

Ultrasound in rheumatology

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Introduction

X-rays have been the mainstay of the radiological assessment of joint disorders. However, conventional radiography is not capable of assessing early bone abnormalities, especially when the lesion is not tangential to the x-ray beam. Early periarticular soft tissue abnormalities and synovitis are also not well seen. The gold standard for the assessment of soft tissue abnormalities is MRI. However, in the last few years, musculoskeletal USG has made its presence felt among rheumatologists and radiologists as the first radiological investigation in the assessment of rheumatoid disease and during follow-up. This has been possible due to the better availability of USG equipment, transducers and softwares.^[1] These changes have allowed USG to be used for the early detection of fluid in the joint spaces and around tendon sheaths. Due to better resolution, even normal, minute amounts of synovial fluid can be seen. Similarly, irregularities on the bone surface, such as erosions and periosteal irregularities as well as sub-periosteal collections / bleed can be now appreciated. Intraosseous abnormalities, however, cannot be appreciated as sound is not able to penetrate bone. Use can also be made of 'real-time' USG to assist in the better evaluation of these abnormalities.^[2]

USG is often called the "rheumatologist's extended finger". However, rheumatologists are still not agreed on whether they should introduce routine USG in their clinical practices.^[1,4,5] There are also issues related to the reproducibility of USG findings and though numerous training programs are available in Europe, there is still some resistance in accepting a 'new' modality, which is operator dependent.

Imaging Requirements

Since most of the joints and periarticular structure to be imaged are superficial, high-resolution and high-definition USG, with 7.5–15 MHz linear probes, is required for adequate resolution. However, lower frequency probes upto 5 MHz are often used for larger joints that require more penetration, such as the shoulders and hips.^[3] Phased-array probes with tissue harmonic imaging and compound imaging are now

routinely used. 3D and 4D usually do not significantly add value. "Extended field-of-view" is very useful, as it allows a larger area to be visualized and measured. The size of the footprint is important, since transducers with a large footprint are often inadequate for visualizing small joints such as the metacarpophalangeal joints, since they cannot be maneuvered adequately.

Power and color Doppler are extremely useful for identifying the degree of inflammation and help in increasing the confidence for diagnosing subtle changes.

USG is an operator dependent modality and it is imperative to have a sound knowledge of its principles and the musculo-skeletal anatomy.

Indications

USG was probably first used in the musculoskeletal system for the identification of Baker's cysts and to differentiate them from thrombophlebitis,^[1] as early as 1972. The indications today are:^[1,3-5]

1. Arthritis
 1. Joints:
 - a) Synovial effusion
 - b) Synovial proliferation
 - c) Cartilage changes
 - d) Erosions
 2. Periarticular soft tissues:
 - a) Tendon disease
 - b) Enthesitis
 - c) Bursal involvement
2. Nonarthritis
 1. Infections
 2. Hemarthrosis
3. Soft tissue rheumatology
4. Nerve involvement assessment
5. MRI contraindications

Synovitis

Most articular diseases affect the synovium. The presence of excess intra-articular fluid suggests the presence of synovitis. USG is capable of detecting synovial fluid in

excess of 1ml [Figure 1] and standards for diagnosing effusion are available for most joints.^[6] This technique is therefore potentially important in the management, diagnosis, monitoring and the assessment of treatment efficacy. USG is more sensitive than physical examination for the diagnosis of synovial effusion.^[7,8] This is true for the smaller joints of the hands and feet as well as the large joints such as the shoulder, hip and knee.^[9,10] USG is however limited in its ability to assess the nature of the joint fluid. The synovial effusion may be due to inflammation, infection or bleed. Aspiration is usually required for confirmation and is often performed under USG guidance..

