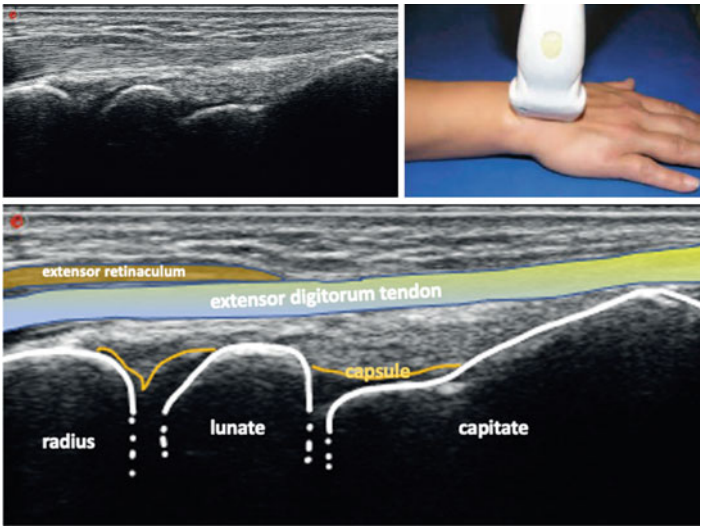
Chapter 7
The Wrist

7.1 Standard Scans of the Wrist

7.1.1 Dorsal Midline Longitudinal View of the Wrist (Standard Scan 7-1)



During examination of the wrist and hand, the examiner sits opposite the patient. The hand is placed in a neutral position on a flat surface. It may be extended and flexed for dynamic examination of the joints and tendons. The examination of the

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wrist starts with a longitudinal scan of the dorsal midline area of the wrist. This scan provides information on the radiocarpal joint and the midcarpal joint. At the first carpal bones row in the midline, the lunate bone is visible. Further distally, at the second row, the large capitate bone is seen in this scan.

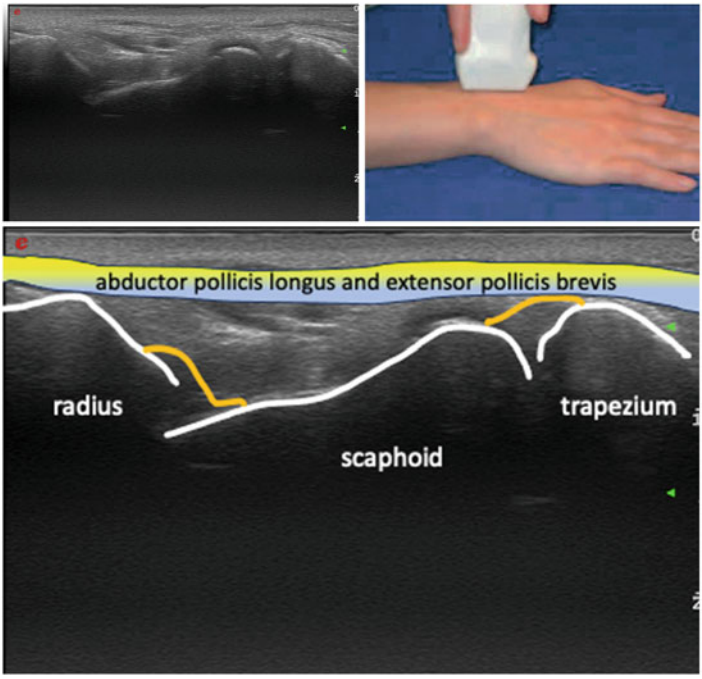
The extensor retinaculum extends from ulnar to radial across the dorsum of the wrist, preventing the extensor tendons from slipping. The retinaculum defines 6 separate extensor compartments, each of which contains a synovial sheath for the tendons that pass through it. The six compartments are readily seen on transverse scanning (Standard scan 7-5). While the retinaculum is hyperechoic, the underlying extensor tendon sheaths have an hypoechoic appearance.

What is normal?

Tendons show a fibrillar pattern. The bone-capsule distance at the scaphoid is 1.7 mm (0–3.4 mm).

7.1.2 Dorsal Radial Longitudinal View of the Wrist (Standard Scan 7-2)

For this view, the probe is swept gently in a radial direction. At the radial side, the radioscaphoid joint is seen. The scaphoid is the second largest carpal bone, conceding only the capitate bone before it. Along with the lunate, the scaphoid covers the complete radial border of the first row. The dorsal bony shape is crescent but shallower than the crescent shape of its ulnar neighbour, the lunate bone. Further distally, the scaphoid articulates with two small bones, i.e., on the far radial side with the trapezium, and between the trapezium and the capitate, with the trapezoid. The trapezoid is the smallest carpal bone. The trapezium articulates with the first metacarpal phalanx.



7.1.3 *Dorsal Ulnar Longitudinal View of the Wrist (Standard Scan 7-3)*

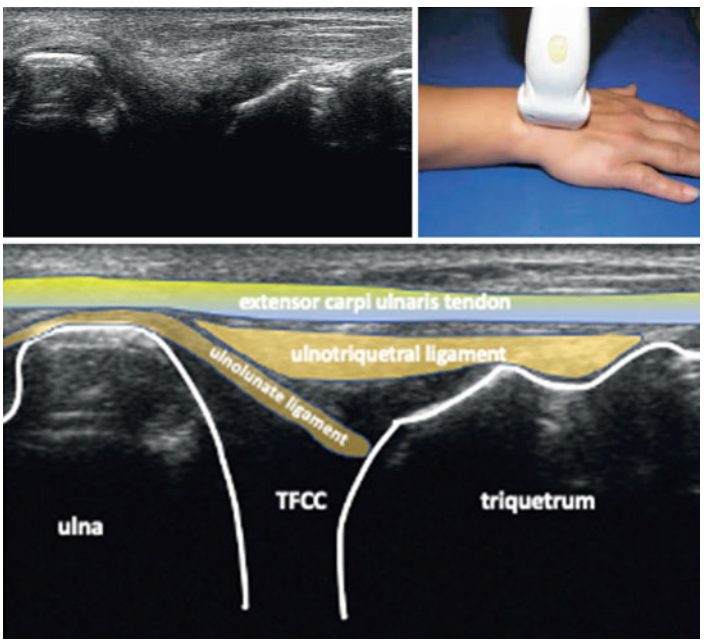
The position of the patient and sonographer including dynamic examination is identical to Standard Scan 7-1 and 7-2. The probe is shifted continuously in an ulnar direction. This scan provides information on the ulno-carpal aspects of the wrist.

An articulation exists between the distal ulna and the distal radius, which is called the distal radio-ulnar joint (DRUJ). Synovitis may occur at the DRUJ. Since there is no joint space strictu sensu between the ulna and the carpal bones at the ulnar side, i.e., the triquetrum and the pisiform bone, spacing material need to be in place. Thus, this area is filled by a fibrocartilaginous disc between the ulna and the lunate, a triangular shaped meniscoid structure and multiple ligaments.

The probe is shifted continuously from the first scan to this position. The wrist may be extended and flexed for dynamic examination of the wrist and the tendons. The distal end of the ulna occupies a smaller area than the radius. When shifting the probe from the radial to the ulnar aspect, the ulna appears with the lunate, then the triquetrum. The distance between the ulna and these midcarpal bones becomes longer when the probe is shifted ulnarly. If synovitis of the DRUJ is present, it extends over the ulna. This scan is also useful to detect erosions of the caput ulnae and the triquetrum.

What is normal?

