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Role of USG in the evaluation of the wrist and hand

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Radiology began with imaging of the hand, albeit accidentally, when Roentgen obtained a radiograph of his wife's hand in 1895. Since then, there have been rapid advances in imaging. Recent advances in transducer technology have led to the development of very high frequency probes that allow imaging of superficial structures with exquisite detail. The fine spatial resolution, speed of examination, and dynamic assessment make USG useful for evaluating pathologies in the wrist and hand.

Technique

Linear array transducers with high frequencies ranging from 8 to 15 MHz are used for tendon imaging. The tendon is traced along its entire extent. Both longitudinal and transverse scans should be performed. The newer machines allow panoramic views, which can demonstrate the entire tendon in a single image. The contralateral extremity should always be scanned to provide a reference for normal anatomy. Dynamic evaluation should be performed by examining the tendon with active and passive mobilization.[1] It is important to make sure that the tendon is parallel to the surface of the transducer in order to avoid the artifact of anisotropy.

Normal anatomy and appearances

Tendons are highly echogenic with a characteristic fibrillar echotexture [Figure 1]. This fine internal architecture of tendons is demonstrated on USG, while MRI shows tendons as dark structures. The tendons can be identified by their mobility during real-time imaging. A tendon sheath may be seen as a very thin hypoechoic lining of the echogenic tendon.[2]

We start scanning the wrist from its extensor aspect. Two key structures define USG anatomy, namely the extensor retinaculum and the Lister tubercle [Figure 2A]. The extensor retinaculum has several deep attachments, which divide the extensor aspect into six separate compartments. The first compartment contains the abductor pollicis longus and the extensor pollicis brevis tendons. The extensor carpi radialis longus and extensor carpi radialis brevis tendons lie in the second compartment. The third compartment contains the extensor pollicis longus tendon. The fourth compartment holds four tendons of the extensor digitorum as well as the extensor indicis tendon [Figure 2B]. The extensor digiti minimi lies in the fifth compartment, while the sixth compartment contains the extensor carpi ulnaris.

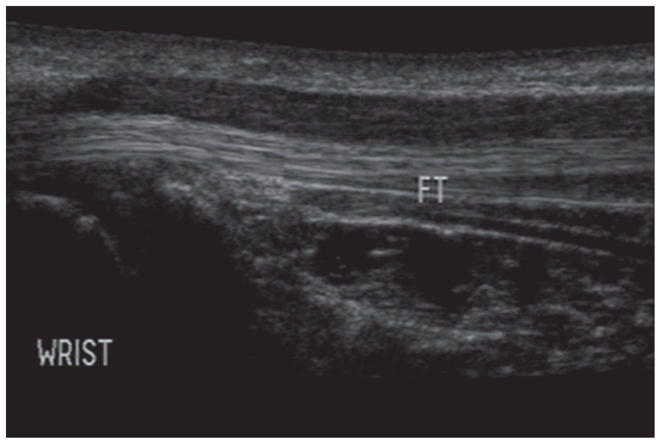

Figure 1: Longitudinal image showing the normal fibrillar architecture of the tendon and the musculotendinous junction

The key anatomic structure on the flexor surface is the flexor retinaculum. This strong fibrous band crosses the front of the carpus and converts its anterior concavity into the carpal tunnel, through which pass the flexor tendons and the median nerve [Figure 3A and B]. The flexor pollicis longus