Since joint effusion usually occurs in an arthropathy and is better seen on USG, the “quantity” and distribution of disease seem to vary from the traditional disease description. The classification criteria of the American College of Rheumatologists for mono-, oligo- and polyarticular diseases may need to be re-evaluated, since more sub-clinical disease can be seen with USG.^[11]

The hands and wrists are the commonest areas evaluated in rheumatology. The pattern and location of synovitis may be diagnostic of the disease. In rheumatoid arthritis (RA), synovitis of the metacarpophalangeal (MCP), metatarsophalangeal (MTP) and proximal interphalangeal (PIP) joints is primarily seen. The target joints in psoriatic arthritis are the distal interphalangeal (DIP) joints. [Figure 2]. However, in early disease, such typical patterns of involvement are often not seen. As a result, in early disease, USG primarily helps in deciding the presence/

absence of synovitis, its location and the number of joints involved along with any associated synovial proliferation, cartilaginous changes or erosions. The palmar and dorsal aspects of the joints both need to be assessed.

Synovial proliferation presents with thickening of the synovium [Figure 3, 4]. If the “fluid” in the joint cannot be compressed, that usually implies the presence of thickened synovium,^[12,13] which may also show increased flow on Doppler. Though complex fluid with high protein contents may mimic synovial proliferation, it can still be easily compressed and will change its appearance on application of pressure. Severe synovial proliferation shows an irregular contour of the synovial membrane with syneciae between the walls of the articular recesses.

Areas of active disease show increased flow on Doppler [Figure 5]. This is due to neo-vascularization in the pannus. The degree of increased flow on Doppler may be a rough indicator of the degree of active disease. A negative Doppler signal does not exclude possible active inflammation. Moreover, the same joint may show different Doppler signals on different machines, as well as with the same machine with change in the surrounding room temperature.

Studies done by Ridder et al and Hau et al, using color and spectral Doppler to assess possible changes in synovial perfusion, after treatment with anti-tumor necrosis factor

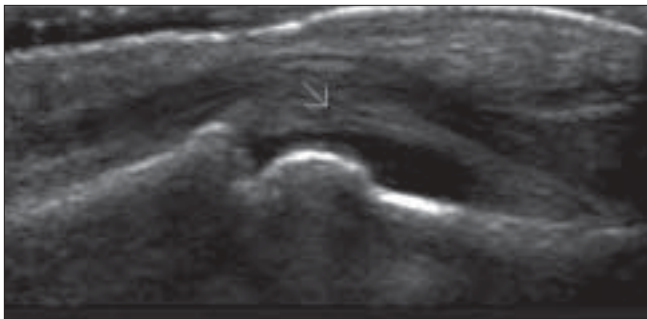


Figure 1: Joint effusion. Longitudinal image shows effusion (arrow) in the left second proximal interphalangeal joint on the palmar aspect

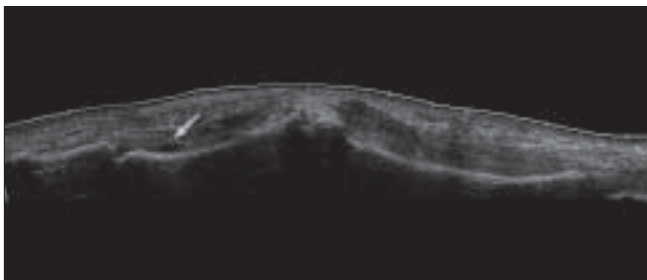


Figure 2: Joint effusion. Extended field of view image shows synovial effusion (arrow) in the right 4th distal interphalangeal joint on the dorsal aspect



Figure 3: Joint effusion. Longitudinal image shows synovial effusion and proliferation (arrow) in the right 3rd MCP joint on the dorsal aspect, in a patient with psoriasis