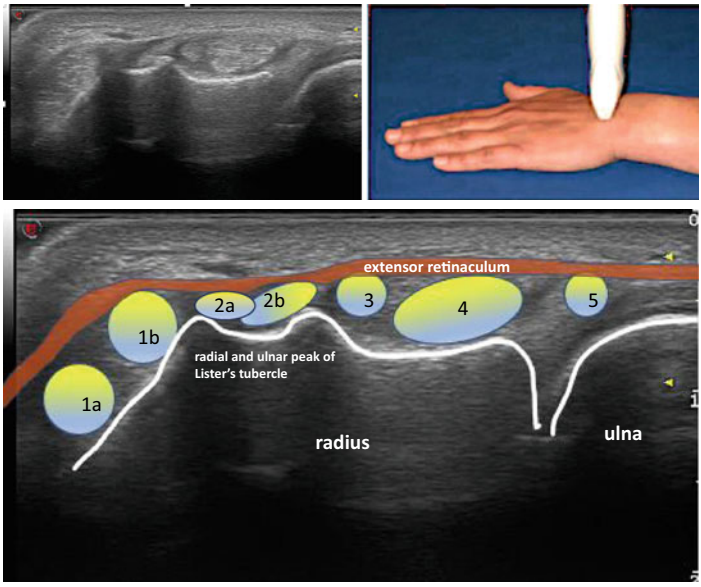
The distance between ulna and joint capsule at the most dorsal point of the ulna is 0.8 mm (0–1.6 mm).



7.1.4 *Dorsal Transverse View of the Wrist (Standard Scan 7-4)*

The positions of patient and sonographer are identical to the previous scans. The probe is rotated by 90° in order to be transverse to the position in Standard Scan 7-1. It is moved from the radial and ulnar area distally to the midcarpal region.

The transverse dorsal scan gives the best view of all the compartments of the extensor tendons. The sonogram shows, from the radius to the ulna, the second, third, fourth and fifth compartments. The radial side of the hand locates the first compartment, which contains the tendons of the abductor pollicis longus and the extensor pollicis brevis muscles (1a, 1b, respectively). These two tendons are inflamed in the condition termed "De Quervain tenosynovitis". The second compartment comprises the tendons of the extensor carpi radialis longus and brevis muscles (2a, 2b). These tendons run radially to the dorsal tubercle (also called Lister's tubercle) of the distal radius. Lister's tubercle functions as a pulley for the next tendon, the extensor pollicis lonus tendon, as this tendon changes course for its mechanical action. The third compartment (3) contains the tendon of the extensor pollicis longus muscle, compartment four (4) contains the tendons of the extensor digitorum and extensor indicis muscles, and in the fifth compartment the tendon of the extensor digiti minimi muscle is found (5). Compartment three lies directly medial to the distal tubercle of the radius, compartment five overlies the DRUJ.



More distally, the ligament between the scaphoid and the lunate can be assessed.

What is normal?

In most persons, Lister's tubercle consist of a single bony prominence on the dorsal distal radius; however as is demonstrated in this image, there is a double peak in a minority of persons. A small hypoechoic rim representing fluid within the sheaths may be present around the extensor tendons. Veins appear as anechoic, compressible structures. The extensor retinaculum appears as a hyperechoic bowed line, but in longitudinal planes may appear hypo-echoic due to anisotropy.

7.1.5 *Longitudinal View of the Extensor Carpi Ulnaris Tendon (Standard Scan 7-5)*

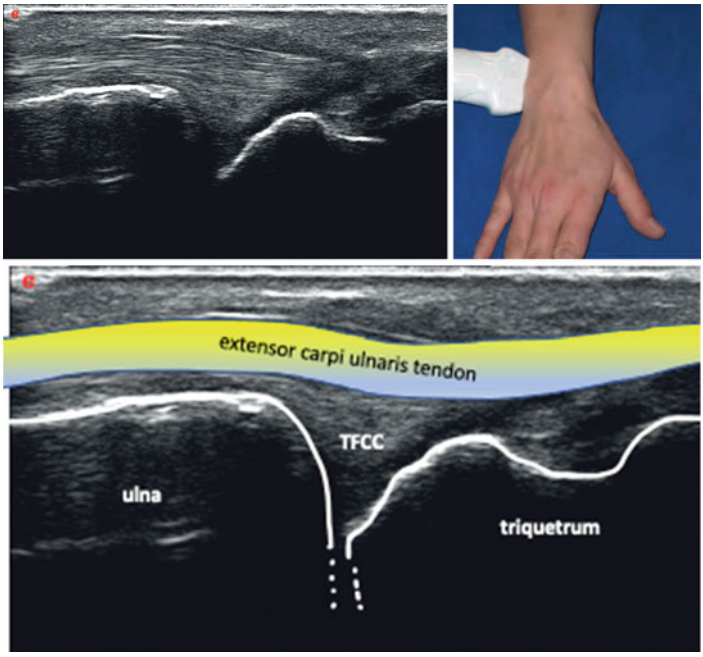
The position of the arm and hand is the same as that in Standard Scans 7-1 through 7-3. The probe is shifted continuously from the position in Standard Scan 7-3 to the ulnar side. The extensor carpi ulnaris tendon occupies the sixth extensor compartment and is in a bony groove adjacent to the styloid process of the ulna. The fibrillar hyperechoic appearance of the tendon is clearly visible on the longitudinal ultrasound scan. It overlies the ulno-carpal area, which is occupied by the triangular fibrocartilage complex (TFCC).

As the extensor carpi ulnaris tendon usually changes its direction at the wrist, one has to be aware of anisotropy and small physiologic hypoechoic areas around the tendon. It is important to investigate the full length of the tendon.

The triangular fibrocartilage complex (TFCC) can be examined in this longitudinal plane. It originates from a groove at the base of the ulnar styloid process and inserts by a broad base along the medial portion of the end of the radius. The fibrocartilage is interposed between the ulna and the carpus, forming an intra-articular disc.

What is normal?

The TFCC appears as a triangular structure with a mixed echogenicity.



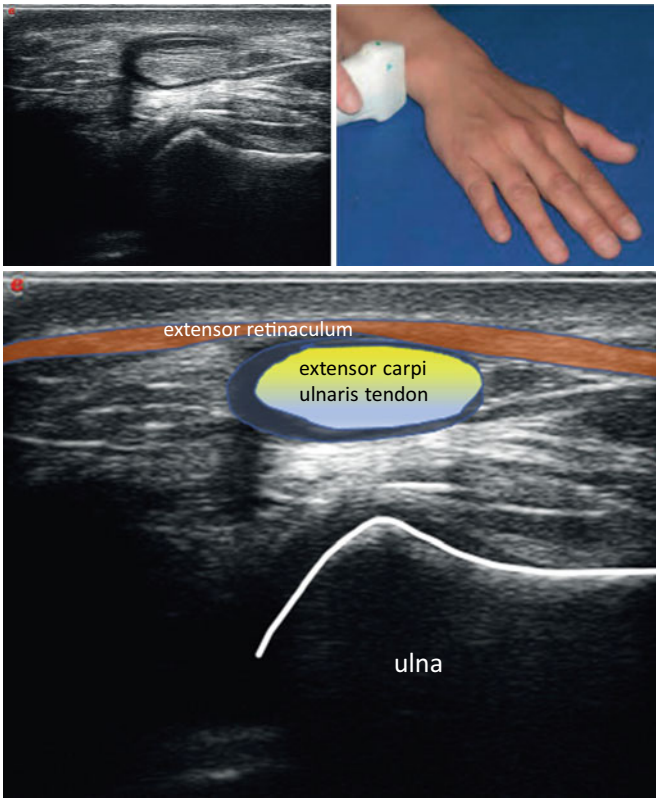
7.1.6 *Transverse View of the Extensor Carpi Ulnaris Tendon (Standard Scan 7-6)*

This scan is the transverse homologue of Standard Scan 7-4. The position of the arm and hand is similar to the position of the previous scans. The probe is shifted along the extensor carpi ulnaris tendon from an area proximal of the caput ulnae to an area distal to it.

This scan evaluates the extensor carpi ulnaris tendon which is frequently involved in inflammatory rheumatoid diseases. It is also used to search for erosions of the ulnar head. The tendon of the extensor carpi ulnaris muscle is located at the ulnar side of the ulna in a dedicated bony groove.

What is normal?

