CME Article

Ultrasonography of the hand and wrist

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ABSTRACT

Musculoskeletal ultrasonography (US) of the hands and wrist has recently been increasing in popularity. Recent rapid technical advances in the US, such as new ultra-high frequency probes and smaller probe sizes, have led to improved image quality. This, in turn, has accelerated the growth of musculoskeletal US. Known advantages of US are its lack of ionising radiation, noninvasiveness, portability and low cost. Dynamic and real-time assessment and Doppler imaging are additional benefits of this modality, especially in the imaging of the hands and wrist. Superficial structures of the hands and wrist, including the tendons, ligaments, nerves and vessels, are amenable to imaging with high frequency US. In this article, we demonstrate a spectrum of hand and wrist pathology using US, including entrapment neuropathy, inflammatory conditions, traumatic injury and masses. Ultrasound-guided procedures applicable to the hand and wrist are also briefly discussed.

Keywords: hands and wrist, musculoskeletal imaging, nerves, tendons, ultrasonography

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INTRODUCTION

Musculoskeletal ultrasonography (US) of the hands and wrist has recently been increasing in popularity. Recent rapid technical advances in US, such as new ultra-high frequency probes and smaller probe sizes, have led to improved image quality. This, in turn, has accelerated the growth of musculoskeletal US. Known advantages of US are its lack of ionising radiation, noninvasiveness, portability and low cost. Dynamic and real-time assessment and Doppler imaging are additional benefits of this modality, especially in the imaging of the hands and wrist.[1] In this article, we demonstrate a spectrum of hand and wrist pathology using US, including entrapment neuropathy, inflammatory conditions, traumatic injury and masses. Ultrasound-guided procedures applicable to the hand and wrist are also briefly discussed.

TECHNIQUE

In our institution, musculoskeletal US is performed using commercially-available equipment, with high frequency linear-array transducers (6–15 MHz) and a standard gel interface. The higher frequency transducers provide better spatial resolution, while the lower frequency transducers provide a greater depth of tissue penetrance. Often, for the small joints of the hand, a water bath is employed in place of the gel interface. Dynamic evaluation with active and passive mobilisation is also frequently performed, as this technique is extremely useful in accentuating pathology and determining the nature of lesions. Colour Doppler US is also performed in most cases as it plays an important

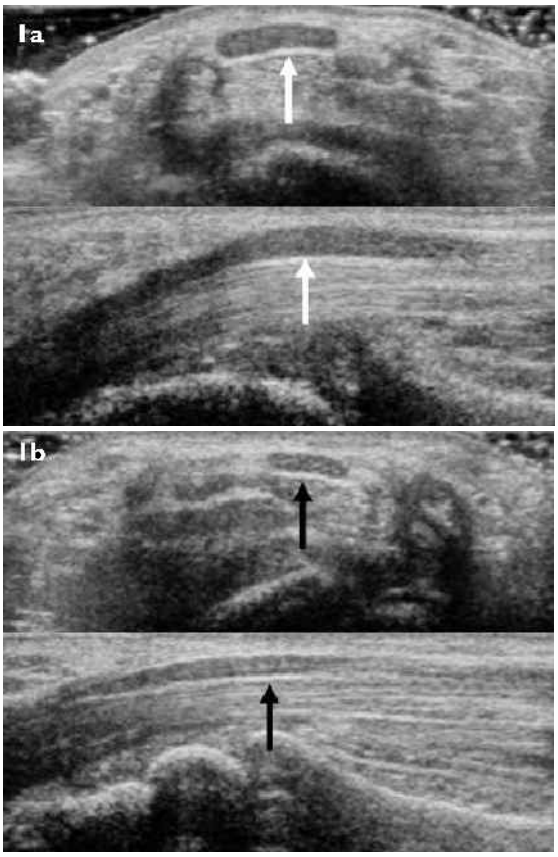

Fig. 1 Carpal tunnel syndrome. Transverse (upper) and longitudinal (lower) US images of the proximal carpal tunnel. (a) Abnormally enlarged median nerve (white arrows) in carpal tunnel syndrome. (b) Normal median nerve (black arrows) in the opposite wrist of the same patient.

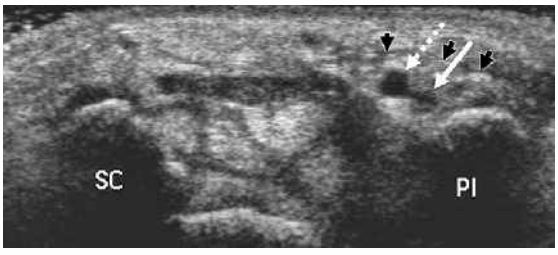

Fig. 2 Guyon's canal. Transverse US image of Guyon's canal at the level of the scaphoid (SC) and pisiform (PI). The ulnar nerve (solid white arrow) and the ulnar artery (dashed white arrow) are seen within the canal, with a thin hyperechoic palmar carpal ligament (black arrows) forming the roof of the canal.

