tear of the ulnar collateral ligament (UCL) of the MCPJ of the thumb. Its name is due to its prevalence in skiers after a fall with the thumb abducted on the ski poles.
• The UCL is an important stabilizer of the first MCPJ limiting valgus opening during forceful grasp. It lies deep to the aponeurosis of the adductor pollicis (AddPA). US is a reliable means to assess the status of this ligament.
• Tear patterns include avulsion of the distal ligament insertion with or without avulsion of a bone fragment from the base of the proximal phalanx; an intrasubstance tear when the ligament ends remain deep to the AddPA; and a displaced tear with proximal migration of the ligament superficial to the cranial edge of the aponeurosis, the Stener lesion.
• Distinguishing a displaced from a non-displaced tear is important as displacement of the proximal end of the ruptured UCL over the AddPA aponeurosis prevents healing. Surgical repair is needed to avoid permanent instability and early osteoarthritis.
• In undisplaced tears, the UCL appears swollen (partial tear) or discontinuous (complete tears) and the AddPA can be appreciated as a thin gliding band overlying the abnormal ligament during flexion and extension of the distal IPJ (Fig. 12A) on page 24.

• In the Stener lesion the ruptured ligament appears as a rounded hypoechoic nodule retracted over the metacarpal neck. During flexion and extension of the distal phalanx, the AddPA is seen as a straight echogenic line clashing against this nodule (Fig. 12B) on page 24. This figure recalls the "yo-yo sign" visible at MR imaging and increases diagnostic confidence in distinguishing displaced from undisplaced tears.

Collateral ligament injuries

• Collateral ligament injuries of the finger joints are very common in sportsmen, especially in ball-handing sports, such as volleyball and basketball. Most occur at the PIPJ level and can be readily assessed with US.

• Joint synovitis secondary to phalanx dislocation, avulsion of small flecks of bone at the ligament insertion sites and palmar plate injuries are often associated with these lesions.

Palmar plate tear

• In the fingers, hyperextension trauma or longitudinal compression may cause PIPJ instability in the sagittal plane leading to palmar plate tear without or with collateral ligament injury.

• These tears occur when the base of the middle phalanx is driven against the head of the proximal phalanx. The impact of the force is absorbed by the volar capsule resulting in simple avulsion of the palmar plate, avulsion of the palmar plate plus a chip of bone from the base of the middle phalanx that can be diagnosed on radiographs or a tear at the attachment of the accessory collateral ligament to the palmar plate.

• In the absence of a fracture, US shows avulsion and proximal migration of the palmar plate over the neck of the proximal phalanx leading to a decreased distance between the flexor tendons and the head of the phalanx.

Wrist Neuropathies

Carpal Tunnel Syndrome (CTS)

• The most common entrapment neuropathy of the upper limb.
• US shows an increased cross-sectional area of the median nerve at the proximal edge of the retinaculum and the flattening of the nerve within the distal tunnel (Fig. 13 and 14) on page . Accessory signs of median neuropathy include palmar bowing of the retinaculum, decreased mobility of the median nerve during passive flexion and extension of the index and long fingers and hyperaemia of the nerve.
• There is no consensus what is an abnormal cross-sectional area measurement of the median nerve: proposed values range from 9mm2 to 12 mm2.
• In order to reduce the impact of intersubject and internerve variability, comparison between the cross-sectional area of the median nerve obtained at the carpal tunnel and more proximally seems a promising alternative.
• Besides assessing the area of the median nerve US can demonstrate extrinsic causes of nerve entrapment (e.g. tenosynovitis of flexor tendons, ganglion cysts, soft-tissue tumors, anomalous muscles and displaced bone).
• After decompression, median nerve swelling may be reversible. An higher reduction of the cross sectional area of median nerve on postoperative US is related with a better clinical outcome.

Guyon Tunnel Syndrome

• The ulnar nerve can be entrapped in the Guyon tunnel (zone-I). Distal to it, its divisional branches can be selectively damaged as they pass alongside the outside slope (motor branch - zone II) or over the tip (sensory branches - zone III) of the hamate hook.
• The leading cause are ganglion cysts arising from the hamate-triquetrum or the piso-triquetrum joints. They are stiff structures and may compress the main nerve trunk against the pisiform or its motor branch against the hamate hook (Fig. 15) on page .