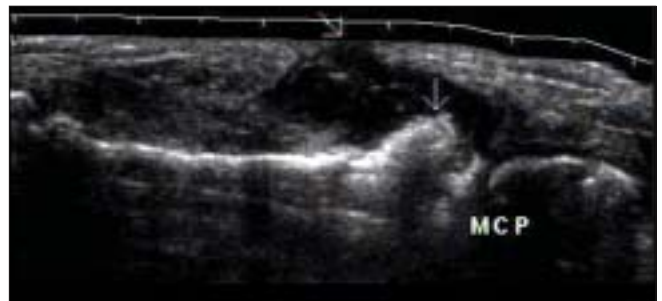


Figure 4: Joint effusion. Longitudinal image shows synovial effusion (arrow) in the right 5th MCP joint due a bacterial infection with a superficial draining sinus as well (arrow)

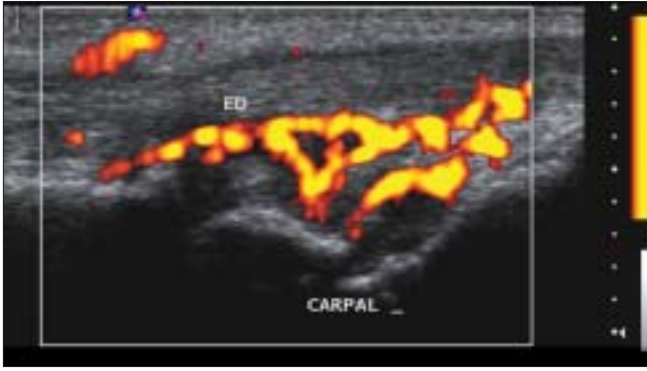


Figure 5: Synovial proliferation. Longitudinal color Doppler image shows synovial effusion and proliferation at the wrist joint with increased Doppler flow

alpha, in patients with RA have shown that it is possible to see reduction in the number of color pixels after treatment, correlating well with symptomatic improvement. In a few cases, USG improvement was seen even prior to symptomatic improvement. Similar improvements have been noted after steroid injections.^[14,15] In a study by Filippucci *et al*, in 70% of patients showed improvement of grey scale and power Doppler findings, after treatment with steroids.^[15]

Tendon disease

In the last decade, USG has become the gold standard for tendon examination.^[16,17] Tenosynovial effusion, tenosynovial proliferation and tendon tears are routinely detected by USG [Figure 6]. Clinical examination of tendon involvement is highly inaccurate. According to Grassi *et al*, USG is even superior to MRI in the detection of longitudinal split tendon tears.^[16] It is the only modality which allows real-time, dynamic assessment, which is extremely useful for identifying subluxed and snapping tendons.^[5,16] USG also demonstrates focal or diffuse tendonitis, calcified tendonitis and tendon xanthomas.

Synovial involvement of the tendons is very common in



Figure 6: Tenosynovitis. Transverse image shows fluid (arrow) in the tendon sheath of the extensor digitorum in a patient with RA

seropositive arthritis and is known as tenosynovitis [Figure 7]. Peri-articular soft tissue swelling may be due to effusion or due to tenosynovitis and USG helps in differentiating between these causes. Tendon involvement may present prior to joint involvement in RA and commonly involves the tendons of the flexor digitorum superficialis and profundus, flexor carpi ulnaris and radialis as well as the extensor digitorum [Figure 8]. The flexor digitorum superficialis and profundus tendons are probably the most common tendons involved in psoriatic arthropathy giving a typical ‘sausage digit’ appearance [Figure 9]. Areas of active disease show increased flow on Doppler application. A negative Doppler signal does not exclude the possibility of tenosynovitis.

Although USG is sensitive in identifying tendon disease, like



Figure 7 (A, B): RA. Plain radiograph (A) shows soft tissue wrist swelling. This is clearly due to tenosynovial effusion and proliferation (arrow) of the flexor carpi ulnaris tendon, as seen on this longitudinal image (B)