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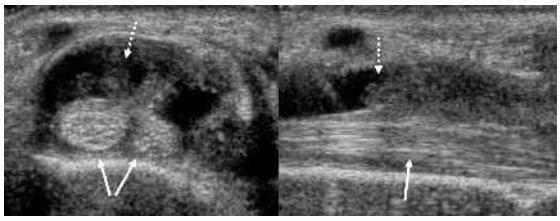

Fig. 3 Tenosynovitis. Transverse and longitudinal US images of the extensor carpi radialis tendons (solid arrows) in the wrist. There is distension of the tendon sheath with hypoechoic fluid (dashed arrows), giving a "target" appearance on the transverse image.

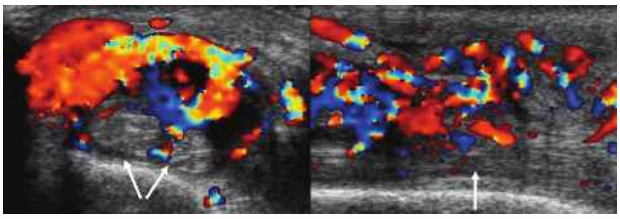

Fig. 4 Tenosynovitis. Transverse and longitudinal US images of the extensor carpi radialis tendons (solid arrows) in the same patient as in Fig. 3, show increased flow in the inflammed tendon sheath on colour Doppler.

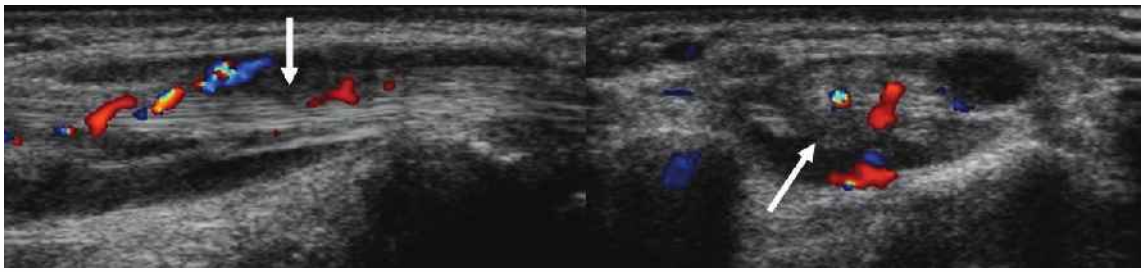

Fig. 5 Tendinopathy. Longitudinal and transverse US images of the extensor digitorum tendon within the proximal wrist show patchy decreased echogenicity, an ill-defined outline (arrows) and intra-tendinous colour Doppler flow.

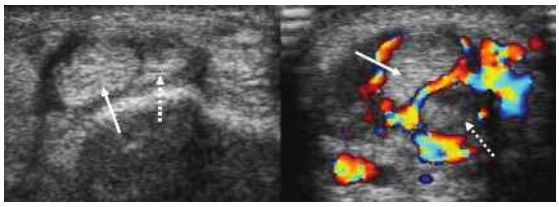

Fig. 6 de Quervain's tenosynovitis. Transverse US images of the abductor pollicis longus (solid arrow) and extensor pollicis brevis (dashed arrow) tendons. Both tendons are enlarged and rounded, with evidence of tenosynovitis.

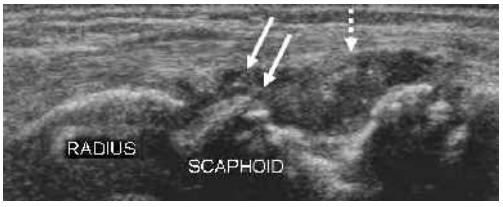

Fig. 7 Rheumatoid arthritis. Longitudinal US image shows the radioscaphoid joint, with amorphous synovial hypertrophy (dashed arrow) over the dorsal aspect of the carpal bones and erosions (solid arrows) in the underlying scaphoid.

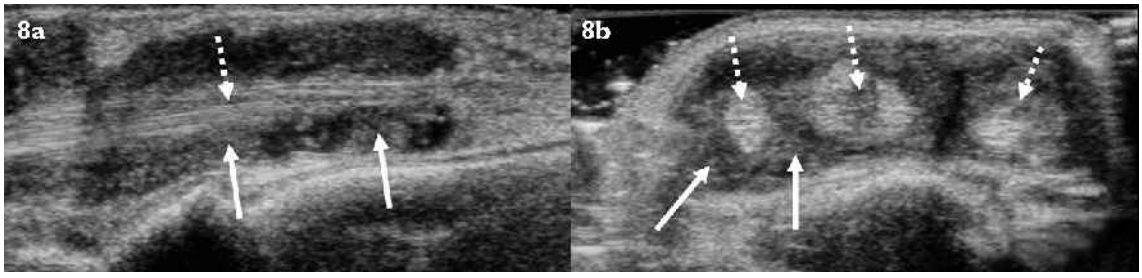

Fig. 8 Rheumatoid arthritis. (a) Longitudinal and (b) transverse US images of the extensor tendons (dashed arrows) at the wrist show hypertrophic echogenic synovium (solid arrows) and fluid distension of the tendon sheath.

role in supporting and confirming diagnoses, by providing valuable information about the pathophysiology of the abnormality.[2]

ENTRAPMENT NEUROPATHY

In the hands and wrist, this includes the more common carpal tunnel syndrome and the rarer Guyon's canal syndrome.

