

Sonography of Non-neoplastic Disorders of the Hand and Wrist Tendons

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Tendon disorders commonly cause hand and wrist disability and curtail the performance of work-related duties or routine tasks. Imaging is often needed for diagnosis, but it requires knowledge of the complex anatomic structures of the tendons of the hand and wrist as well as familiarity with related disorders. This review article aims to provide medical professionals with guidelines for the sonographic assessment of the tendons of hand and wrist and related disorders. Sonographic features of tendon disorders affecting the hand and wrist are described here, specifically: infectious tenosynovitis; tendon rupture or tearing; stenosing forms of tenosynovitis such as De Quervain disease and trigger finger; intersection syndrome; insertional tendinopathy; several forms of tendinous instability such as extensor carpi ulnaris instability, climber finger, and boxer knuckle; and tendinopathy in inflammatory rheumatic diseases. Postsurgical evaluation of the hand and wrist tendons is also discussed, including the healthy and pathologic appearances of operated tendons as well as impingement from orthopedic hardware. In conclusion, sonography is effective in assessing the tendons of the hand and wrist and related disorders and represents a valuable tool for diagnosis.

Key Words—hand; musculoskeletal imaging; sonography; tendon; wrist

Tendon disorders are common causes of hand and wrist disability that affect the quality of life and curtail the performance of work-related duties or routine tasks. Overuse in daily life and sports as well as the long and superficial course of these tendons across the wrist and hand represent risk factors for their derangement.¹ Imaging is often required for diagnosis, but it requires knowledge of the complex structures and anatomic relationships of the tendons of the hand and wrist as well as familiarity with related disorders. As an inexpensive, time-saving, and largely available imaging modality that allows for the focused, dynamic, and comparative evaluation of small superficial structures with high resolution, sonography is valuable for examining the tendons of the hand and wrist.^{2,3} This review article aims to provide medical professionals with simple and systematic guidelines for sonographic assessment of the tendons of hand and wrist and related disorders. These guidelines are generated from the combined experience of our centers, as indicated by the references in the text, with a thorough analysis of the literature from the last 16 years (2001–2016). A systematic search of the literature was performed in PubMed and included original studies and review articles in English dealing with sonographic descriptions of the tendons of the hand and wrist and related disorders. Case reports and case series were selected according to clinical relevance.

Received February 8, 2017, from the Postgraduate School in Radiodiagnostics, Università Degli Studi di Milano, Milan, Italy (S.G.); and Radiology Institute, Fondazione Istituto di Ricovero e Cura a Carattere Scientifico Policlinico San Matteo, Università Degli Studi di Pavia, Pavia, Italy (A.G.D., F.D.). Manuscript accepted for publication March 27, 2017.

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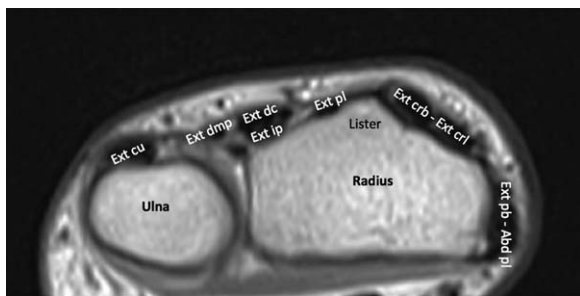
doi:10.1002/jum.14313

Normal Anatomy and Sonographic Appearance

Extensor Tendons

On the dorsal aspect of the wrist, the extensor tendons run through 6 osseofibrous compartments or tunnels that are numbered from first (radial) to sixth (ulnar); (Figure 1).^{4,5} The roof of these compartments is the extensor retinaculum, also known as the dorsal carpal ligament, a fibrous band that spreads obliquely from the radius to the triquetrum and pisiform, becoming thicker at the level of the fourth compartment. Vertical fibrous septa extend downward from the extensor retinaculum, forming the medial and lateral walls of the dorsal compartments, and then attach to the radius, ulna, and distal radioulnar joint. On the dorsal wrist, the main anatomic landmark is the Lister tubercle, a dorsal bony

Figure 1. Tendons of the dorsal wrist. Axial T1-weighted magnetic resonance scan shows, from radial to ulnar: the extensor pollicis brevis and abductor pollicis longus (Ext pb - Abd pl); the extensor carpi radialis brevis and extensor carpi radialis longus (Ext crb - Ext crl); the extensor pollicis longus (Ext pl); the extensor digitorum communis and extensor indicis proprius (Ext dc and Ext ip); the extensor digiti minimi proprius (Ext dmp); and the extensor carpi ulnaris (Ext cu).



prominence of the distal radius that separates the second and third dorsal compartments.^{4,5} Table 1 details the extensor tendons contained in each dorsal compartment along with their distal insertions.

On the dorsal aspect of the hand, there are 3 variable intertendinous connections called the juncturae tendinae, which link adjacent tendons extending from the middle finger to the index finger and from the ring finger to the middle and little fingers, respectively.⁶ At the level of the metacarpophalangeal joints, the extensor tendons are held in a central position by a fibrous expansion that emits peripheral transverse fibers directed to the volar plate and termed the sagittal bands.⁷

Flexor Tendons

On the volar aspect of the wrist, there are 3 tendinous layers that correspond to the muscle layers of the anterior forearm. The fourth muscle layer of the anterior forearm includes the pronator quadratus, which originates and inserts within the forearm and does not extend to the wrist (Figure 2).⁴ Table 2 details the flexor tendons grouped in each myotendinous layer along with their distal insertions.

The first tendinous layer is generally superficial to the flexor retinaculum, also known as the transverse carpal ligament, a fibrous band that extends from the scaphoid and trapezium to the pisiform and hamate.^{4,5} Some anatomic variations may occur, however, and mostly involve the palmaris longus muscle.⁸ The flexor tendons of the second and third layers run through the carpal tunnel along with the median nerve.^{4,5} The carpal tunnel is delimited volarly by the flexor retinaculum and dorsally by the carpal bones, specifically the scaphoid and trapezium on the radial side and the pisiform and hamate on the ulnar side.⁹ A further key structure of the

Table 1. Dorsal Osteofibrous Compartments of the Wrist, From Radial (1st) to Ulnar (6th)

Dorsal Compartment	Tendon	Insertion
1st	Abductor pollicis longus Extensor pollicis brevis	Radial side of the base of the 1st metacarpal Base of the proximal phalanx of the thumb
2nd	Extensor carpi radialis longus Extensor carpi radialis brevis	Base of the 2nd metacarpal Base of the 3rd metacarpal
3rd	Extensor pollicis longus	Base of the distal phalanx of the thumb
4th	Extensor digitorum communis	Each of the 4 tendons directed to digits 2–5 emits a central terminal slip inserting into the base of the middle phalanx and medial and lateral terminal slips inserting into the base of the distal phalanx
5th	Extensor indicis proprius	Ulnar side of the middle phalanx of the index finger
6th	Extensor digiti minimi proprius Extensor carpi ulnaris	Ulnar side of the proximal and middle phalanges of the little finger Base of the 5th metacarpal

volar wrist is the Guyon canal, through which the ulnar neurovascular bundle passes. The Guyon canal extends from the pisiform to the hook of the hamate; it is

Figure 2. Myotendinous layers of the volar aspect of the distal forearm. Axial T1-weighted magnetic resonance scan shows, from radial to ulnar: the first layer containing the flexor carpi radialis (Fle cr), palmaris longus (Pl), and flexor carpi ulnaris (Fle cu); the second layer containing the flexor digitorum superficialis (Fle ds); the third layer containing the flexor pollicis longus (Fle pl) and flexor digitorum profundus (Fle dp); and the fourth layer containing the pronator quadratus (Pronator q).