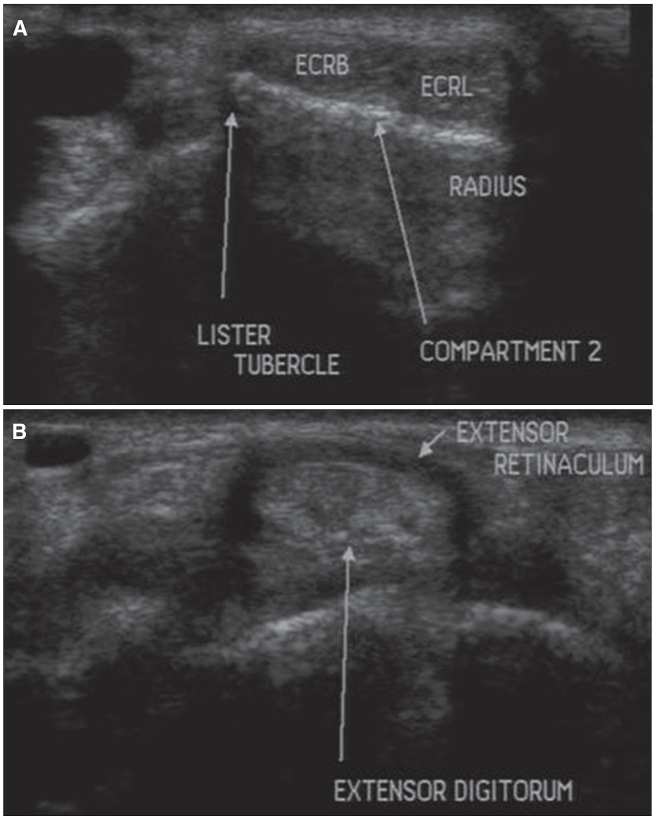

Figure 2 (A, B): Transverse image (A) at the dorsum of the wrist showing the compartment 2 tendons, lateral to the Lister tubercle (ECRB - extensor carpi radialis brevis, ECRL - extensor carpi radialis longus). Transverse image (B) at the dorsum of the wrist showing the extensor digitorum tendons and the extensor retinaculum.

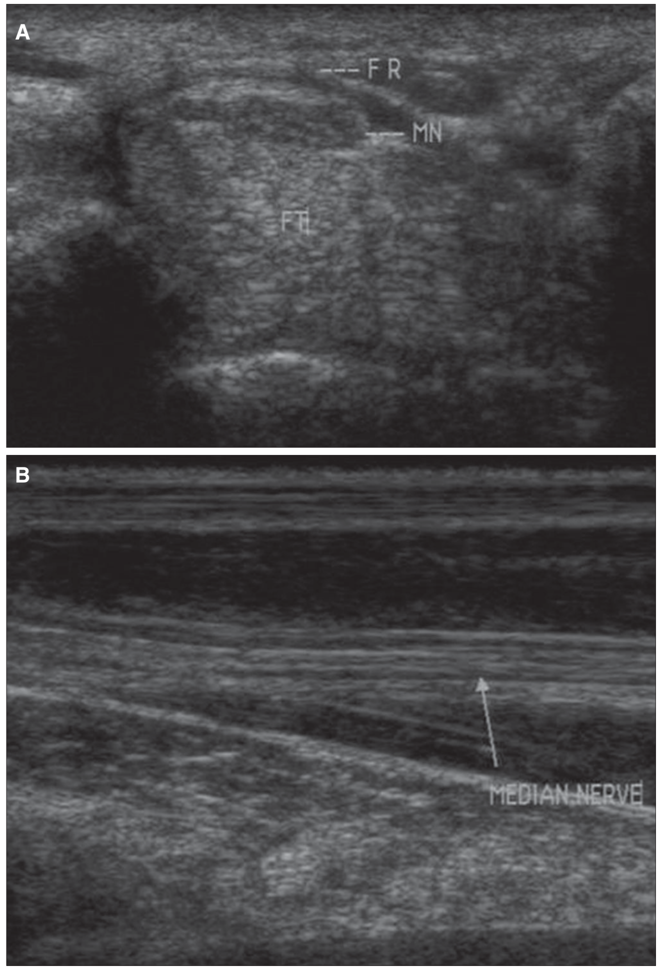

Figure 3 (A, B): Transverse image (A) at the volar aspect of the wrist showing the flexor retinaculum and median nerve (FR - flexor retinaculum, MN - median nerve, FT - flexor tendon). Longitudinal image (B) of the median nerve in the distal forearm showing the linear nerve fasicles.

tendon passes through the radial side of the tunnel. The superficialis tendon is superficial to the profundus tendon in the palm, until it divides at the level of the proximal third of the proximal phalanx. Here the two lateral slips of the superficialis tendon course on either side of the profundus tendon and then unite and insert on the proximal half of the middle phalanx. The profundus tendon passes through the divided superficialis tendon and inserts at the base of the distal phalanx [3] [Figure 4 A and B].