Carpal tunnel syndrome

The carpal tunnel is a restricted fibro-osseous passageway in the wrist through which the median nerve enters the hand. It is bounded by an inextensible flexor retinaculum ventrally and the carpal bones dorsally. Carpal tunnel syndrome results from the compression of the nerve by a wide spectrum of extrinsic causes, which may relate to congenital or acquired conditions.[3] Classic symptoms are pain and paraesthesia in the median nerve distribution of the affected hand. On US, the characteristic findings include swelling of the nerve in the proximal carpal tunnel, flattening of the nerve in the distal tunnel and palmar bowing of the flexor retinaculum (Fig. 1).[1,3] It has also been shown that a cross-sectional area of greater than 0.1 cm^2 at the level of the proximal tunnel is the best indicator for the diagnosis on US.[1,3]

Guyon's canal syndrome

The Guyon's canal is another fibro-osseous passageway

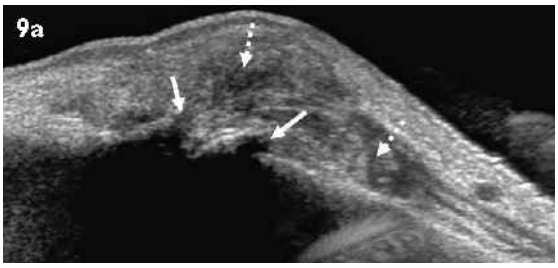

Fig. 9 Gout. (a) Longitudinal US image of the proximal interphalangeal joint of the right index finger shows juxta-articular erosions (solid arrows) and an overlying heterogenous amorphous soft tissue swelling, representing tophus (dashed arrows). (b) Corresponding radiograph of the same patient shows juxta-articular erosions (arrows) and overlying soft tissue swelling.

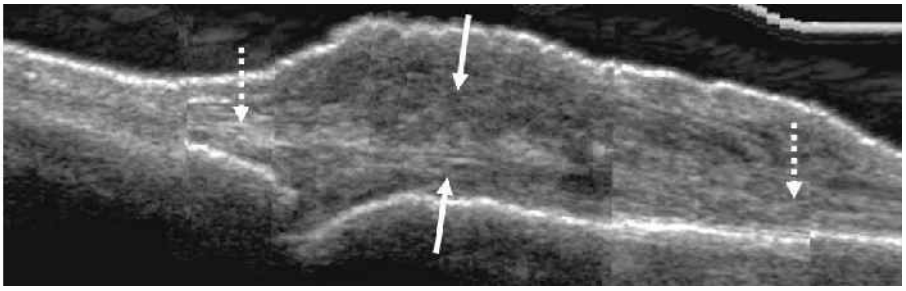

Fig. 10 Granulation tissue. Longitudinal US image over the dorsum of the third metacarpophalangeal joint shows ill-defined heterogeneous soft tissue (solid arrows) at the extensor tendon repair site, with normal-appearing tendon seen proximal and distal to it (dashed arrows).

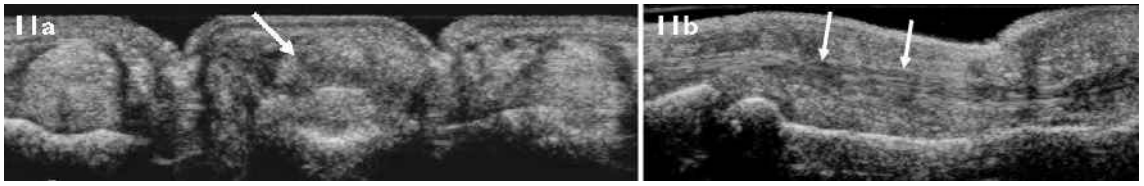

Fig. 11 Partial tendon tear. (a) Transverse and (b) longitudinal US images of the flexor tendons of the middle finger show a partial tear of the flexor digitorum superficialis (arrows). The affected tendon is attenuated with reduced echogenicity.

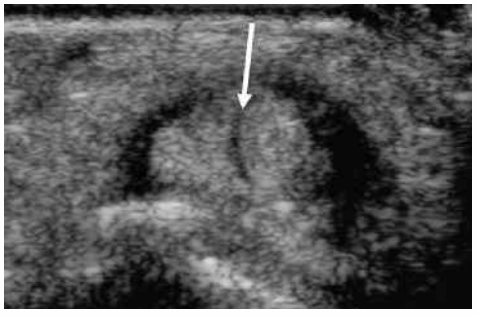

Fig. 12 Longitudinal tendon tear. Transverse US image of the extensor carpi ulnaris tendon shows a longitudinal split in the tendon (arrow).