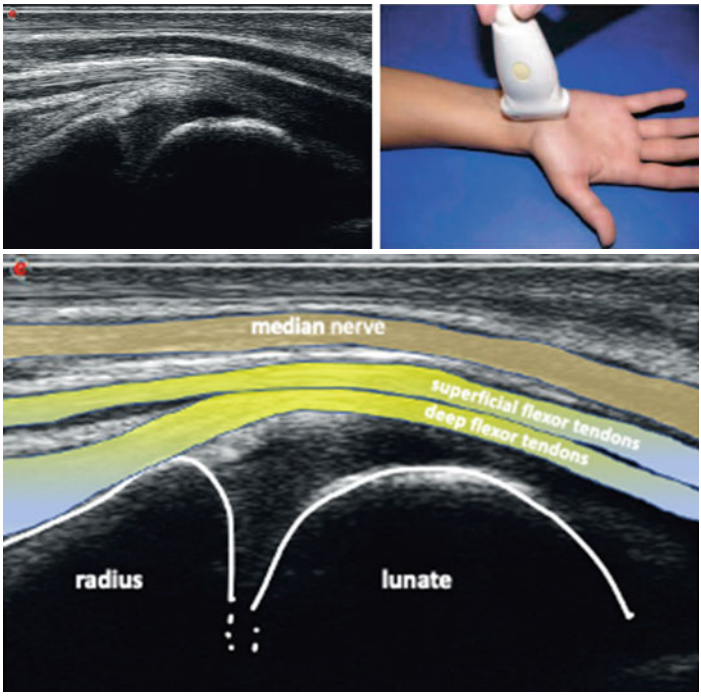
A hyperechoic layer around the tendon indicates the retinaculum. In addition, a variable amount of tenosynovial fluid is usually present around a normal tendon. The normal diameters directly distal to the head of the ulna are as follows: transverse diameter of the exensor carpi ulnaris tendon 5.4 mm (2.8–8.0 mm), sagittal diameter 2.7 mm (0.6–4.8 mm) and hypoechoic rim 1.2 mm (0.2–2.2 mm).



7.1.7 Volar Midline Longitudinal View of the Wrist (Standard Scan 7-7)

The forearm should rest on a flat surface. The wrist should be in supination. The wrist may be dynamically examined by flexion and extension maneuvers. The probe is placed in the midline of the wrist and shifted from ulnar to radial or vice versa.

In the midline of the wrist, the distal radius articulates with the lunate. In addition, the median nerve is visible anterior to the flexor tendons. There is a common joint space between the radius, the lunate, and the scaphoid, i.e., the radiocarpal joint, which is among the wrist joints one of the most affected by synovitis.



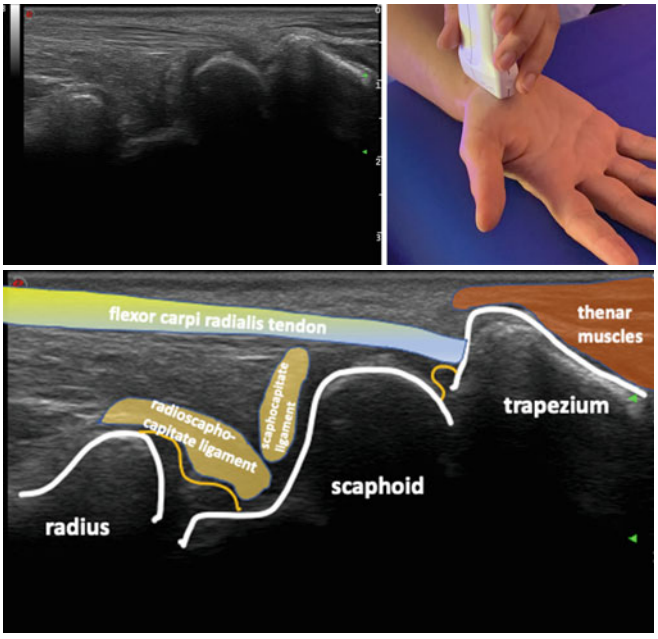
7.1.8 *Volar Radial Longitudinal View of the Wrist (Standard Scan 7-8)*

From the position in Standard Scan 7.1.7, the probe is swept radially. The forearm stays resting on a flat surface. The wrist should be in supination. The wrist may be dynamically examined by flexion and extension maneuvers.

The lateral distal radius articulates with the scaphoid bone. The tendon of the flexor pollicis longus muscle passes through the radial side of the carpal tunnel towards the thumb. This tendon has a long separate synovial sheath. The flexor carpi radialis tendon runs through the radial side of the carpus, and courses over the tubercle of the scaphoid to subsequently follow its course in a groove of the trapezium. In this scan, the three small thumb muscles, i.e., flexor pollicis brevis, abductor pollicis brevis, and opponens pollicis can be seen originating from the tubercle of the trapezium.

What is normal?

In the longitudinal plane, the nerve runs parallel and anterior to the tendons. It is delineated as a hypoechoic, less fibrillar structure and has continuous hyperechoic anterior and posterior borders, that represent the nerve sheath. Finger tendons, on the other hand, appear as tightly packed echogenic structures with fine parallel internal linear echoes, separated by hypoechoic lines.

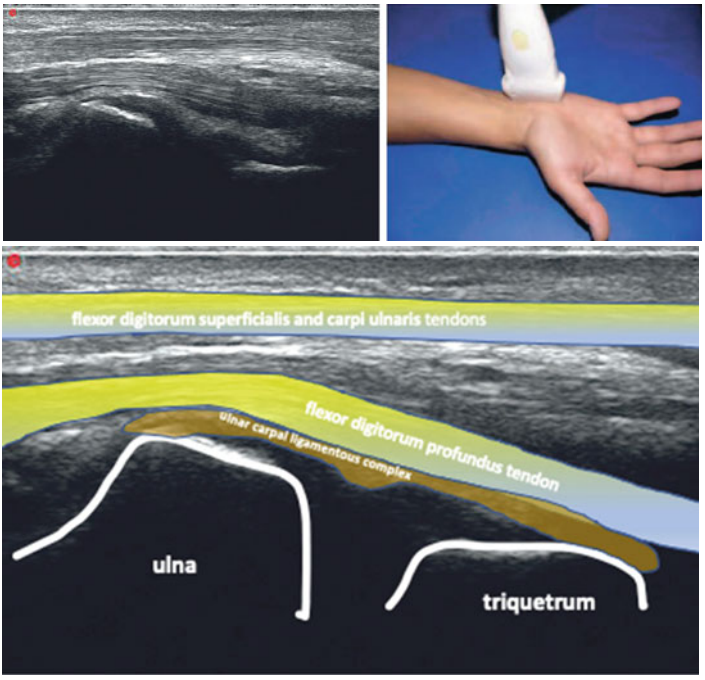


7.1.9 Volar Ulnar Longitudinal View of the Wrist (Standard Scan 7-9)

The movement of the probe is continued from the previous scan to this position. The wrist may be extended and flexed for dynamic examination of the joint and the tendons. On the ulnar volar aspect, the bony landmark is the ulnar head and more distally, the triquetrum. Superficial to the triquetrum, the small pisiform bone is visualized, which together with the former make up a synovial-lined articulation, the pisotriquetral joint.

The longitudinal scan shows the flexor carpi ulnaris tendon, inserting at the pisiform bone. Medial to the flexor tendon, the ulnar nerve and artery may become visible in a separate compartment outside the carpal tunnel, the canal of Guyon.

Compared with the nerve, the tendon is hyperechoic, but if the scan head is not in a plane perpendicular to the tendon surface, the tendon will appear hypoechoic due to anisotropy.



The tendon of the flexor carpi ulnaris muscle is the only wrist flexor tendon without a synovial sheath. The ulnar nerve and ulnar artery run lateral to this flexor tendon in a separate canal called canal of Guyon. The nerve enters the canal medial to the artery and splits in the tunnel into a superfical sensitive branch and a deep motor branch.

What is normal?

The distance between ulna and joint capsule 1 cm proximal of the wrist joint is 1.1 mm (0.1–2.1 mm).