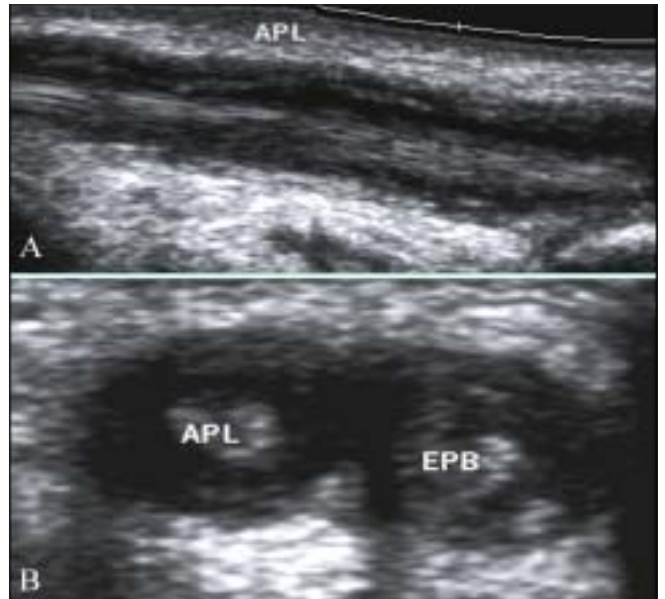


Figure 8 (A, B): DeQuervain's tenosynovitis. Longitudinal (A) and transverse (B) images show tenosynovitis of the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons

synovitis, it is non-specific. Correlation with biochemical parameters and history is important to achieve a diagnosis.

Cartilage Changes

Normal weight-bearing cartilage ranges from 1.2 – 1.9 mm in thickness. The cartilage in the wrists and hands is thinner. The earliest radiological finding is usually thinning of the cartilage, though rarely, USG may show thickening due to edema, in very early stages of arthritis. However, non-visualization of the cartilage is not necessarily an ominous sign, as the cartilage may not always be seen, depending on the site. Irregular thinning or thickening of the cartilage is usually abnormal [Figure 10].

Erosions

MRI is the gold standard for the assessment of erosions. USG has of late shown to be useful in the early diagnosis of erosions.^[18-22] Radiographic detection of small erosions may be delayed due to patient positioning or technical reasons. The multiplanar capabilities of USG, allow a careful assessment of the bone surfaces on more views than those allowed by standard radiographs. This improves the sensitivity of USG in detecting small erosions, especially in areas not well seen on standard views.^[18] Marginal erosions are seen as crater-like defects, along the edges of the articular cartilage, affecting the so-called “bare” areas [Figure 11]. In RA, pannus is seen as hypoechoic soft tissue filling these erosions. Color and power Doppler usually show an intense increase in flow at these sites especially in active disease. In acutely inflamed joints with erosions, it is not uncommon

to see a vascular pedicle supplying the pannus up to the erosion crater [Figure 12].

USG of MCP joints with good accessibility (second and fifth) exhibit better correlation with MRI than USG of joints only accessible in two planes (third and fourth). Using USG, Szkudlarek et al, found more bone erosions in PIP joints as compared to MRI and radiographs, probably due to the use of 3 mm thick slices on MRI, which is a suboptimal slice thickness for the small PIP joints.^[9] Backhaus and coworkers employing thinner MRI slices (1 mm) found that MRI scored over USG. Small erosions of the carpal bones



Figure 9 (A, B): Sausage finger. A clinical photograph (A) shows typical sausage fingers, which are due to tenosynovial effusion, as seen in this extended field of view image (B) of the flexor digitorum superficialis and profundus tendons of the left 5th digit