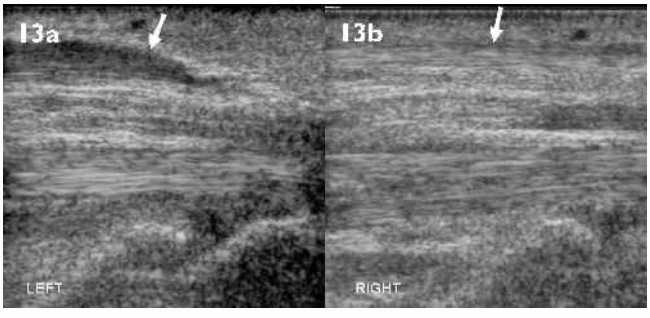

Fig. 13 Complete tendon tear. Longitudinal US images of the palmar aspects of both wrists in the same patient. (a) In the left wrist, a fusiform hypoechoic structure with no normal fibrillar tendinous pattern is seen in place of the palmaris longus tendon, indicating tendon rupture. (b) In the right wrist, a normal palmaris longus tendon is seen.

in the anteromedial aspect of the wrist, through which the ulnar nerve, artery and vein traverse (Fig. 2). The floor is formed by the flexor retinaculum, the roof by the palmar carpal ligament and the lateral and medial walls by the hook of hamate and the pisiform, respectively. Guyon's tunnel syndrome is rare and may be caused by chronic repeated external pressure, space-occupying lesions or as a sequelae of fractures.[3]

INFLAMMATORY CONDITIONS

Tenosynovitis and tendinopathy

In tenosynovitis, where the synovial lining of the tendon sheath is inflammed, a characteristic "target" appearance on transverse images is seen, with distension of the tendon sheath with fluid and/or synovial thickening (Fig. 3). Increased flow on colour Doppler US is seen in the inflammed tendon sheath (Fig. 4).[1,2,4] Causes include

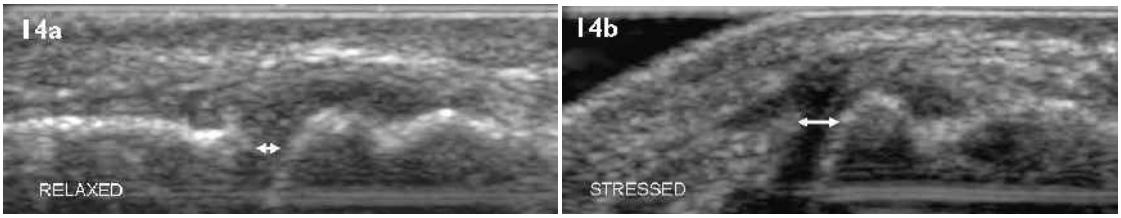

Fig. 14 Ligament injury. (a & b) Transverse US images of the metacarpophalangeal of the thumb show non-visualisation of the ulnar collateral ligament, with widening of the joint space on the stress image.

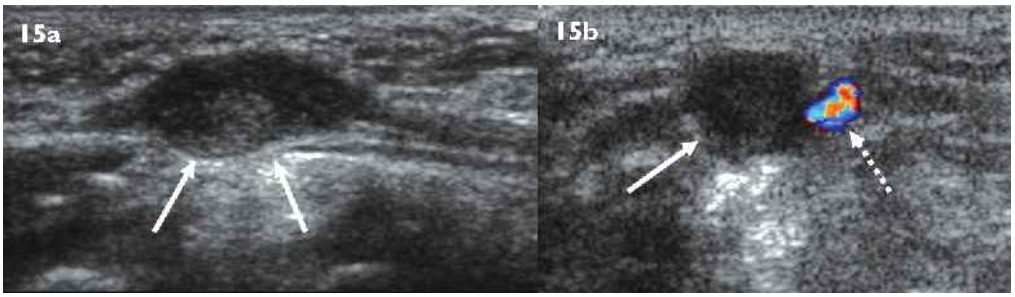

Fig. 15 Ulnar nerve neuroma. (a) Longitudinal and (b) transverse US images of the volar aspect of the wrist show a fusiform hypoechoic mass (solid arrows), orientated along the longitudinal axis and adjacent to the ulnar artery (dashed arrow).

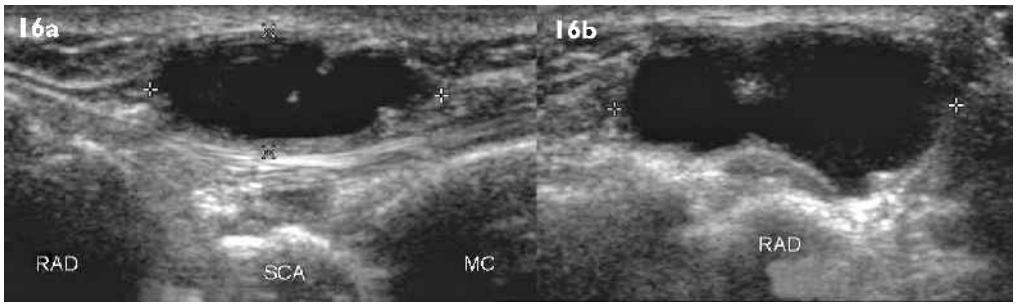

Fig. 16 Ganglion cyst. (a & b) Lobulated cystic mass in the dorsum of the wrist, overlying the scaphoid (SCA) and between the radius (RAD) and second metacarpal bone (MC).