The pulley system refers to a number of ligaments, including annular pulleys and cruciform pulleys, that span from side-to-side across the volar margin of the finger phalanges. They stabilize the flexor tendons during finger flexion, thereby avoiding radial displacement or volar bowstringing. The annular pulleys are located at five specific points along the tendon sheath and are numbered from proximal to distal. The first (A1) extends from the metacarpophalangeal joint to the base of the proximal phalanx. The second (A2) extends from the base of proximal phalanx to the junction of the proximal two-thirds and the distal third of the proximal phalanx. The third (A3) is small in size and is located over the proximal interphalangeal joint. The fourth (A4) lies in the middle third of the middle phalanx, and the fifth (A5) is placed over the distal interphalangeal joint. Of the five annular pulleys, all formed by thick fibrous tissue, the A2 pulley is the strongest and the A4 pulley has the greater stiffness.[4] Normal annular pulleys are < 1mm thick, but they can be demonstrated with high-resolution USG as very thin anisotropic bands covering the flexor tendons.[5] Transverse planes are the best for depicting them [Figure 5]. Using high-resolution probes, the A1, A2, and A4 pulleys can be demonstrated in virtually all normal subjects (thickness 0.3–0.5 mm).

Acute tears of the annular pulleys are typically encountered in rock climbers. Although USG can directly assess the annular pulleys, the diagnosis can be confidently made by measuring the increased tendon–phalanx distance and the consequent bowstringing of the tendon. This is measured at the level of the A2 and A4 pulleys, at rest and on flexion against resistance.

The normal distance at the A2 pulley is < 1mm and at the A4 pulley is < 2.5 mm. A distance of > 1mm but < 3mm is considered a sign of incomplete A2 pulley rupture, whereas a distance > 3 mm is a sign of complete rupture. A tendon–phalanx distance of > 5 mm is a sign of A2 and A3 pulley rupture. For the A4 pulley, a distance of > 2.5 mm is a sign of complete rupture.[6]

Tendon disorders are common and are usually associated with athletic and occupational activities leading to overuse. Due to their superficial location, the tendons of the hand are well suited for evaluation by USG. Pathologies like tendinitis, tenosynovitis, tears, and tumors can be diagnosed with confidence.

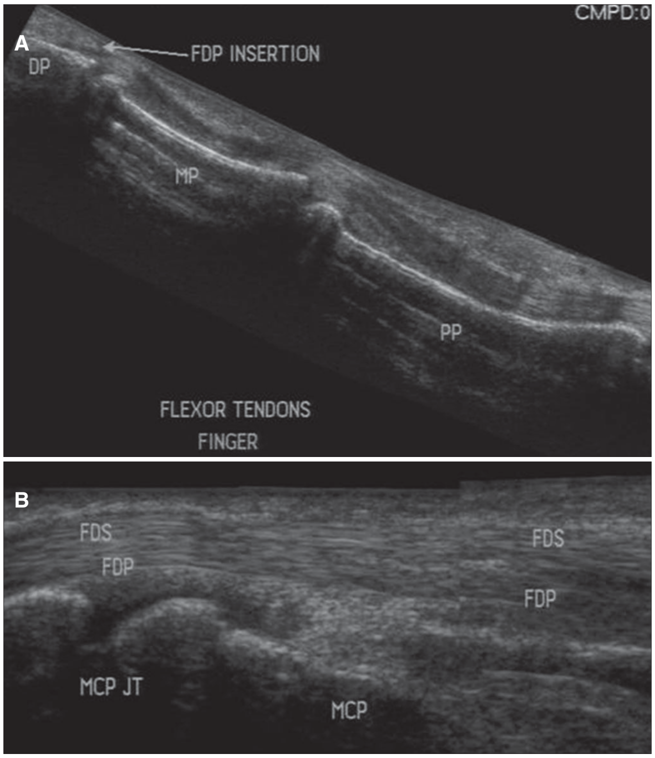

Figure 4 (A, B): Longitudinal images (A, B) revealing the course of the normal flexor tendons in the middle finger. (PP - proximal phalanx, MP - middle phalanx, DP- distal phalanx, FDP- flexor digitorum profundus, FDS - flexor digitorum superficialis, MCP - metacarpophalangeal joint)

