Musculoskeletal ultrasound in adults

Introduction

Ultrasound is widely used in the imaging of many musculoskeletal conditions (Van Holsbeeck and Introcaso, 2001; McNally, 2005). Advances in technology, including higher resolution probes, power Doppler sonography, extended field-of-view imaging and compound imaging, have expanded its applications in musculoskeletal disorders.

Ultrasound has the advantages of low cost, accessibility, portability, lack of ionizing radiation, non-invasiveness, and multiplanar imaging. But one of its most important diagnostic advantages over other techniques is its real-time imaging capability, allowing for dynamic evaluation.

The real-time imaging feature of sonography is of particular interest because some disorders of muscles, tendons, nerves, and joints are better or, in some cases, only seen dynamically, during motion of the extremity, muscle contraction, probe compression, or position change of the patient. Real-time imaging can also be used for joint injections, aspirations and biopsy. Doppler allows the detection of hyperaemia which may be a feature of inflammation, trauma and neoplasia.

Ultrasound can also be used to assess response to therapy. Limitations include its operator dependence and the fact that the internal structure of bones cannot be imaged as dense acoustic shadowing is produced.

Transducers and technique

High frequency transducers (8–15 MHz) are used to image superficial structures. These produce high contrast resolution images. For deeper structures such as the hip lower frequency probes (3.5–5 MHz) are used to allow tissue penetration.

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One common problem seen in musculoskeletal ultrasound is anisotropy. A tendon normally appears as echogenic fibrils if the probe is perpendicular to the tendon. If the scanning angle is not 90° this produces spurious echopoor areas which can mimic tears (*Figures 1a* and *b*). This is especially a problem in curved tendons such as the supraspinatus.

Ultrasound is extremely useful in diagnosing joint disorders such as effusions, synovitis, erosions and some cartilaginous abnormalities. It is also excellent in the assessment of cysts, bursae, soft tissue masses, ligaments, nerves and tendons. A comprehensive review of all the indications for ultrasound in musculoskeletal disorders is beyond the remit of this article. Instead, we will focus on some common musculoskeletal conditions.

Shoulder

Rotator cuff disease

Shoulder pain is one of the commonest orthopaedic problems and rotator cuff disease is a frequent cause. Ultrasound is the modality of choice in the initial assessment of the rotator cuff as the tendons can be imaged in at least two planes together with dynamic stress testing.

Rotator cuff tears may be complete or partial (*Figures 2* and *3*). Partial thickness tears can be articular surface, bursal surface or intrasubstance delaminating tears. Partial thickness articular surface tears are more common than those of the bursal surface. Ultrasound is highly sensitive and specific in the diagnosis of full thickness tears, comparable with magnetic resonance, but is less accurate in the detection of partial tears. Ultrasound has been shown to have a sensitivity of 97% for full thickness tears and 91% for partial thickness tears with an overall accuracy of 90%.

The supraspinatus tendon is the commonest tendon to be involved followed by the infraspinatus. Isolated tears of the infraspinatus without any concomitant tears of the supraspinatus are rarely seen. Cuff tears are typically seen as hypoechoic areas within the echogenic tendons. There may be haemorrhage and oedema at the site of the tear masking the tear.

Figure 1. Anisotropy of the supraspinatus tendon. a. Echopoor segments (mimicking tears) are seen in the tendon (arrows) when imaged with an incident angle of less than 90°. b. The echopoor segments are no longer seen when the tendon is correctly imaged at 90°.

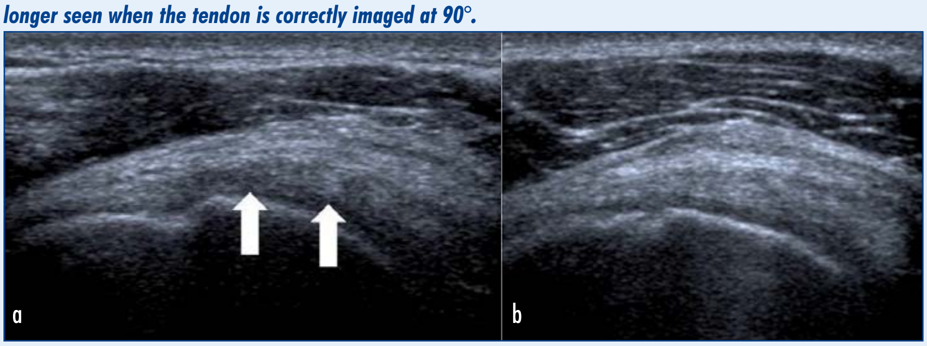


Figure 2. Complete tear of the rotator cuff with a defect in the supraspinatus tendon (arrows).