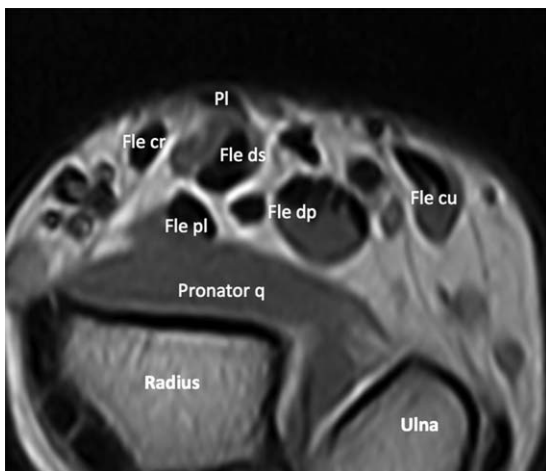


Table 2. Myotendinous Layers of the Volar Wrist, From Superficial (1st) to Deep (3rd)

Myotendinous Layer	Tendon	Insertion
1st	Flexor carpi radialis	Base of the 2nd and 3rd metacarpals
	Palmaris longus	Palmar aponeurosis
	Flexor carpi ulnaris	Pisiform, hamate, and base of the 5th metacarpal
2nd	Flexor digitorum superficialis	Each of the 4 tendons directed to digits 2–5 emits 2 bundles that pass around the deep flexor tendon before inserting into the base of the middle phalanx
3rd	Flexor pollicis longus	Base of the distal phalanx of the thumb
	Flexor digitorum profundus	Each of the 4 tendons directed to digits 2–5 inserts into the base of the distal phalanx

In each myotendinous layer, the flexor tendons are ordered from radial to ulnar.

delimited dorsally by the flexor retinaculum and volarly by the palmar carpal ligament, which represents a distal extent of the antebrachial fascia and palmaris brevis muscle.¹⁰

At the base of each finger, the flexor tendons enter an osteofibrous tunnel formed by the volar aspect of the phalanges and a fibrous sheath composed of the annular and cruciform pulleys.¹¹ The annular pulleys keep the flexor tendons closely applied to the phalanges and are numbered from A1 to A5: the A1, A2, and A3 pulleys are located at the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints, respectively; and the A2 and A4 pulleys are located at the level of the proximal and middle phalanges, respectively. The cruciform pulleys consist of flexible crisscrossing fibers between the components of the annular pulley system and allow flexion of the interphalangeal joints.^{11,12} Only the A1 and A2 pulleys are present in the thumb, at the metacarpophalangeal joint and just proximal to the interphalangeal joint, respectively, with one oblique pulley located over the proximal phalanx.⁶

Synovial Sheaths

With the exception of the flexor carpi ulnaris and palmaris longus, all tendons of the hand and wrist are enclosed within synovial sheaths, which extend a few centimeters proximally in the forearm.⁶ On the dorsal wrist, regardless of the number of tendons it contains, each compartment is generally enveloped by a single synovial sheath. The synovial sheaths of the first, second, third, and sixth dorsal compartments stop immediately proximal to the bases of the metacarpals; those of the fourth and fifth dorsal compartments are prolonged a little more distally along the metacarpals.⁶

In the most superficial tendinous layer of the volar wrist, only the flexor carpi radialis tendon is encircled within a synovial sheath, which ends at the tendon distal insertion. Among the tendons of the second and third layers, the flexor digitorum superficialis and profundus tendons overlap on the ulnar side of the carpal tunnel and share a common sheath. The sheath of the flexor tendons directed to the index, middle, and ring fingers stops about halfway along the metacarpals. For each of the index, middle, and ring fingers, a separate digital synovial sheath generally envelopes the flexor tendons from mid palm to the distal phalanx. The sheath of the flexor tendons directed to the little finger is usually contiguous with their digital synovial sheath. The flexor

pollicis longus tendon, located at the radial border of the carpal tunnel, has its own sheath that continues along the thumb as far as the tendon distal insertion.⁶

Normal Sonographic Appearance

Tendons consist of longitudinally oriented bundles of type I collagen fibers. On sonograms, collagen bundles are hyperechoic and embedded within a background of a hypoechoic matrix, thus resulting in a fibrillar pattern with multiple parallel lines on longitudinal scans and multiple dots on transverse scans.^{13,14} Synovial sheaths may eventually be depicted as thin echogenic fluid-containing structures. Retinacula and annular pulleys are best visualized on transverse scans and often appear as hypoechoic bands because of anisotropy.^{15,16}

Infectious Tenosynovitis

The term *tenosynovitis* indicates an inflammation of the tendon synovial sheath and is common in the wrist and hand, as almost all tendons are enclosed within a synovial sheath. Specifically, it may affect the proximal portion of the extensor tendons, the flexor carpi radialis (Figure 3), and the flexor tendons that pass through the carpal tunnel (Figure 4). The etiology mainly includes infections, local trauma and overuse, systemic inflammatory disorders, impingement from orthopedic hardware, carpal bossing, or fractured bones.¹⁷ Noninfectious forms of tenosynovitis will be discussed later in the article.

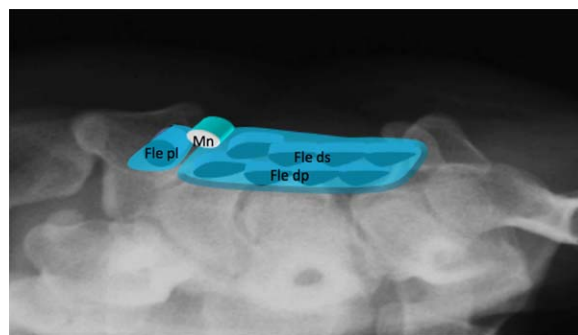
Figure 3. Schematic diagram of the flexor carpi radialis. The flexor carpi radialis, shown here in gray, belongs to the most superficial myotendinous layer of the anterior forearm and is located laterally. Its tendon fibers attach to the second metacarpal, sending a slip to the third metacarpal. This tendon is surrounded by a synovial sheath that begins approximately 3 cm above the wrist and ends at its distal insertion.



The tendons of the hand and wrist are at risk of infection because of their superficial location. Infectious tenosynovitis may be caused by penetrating injuries with or without a foreign body or, less commonly, spreading of an adjacent soft tissue infection or hematic dissemination. The main risk factors include intravenous drug abuse, diabetes mellitus, and immunosuppression.¹⁸ A variety of microbial agents may be responsible for infectious tenosynovitis: *Staphylococcus* and *Streptococcus* species are most often involved in cases of injections, anaerobic agents in diabetic patients, and polymicrobial agents in case of bite wounds; typical or atypical mycobacteria as well as *Neisseria gonorrhoeae* may also be found.¹⁸ Clinical findings include local pain, tenderness, and swelling along the affected tendon. Absence of an obvious portal of injury is frequent.¹⁹ Peculiarly, digital flexor tenosynovitis may irritate the median nerve and cause carpal tunnel syndrome.⁹

Sonographic features of infectious tenosynovitis include intrasynovial fluid, inhomogeneous tendon thickening, peritendinous edema, and hyperemia (Figures 5–7).^{20–22} These findings are, however, nonspecific; thus, a detailed knowledge of the medical history as well as a physical examination is crucial when considering other etiologies of tenosynovitis in the differential diagnosis (Figures 8 and 9). The density of septic intrasynovial fluid varies according to the microbial agent involved.²⁰ In the case of flexor tenosynovitis that involves the fingers, intrasynovial fluid often appears lobulated because of the discontinuous array of the

Figure 4. Schematic diagram of the carpal tunnel. The tendons of the flexor digitorum superficialis (Fle ds) and profundus (Fle dp) muscles (4 tendons in each), the flexor pollicis longus tendon (Fle pl), and the median nerve (Mn) all pass through the carpal tunnel on the volar aspect of the wrist. The flexor pollicis longus tendon has its own sheath; the tendons of the flexor digitorum superficialis and profundus tendons share a common sheath.



pulleys (Figure 10).¹⁶ Rice bodies may develop in the case of typical or atypical mycobacterial infections, although they are not specific and can also be identified

Figure 5. Infectious tenosynovitis of the flexor carpi radialis tendon. On a transverse scan, the flexor carpi radialis tendon (Fle cr) is thickened and surrounded by a large intrasynovial effusion that is corpuscular because its septic nature.