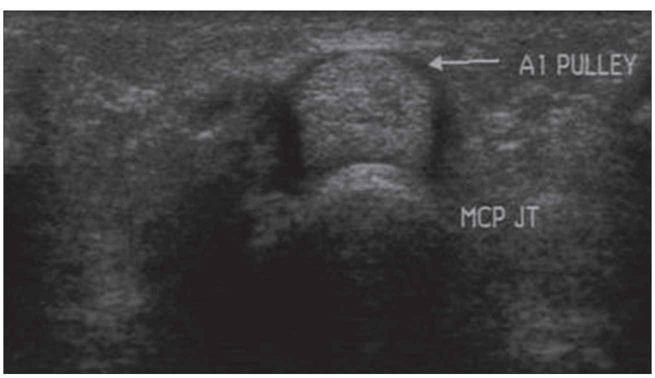

Figure 5: Transverse image at the metacarpophalangeal joint of the finger showing the thin band of the A1 pulley (MCP - metacarpophalangeal joint)

Tendinitis is mostly associated with athletic and occupational activities, which lead to repeated microtrauma. In acute tendinitis, the tendon is thickened with ill-defined margins and decreased echogenicity. In chronic tendinitis, the tendon may have a bumpy appearance or intra-tendinous calcifications may be seen.[1]

Tenosynovitis is an inflammation of the tendon sheath and can be caused by trauma, pyogenic infectionor rheumatoid arthritis.[7] USG reveals fluid in the tendon sheath. This is seen as an anechoic halo around the tendon on transverse images [Figure 6A and B]. Debris may be seen within this fluid. During USG, percussion of the tendon sheath can be used to differentiate between fluid and inflamed synovium. Swirling movements of the debris are seen within the fluid on percussion.[8] Hypoechoic synovial sheath thickening is seen in chronic tenosynovitis.

De Quervain's tenosynovitis involves the tendons of the abductor pollicis longus and extensor pollicis brevis. The affected tendons get trapped within the fibroosseus canal.

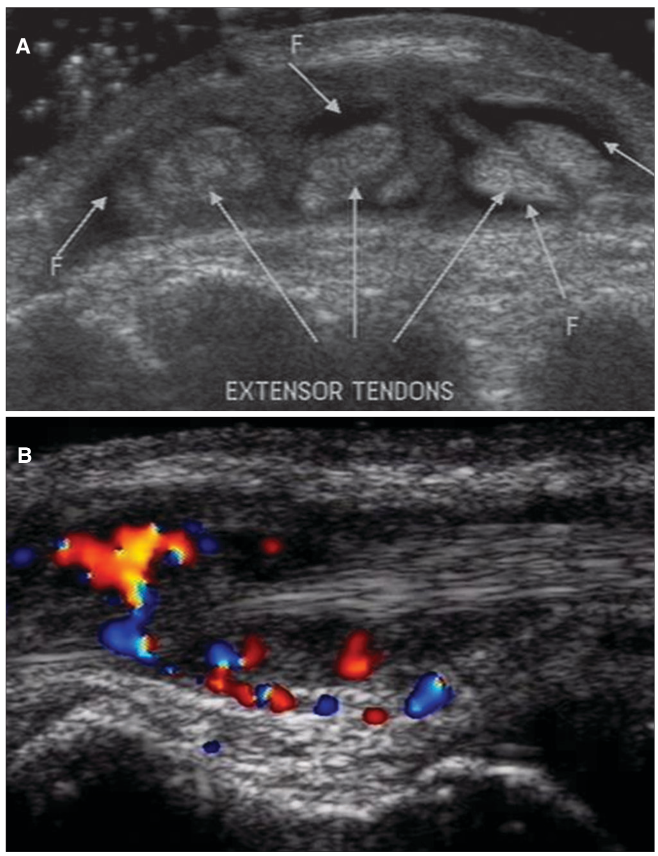

Figure 6 (A, B): Transverse image (A) at the dorsum of the wrist showing fluid and thickened synovium in the extensor tendon compartments (F - fluid), with a longitudinal image (B) of the extensor tendons at the wrist showing increased vascularity in the synovium, indicating acute synovitis.