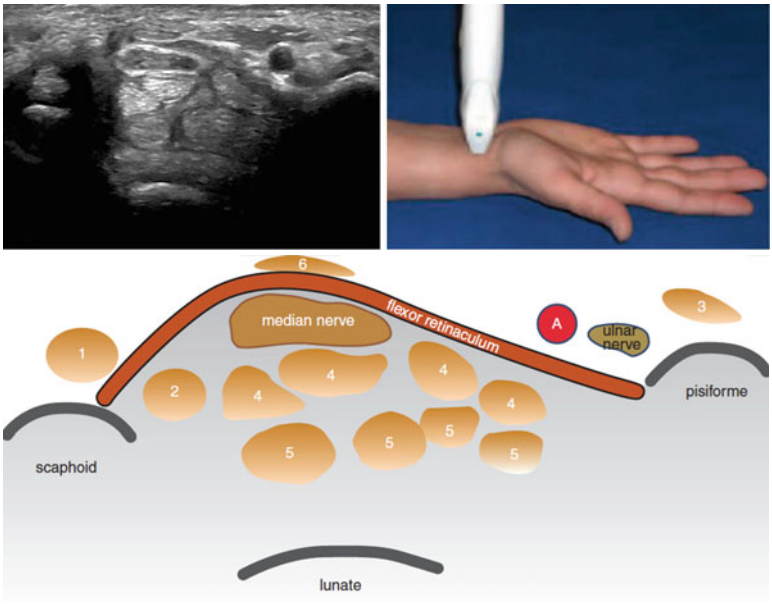
7.1.10 *Volar Transverse View of the Wrist (Standard Scan 7-10)*

The probe is rotated by 90° from the positions in Standard Scans 7-7 and 7-8 and then shifted from an area proximal to the wrist to an area distal to the wrist.

The volar transverse view is the best scan to assess the carpal tunnel. At the proximal carpal tunnel, the radial landmark is the tubercle of the scaphoid, whereas the medial landmark is formed by the ulnar artery and the pisiform. The distal carpal tunnel landmark is formed radially by the trapezium and ulnar by the hamulus (hook) of the hamate bone. The flexor retinaculum is stretched out between these four points.

The median nerve passes through the carpal tunnel to the radial side of the superficial row of flexor digitorum tendons and below the flexor retinaculum.

The flexor carpi radialis tendon (1) does not pass through the tunnel in contrast to the tendons of the superficial finger flexors and the profundus muscles, the tendon of the flexor pollicis longus muscle (2) and the median nerve which do pass through the tunnel. The third and fourth superficialis tendons lie superficial to the second and fifth superficialis tendons (4), and the 4 profundus tendons (5) lie side by side, deep to the second and fifth superficalis tendons (4). The flexor carpi ulnaris tendon courses superficial to the pisiform bone (3).



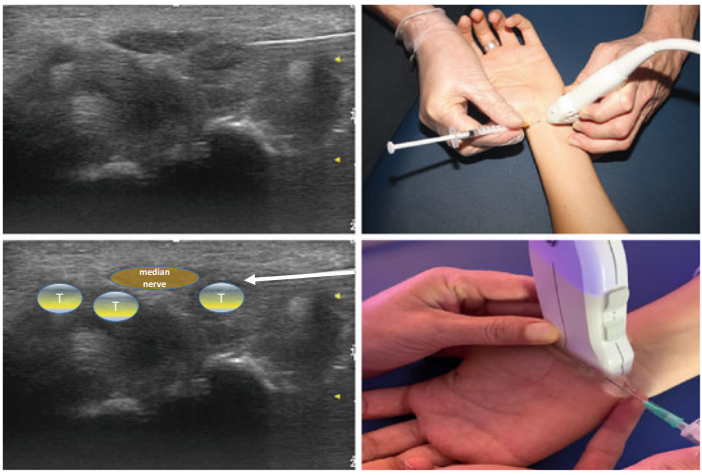
What is normal?

The median nerve is oval or rounded at the entrance of the carpal tunnel. The nerve flattens progressively as it courses through the tunnel. Nerve enlargement can be assessed in the transverse plane at the inlet or the outlet of the carpal tunnel. At the inlet and outlet, the median nerve is considered enlarged if the cross-sectional area >12 mm^2 and >11 mm^2, respectively. A normal nerve has hypoechoic rounded areas embedded in a hyperechoic background. In about 80% of persons, a palmaris longus tendon is present (6).

7.1.11 Ultrasound-Guided Injection of the Carpal Tunnel

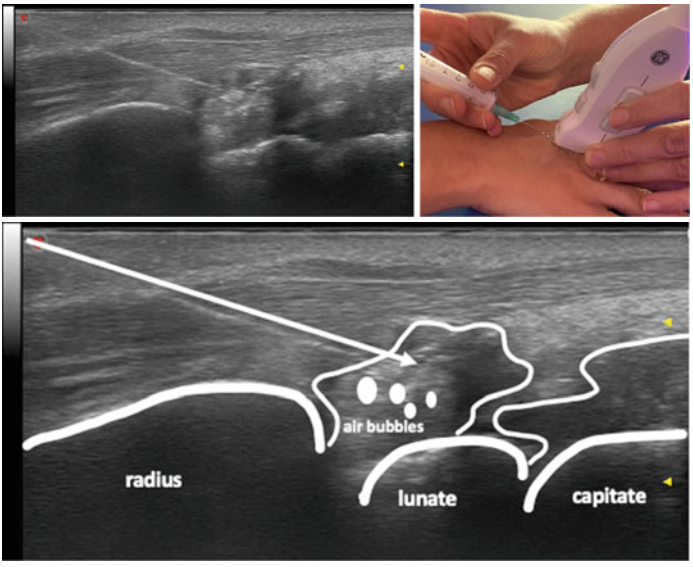
US-guided injection into the carpal tunnel can be performed either in a plane parallel to the long axis of the arm or transversely to it. Since various important anatomical structures are localized in the carpal tunnel, it is key to check the needle tip in two planes. Cadaver studies have shown that injection of the carpal tunnel can be safely done either by a radial volar or by an ulnar volar approach.

In this case, carpal tunnel syndrome due to flexor tenosynovitis is present. The ultrasound scan is showing the radial approach. The bony landmarks of the carpal tunnel inlet are radially the scaphoid bone and ulnarly the pisiform bone. A prescan showing the median nerve and its immediate radial neighbour within the tunnel, the flexor pollicis longus tendon, is done. Subsequently, the sites of the flexor carpi radialis tendon and the median nerve are marked with a skin marker. The needle is then introduced using a radial window, inserted between the flexor carpi radialis and flexor pollicis longus tendons. The case only shows a transverse scan; however, the exact localization of the needle tip should be checked for in a longitudinal plane.



7.1.12 Ultrasound-Guided Injection of the Dorsal Wrist Joint

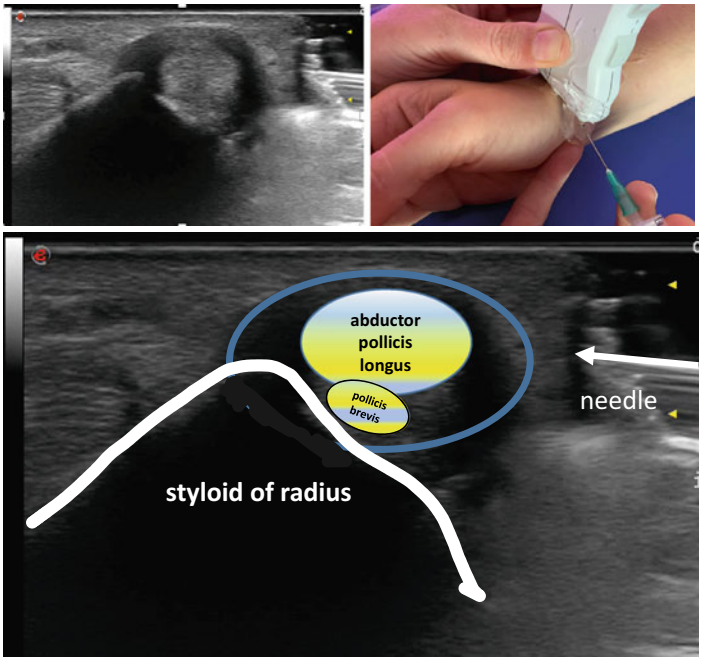
Ultrasound-guided injection of the wrist is generally performed in a long axis plane. Synovitis of the carpus can be demonstrated both dorsally and volarly, however for injection purposes the dorsal approach is somewhat easier, as there are fewer key anatomical structures present. The patient is comfortably seated with the arm extended on the table. A prescan is performed to identify—from proximal to distal - the radius, scaphoid or lunate bone, and the capitate bone. The probe is positioned in a longitudinal orientation on the target area. Then, the needle is inserted closely to the foot of the probe and directed into the radiocarpal joint space using an in-plane approach. Injection into the extensor tendons should be avoided at all costs.