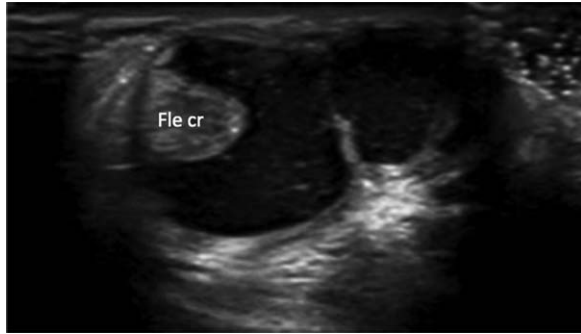


Figure 6. Flexor carpi radialis tenosynovitis. Sonography shows the flexor carpi radialis tendon (Fle cr) surrounded by an intrasynovial effusion, which needs to be distinguished from a ganglion cyst of the radiocarpal joint.

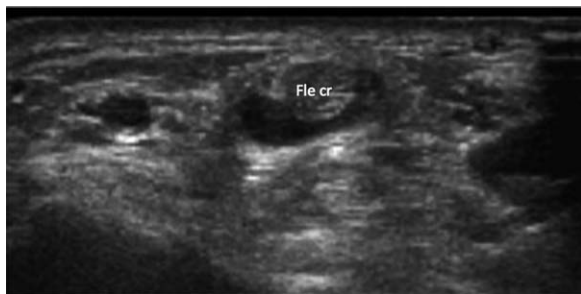
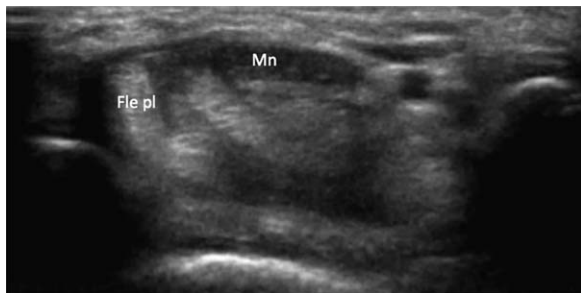


Figure 7. Flexor pollicis longus tenosynovitis and carpal tunnel syndrome. At the level of the carpal tunnel, sonography shows an intrasynovial effusion of the flexor pollicis longus tendon (Fle pl). The median nerve (Mn) is hypoechoic with loss of the fascicular structure.



in rheumatoid arthritis and seronegative spondyloarthritis. They are intrasynovial deposits of fibrin that sonographically appear as multiple well-defined hypoechoic

Figure 8. Flexor tenosynovitis and carpal tunnel syndrome in dialysis-associated amyloidosis. On the volar wrist, sonography shows synovial thickening of the flexor carpi radialis tendon (Fle cr) and flexor tendons within the carpal tunnel due to deposition of β_2 -microglobulin. The median nerve (Mn) is hypoechoic as a sign of carpal tunnel syndrome.

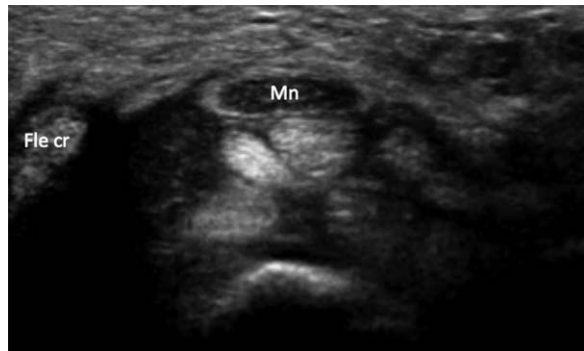
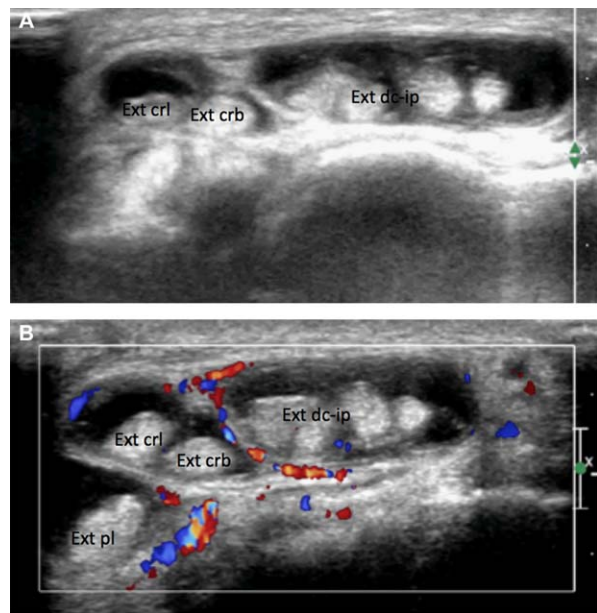


Figure 9. Allergic tenosynovitis of the extensor tendons after surgical excision of a radiocarpal ganglion cyst. Beyond the site of the intersection between the extensor pollicis longus (Ext pl) and the tendons of the second dorsal compartment, sonography shows an intrasynovial effusion of the extensor carpi radialis longus (Ext crl), extensor carpi radialis brevis (Ext crb), and extensor digitorum communis and extensor indicis proprius (Ext dc-ip) tendons resulting from an allergic reaction to the sutures (A). On a color Doppler scan, synovial hyperemia is seen (B).



or anechoic masses.²³ In the case of spreading of an adjacent soft tissue infection, a subcutaneous abscess may be contiguous with the involved tendon and appears as an inhomogeneously hypoechoic fluid collection with irregular margins and peripheral hyperemia on Doppler imaging (Figure 11).¹⁷ If present, a foreign body is depicted as extraneous material with posterior acoustic shadowing or reverberation artifacts.²⁴ Chronically, mycobacterial or fungal tenosynovitis may result in synovial thickening.²⁴

Traumatic Tendon Injuries

Tendon Tears

Tears of the tendons of hand and wrist include avulsions that involve the tendon distal insertion and, less commonly, midsubstance tears often related to lacerations.²⁵ Underlying inflammatory conditions (eg, rheumatoid arthritis),²⁶ local steroid injections,²⁷ connective tissue disease (eg, Ehlers-Danlos syndrome),²⁸ and adjacent orthopedic hardware²⁹ represent risk factors for tendon tearing. The clinical presentation reflects the underlying functional deficit and consists of a loss of active motion, even though some degree of compensation may occur (eg, in proximal tears of the middle finger extensor tendon due to the juncturae tendinae).⁶

Tears may be classified as complete or partial tears. Sonographically, complete ruptures present with complete interruption of tendon fiber continuity. Close to the site of injury, the tendon is hyperechoic and thickened, with a loss of the fibrillar echo texture. Widening of the gap between the proximal and distal tendon stumps can be proved by using dynamic maneuvers (Figure 12).^{30–33} Partial tears present with incomplete disruption of tendon fiber continuity and are seen as

Figure 10. Infectious tenosynovitis of the flexor tendons of the little finger. On a longitudinal scan, an intrasynovial effusion (arrowheads) of the flexor digitorum superficialis and profundus tendons (Fle d s-p) is seen and appears lobulated because of the discontinuous array of the digital pulleys.