USG shows hypoechoic thickening of the tendon sheath.[9]

Rheumatoid tenosynovitis can be demonstrated effectively by USG. The pannus involving the tendon sheath is markedly hypoechoic and shows significant hypervascularity on color Doppler [Figure 7]. The tendon is thickened and inhomogeneous. Later, the tendon may show a pathologic rupture. In the wrist, a hypoechoic area near the ulnar styloid is the hallmark of rheumatoid disease (caput ulnae syndrome).[10] Rheumatoid nodules may be seen in the soft tissues around the joint as hypoechoic areas. If near a tendon, they can be easily differentiated from tenosynovitis: Tenosynovitis shows a target pattern, with the tendon in the centre, while a rheumatoid nodule is homogeneous.[11]

Aging, steroids, rheumatoid arthritis, and diabetes mellitus predispose to tendon tears. USG can differentiate between complete and incomplete tears. It has a role in diagnosing, staging, and locating the tear. Depending on the delay in imaging following the tear, the gap between the fragments may be filled with hemorrhagic fluid or granulation tissue.[3] Longitudinal scans show the discontinuity of the fibrillar pattern and the gap between the torn fragments can be measured [Figure 8A and B]. The tendon may not be visualized at all if the torn fragments are widely separated[1] [Figure 9A and B]. Thus late-stage tendon ruptures present diagnostic challenges.

Acute injuries to wrist nerves are usually the result of penetrating injuries. USG has a complementary role in confirmation of the nerve lesion and accurate assessment of the precise site of the tear. Partial tears are seen as fusiform nerve swellings with hypoechoic echotextural changes (fusiform neuroma) in the absence of defects in nerve continuity. With very high frequency probes, a careful assessment shows fasicular involvement. In chronic nonoperated tears of the median and ulnar nerves, a hypertrophied neuroma develops at the level of nerve section. This appears hypoechoic on USG. Also, on USG we can measure the distance between the two nerve fragments, in cases of complete tears.[12]

Carpal tunnel syndrome arises from compression of the median nerve at the wrist. This can be due to space occupying lesions, diabetes, systemic neuropathies, pregnancy, hypothyroidism, amyloidosis, and anatomic variants like narrow tunnel and abnormal / accessory muscles or vessels. In early carpal tunnel syndrome, gross morphologic abnormalities of the median nerve do not occur. Later on, the nerve becomes swollen and exhibits changes in shape and histology with progressive demyelination and fibrosclerosis. On USG, there is a change in the shape and echotexture of the nerve. The nerve shows an abnormal bulge proximal to the carpal tunnel with an abrupt caliber change at the entrance to the tunnel. This is referred to as the 'notch' sign.[Figure 10A and B] The nerve appears swollen at the proximal aspect of the tunnel and flattened at the distal aspect. A cross-sectional area of > 10 mm^2 of the median nerve, is considered diagnostic at the proximal tunnel level.[12]

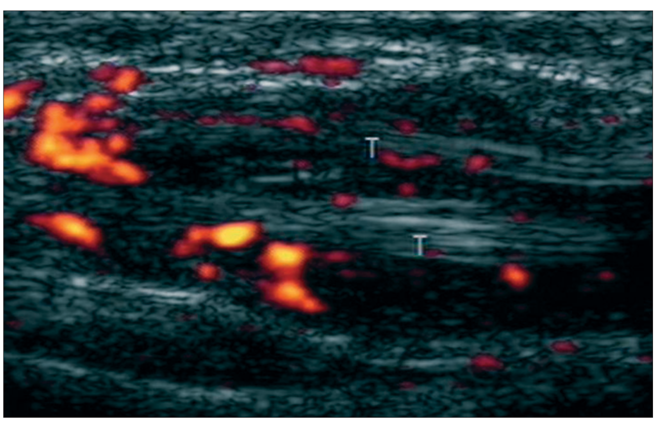

Figure 7: Longitudinal image of the flexor tendons in the palm showing hypoechoic pannus with increased vascularity in active rheumatoid arthritis.