7.1.13 *Ultrasound-Guided Injection of the First Extensor Compartment*

In tenosynovitis of the first extensor compartment or tenosynovitis of De Quervain, ultrasound can be very useful both for diagnosis and for treatment. Differential diagnosis is with the intersection syndrome and the Wartenberg syndrome. In addition, the first extensor compartment is sometimes divided into two compartments by a retinaculum.

The hand should be placed with the hypothenar on the examination table. The probe should be positioned in a short axis relative to the axis of the wrist plane. Next, the needle should be aligned with the probe to perform an in-plane injection. UItrasound-guidance is important since the radial artery is located just beneath the first extensor compartment.



7.2 Pathology of the Wrist

7.2.1 Synovitis of the Wrist I

Best Scans: Standard Scans 7-1, 7-2, 7-4, 7-6, 7-7 and 7-8.

Synovitis of the wrist is typically found anteriorly to the carpal bones as shown in Fig. 7.1. It localizes anteriorly to the scaphoid and lunate in the radiocarpal joint (⇓) or ulnocarpal joint and anteriorly to the capitate in the midcarpal joint area (⇑). Both areas are separated by ligaments. In advanced arthritis, these ligaments may be torn, so that these compartments communicate. Synovitis often extends to the radial, ulnar, and palmar sides.

Power Doppler studies show the inflammatory nature of active synovitis (Fig. 7.2). The intensity of power Doppler signals is graded as follows:

Grade 0: no signals

Grade 1: up to 3 signals and <1 confluent signal in one scan

Grade 2: Signals covering <50% of the synovium in one scan

Grade 3: Signals covering >50% of the synovium in one scan.

After steroid treatment, a dramatic reduction in power Doppler signal can be observed. The presence of intraarticular Doppler signals is a strong predictor of erosive disease in RA.

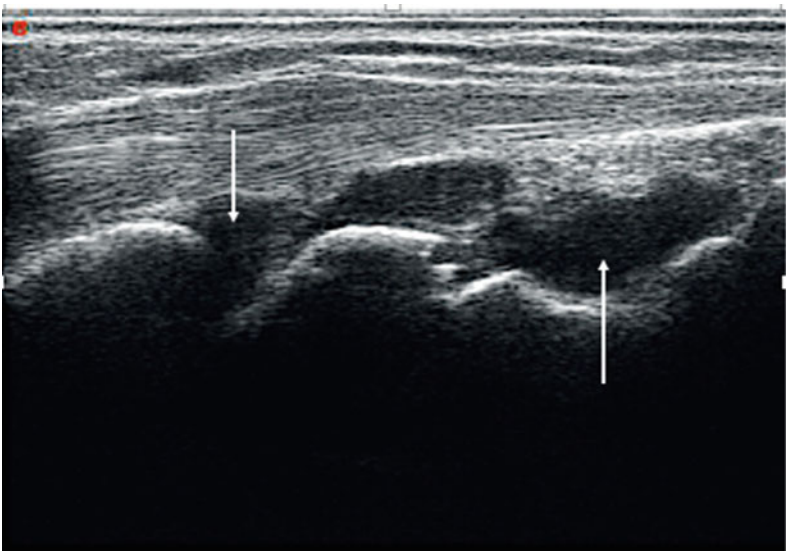


Fig. 7.1 Synovitis of the radiocarpal and the midcarpal joints (dorsal longitudinal view)

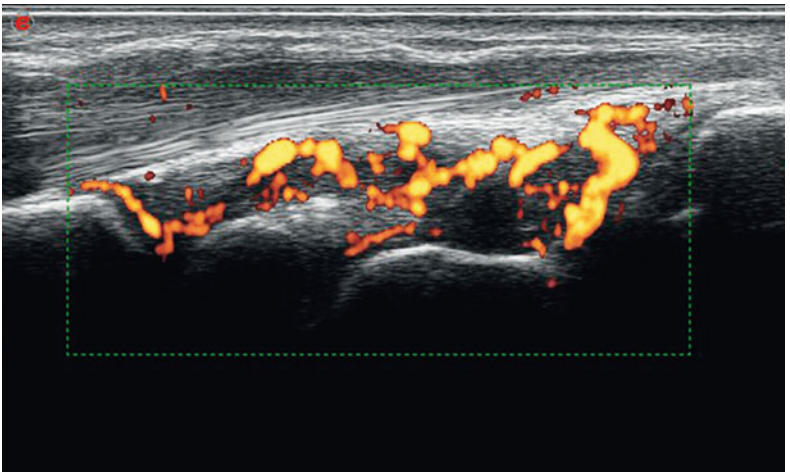


Fig. 7.2 Synovitis with grade 3 power Doppler vascularity of the radiocarpal joint and midcarpal joints (dorsal longitudinal view)

Figure 7.3 shows wrist synovitis (⇓) in a dorsal transverse plane at the level of the lunate and scaphoid. The hypoechoic rim around the extensor digitorum tendons is normal. There is no additional tenosynovitis.

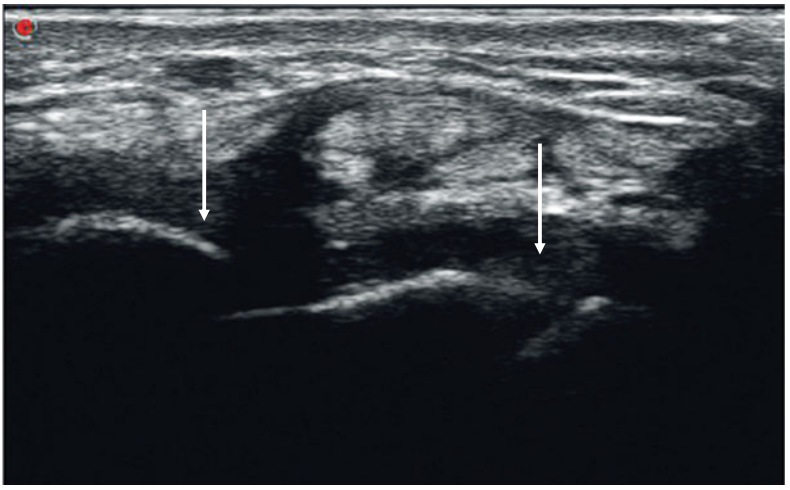


Fig. 7.3 Synovitis of the radiocarpal and ulnocarpal joints (dorsal transverse view)

7.2.2 *Synovitis of the Wrist II*

Best Scans: Standard Scans 7-1, 7-2 and 7-4.

Figure 7.4a shows a longitudinal sonogram at the level of the joint space between radius and scaphoid showing synovial thickening. There are clearly associated power Doppler signals corresponding to synovial hyperemia (grade 2) at the midcarpal joints. At the radiocarpal joint (wrist), synovitis exhibits only two single signals at the very distal end of the synovium (grade 1). Figures 7.4b and c show active synovitis of the radiocarpal and midcarpal joint space.

Figure 7.5 shows a dorsal longitudinal image of a patient's wrist, with synovitis of the distal radio-ulnar joint, extending both proximally over the ulnar head (⇑) and distally to the triquetrum. There are cortical irregularities but no erosions of the ulnar bone surface.

In Fig. 7.6, there is an effusion of the radiocarpal joint. The fluid extends proximally to the radial head.