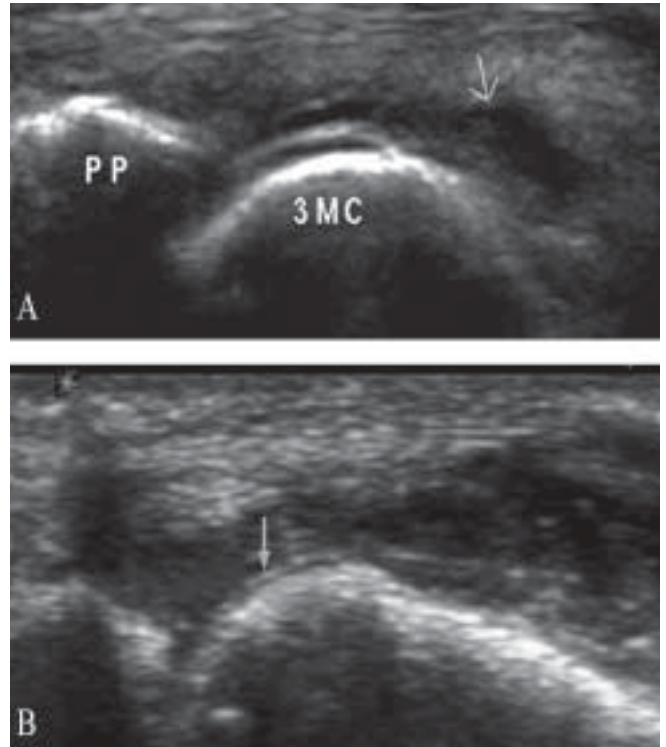


Figure 10 (A, B): Articular cartilage. Longitudinal images of normal (A) and abnormal (B) joints, showing normal articular cartilage (arrow) and irregular thinned-out articular cartilage (arrow), respectively

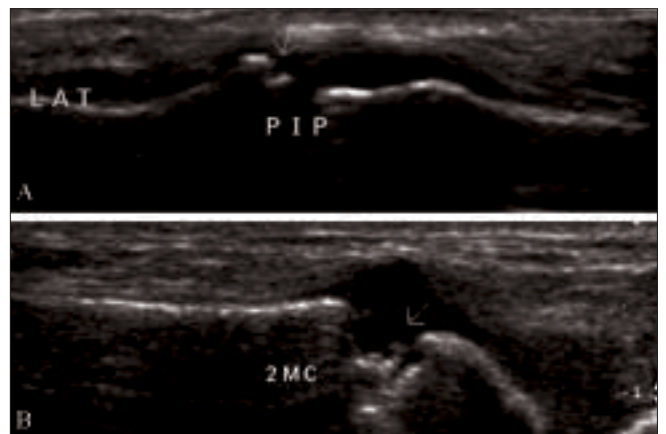


Figure 11 (A, B): Erosions. Longitudinal images in two different patients, show erosions (arrows) in the 2nd middle phalanx base (A) and the 2nd metacarpal base (B)

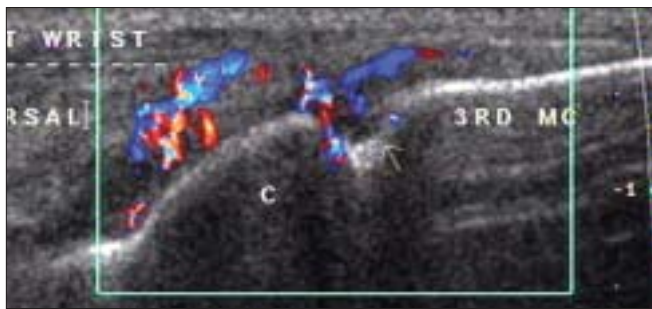


Figure 12: Erosions. Longitudinal color Doppler image, in an acutely inflamed MCP joint shows a vascular pedicle supplying the pannus up to the erosion (arrow)

are also difficult to interpret on USG, as the normal carpal bones have irregular margins. MRI is superior in the carpal bones.. Bone marrow edema and cartilaginous changes are also better seen on MRI.^[10] Subarticular cysts are often completely missed on USG.