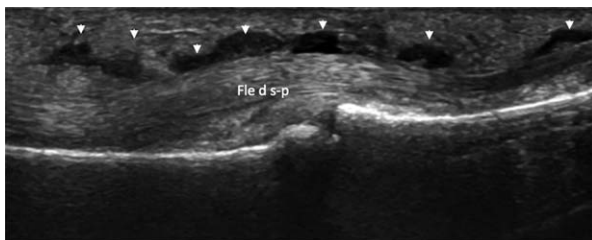
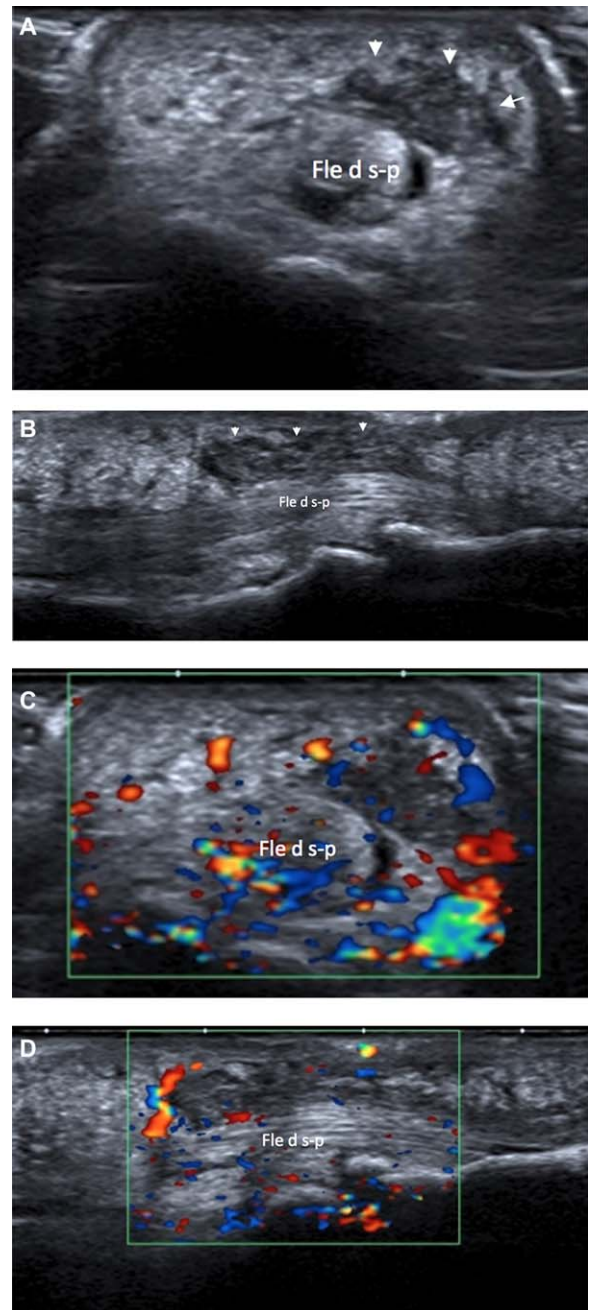


Figure 11. Subcutaneous abscess and septic tenosynovitis. The flexor digitorum superficialis and profundus tendons (Fle d s-p) of the index finger are depicted on B-mode transverse (A) and longitudinal (B) scans; they show some intrasynovial inflammatory fluid and are contiguous with a subcutaneous abscess (arrow and arrowheads), which appears as a hypoechoic area with irregular margins and extends to the tendon sheath. On transverse (C) and longitudinal (D) color Doppler sonograms, peripheral hyperemia of the abscess as well as tendinous and peritendinous hypervascularization are seen.



focal hypoechoic defects and tendon thickening at the site of injury (Figure 13).³⁴ Hemorrhage is present in cases of acute or subacute tears. There is no evidence of hematoma in the case of chronic injuries.³⁵

Importantly, in patients with pain and swelling after trauma to the hand and wrist, occult or undetected fractures should be considered as differential diagnoses and ruled out by sonographic examination.³⁶ Undetected fractures may result in hematoma formation and conflict with the digital tendons, thus mimicking a tendon injury (Figure 14).³⁷

Mallet Finger

An avulsion injury may result in a bone fragment detachment, typically found dorsally at the base of the distal phalanx. This condition is known as hammer finger or mallet finger and clinically presents with permanent

Figure 12. Subacute complete tear of the flexor carpi radialis tendon. At the level of the distal radius, transverse (A) and longitudinal (B) sonograms show a large, partially organized hematoma (arrowheads) within the synovial sheath of the flexor carpi radialis tendon, which is completely torn and not seen in its expected anatomic location.

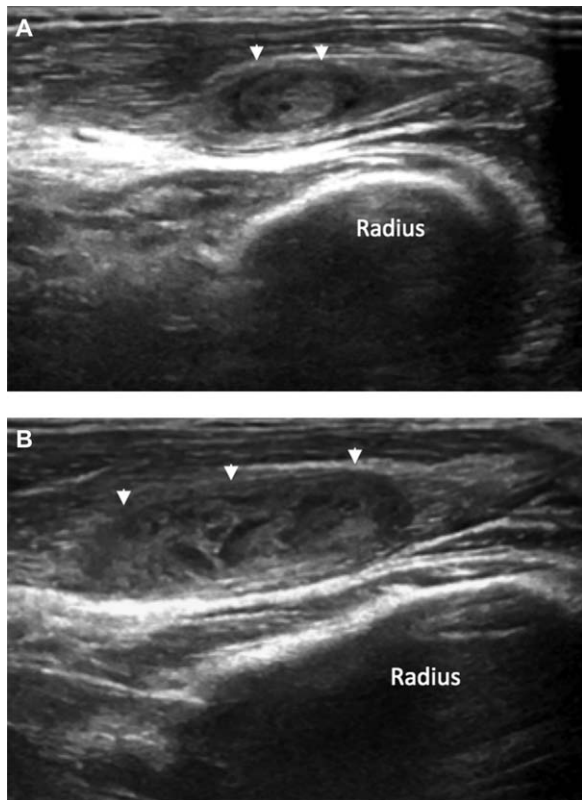


Figure 13. Acute partial tear of the flexor carpi ulnaris tendon. Longitudinal sonogram shows a hypoechoic hematoma (arrowheads) surrounding the flexor carpi ulnaris tendon proximal to its insertion into the pisiform. Close to the hematoma, the tendon shows a focal hypoechoic defect, which indicates a partial tear.

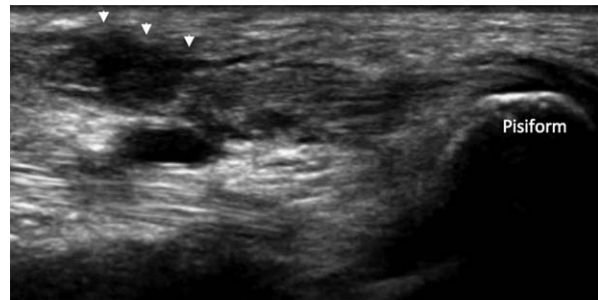


Figure 14. Occult fracture of the third finger. In a patient with digital pain and swelling after trauma, plain radiography (A and B) was unremarkable. Longitudinal (C) and transverse (D) sonograms show a fracture of the head of the third metacarpal (arrows) and a hematoma surrounding the site of fracture and resulting in a conflict with the extensor tendon (Ext).



flexion of the distal phalanx.³⁸ Sonographic features of mallet finger include a hyperechoic bone fragment with posterior shadowing, partial or complete discontinuity of tendon fibers, lack of movements of the extensor tendon under dynamic assessment, and hematoma at the avulsion site (Figure 15).³⁹

Stenosing Tenosynovitis

Stenosing forms of tenosynovitis affect tendons that, enveloped by their own synovial sheath, run through osteofibrous tunnels. These tunnels are delimited deeply by cortical bone and superficially by a retinaculum or pulley according to their location. Retinaculum or pulley thickening, mainly due to mechanical overuse and repetitive microtrauma, is responsible for narrowing of the osteofibrous tunnel and the following tenosynovitis. Sonographic diagnosis of stenosing tenosynovitis relies on an assessment of retinaculum or pulley thickening and decreased tendon motion under dynamic maneuvers. De Quervain disease and trigger finger represent the main types of stenosing tenosynovitis affecting the wrist and hand.⁴⁰