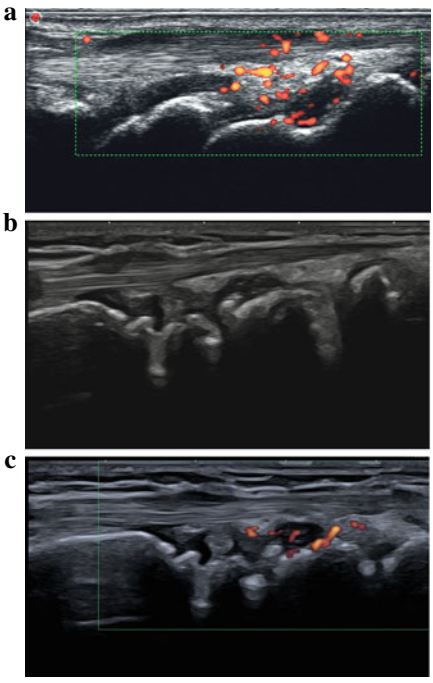


Fig. 7.4 **a** Synovitis of the wrist. The inflammatory activity is higher in the midcarpal region than in the radio-carpal joint (dorsal longitudinal view); **b** Synovitis of the wrist and erosions of the lunate bone in a patient with rheumatoid arthritis (dorsal longitudinal view); **c** Doppler signals in the radiocarpal and midcarpal wrist in a patient with rheumatoid arthritis (dorsal longitudinal view)

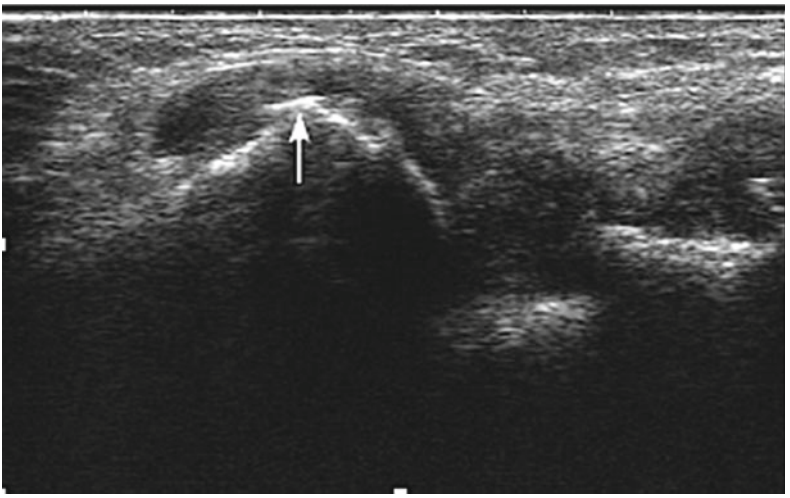


Fig. 7.5 Synovitis of the ulnocarpal joint with bony irregularities of the ulnar head (dorsal ulnar longitudinal view)

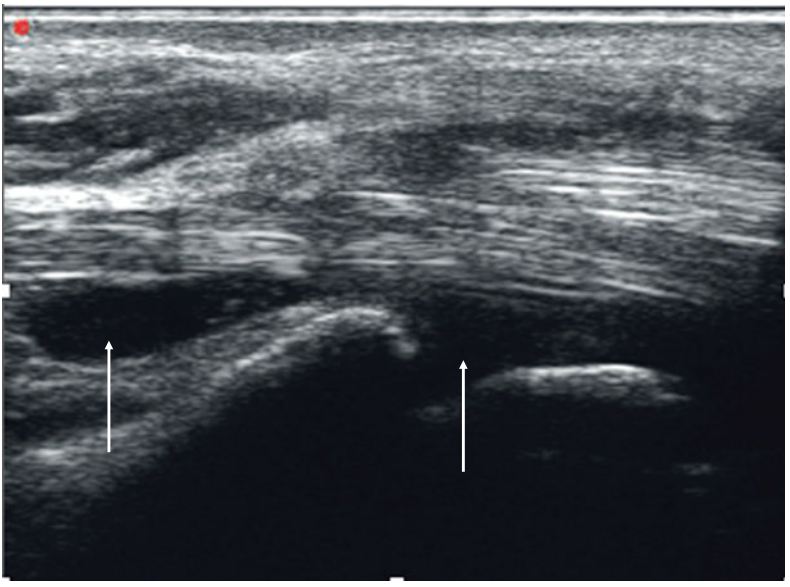


Fig. 7.6 Effusion of the radio-carpal joint (arrows; volar longitudinal view)

7.2.3 *Tenosynovitis of the Wrist I*

Best Scans: Standard Scans 7-1 to 7-8.

In Fig. 7.7, a longitudinal sonogram shows hypoechoic material at the dorsal radiocarpal joint and the midcarpal joints representing synovitis (⇑). In addition, there is hypoechoic material around the extensor digitorum tendons representing tenosynovitis (⇓).

Figure 7.8 shows a transverse sonogram of the extensor digitorum tendons of the right wrist. The ulnar side with the extensor minimi tendon, representing the fifth compartment, is on the left. The extensor digitorum tendons including the extensor indices tendon (fourth compartment) are surrounded by an increased amount of hypoechoic material representing tenosynovitis (**). The hypoechogenicity of the surrounding material enhances the normal echogenicity of the tendons, thus improving their visibility. Further to the right side of the scan, the third compartment with the extensor pollicis longus tendon is seen (*).

Figure 7.9 shows a transverse plane of the sixth compartment, i.e., the tendon of the extensor carpi ulnaris muscle. This sonogram demonstrates tenosynovitis with hypoechoic fluid surrounding the tendon. The cause may be inflammatory disease, trauma, or infection. In addition, there are erosions of the ulnar head.

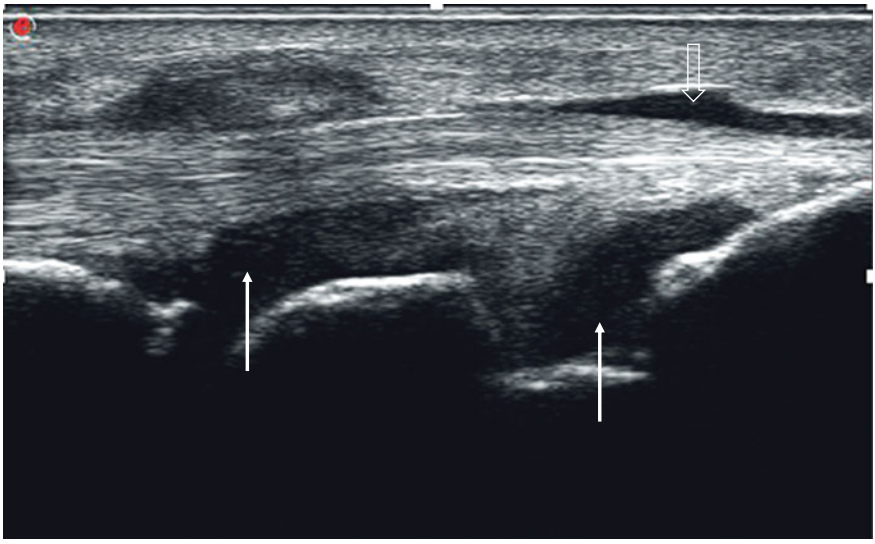


Fig. 7.7 Synovitis of radiocarpal and midcarpal joints and tenosynovitis of extensor digitorum tendons (dorsal longitudinal view)

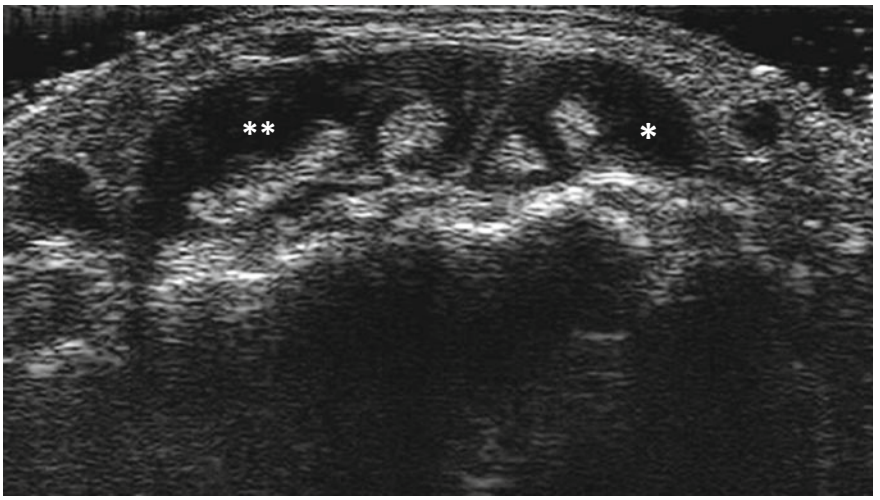


Fig. 7.8 Tenosynovitis of extensor digitorum tendons (dorsal transverse view)

Fig. 7.9 Tenosynovitis of the extensor carpi ulnaris tendon with erosions of the ulnar head (transverse dorsal ulnar view)

7.2.4 Tenosynovitis of the Wrist II

Best Scans: Standard Scans 7-1 to 7-8.