Crystal Deposition Disease

A few papers have described the USG appearance of articular and periarticular changes caused by calcium pyrophosphate dihydrate (CPPD) disease. In some cases, calcification detected by USG may not be found on radiographs, either because of the location of the calcium deposit or the technique used. MRI is not good for the evaluation of calcium. Frediani *et al.*, have identified the following patterns of CPPD^[23] calcification

- Thin hyperechoic bands, parallel to the surface of the hyaline cartilage (frequently observed in the knee).
- A "punctate" pattern composed of several thin hyperechoic spots, more common in fibrous cartilage and in tendons.
- Homogeneous hyperechoic nodular or oval deposits localized in bursae and articular recesses (frequently mobile).^[23]

Bursae

Bursitis is a common disease entity in joint diseases. Subacromial-subdeltoid bursitis is a common USG finding in RA [Figure 13]. A Baker’s cyst is often seen in chronic cases. It may be anechoic or may show calcified or non-calcified loose bodies. A ruptured Baker’s cyst can be readily diagnosed on USG and can be differentiated from deep vein thrombosis [Figure 14]. Differentiation of joint effusion from bursitis, for example in the popliteal fossa, can be easily accomplished by USG.

Enthesitis

Enthesitis is the inflammation at the origin and insertion of ligaments and tendons and is commonly seen in seronegative spondyloarthropathy (SpA). and may be the first sign of an SpA in some cases. There is initially inflammation, followed by fibrosis in the involved ligaments

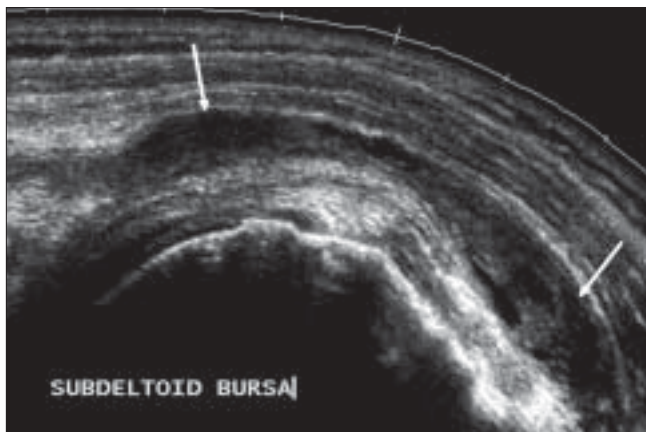


Figure 13: Bursitis. Panoramic image shows fluid (arrows) in the subdeltoid bursa with synovial proliferation, in a patient with RA

and tendons. This is followed by ossification. The involved segment of bone shows erosions.

Balintz *et al.*, found that compared with USG, clinical examination had a low sensitivity (22.6%) and moderate specificity (79.7%) for the detection of enthesitis of the lower limbs.^[24] Acute enthesitis on USG, is seen as a tender area with increased thickness of the tendon and ligament insertion with hypoechogenicity and loss of normal echopattern. The adjoining bone may be normal or may show irregularity at the site of tendon insertion [Figure 15]. In chronic cases, there is evidence of intratendinous and interligamentous calcification adjacent to the enthesal insertion. Various studies have identified that there is considerable sub-clinical enthesitis in SpA, which can be objectively measured by USG using standardized protocols.

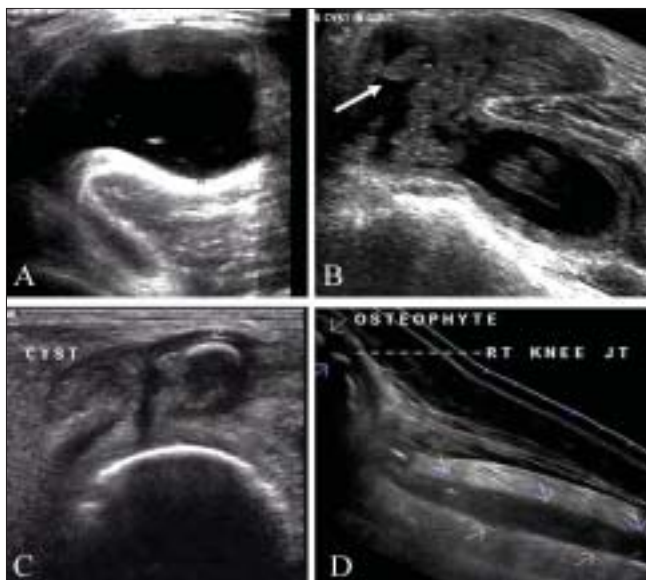


Figure14: Baker's cyst. Images from different patients show a typical Baker's cyst (A), a cyst with synovial proliferation and a non-calcified loose body (arrow in B), a cyst with a calcified loose body (arrow in C) and a ruptured cyst (arrows in D), extending along the leg