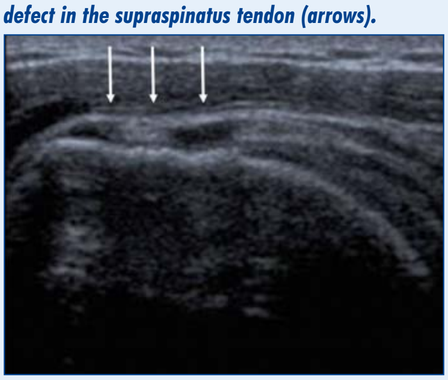
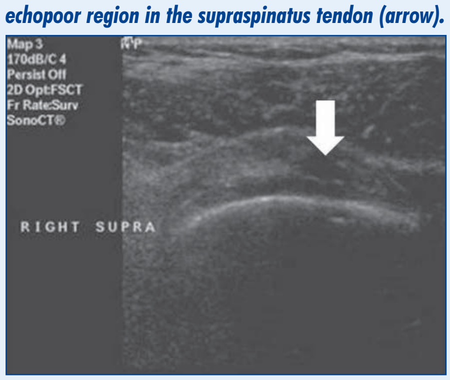


Figure 3. Partial tear of the rotator cuff seen as an echopoor region in the supraspinatus tendon (arrow).



Dynamic ultrasound with application of gentle pressure may displace the fluid and demonstrate the tear. Secondary signs of a cuff tear include flattening of the normal convex superior contour of the supraspinatus tendon implying a full thickness tear, subacromial subdeltoid bursa fluid along with gleno-humeral joint effusion.

Shoulder impingement syndrome

In shoulder impingement syndrome, pain is generated when the greater tuberosity of the humerus or soft tissue structures (supraspinatus tendon and subacromial-subdeltoid bursa) encroach on the coracoacromial arch (acromion, coracoacromial ligament and acromioclavicular joint) in abduction or abduction-flexion internal rotation of the shoulder. Dynamic sonography is an ideal tool to make the diagnosis of shoulder impingement because it can directly show this dynamic process in addition to evaluating the rotator cuff and other associated abnormalities such as supraspinatus tendon thickening, focal tendon calcification and subacromial subdeltoid bursa fluid.

Dynamic evaluation may be used to classify the severity of shoulder impingement. In mild impingement grade 1, there are no objective sonographic findings of impingement, but there is a correlation between passage of the tendon under the acromion and pain. With moderate grade 2 impingement, there is accumulation of subacromial-subdeltoid bursal synovium or fluid lateral to the acromion. The supraspinatus tendon may catch on the acromion (ratchet motion). With severe grade 3 impingement, there is superior migration of the humeral head and the tendon bunches up or bulges laterally because the greater tuberosity cannot glide under the acromion.

In the assessment of impingement syndrome of grades I–III when compared with surgical results, ultrasound showed a sensitivity of 81%, a specificity of 95% and an accuracy of 90%. The positive predictive value of sonography is 91% and the negative predictive value 90% (Farin et al, 1990).

Non-rotator cuff disease

Shoulder pain may be the result of tendinopathy or bursitis and injection of the subacromial subdeltoid bursa may be performed under ultrasound guidance. Ultrasound can also be used to aspirate the glenohumeral joint in suspected septic arthritis. The acromioclavicular and sternoclavicular joints can also be imaged in trauma, osteoarthritis, septic arthritis and synovial conditions. Ultrasound is also useful in diagnosing dislocation, tendinopathy and rupture of the long head of biceps tendon.

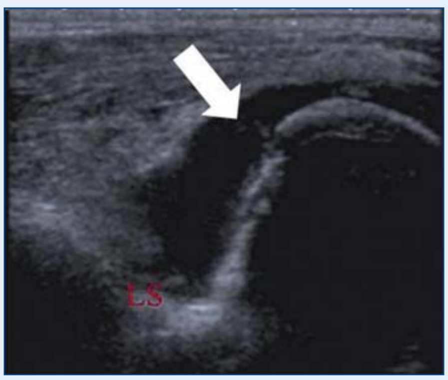
Elbow

'Tennis elbow' (lateral epicondylitis) (*Figure 4*) and 'golfer's elbow' (medial epicondylitis) can be diagnosed on ultrasound and studies comparing operative findings with ultrasound and magnetic resonance indicate that they are of similar diagnostic accuracy. These are usually seen as focal hypoechoic areas at the common tendinous origin with or without increased vascularity. Ultrasound is also used to guide injections in these patients. Miller et al (2002) reported a sensitivity of 64–82% and a specificity of 67–100% between two independent reviewers for diagnosing lateral epicondylitis.