De Quervain Disease

De Quervain disease is tenosynovitis of the abductor pollicis longus and extensor pollicis brevis tendons contained within the first dorsal compartment of the wrist (Figure 16).⁴¹ Risk factors include sport-related or

occupational overuse and anatomic variants, such as a longitudinal fibrous septum separating the first compartment into two parts that respectively contain the abductor pollicis longus and extensor pollicis brevis tendons and multiple terminal laminae of the abductor pollicis longus instead of a single distal insertion.^{42–47} Clinically, De Quervain disease usually arises in 30- to 50-year-old individuals and presents with wrist pain at the level of the radial styloid that is evoked or exacerbated by the Finkelstein test. This test consists of an ulnar deviation of the wrist with the thumb flexed into the palm and covered by the remaining digits.⁴¹

Sonographic features of De Quervain disease include hypoechoic thickening of the extensor retinaculum and enlargement of the abductor pollicis longus and extensor pollicis brevis tendons, which appear rounder than usual on transverse scans. Loss of clear demarcation between these tendons may occur as a result of tendon thickening. Increased vascular flow on Doppler imaging and a variable amount of inflammatory fluid within the synovial sheath are seen in the acute stage of De Quervain disease (Figures 17 and 18); chronically, there may be either little or no intrasynovial fluid.^{48–50} If a complete fibrous septum divides the first dorsal compartment longitudinally into two parts, pathologic changes may be confined to only a single tendon (usually the extensor pollicis brevis tendon), thus requiring the treatment to be targeted accordingly (Figure 19).^{51,52}

Figure 15. Mallet finger. Plain radiography (A) and sonography (B) show an avulsion fracture (arrows) involving the base of the distal phalanx, at the tendon distal attachment.

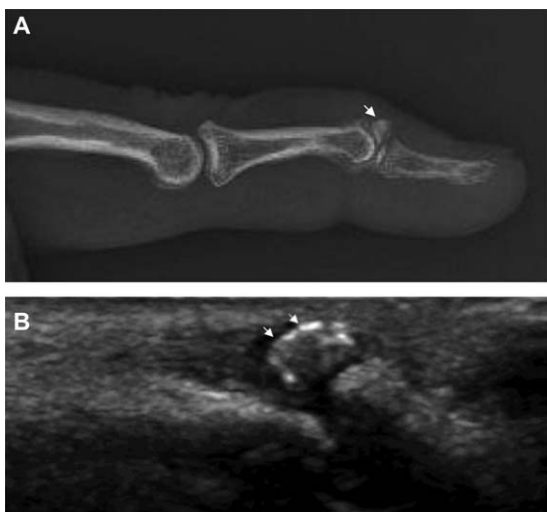
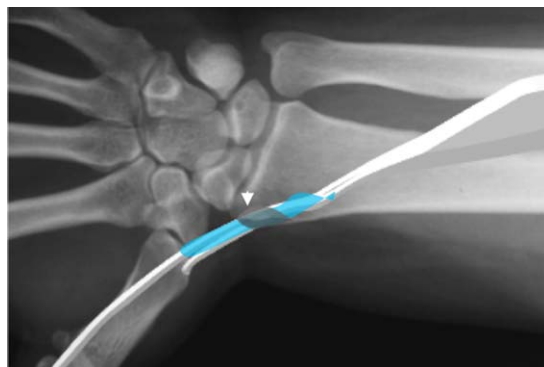


Figure 16. Schematic diagram of the first dorsal compartment. The tendons of the abductor pollicis longus and extensor pollicis brevis muscles run through the first compartment. These tendons usually share a common synovial sheath, shown here in light blue. The extensor retinaculum (arrowhead) overlies the first compartment and is shown in gray.



Trigger Finger

Trigger finger is a common disorder of the hand with a lifetime risk of 2% to 3%. It is seen more frequently in diabetics and in women, typically in the fifth to sixth decade, and both chronic overuse and local blunt traumas are regarded as etiologic factors.⁵³ The clinical presentation includes a painful blockage and triggering of the affected digit from flexion to extension. It mostly involves the metacarpophalangeal joint and is due to thickening of the A1 pulley with subsequent restriction of motion of the flexor tendons (Figure 20). The ring finger is most commonly involved, followed by the thumb and middle finger.⁵³ Sonographic features of trigger finger include hypoechoic thickening of the A1 pulley and flexor tendon tenosynovitis with intrasynovial fluid (Figure 21).^{54–56}

Intersection Syndrome

Intersection syndrome is an uncommon overuse disorder of the dorsal tendons of the wrist and is classified into proximal and distal intersection syndrome.^{57,58}

Figure 17. Acute De Quervain disease. Sonography shows thickening of the extensor retinaculum (arrows and arrowhead) and enlargement of the abductor pollicis longus (Abd pl) and extensor pollicis brevis (Ext pb) tendons with loss of clear demarcation between them (A). A large amount of fluid is seen within their common synovial sheath (B).

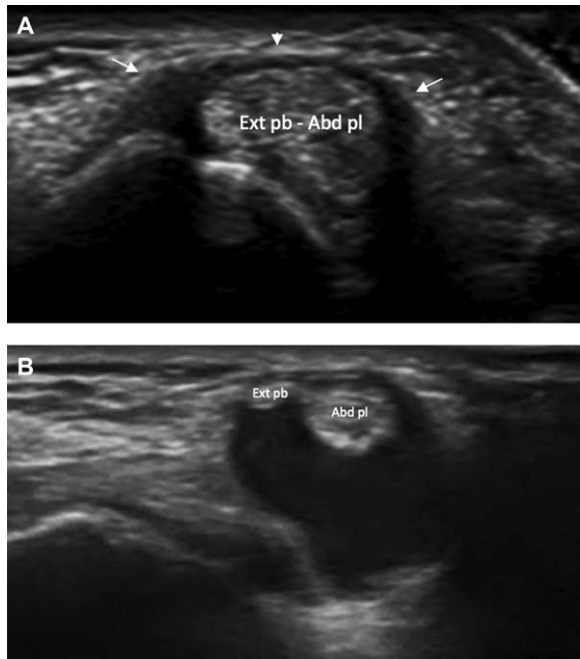


Figure 18. Acute De Quervain disease. Sonography shows thickening of the extensor retinaculum (arrowheads), enlargement of the abductor pollicis longus (Abd pl) and extensor pollicis brevis (Ext pb) tendons, and intrasynovial fluid (A). Two anatomic variations occur: a distal split of the synovial sheath into two sheaths, one for each tendon, and multiple terminal laminae of the abductor pollicis longus tendon (B).

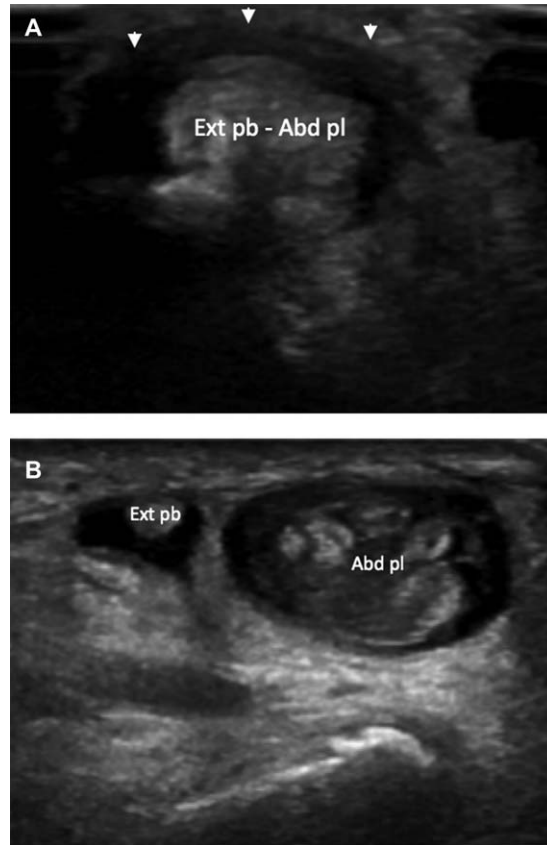


Figure 19. Acute De Quervain disease. A vertical fibrous septum (arrows) divides the first dorsal compartment into two parts, which contain the abductor pollicis longus (Abd pl) and extensor pollicis brevis (Ext pb) tendons, respectively. Pathologic changes with intrasynovial fluid are confined to the extensor pollicis brevis tendon.