This longitudinal scan of Fig. 7.10 shows tenosynovitis of the extensor carpi ulnaris tendon. The hyperechoic fibrillar echotexture of the tendon is readily recognized. The tendon runs over the ulna, ulnar head, ulnocarpal joint and triquetrum. Hypoechoic material representing tenosynovial proliferation and / or fluid is visualized. The surface of the ulnar head is irregular.

In Fig. 7.11, a volar longitudinal scan shows tenosynovitis of both the superficial (⇓) and deep (⇑) tendons of the flexor digitorum muscles. In addition, there is effusion of the radiocarpal joint that extends proximally over the radial head (⇒).

Figure 7.12 shows a hypoechoic widening of the extensor tendon sheath of the dorsal wrist.

The transverse sonogram of Fig. 7.13 shows the double rows of superficial and deep flexor digitorum tendons separated by fluid (hypoechoic areas) caused by tenosynovitis. Superficial to the flexor tendons, the median nerve is clearly visible. Anterior to the median nerve, the strong flexor retinaculum appears as a hypoechoic band.

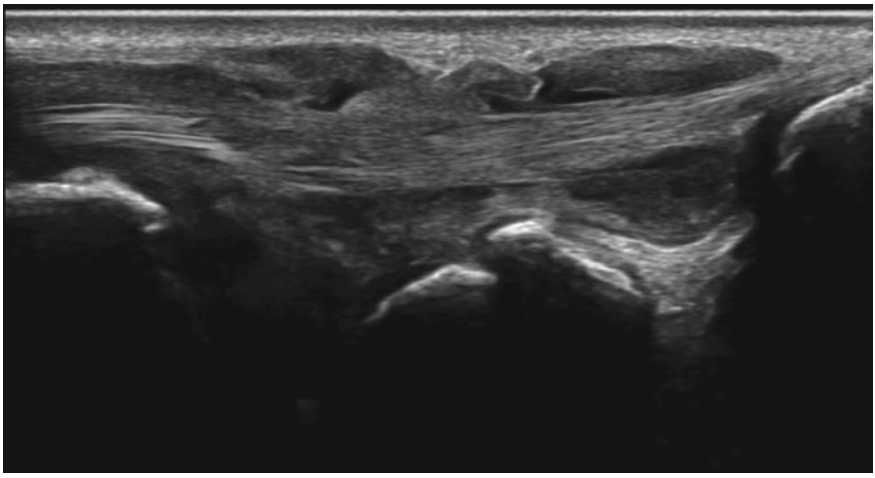


Fig. 7.10 Tenosynovitis of the extensor carpi ulnaris tendon at the wrist (longitudinal dorsal ulnar view)

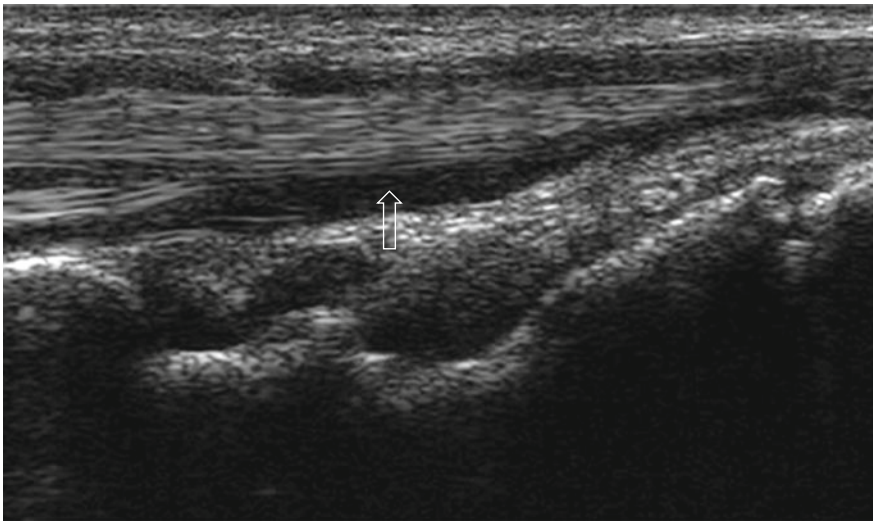


Fig. 7.11 Tenosynovitis of flexor digitorum tendons and effusion of the radiocarpal joint (volar longitudinal view)

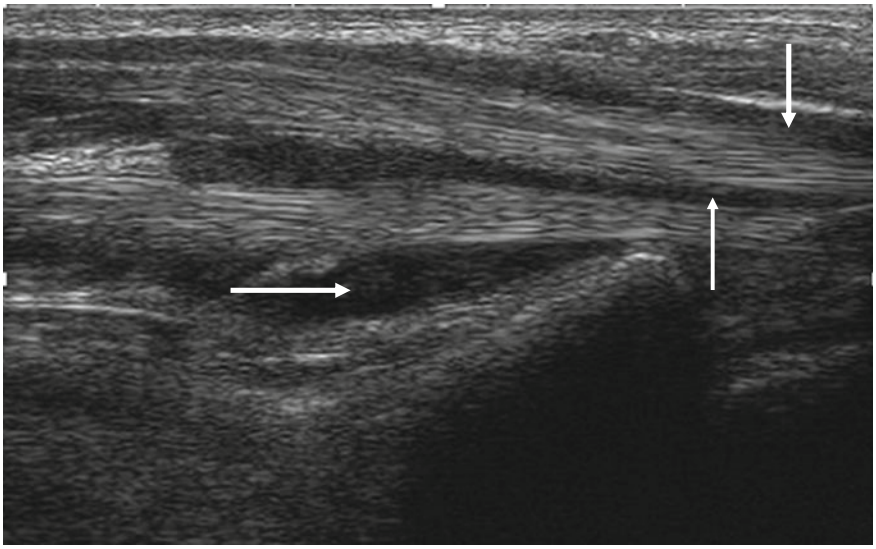


Fig. 7.12 Tenosynovitis of the extensor tendons and wrist effusion (dorsal longitudinal view)

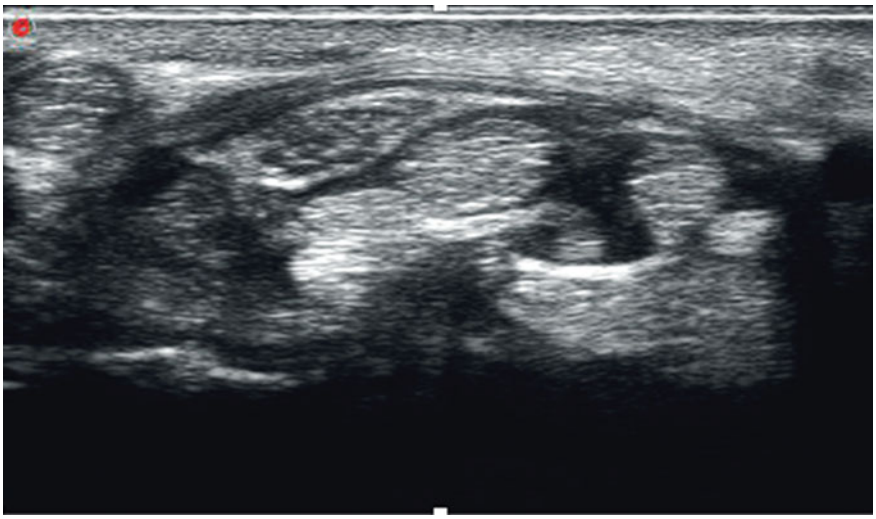


Fig. 7.13 Tenosynovitis of the flexor digitorum tendons in the carpal tunnel with normal median nerve (volar transverse view)

7.2.5 Carpal Tunnel Syndrome

Best Scans: Standard Scans 7-6 and 7-8.