Ultrasound is very sensitive in the detection of joint effusions (*Figure 5*) and can detect 1–2 ml which can be aspirated. Ultrasound can also detect bursitis, synovial cysts and ulnar nerve compression or dislocation in the cubital tunnel. In addition tears of the distal biceps insertion and brachialis can be elegantly demonstrated on ultrasound.

Figure 4. Lateral epicondylitis (tennis elbow) seen as echopoor change and loss of the normal fibrillar pattern at the tendon insertion (arrow).

Figure 5. Joint effusion (arrow) seen as anechoic fluid.



Hands and wrists

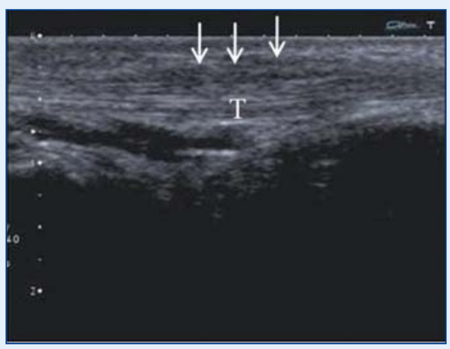
Synovitis

The detection of early erosions and synovitis in inflammatory arthritides has been revolutionized by ultrasound and magnetic resonance which has facilitated the early introduction of disease-modifying drugs shown to prevent progression of joint destruction. Conventional radiographs lag behind the pathological disease process by up to a year. While magnetic resonance may be the modality of choice, ultrasound is easy to perform and widely available in the outpatient setting. Synovial thickening (*Figure 6*), tenosynovitis (*Figure 7*), bony erosions and cartilage damage can be demonstrated.

The presence of joint, bursal or tendon sheath effusion may be used as an indirect correlate of synovial inflammation and improves ultrasound visualization of synovial thickening. When there is no effusion, synovitis may be diagnosed by the presence

Figure 6. Synovitis seen as thickened echopoor tissue (measured between callipers) and a bony erosion (arrows).

Figure 7. Tenosynovitis. Synovial thickening (arrows) is seen adjacent to a tendon (T).



of an abnormally thickened hypoechoic region. Ultrasound detects significant degrees of synovitis not determined by clinical examination and can reliably discriminate inflammatory and non-inflammatory joint disease.

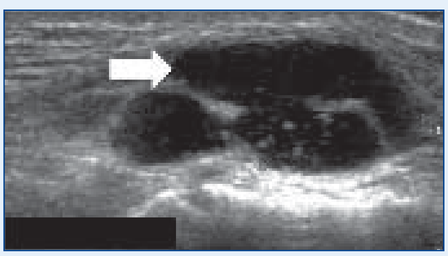
Improvements in imaging resolution and the use of power Doppler now allow imaging of smaller degrees of synovitis with an accuracy equal to that of dynamic magnetic resonance. No signal is detected in the normal synovial membrane but power Doppler ultrasound allows quantification of low-velocity flow in the synovium. A significant correlation between the power Doppler signal and the degree of vascularity of the synovium has been reported. Therapy-induced power Doppler changes, linked to clinical improvement, have also been shown after treatment with disease-modifying agents and intra-articular steroid injections.

Carpal tunnel syndrome

The most common nerve entrapment syndrome is the carpal tunnel syndrome. Ultrasound easily differentiates the median nerve from tendons as it is hyperechoic and speckled in transverse section but does not demonstrate anisotropy and has a hypoechoic fascicular pattern in longitudinal section. Ultrasound can demonstrate changes in the nerve and carpal tunnel. The median nerve diameter and cross-sectional area can be measured both at the inlet and outlet of the carpal tunnel. In addition volar bulging and thickening of the flexor retinaculum, nerve oedema, swelling, flattening and hypervascularization can be seen.

Ultrasound is also useful in imaging traumatic conditions such as ligamentous injuries as well as diagnosing tears of the flexor and extensor tendons. Ultrasound is excellent in the characterization of soft tissue masses such as ganglia (*Figure 8*), lipomas (*Figure 9*), neural and glomus tumours. Ultrasound is very useful for injection of the synovial sheaths of the tendons.

Figure 8. Multiloculated ganglion (arrow).



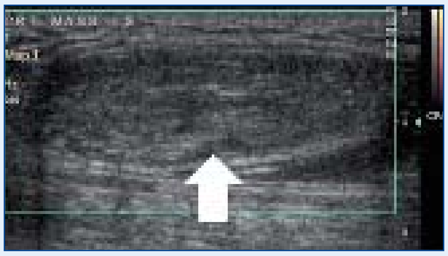


Figure 9. Lipoma (arrow) seen as a characteristic avascular encapsulated whorled soft tissue mass.