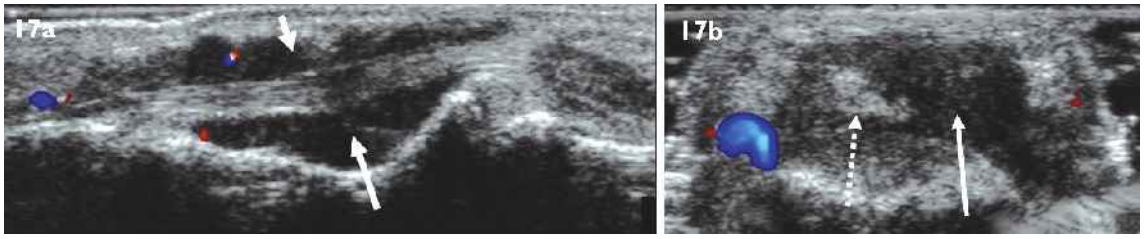

Fig. 17 Giant-cell tumour of the tendon sheath. (a) Longitudinal and (b) transverse US images at the proximal middle phalanx show a lobulated hypoechoic mass (solid arrows) surrounding the flexor digitorum tendon of the left index finger (dashed arrow). The tendon is seen to move independent of the mass on dynamic assessment.

trauma, infection or rheumatoid arthritis. Tendinopathy is a tendon pathology, which may be caused by inflammation (tendinitis) or repeated microtrauma (tendinosis). Findings on US include enlargement of the tendon with an ill-defined outline and decreased tendon echogenicity (Fig. 5). Increased intra-tendinous colour Doppler flow may also be seen, due to vascular in-growth.[1,5] Often, findings of tendinopathy and tenosynovitis may coexist.

de Quervain's tenosynovitis

de Quervain's tenosynovitis is a stenosing tenosynovitis, where there is thickening of the synovial sheaths of the abductor pollicis longus and extensor pollicis brevis tendons, resulting in entrapment.[2,6] This occurs at the level of the radial styloid, deep to the flexor retinaculum.[6] Patients typically have a weak hand grip with pain in the wrist, especially with abduction of the thumb. Causes include rheumatoid arthritis, pregnancy and other synovial inflammatory disorders.[6] Findings on US are similar to those of tenosynovitis, with thickening of the synovial sheath, distension of the tendon sheath with fluid and hypervascularity on colour Doppler US (Fig. 6).[2,6]

Rheumatoid arthritis

Rheumatoid arthritis is a systemic disorder, characterised by chronic synovitis, leading to articular cartilage and bone

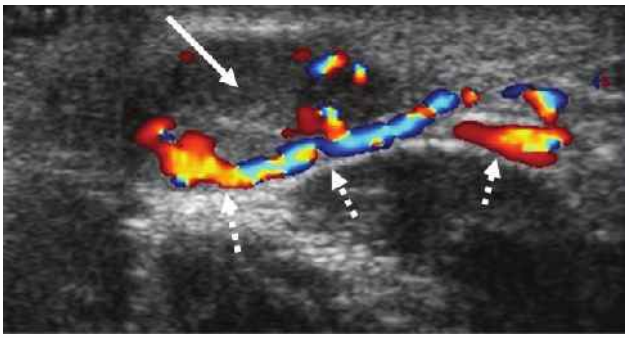

Fig. 18 Haemangioma. Well-defined lobulated slightly echogenic mass (solid arrow) in the subcutaneous tissue of the palm, with several adjacent dilated vessels (dashed arrows).