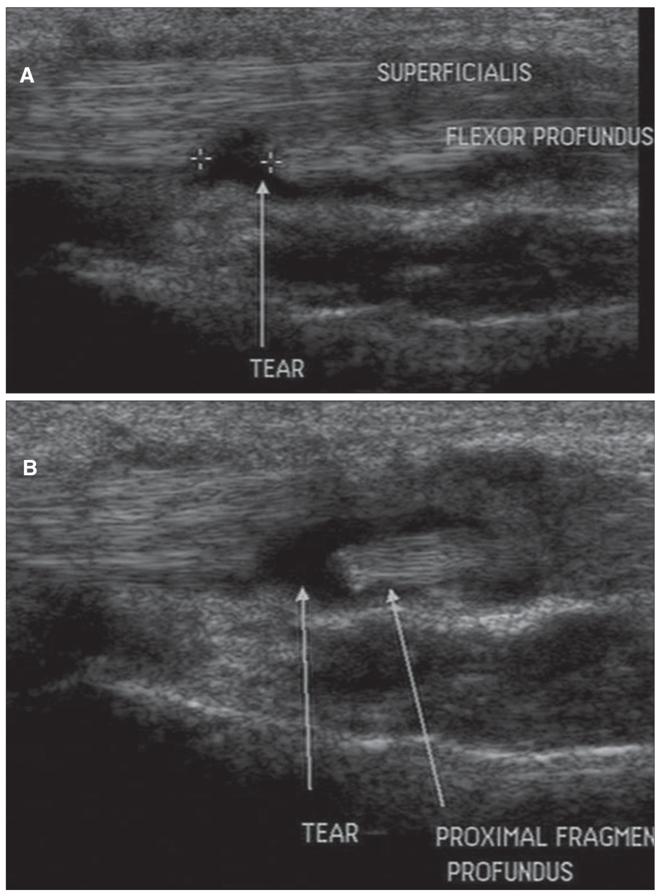

Figure 8 (A, B): Longitudinal image (A) shows a full thickness tear of the flexor digitorum profundus tendon (MCP - metacarpophalangeal joint). On complete flexion (B) at the proximal interphalangeal joint, there is an increase in the distance between the fragments.

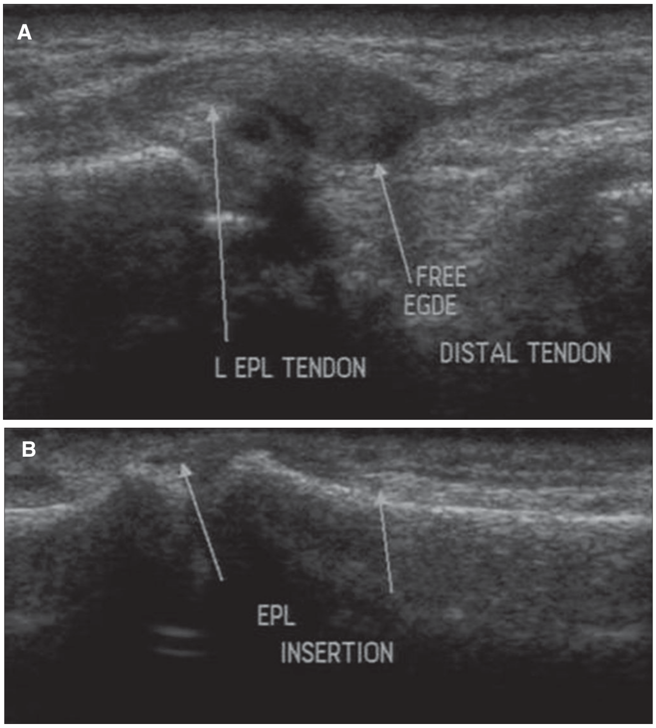

Figure 9 (A, B): Chronic full thickness tear (A) of the extensor pollicis longus tendon showing retraction and bunching up of the distal fragment fibres (EPL - extensor pollicis longus). Note the appearance of the normal insertion of the distal extensor pollicis longus tendon at the base of the distal phalanx (B), in a normal finger.

Ganglia are the most common swelling in the hand. They are cystic masses filled with viscous fluid and lack a true synovial lining. They are derived from degeneration of periarticular soft tissues. They are usually periarticular or peritendinous in location. The common sites are the dorsal and volar aspects of the wrist and distal phalanges. On USG, they are seen as anechoic lesions with thin margins [Figure 11]. A small anechoic communicating duct may be seen extending from the ganglion to the articular space; it is seen in 70% of cases.[12]

Giant cell tumors are the second most frequent cause of swelling in the hand. The most common sites are the palmar aspects of the fingers. They arise from the synovium of the flexor tendon sheaths or the interphalangeal joints.[4] On USG, they appear as hypoechoic masses, sometimes with lobulated contours.[6]

Operator dependency is a disadvantage of USG but can be overcome by adequate training of the radiologist. Effective communication with the referring doctor is very helpful. Also one should try to label the images and give panoramic images to document the anatomy and pathology.