Hip

Effusions are well demonstrated on ultrasound and result in distension of the joint capsule in scans orientated along the long axis of the femoral neck. They may be easily aspirated under ultrasound guidance. Peri-prosthetic fluid is well demonstrated in patients with hip arthroplasties where magnetic resonance is limited by artefact. Ultrasound is also used to evaluate and inject patients with trochanteric bursitis seen as localized soft tissue thickening, calcification and localized tenderness.

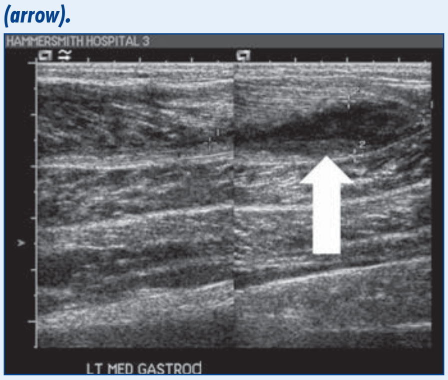
Knee

The most common applications are sports-related injuries (*Figure 10*), evaluation of fluid collections, synovitis and soft tissue masses.

Ultrasound can assess the extensor mechanism allowing tendinopathy and tears of the quadriceps and patellar tendons to be diagnosed.

There are numerous bursae (pre-, infra- and suprapatellar) around the knee which can become inflamed (*Figure 11*). Rupture of the semimembranosus or gastrocnemius bursa (Baker's cyst) can mimic a deep vein thrombosis (*Figure 12*). Popliteal masses such as popliteal aneurysms can be easily assessed by ultrasound as well as deep vein thrombosis.

Figure 10. Tear of medial head of gastrocnemius (arrow).



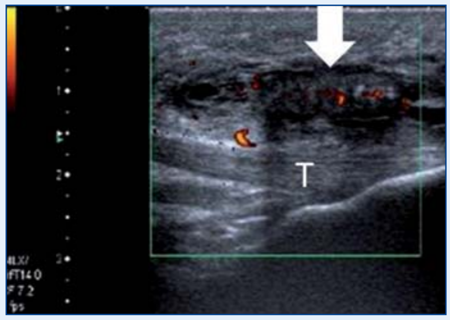


Figure 11. Prepatellar bursitis seen as echopoor hyperaemic tissue (arrow) anterior to the patellar tendon (T).

Ankle and foot

As in the wrist and hands synovitis, erosions and effusions may be demonstrated. In addition ultrasound is excellent in impingement syndromes and for imaging of the tendons especially the Achilles tendon for rupture (*Figure 13*) and tendinopathy as well as bursitis. Plantar fasciitis can be diagnosed and injections guided by ultrasound.

Forefoot pain and evaluation of intermetatarsal region for Morton's neuroma is another important application of ultrasound in the foot region. Sonography is sensitive and specific in confirming the diagnosis of Morton's neuroma, with a 95–98% accuracy, similar to magnetic

Figure 12. Extended field of view image of a ruptured Baker's cyst with fluid (arrow) seen tracking down into the calf muscles.

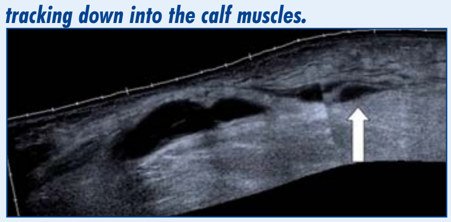


Figure 13. Extended field of view image of complete rupture of the Achilles tendon with a large defect between retracted tendon ends (arrow).

resonance (Quinn et al, 2000). In addition ultrasound is useful for injection of neuromas.

Conclusions

Ultrasound is widely used by radiologists, rheumatologists and orthopaedic surgeons and is the investigation of choice in a huge spectrum of musculoskeletal conditions. Technological advances continue to extend its role in diagnosis, follow up and determining response to treatment. **BJHM**

Conflict of interest: none.

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KEY POINTS

- Ultrasound is the modality of choice in a wide spectrum of musculoskeletal conditions.
- Ultrasound allows dynamic real-time imaging which is useful in provocative joint and tendon imaging as well as joint injections, aspiration and biopsy.
- Ultrasound is highly sensitive and specific in the diagnosis of rotator cuff tears.
- Ultrasound is highly accurate in the detection of erosions and synovitis in inflammatory arthritides allowing early introduction of disease-modifying agents.
- Ultrasound allows excellent demonstration of traumatic tears of muscles, tendons and ligaments.
- Ultrasound allows accurate characterization of superficial soft tissue masses and periarticular cysts and bursae.