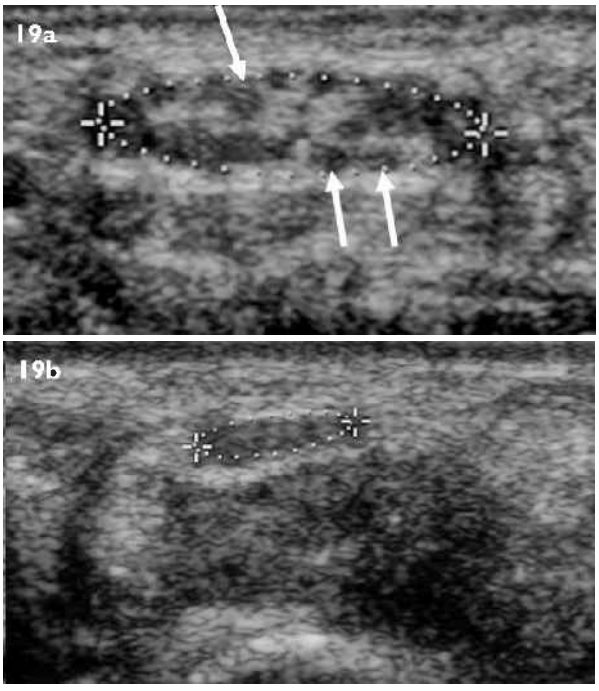

Fig. 19 Fibrolipomatous hamartoma. Transverse US images of the median nerves of the same patient. (a) The upper image shows a grossly enlarged median nerve (cross-sectional area: 0.450 cm^2), with splaying of the hypoechoic nerve fascicles (arrows) and increased echogenic fatty tissue. (b) The normal median nerve is seen in the lower image as comparison (cross-sectional area: 0.073 cm^2).

destruction.[7,8] Despite advances in the treatment of this disease, it is associated with significant morbidity, mortality and healthcare costs.[8] Radiography of the hands and wrist has long been the standard imaging modality for the diagnosis, grading and assessment of disease progression in rheumatoid arthritis.[7,8] However, it is only an indirect method of evaluating the underlying pathophysiology, which mainly involves the articular and periarticular tissue. Furthermore, the first radiological changes of bone erosions only occur late in the disease process.[1] US is a convenient method of directly visualising the articular and periarticular pathology in rheumatoid arthritis, and can also detect the early inflammatory changes, such as synovitis, bone erosions, and to a lesser extent, cartilage loss. It is now used as an indicator for disease activity, especially with quantified power Doppler US, to diagnose subclinical cases of arthritis and evaluate treatment response.[1,7] Findings on US include bone erosions (Fig. 7), tenosynovitis with tendon thickening and increased colour Doppler flow in the thickened tendon sheath and joint effusion with hypertrophic synovium (Fig. 8).[7] Pannus is seen as hypoechoic soft tissue in continuation with the hypertrophic synovium at the articular margins with hypervascularity.[1]

Gout

Gout is one of the commonest forms of inflammatory arthritis, mediated by the deposition of monosodium urate crystals in the superficial portions of the articular cartilage, resulting in an inflammatory response. The most reliable method of diagnosing gouty arthritis continues to be needle aspiration of joint fluid and identification of the crystals on polarising microscopy. Of late, US has been identified as a viable modality for providing an early noninvasive tool for diagnosis.[9] Findings on US include the "double contour" sign, with a superficial hyperechoic band over the articular cartilage, hypoechoic to hyperechoic tophi surrounded by an anechoic rim and erosions adjacent to the tophi (Fig. 9).[9]

TRAUMATIC INJURY

Tendon injury

Tears of the extensor tendons are commonly a sequela of rheumatoid tenosynovitis. Other cases may be due to direct injury or contusions. Tears of the flexor tendons, on the other hand, are usually associated with penetrating injury rather than contusions.[1,10] US is useful in determining if the tendon tear is partial or complete. It can also locate the exact site of rupture and the degree of retraction of the torn ends, which is essential for planning reconstructive surgery.[1,10] Postoperatively, US is useful for follow-up to identify suture dehiscence or entrapment due to granulation tissue (Fig. 10), especially with dynamic assessment during active and passive movement. Partial tendon tears are difficult to evaluate on US and appear as focal hypoechoic areas within the tendon (Fig. 11). Often, tendon tears may be longitudinal along the length of the tendon (Fig. 12). Complete tears show up as complete disruption of the normal fibrillar tendon fibres (Fig. 13) and lack of tendon movement on dynamic assessment.[10]

Ligament injury

In the wrist, the scapholunate, lunotriquetral and the triangular fibrocartilage are amenable to assessment with US. However, magnetic resonance (MR) imaging and MR arthrography remain the diagnostic modalities of choice.[1] In the hand, US can aid in assessing the radial

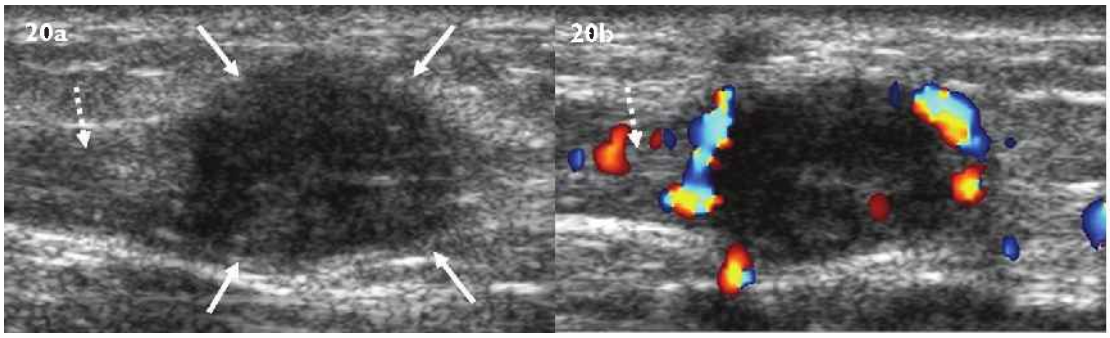

Fig. 20 Myosarcoma. (a) Longitudinal and (b) transverse US images show a hypoechoic mass arising (solid arrows) from the belly of the flexor carpi ulnaris (dashed arrows) at the distal musculotendinous junction in the wrist. There is internal and peripheral vascularity on colour Doppler US.