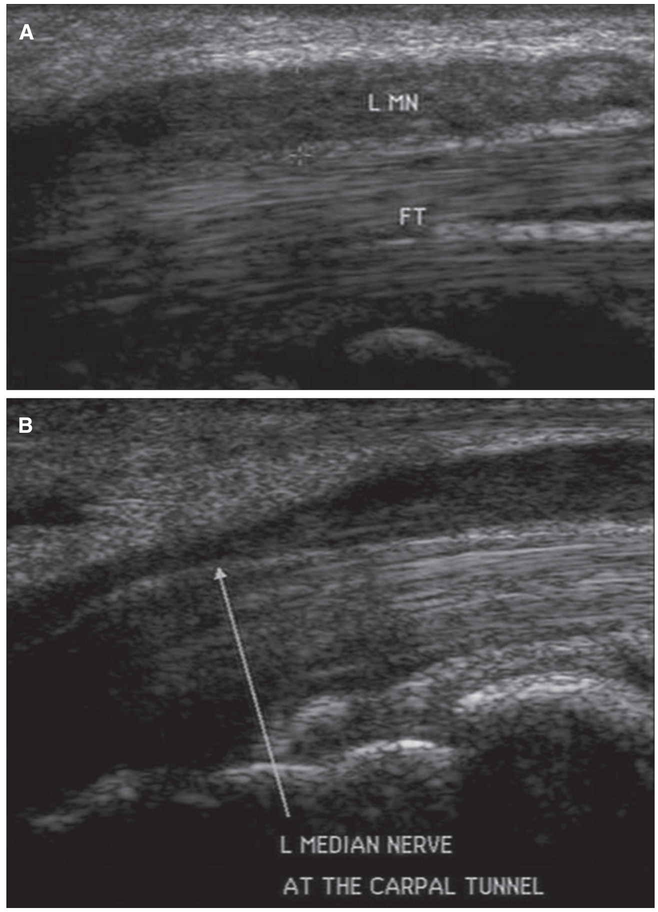

Figure 10 (A, B): Thickened heterogeneous median nerve (A) in a case of chronic carpal tunnel syndrome (L MN - left median nerve, FT - flexor tendon). Flattening of the median nerve (B) is seen in the carpal tunnel, with a proximal bulge.

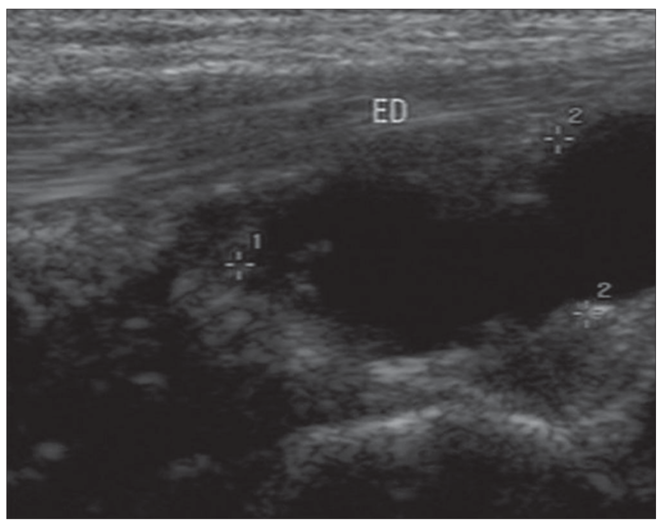

Figure 11: Longitudinal image at the dorsum of the wrist showing a ganglion deep to the extensor digitorum tendons (ED - extensor digitorum tendon)

Conclusion

USG has not been fully utilized in the musculoskeletal system. It provides a cheap and easily available alternative to costlier modalities like MRI. Its real-time imaging ability is a boon while evaluating tendons of the hand. Thus in our country, where cost effectiveness and availability are issues in most regions, USG can play an important role in imaging of the wrist and hand.

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