Proximal intersection syndrome develops in a friction site located 3.5 to 4.8 cm proximal to the Lister tubercle, where the tendons of the second compartment run beneath those of the first compartment.⁵⁹ Distal intersection syndrome is rarer and develops in a further friction site located just beyond the Lister tubercle, where the third dorsal compartment tendon crosses over those of the second compartment (Figure 22).⁶⁰ Risk factors

comprise trauma and repetitive stress at the wrist during occupational duties or sport activities, such as rowing and weightlifting.²⁵ The clinical presentation resembles that of De Quervain disease and includes pain, swelling, and an audible crepitus related to wrist motion at the level of distal radial epiphysis.⁶¹

The main sonographic feature of proximal intersection syndrome is an effusion within the synovial sheath of the second dorsal compartment of the wrist, variably

Figure 20. Schematic diagram of the A1 pulley and digital flexor tendons. The A1 pulley (arrowhead), shown here in gray, is located on the volar aspect of the metacarpophalangeal joint and stabilizes the deep and superficial digital flexor tendons.



Figure 21. Trigger finger. Sonography shows hypoechoic thickening of the A1 pulley (arrows) and moderate tenosynovitis of the flexor digitorum superficialis and profundus (Fle d s-p) tendons of the middle finger. Normal A1 pulley of the ring finger and the volar plates (V p) are also shown.



Figure 22. Schematic diagram of the proximal and distal intersection sites. The proximal intersection site (arrowhead) is located 3.5 to 4.8 cm proximal to the Lister tubercle, where the tendons of the second compartment run beneath those of the first compartment. The distal intersection site (arrow) is located just beyond the Lister tubercle, where the tendon of the third dorsal compartment crosses over those of the second compartment. Tendon synovial sheaths are shown here in light blue.

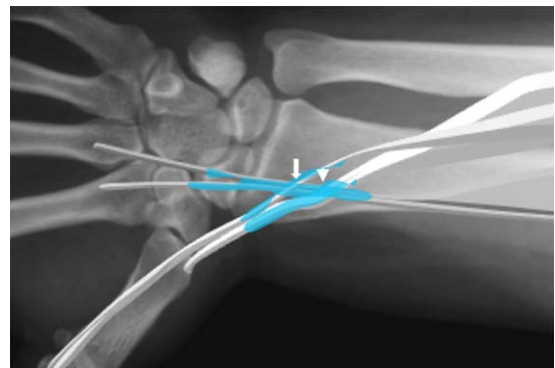
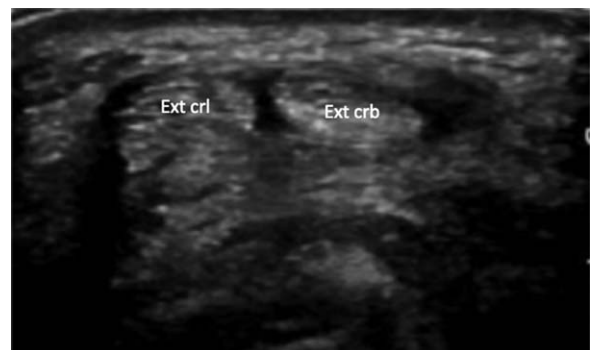


Figure 23. Proximal intersection syndrome. Sonography shows an intrasynovial effusion within the second dorsal compartment containing the extensor carpi radialis longus (Ext crl) and brevis (Ext crb) tendons.



located between the proximal and distal intersections; occasionally, some amounts of inflammatory fluid may be found within the synovial sheath of the first dorsal compartment (Figure 23).^{62,63} If each tendon of the second compartment has its own synovial sheath as an anatomic variant, inflammatory changes may be confined to only a single tendon, usually that of the extensor carpi radialis brevis.⁴³ Tendon thickening may occur at the proximal intersection site.⁶⁴ Sonographically, distal intersection syndrome presents with an effusion within the synovial sheaths of the second and third dorsal compartments, usually distal to the distal intersection site.⁶² In both proximal and distal intersection syndromes, sonography may show soft tissue edema or an adventitial bursitis between the two groups of affected tendons.^{62,63} Increased vascularization may be seen on Doppler imaging.²⁵

Insertional Tendinopathy

Among the tendons of the hand and wrist, insertional tendinopathy most commonly affects the flexor carpi ulnaris tendon at or near its attachment to the pisiform (Figure 24).⁶⁵ Repetitive microtrauma is responsible for collagen fiber degeneration and compensative repair processes, finally resulting in tendon weakening and an increased risk of rupture.⁶⁶ The clinical presentation includes pain and tenderness 2 to 3 cm proximal to the flexor carpi ulnaris insertion into the pisiform.⁶⁵

Sonography shows tendon enlargement and a hypoechoic or anechoic appearance with loss of the fibrillar pattern. Enteseal calcification as well as erosive cortical

Figure 24. Schematic diagram of the flexor carpi ulnaris. The flexor carpi ulnaris, shown here in gray, belongs to the most superficial myotendinous layer of the anterior forearm and is located medially. Its tendon fibers insert into the pisiform, the flexor retinaculum, the hook of the hamate, and the base of the fifth metacarpal.

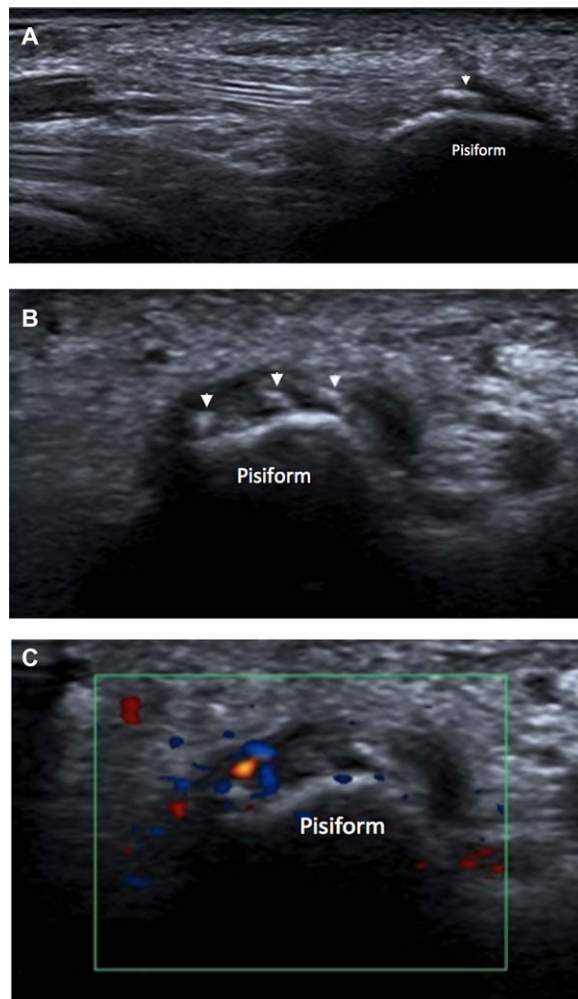


irregularities of the pisiform may develop. Increased peritendinous and intratendinous vascularization on Doppler imaging may also be seen and correlates with symptoms (Figure 25).⁶⁷

Tendinous Instability

This peculiar group comprises a series of pathologic conditions in which some of the stabilizing mechanisms of the involved tendon are damaged, thus causing tendon subluxation or dislocation.³⁷ The etiology may be either traumatic or, less commonly, related to congenital laxity.¹⁷