Wartenberg Syndrome

• The sensory branch of the radial nerve can be damaged as a result of penetrating trauma, tight watch-straps or iatrogenic events, such as the incidental nerve damage related to cephalic vein cannulation procedures or to retinaculum release in de Quervain disease.
• Symptoms are pain and sensory loss over the dorsoradial aspect of the hand and dorsal thumb (cheiralgia paresthetica).
• US can detect scar encasement of the nerve secondary to previous surgery or a stump neuroma involving the main nerve trunk or one of its distal branches as a result of penetrating trauma.

Penetrating And Closed Injuries Of Nerves
Complete nerve tears

- Assessing the exact location of the nerve ends and measuring the gap between them on longitudinal scans is crucial in a preoperative setting for selection of the adequate treatment.
- US is more accurate than MR because in the acute setting oedema and haemorrhage at the operation site lead to a local high T2-weighted signal intensity that may be similar to the hyperintense signal of the nerve ends.

Partial nerve tears

- US can establish the percentage of injured fascicles per nerve CSA and shows that generally the superficial fascicles are interrupted whereas the deep ones retain a normal appearance. In other cases, a fusiform hypoechoic swelling develops in absence of nerve discontinuity.

Space-occupying Lesions

Several masses may be found in the soft-tissues of the wrist and hand, including neurogenic tumors, lipomas, pseudoaneurysms, accessory muscles and the glomus tumor.

Ganglion Cysts

- The most common masses of the wrist and hand.
- They appear as well-defined anechoic cystic masses with posterior acoustic enhancement and contain jelly-like viscous fluid and an epithelial lining. They may exhibit fine septa and, often, a thin and tortuous stalk connecting the bulk of the cyst with the level of the joint capsule.
- Based on their location, 70% of the ganglia occur on the dorsal and 30% on the volar aspect of the wrist. Most of dorsal wrist ganglia take their origin from the level of the joint capsule, just superficial to the SLL (Fig. 16A) on page ... Ventral wrist ganglia are usually located on the radial aspect of the wrist (Fig. 16B) on page ... In the fingers, ganglia usually present as small stiff cysts located palmar to the proximal phalanx, in close relationship with the A1-pulley. More rarely, ganglia take their origin from a tendon sheath (sheath ganglia) or expand within the tendon substance (intratendinous ganglia).

Giant Cell Tumor Of The Tendon Sheat
• Solid slowly-growing mass which preferentially arises at the synovium of tendon sheaths and can cause bone erosions.
• US demonstrates a solid well-delineated hypoechoic mass adjacent to a flexor tendon and often encircling it (Fig. 17) on page 26. Despite the close contact, the mass does not move with the tendon when the tendon glides: this is related to the fact that the lesion arises from the parietal sheath and not from the tendon.
• MR imaging is the confirmatory tool as this histotype is typified by low signal intensity in the T2-weighted sequences due to hemosiderin content.

Images for this section:

![Fig. 5. Screw tip impingement of the ECRL tendon in a 45 year-old woman who had undergone volar plating for distal radial fracture. A Transverse and B longitudinal 17-5MHz US images obtained over the 2nd compartment at the level of the Lister tubercle show the tip of a screw protruding inside the ECRL tendon. The adjacent ECRB is spared.](image)

Fig. 1
Fig. 4. Extensor pollicis longus tendon tear in a 43 year-old man patient complaining of weak thumb extension after distal radial fracture. A Transverse 12-5MHz US image shows fragmentation (asterisk) and discontinuity (arrowheads) of the floor of the 3rd compartment at the level of the Lister tubercle and an empty EPL tendon sheath (arrows) due to a torn and retracted EPL tendon. B Correlative lateral radiograph demonstrates a non-displaced fracture (arrows) of the distal radius.
Fig. 7. Flexor carpi radialis tendinopathy in a 65 year-old woman complaining of a painful palpable lump over the ventral radial aspect of the right wrist. The patient was referred for US examination for a suspected ventral ganglion cyst. A AP radiograph reveals scapholunate diastasis and advanced triscapho arthritis (arrows). B Transverse 17.5-MHz US image over the lump demonstrates a swollen and heterogeneous FCR tendon (arrows) stabilized over the scaphoid tubercle by a thickened retinaculum (white arrowheads). C Longitudinal 17.5-MHz US image shows bony spurs (void arrowhead) from the ventral aspect of the scaphoid and the trapezium (tra) impinging the undersurface of the abnormal tendon.