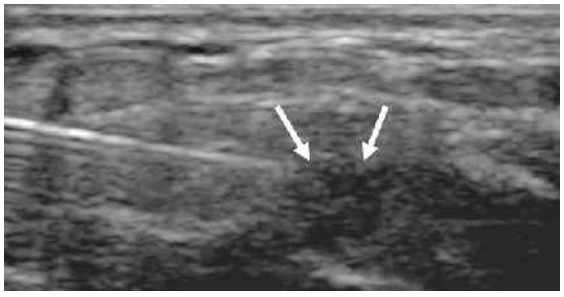

Fig. 21 Ultrasound-guided right wrist injection using a 23-gauge needle directed towards synovial thickening (arrows) in a patient with rheumatoid arthritis.

and ulnar collateral ligaments of the metacarpophalangeal and interphalangeal joints (Fig. 14), which are commonly prone to sprains. Here, a water bath is preferred to a standard gel interface due to the small size of the joints examined.

Pulley injury of the hands

The pulley system in the hands is composed of focal thickenings in the flexor tendon sheaths on the volar aspect, which prevents tendon excursion during flexion.[11] Loss of this pulley system results in impaired digital function. Two types of pulleys are identified, the annular pulleys (A1–A5) and the cruciform pulleys (C1–C3). The A2 pulley, which lies in the proximal third of the proximal phalanx, and the A4 pulley, which lies across the middle phalanx, appear to be the two most important pulleys for precise flexor tendon function.[1,11] On US, these pulleys can be difficult to identify. They are seen as thin hyperechoic bands found anterior to the flexor tendons. Tears result in the disruption of these bands with bowing of the flexor tendon on forced flexion.[1]

Nerve injury

Nerve injuries are commonly seen following traumatic penetrating injuries or surgical amputation. Often as a sequela, traumatic neuroma formation is seen at the end of the severed nerve or at the repair site. These represent disorganised neural tissue that grow at the ends of the severed nerve and can cause continued symptoms of pain and paraesthesia. On US, a traumatic neuroma is seen as a well-defined hypoechoic bulbous mass arising from the nerve sheath at the severed end (Fig. 15).[1,2]

MASSES

Cystic lesions

Ganglions are the most common lesions of the hand and wrist.[1,2,5] They are filled with thick viscous fluid with no synovial lining. These lesions are often indistinguishable from synovial cysts on imaging.[1,5] Most ganglia arise from the dorsum of the wrist, in relation to the dorsal scapholunate ligament. On US, they are classically well-defined, lobulated hypoechoic cystic masses with posterior acoustic enhancement and fine septations (Fig. 16).[2,5] A tail may be seen extending to the adjacent joint or tendon.

Benign tumours

Giant-cell tumours of the tendon sheath are the second most common lesions of the hand and wrist.[1,12] They are sometimes known as focal pigmented villonodular synovitis due to the histological appearance. They arise from the tendon sheath and can progressively enlarge, causing erosions to the adjacent bone. Most commonly, these lesions involve the volar surface of the fingers at or distal to the metacarpophalangeal joints.[1,12] On US, these lesions are well-defined solid hypoechoic masses with vascularity demonstrated on colour Doppler US (Fig. 17).[1,12] On dynamic assessment, these lesions do not move with the tendons.[12]

Haemangiomas are common soft tissue lesions in the hands and wrist, especially seen in young adults, representing about 10% of benign tumours. On US, these lesions have a variable appearance, but often are well-defined compressible solid echogenic or hypoechoic masses with cystic sepiginous areas representing dilated vessels (Fig. 18).[1,10] Echogenic phelboliths may be seen, with posterior acoustic shadowing. Vascularity is usually demonstrated on colour Doppler US, although in cavernous lesions, slow flow may not be detected.[1] Of note, highly vascular lesions may also mimic haemangiomas and thus,

if in doubt, MR imaging should be performed.

Fibrolipomatous hamartomas are rare lesions that most commonly affect the median nerve and its branches.[13] Symptoms include pain and paraesthesia along the distribution of the involved nerve, due to the proliferation of the fibroadipose tissue of the nerve sheath. On US, there is enlargement of the involved nerve with splaying of the nerve fascicles by a proliferation of slightly echogenic fatty tissue (Fig. 19).