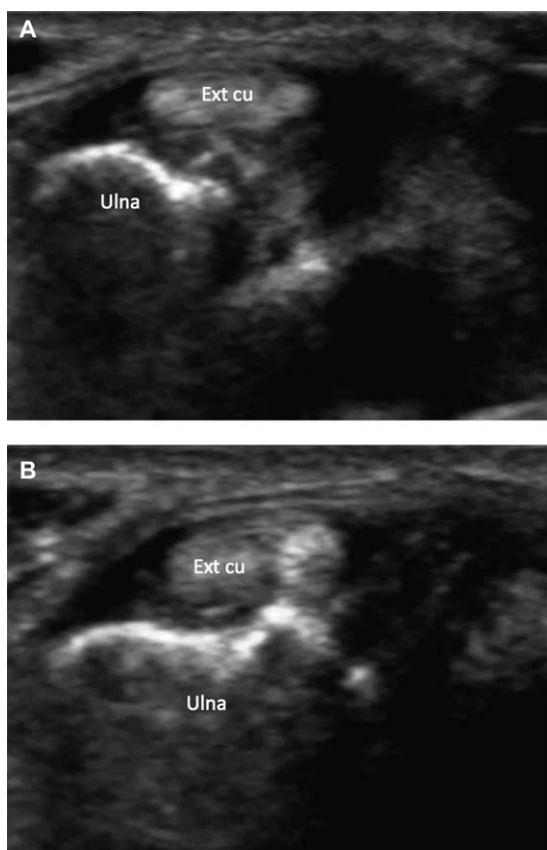
Figure 25. Enthesopathy of the flexor carpi ulnaris tendon. Longitudinal (A) and transverse (B) sonograms show tendon enlargement, a hypoechoic appearance with loss of the fibrillar pattern, and enteseal calcifications (arrowheads). On Doppler imaging, increased vascularization is seen (C).



Extensor Carpi Ulnaris Instability

Extensor carpi ulnaris instability includes a spectrum of disorders ranging from minor subluxation to frank dislocation of the extensor carpi ulnaris tendon during wrist movements. It has been described in athletes such as tennis players,^{68,69} in rheumatoid patients,⁷⁰ and in asymptomatic individuals.⁷¹ Within the sixth dorsal compartment, the extensor carpi ulnaris tendon is held in place by an overlying synovial subsheath that is located beneath the extensor retinaculum.⁷² Even though the extensor retinaculum is intact, injury of this subsheath causes the extensor carpi ulnaris tendon to repeatedly dislocate in the ulnar direction. It clinically presents with pain and audible snapping of the tendon in ulnar deviation or supination.^{73–75} A dynamic sonographic assessment allows for the identification of subluxation-dislocation of the extensor carpi ulnaris tendon as well as associated tears (Figure 26).^{76–78}

Figure 26. Extensor carpi ulnaris instability in a rheumatoid patient. Transverse sonograms show the extensor carpi ulnaris tendon (Ext cu), which dislocates out of the ulnar groove and in the ulnar direction during wrist supination (A) and ulnar deviation (B).



Climber Finger

Acute tears of annular pulleys are frequently related to sport activities, specifically rock climbing, and mostly involve the middle and ring fingers.⁷⁹ Patients present with pain and swelling over the affected pulley and may have a “pop” at the time of injury.⁸⁰ Sonographic findings include variable degrees of anterior subluxation of the digital flexor tendons that are no longer in contact with the bony surface and, in the acute stage, a hematoma within the tendon sheath. Anterior instability increases if the affected finger is flexed against resistance. Ruptured pulleys are usually not seen on sonography.^{81–83} A lobulated hematic effusion should be distinguished from articular ganglia arising at the level of the pulleys under a dynamic sonographic assessment.⁸⁴

Boxer Knuckle

Boxer knuckle is an uncommon injury to the sagittal bands that stabilize the extensor tendons at the dorsal aspect of metacarpal heads.⁸⁵ It typically occurs in boxers, mostly affecting the middle finger, and clinically presents with pain, swelling, loss of full extension, and either ulnar or radial snapping subluxation of the extensor tendon.^{86,87} Sonography reveals tendon subluxation contralateral to the torn sagittal band under a dynamic examination: the involved tendon dislocates when the patient is asked to make a fist and returns to its normal position during finger extension.^{88,89}

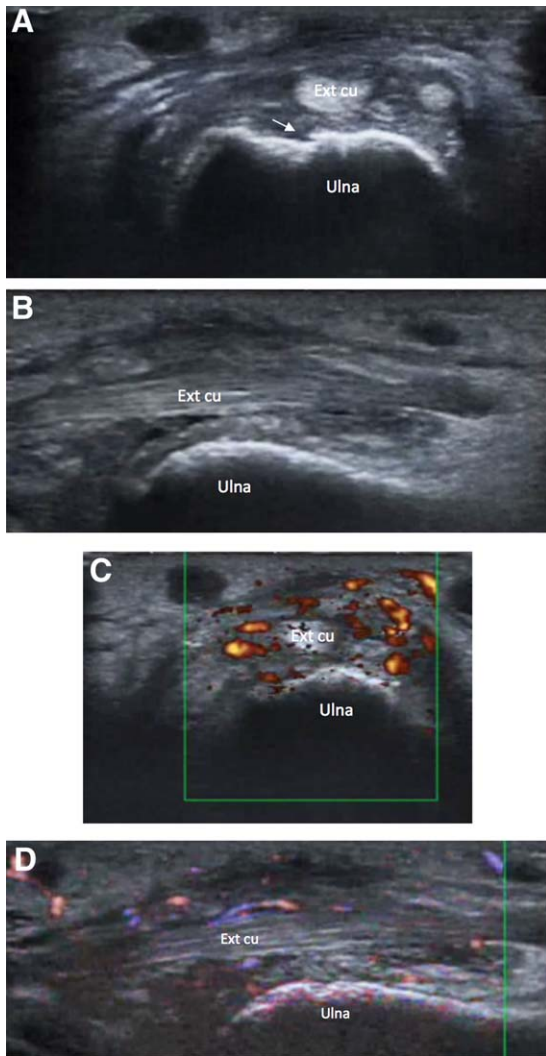
Tendinopathy in Inflammatory Rheumatic Diseases

Rheumatoid arthritis and psoriatic arthritis represent the two most common inflammatory rheumatic diseases affecting the tendons of the hand and wrist.⁹⁰ Rarely, systemic sclerosis may be responsible for tenosynovitis and tendon tearing. Systemic lupus erythematosus may produce tendon rupture.⁹¹

Rheumatoid arthritis affects up to 1% of the general population, often involves the hand and wrist, and is typically symmetric.⁹² The main site of inflammation is the synovial membrane, which becomes abnormally thickened, thus forming the so-called synovial pannus.⁹³ Synovitis involves not only joints but also tendon sheaths, and it may result in structural articular and periarticular damage in the long term.^{94,95} Tenosynovitis of the hand and wrist has been estimated to develop in up to 95% of patients with rheumatoid arthritis and most often affects

the extensor carpi ulnaris tendon.⁹⁶ Sonographic findings of rheumatoid tenosynovitis include thickening of the tendon sheath, intrasynovial fluid, and alterations in the tendon echo texture ranging from diffuse blurring to focal defects.^{97–99} Doppler imaging reveals synovial hyperemia as a sign of active inflammation; a decrease in synovial vascularization indicates fibrous pannus formation as well as a good response to treatment (Figure 27).^{100,101} Complete and partial tears of the hand and

Figure 27. Extensor carpi ulnaris tenosynovitis in a rheumatoid patient. Transverse (A) and longitudinal (B) B-mode sonograms depict the extensor carpi ulnaris tendon (Ext cu) within the sixth dorsal compartment; synovial thickening and bone erosions of the ulnar styloid process (arrow) are seen. Transverse (C) and longitudinal (D) Doppler sonograms reveal marked hyperemia, which indicates active inflammation.



wrist tendons have been reported in 1% of patients with rheumatoid arthritis, specifically in cases of advanced disease.⁹⁶ The most common sites of tendon rupture in rheumatoid wrists are the extensor pollicis longus and extensor digiti minimi proprius tendons.⁹¹ Finally, subluxation-dislocation of the extensor carpi ulnaris tendon may develop in rheumatoid patients (Figure 26).⁷⁰