Fig. 3: .
Fig. 6. Flexor tendon tear. A Longitudinal 17-5MHz US image over the thenar compartment demonstrates complete rupture of the FPL tendon. The torn tendon appears slightly hypoechoic with loss of the fibrillar echoes. Some fluid (asterisk) in the empty sheath is visible distal to the tendon end (arrows). B, C Corresponding transverse 17-5MHz US images of the same case obtained (B) over the ruptured tendon and (C) distal to the rupture.
Fig. 5: Flexor carpi ulnaris tendinopathy in a 50 year-old patient with sudden onset of pain in the right pisiform region. A Plain film reveals amorphous calcific deposits (arrow) proximal and volar to the pisiform. B US identifies a conglomerate of slurry echogenic calcifications (arrowheads) within and around a heterogenous FCU tendon reflecting calcifying tendinitis. C Correlative fat-suppressed GRE T2* MR image confirms a hyperintense peritendinous mass (arrowheads) related to reactive inflammatory changes.
Fig. 11. Scapholunate ligament. Transverse 17-5 MHz US image over the dorsal aspect of the wrist shows the normal dorsal component of the scapholunate ligament (arrows) which appears as an echogenic fibrillar band joining the scaphoid and the lunate. **B, C** Scapholunate dissociation. Transverse 17-5 MHz US images over the dorsal aspect of the scapholunate joint obtained **B** with ulnar (diverging arrows) and **C** radial deviation (converging arrows) of the wrist demonstrate non-visualization of the ligament and widening of the scapholunate distance (distance between the vertical bars) while in ulnar deviation. This can be considered an indirect sign of ligament tear.
Fig. 10. Annular pulleys and climber’s finger. A Longitudinal and B transverse 17-5MHz US images over the left long finger of an elite rock climber show the normal A2-pulley as a thin hypoechoic band (arrowheads) restraining the flexor tendons against the shaft of the proximal phalanx. C Longitudinal and D transverse 17-5MHz US images over the injured right long finger of the same patient demonstrate bowstringing and volar displacement of the flexor tendons secondary to A2-pulley rupture. An increased tendon-to-bone distance (double arrow) is appreciated over the proximal phalanx. An effusion (asterisks) is also seen intervening between tendons and bone.

Fig. 7: .
**Fig. 9.** de Quervain disease: spectrum of findings. A Transverse 17-5MHz US image obtained over the radial styloid reveals a thickened and hypoechoic retinaculum (arrowheads) and the swollen EPB (1) and APL (2). Note that the two tendons form a rounded complex and cannot be separated from each other as they are constricted by the abnormal retinaculum. B Transverse 17-5MHz US image obtained over the radial styloid shows selective thickening of the dorsal portion of the retinaculum (void arrowheads) and the vertical septum (arrow) enveloping the EPB tendon (1), whereas the more ventral portion of the retinaculum (white arrowheads) and the APL tendon (2) retain a normal appearance. In this case, the injection of corticosteroids was selectively directed into the sheath of the EPB.

**Fig. 8:**
Fig. 12. Gamekeeper’s thumb and Stener lesion. A Non-displaced ligament tear. Coronal 17-5MHz US image obtained over the ulnar aspect of the MIPJ of the thumb shows an abnormally thickened ligament (asterisk) lying deeply to the adductor aponeurosis (arrowheads). B Stener lesion. Coronal 17-5MHz US image over the ulnar aspect of the first MCPJ reveals a swollen and retracted ulnar collateral ligament presenting as a hypoechoic pseudomass (asterisk) located proximally and in a more superficial position relative to the AddPA (arrowheads).

Fig. 9: .
Fig. 13. Carpal tunnel syndrome. A Longitudinal 12-5MHz US image over the carpal tunnel shows definite calibre change of the MN as it passes underneath the proximal edge of the retinaculum (arrowheads). The MN appears flattened in the carpal tunnel and swollen proximal to it. Note synovial sheath distension of the underlying flexor tendons (asterisks).

Fig. 10: .
Fig. 17. Giant cell tumour of the tendon sheath. A Longitudinal 17-5MHz US image in a patient with a painless mass in the thenar region demonstrates a lobulated, solid hypoechoic mass (arrows). B Corresponding T2-weighted TSE MR image shows a low signal intensity mass (arrow). Note the close relationship of the tumour with the FPL tendon (arrowhead).
Conclusion

The US examination of the hand and the wrist is useful for the diagnosis of extensor and flexor tendon abnormalities, retinacula-related disorders, some ligament injuries and compressive or traumatic neuropathies affecting the main trunks and divisional branches of the median, ulnar and radial nerves.

Personal Information

References