Malignant tumours

Malignant lesions of the hand and wrist are uncommon and those that are seen on US are mostly soft tissue sarcomas. Metastases are less common. In general, the various types of soft tissue sarcomas have similar non-specific US appearances. They are generally well-defined heterogenous, overall hypoechoic, masses with vascularity demonstrated on colour Doppler US (Fig. 20). An exception is a well-differentiated liposarcoma, which is usually homogeneously hyperechoic.[1] MR imaging, however, is the preferred modality for preoperative evaluation.

ULTRASOUND-GUIDED PROCEDURES

A useful clinical application of US due to the advent of new generation high-frequency transducers is that of ultrasound-guided percutaneous tendon sheath, bursal and joint injections with corticosteroids and local anaesthetic.[1,14] Due to the ability for real-time assessment, accurate needle placement and observed delivery of the therapeutic agents can be made (Fig. 21). Common indications include sports-related injury, chronic repetitive injury or underlying inflammatory disorders like rheumatoid arthritis and de Quervain's tenosynovitis.[1,14]

In carpal tunnel syndrome, compressive symptoms may also be relieved by ultrasound-guided percutaneous injection of anti-inflammatory agents, usually in the space between the flexor carpi radialis tendon and the median nerve.[1] Ultrasound-guided percutaneous synovial biopsy of the wrist joint is another useful procedure that is usually performed in cases of arthritis of uncertain aetiology. This is performed using a side-notch cutting needle inserted into the joint space.[14]

CONCLUSION

Rapid technical advances in US have allowed for the imaging of superficial structures with exquisite detail. In turn, this has allowed accurate dynamic US assessment and guided percutaneous procedures of the hand and wrist, with a wide range of pathology amenable to evaluation. The lack of ionising radiation, noninvasiveness, portability and low cost are also attractive added benefits. Thus, US should play an important role in the imaging of hand and wrist pathology, as an alternative to costlier modalities like MR imaging.

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SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
Multiple Choice Questions (Code SMJ 200902B)

	True	False
Question 1. Regarding the carpal tunnel syndrome on ultrasonography:		
(a) Swelling of the median nerve in the proximal carpal tunnel is a characteristic finding.	☐	☐
(b) Increased echogenicity of the median nerve is a characteristic finding.	☐	☐
(c) Palmar bowing of the palmar carpal ligament is a finding.	☐	☐
(d) A median nerve cross-sectional area of > 0.1 cm^2 at the level of the distal tunnel indicates the diagnosis.	☐	☐
Question 2. Regarding de Quervain's tenosynovitis:		
(a) It is a stenosing tenosynovitis.	☐	☐
(b) The abductor pollicis longus and the flexor pollicis brevis tendons are implicated in the condition.	☐	☐
(c) On ultrasonography, there is distension of the tendon sheath, thickening of the synovium and hypervascularity on colour Doppler.	☐	☐
(d) It is amenable to ultrasound-guided therapy.	☐	☐
Question 3. Regarding rheumatoid arthritis:		
(a) MR imaging is established as the standard imaging modality for the assessment of disease progression.	☐	☐
(b) Ultrasonography can detect early inflammatory changes in the hands and wrist.	☐	☐
(c) Bone erosions, tenosynovitis and increased colour Doppler flow in the tendon sheath are characteristic findings.	☐	☐
(d) Pannus is hyperechoic on ultrasonography.	☐	☐
Question 4. Regarding traumatic injury of the hand and wrist:		
(a) Partial tendon tears are accurately detected on ultrasonography.	☐	☐
(b) A standard gel interface is preferred in the assessment of the collateral ligaments in the fingers on utrasonography.	☐	☐
(c) The A2 and C1 pulleys appear to be the most important pulleys for flexor tendon function.	☐	☐
(d) Traumatic neuromas are disorganised neural tissue that forms at the ends of severed nerves.	☐	☐
Question 5. Regarding masses in the hands and wrist:		
(a) Ganglions are the most common lesions found.	☐	☐
(b) Giant cell tumours of the tendon sheath move with the tendons on dynamic assessment.	☐	☐
(c) Vascularity is always demonstrated in haemangiomas on colour Doppler ultrasonography.	☐	☐
(d) On ultrasonography, fibrolipomatous hamartomas cause enlargement of the involved nerve.	☐	☐

Doctor's particulars:

Name in full: _____

MCR number: _____ Specialty: _____

Email address: _____

SUBMISSION INSTRUCTIONS:
(1) Log on at the SMJ website: http://www.sma.org.sg/cme/smj and select the appropriate set of questions. (2) Select your answers and provide your name, email address and MCR number. Click on "Submit answers" to submit.

RESULTS:
(1) Answers will be published in the SMJ April 2009 issue. (2) The MCR numbers of successful candidates will be posted online at www.sma.org.sg/cme/smj by 15 April 2009. (3) All online submissions will receive an automatic email acknowledgment. (4) Passing mark is 60%. No mark will be deducted for incorrect answers. (5) The SMJ editorial office will submit the list of successful candidates to the Singapore Medical Council.

Deadline for submission: (February 2009 SMJ 3B CME programme): 12 noon, 8 April 2009.