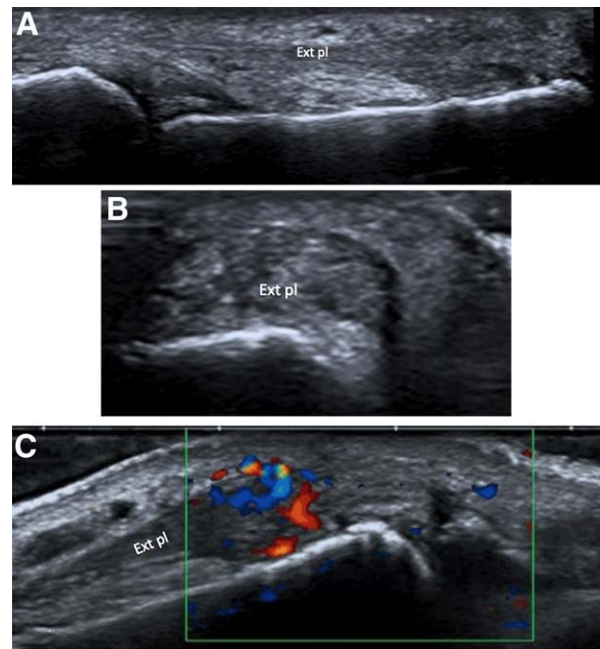
Psoriatic arthritis presents with asymmetric joint involvement, predominating in the distal interphalangeal joints. Dactylitis develops in up to 40% of patients and is characterized by subcutaneous tissue swelling and tenosynovitis of the flexor tendons.^{102–104} Extensor tenosynovitis as well as enthesopathy of the flexor and extensor tendons may also be found.^{105–107}

Postsurgical Examination

Operated Tendon Appearance: Healthy and Pathologic

Sonography has been proven to be effective in evaluating tendon integrity and detecting complications after surgical repair. However, the postintervention tendon

Figure 28. Operated tendon. In the first few months after surgical repair, on longitudinal (A) and transverse (B) B-mode scans, the healthy extensor pollicis longus tendon (Ext pl) is thickened and shows a heterogeneous echo texture with loss of the fibrillar pattern and fine intratendinous calcifications. Doppler imaging (C) shows intratendinous hyperemia.



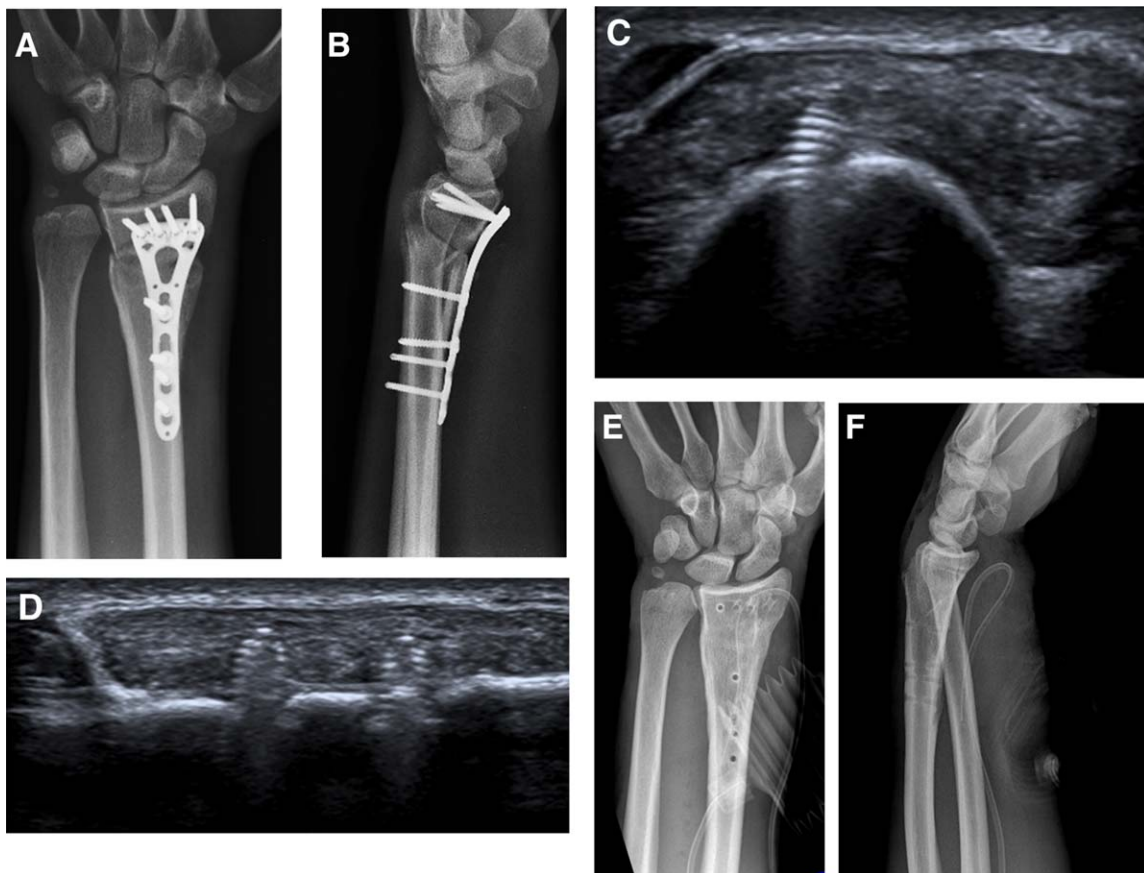
appearance differs from that of a healthy nonoperated tendon in several characteristics; thus, knowledge of the normal and pathologic sonographic features after surgery as well as the surgical technique used is required.¹⁰⁸ Healthy repaired tendons are larger and wider than nonoperated ones and show an inhomogeneous echo texture with a loss of the fibrillar pattern and irregular contours (Figure 28). The surgical material can be found in the context of the tendon. Tendon gliding is physiologically reduced under a dynamic examination. Large fluid collections as well as extensive calcifications should instead be considered pathologic findings. Doppler imaging shows no vascularization in the immediate postoperative period. Intratendinous vascularization physiologically increases in the first 3 months after surgery and then stabilizes and finally regresses within 6 months

(Figure 28). Beyond the first 6 months, persistent hypervascularization is pathologic.^{108,109} The main postsurgical complications include rerupture, adhesions, and lengthening of the tendon callus that results from healing process.¹⁰⁸

Orthopedic Hardware Impingement

As the tendons of the hand and wrist are in close contact with the bone plane, specifically within their osteofibrous tunnels, during muscle contraction, they may conflict with orthopedic hardware positioned in several surgical interventions. The risk of impingement varies according to the site and nature of the surgical procedure.²⁹ If the patient has local pain, pressure should be exerted with the transducer to reproduce the described symptoms under sonographic monitoring.¹¹⁰ Tenosynovitis and

Figure 29. Orthopedic hardware impingement. Plain radiography (A and B) shows a distal radial fracture fixed with a plate and screws. Transverse (C) and longitudinal (D) sonograms show screw impingement on the myotendinous junction of the abductor pollicis longus and extensor pollicis brevis at the dorsal radius. The orthopedic hardware appears hyperechoic with a posterior reverberation artifact. In a case of impingement, orthopedic hardware removal is indicated (E and F).



local hypervascularization on Doppler imaging are common sonographic findings of impingement. The orthopedic hardware typically appears hyperechoic with a posterior reverberation artifact (Figure 29). A persistent conflict may result in partial tearing and finally complete rupturing of the involved tendon. Inflammation of a pre-existing bursa or an adventitial bursitis may also develop. A local entrapment should be excluded both clinically and sonographically.^{110,111}

Conclusions

A variety of tendon disorders affecting the hand and wrist are commonly encountered in daily clinical practice. Knowledge of the medical history as well as symptoms and signs is basic for a correct diagnostic approach. However, the clinical presentations are often similar, and imaging is required to narrow down the list of differential diagnoses. Sonography is effective in assessing the tendons of the hand and wrist and related disorders, thus representing a valuable tool to ensure appropriate management and limit functional impairment.

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