Ultrasound can distinguish between primary and secondary carpal tunnel syndrome. In primary carpal tunnel syndrome, the flexor retinaculum is thickened (about 1.0 mm or more) or the median nerve is altered and no other reason for this can be found. Secondary carpal tunnel syndrome can result from tenosynovitis of the flexor digitorum tendons, wrist synovitis, ganglia or other space-consuming lesions.

Sonographic findings can be divided into qualitative or subjective and quantitative or objective criteria. Subjective findings are hypoechoic enlargement of the nerve at the inlet of the carpal tunnel; volar bulging of the flexor retinaculum; large fluid or soft tissue masses surrounding the tendons; decreased mobility of the median nerve on flexion and extension of the fingers, hand and wrist.

The mean cross-sectional area of the median nerve >12 mm^2 at the inlet of the carpal tunnel seems to have the highest sensitivity and specificity for the presence of carpal tunnel syndrome. Other objective but less specific and sensitive criteria are an increased flattening ratio of the nerve, i.e., transverse diameter divided by the anterior–posterior diameter >4 at the level of the hamate, and volar bulging of the flexor retinaculum >3.1 mm.

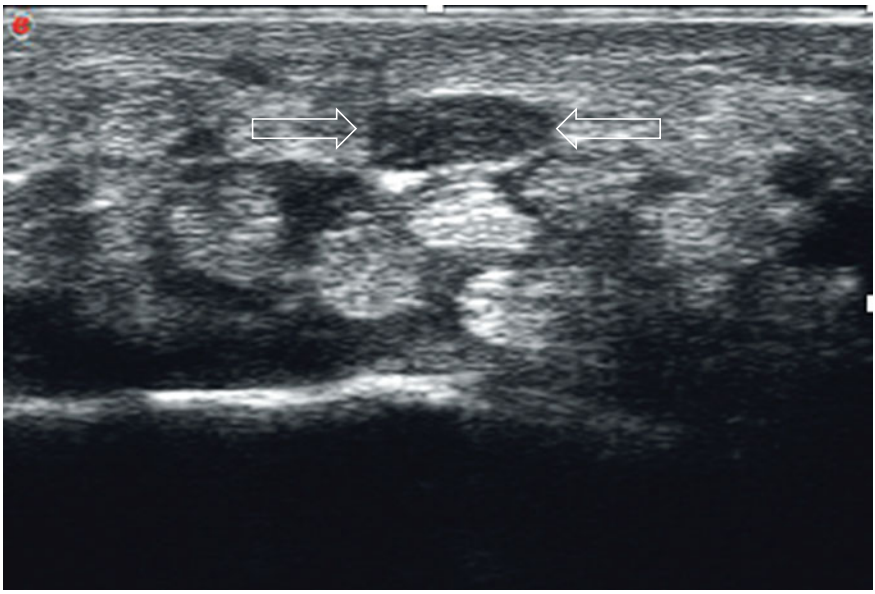


Fig. 7.14 Hypoechoic, enlarged median nerve and tenosynovitis of the flexor digitorum tendons in secondary carpal tunnel syndrome (volar transverse view)

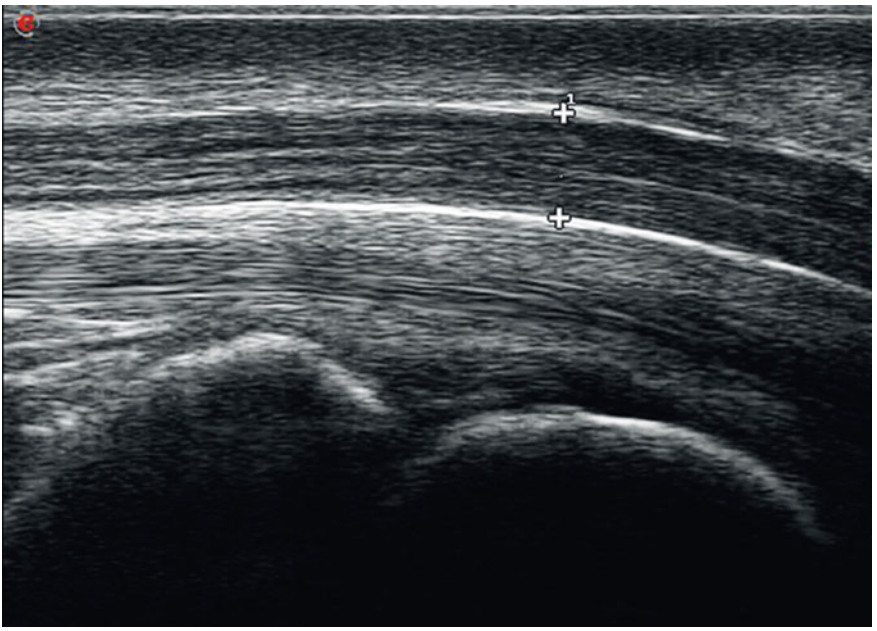


Fig. 7.15 Hypoechoic, enlarged median nerve without any further abnormalities in primary carpal tunnel syndrome (volar longitudinal view)

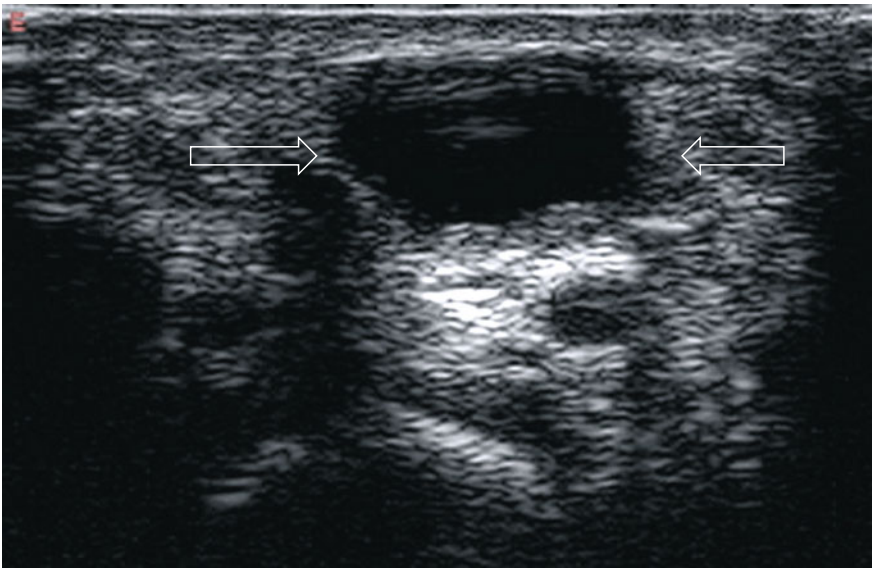


Fig. 7.16 Ganglion at the wrist (volar transverse view)

Figures 7.14 and 7.15 show a swollen, hypoechoic median nerve (arrows), anterior to the flexor tendon. The transverse image delineates tenosynovitis whereas the longitudinal image does not depict any further abnormality suspective of primary carpal tunnel syndrome.

Figure 7.16 shows a ganglion (⇒⇐), which appears as a well-defined anechoic, non-compressible structure that does not exhibit color Doppler signals. Ganglia often occur at the volar radial aspect of the wrist.