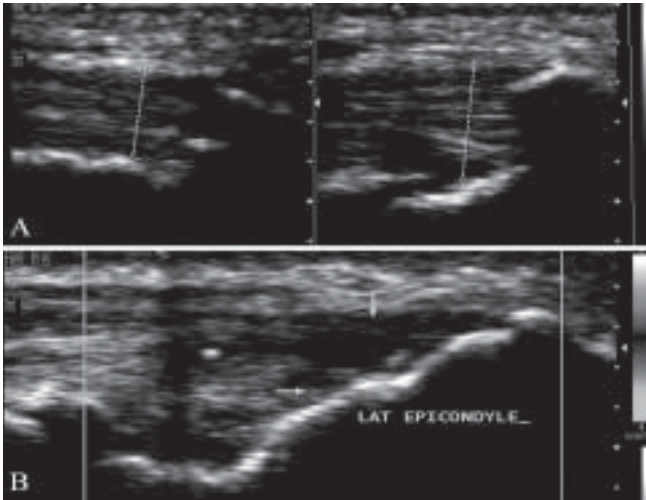


Figure 15: Enthesitis. Longitudinal images of the Achilles tendon (A) show increased thickness of the tendon and ligament insertion with hypoechogenicity and loss of normal echopattern. Longitudinal image of the elbow (B) shows irregularity (arrow) of the lateral epicondyle at the site of the common extensor origin, which is thickened (arrow), as well

Nerves:

The median nerve at the wrist is the most involved nerve in rheumatology practice, as part of the carpal tunnel syndrome (CTS). CTS is primarily a clinical diagnosis and imaging is used mainly to identify a secondary cause such as wrist joint effusion, tenosynovitis, amyloid deposition, hypertrophied accessory muscle, increased fatty tissue, ganglion cyst or a variant median artery^[5] [Figure 16].

Many investigators have attempted to define USG criteria for the diagnosis of CTS. According to Wong et al, these include volar bulging and thickening of the flexor retinaculum and focal or diffuse swelling or flattening of the nerve. A median nerve cross-sectional diameter of $>0.098\text{ cm}^2$ at the tunnel inlet has been reported to have a sensitivity of 89% and a specificity of 83%.^[25]

Conclusion

USG in rheumatology has already gained acceptance in numerous clinics in Europe. Various training programs are available from time to time. Consensus is being developed for 'normal' and 'abnormal' patterns. The "operator-dependence" is an issue that rheumatologists have to overcome. With time, USG will become an important modality in the evaluation of rheumatologic conditions.

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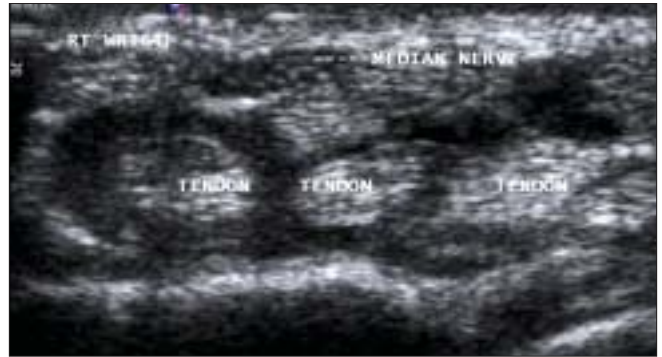


Figure 16: Carpal tunnel syndrome. A transverse image at the wrist through the carpal tunnel shows tenosynovitis of the flexor tendons, which was responsible for the carpal tunnel syndrome. Note the flattening of the median nerve

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