Ultrasound has become a powerful tool for the assessment of joints with the advent of high frequency probes. It has advantages over other imaging modalities due to its superior spatial resolution, lack of radiation, dynamic examination, cost-effectiveness, and easy accessibility. Sonography can be performed in a position that is comfortable for the patient, which may not be possible with other imaging modalities.

**Normal US joint anatomy**

Ultrasound is a useful modality in assessing a wide variety of joint disorders. Normal joints comprise of bones, articular cartilage, joint capsule, synovial lining, surrounding ligaments, tendons and bursae. All of these structures can be assessed by ultrasound.

Tight joints are more difficult to evaluate. However, large and lax joints can be assessed by manoeuvres that will expose different areas of the joint for sonographic evaluation. Metacarpal heads can be completely evaluated in different degrees of flexion. Articular cartilage appears as a smooth linear hypoechoic band with underlying continuous hyperechoic subchondral bone.

Variation in the thickness of hyaline cartilage can be assessed precisely with ultrasound. Menisci in the knee joint, labrum in the shoulder and TFC of the wrist are fibrocartilaginous structures attached to the bone or joint capsule that appear hyperechoic on sonography. However, due to their deep position and close contact with bones, ultrasound assessment is not reliable.

In normal joints, synovial membrane is too thin to be visualised on the ultrasound. This can only be seen in pathological conditions leading to its hypertrophy and thickening. Joint capsule appears as a hyperechoic line between the joint and paraarticular soft tissues. Ligaments appear as hyperechoic structures that stabilise the joint. Because of their fibrillar structure they are anisotropic, meaning that they appear hyperechoic when the ultrasound beam is perpendicular to their surface. However, when the beam is oblique they may appear as hypoechoic and can be misinterpreted as pathological.

As ligaments are joint stabilisers, these are best assessed when stretched. Paraarticular tendons are hyperechoic structures with linear fibrillar pattern and, like ligaments, are also prone to anisotropy. Paraarticular bursae are thin walled hypoechoic structures, usually present in the areas of friction. Normal bursae are best seen with high frequency probes and when superficial in location.

**Pathologies**

**Joint effusion**

Diagnosis of joint effusion is essential as it can exclude the extrarticular causes of pain and disability. Clinical examination is accurate for joint effusion of elbow and knee but less accurate in wrist, ankle and deep-seated joints like the hip. Radiography can also be quite insensitive for the presence of fluid in the joint.

Ultrasound is very sensitive for reliable diagnosis of even small amounts of joint effusion. However, joint effusion can be due to many causes, including inflammatory conditions, trauma, mechanical or infection. Joint fluid generally is anechoic but can have internal echoes, debris or fibrin septae depending on the nature of its contents.

**Inflammatory arthritis**

Sonography is being used increasingly as the first line of investigation for assessment and follow-up of inflammatory arthopathies. As early changes in these cases are non-osseous in nature, sonography is superior to plain radiography in disease detection. Sonography can directly visualise synovial pathology at an early stage, which in turn can help in starting disease modifying medication.

Thickened synovium or pannus can completely fill the joint space and may be associated with joint fluid. Pannus can be differentiated from joint effusion on ultrasound as thickened synovium, unlike joint fluid, can be deformed but not displaced with probe pressure. Increased blood flow is seen on Doppler imaging in active synovitis while it is absent in cases of chronic disease. This can help to assess the response of therapy. Development of erosions is a significant step in the natural history of inflammatory arthropathies. Erosion can be seen at the bare areas of small joints of hands and feet. These appear as areas of cortical irregularity with ill-defined base and filled with pannus (figure 1). Sonography is very efficient in detection of erosions in the early stages of disease.

Another advantage of ultrasound is that multiple joints in different body areas can be assessed at the same time. Synovial neovascularity can be directly assessed with ultrasound whereas MR requires injection of gadolinium. Conversely, MR is more useful in the detection of intraosseous abnormalities such as subchondral oedema in which the overlying cortex is intact. Ultrasound can also be helpful for synovial biopsy in doubtful cases and guided injection for the treatment.

**Septic arthritis**

Early diagnosis of septic arthritis is essential to avoid joint destruction and secondary osteoarthritis. Patients usually present with pain, joint swelling and redness of the joint. Ultrasound is accurate as it shows joint effusion even before the start of cartilage loss when plain x-rays are normal. On ultrasound, infected joint effusion generally has internal echoes with thickened synovium. In advanced cases, septations and debris can also be seen and increased flow is almost always seen on Doppler imaging. However, ultrasound features are non-specific and hence an ultrasound-guided aspiration of the fluid or a synovial biopsy should be performed.

**Bone and cartilage lesions**

Bone and articular cartilage, when accessible, can be evaluated with ultrasound. In osteoarthritis, there is gradual thinning and loss of articular cartilage with progressive irregularity of underlying hyperechoic bone. Osteophytes appear as bony projections arising from the joint margins. These can be seen easily on ultrasound at the posterior aspect of humeral head and MCP joints.

Hill-Sachs lesion is traumatic impaction of the posterosuperior aspect of humeral head cortex that occurs when it impacts against the anteroinferior glenoid during anterior dislocation. It appears as a localised area of concavity of the posterosuperior aspect of the humeral head, just underneath the infraspinatus tendon fibres. Ultrasound may also demonstrate callus formation in stress fractures especially in the metatarsal bones.

Articular cartilage may also be affected in depositional diseases like CPPD when calcium crystals deposit in the cartilage. Multiple hyperechoic shadows are produced on ultrasound that are best seen at the femoral condyles.
Ligaments
Ligament injuries can be assessed with ultrasound in the knee, ankle and thumb. In acute partial thickness tear, ligaments may be thickened with hypoechogenecity, however, continuity of few fibres remains intact. In an acute full thickness tear, torn ends of ligaments appear wavy, retracted and the gap is filled with haematoma. In doubtful cases, ligament can be stretched during dynamic scanning which is a unique advantage of ultrasound over other imaging modalities. A normal ligament will prevent excessive joint widening. When ligament is torn, paradoxical movement is seen which reflects joint instability. Ligament appears thickened in chronic tear and may have calcification. Superficial ligament injuries are also associated with internal derangement of joints, which cannot be assessed on ultrasound. In these cases MR imaging should be performed.

Joint instability is best assessed on plain radiographs. However, in certain joints, complex anatomy and surrounding structures make detection of subluxation or dislocation quite difficult on plain x-rays. Ultrasound can help in diagnosis of mild AC joint subluxation and occult posterior shoulder dislocation.

Intraarticular fibrocartilage structures
As already mentioned, fibrocartilaginous structures can only be evaluated in part and ultrasound cannot accurately assess fibrocartilage tear. However, ultrasound is quite efficient in detecting parameniscal and paralabral cyst. As these cysts are invariably associated with fibrocartilage tear, diagnosis of labral or meniscal tear can be made in doubtful cases. These cysts have regular margins and mixed internal echotexture. Care should be taken, as these can present as palpable soft tissue mass, which can track for some distance and remain connected to the fibrocartilage with a thin pedicle (figure 2). These cysts, even small in size, can produce neuropathy by compressing adjacent nerves, eg suprascapular nerve from a posterior glenoid cyst and femoral nerve by anterior acetabular labral cyst.

Tendons
Ultrasound is the most efficient modality for the evaluation of the paraarticular tendons. It has a big advantage of dynamic scanning and is reported to be equal to or even better than MR in assessment of shoulder and ankle tendons. In tendinosis, thickening and low echogenicity of tendon is seen with loss of normal musculo-tendinous differentiation. Tendon becomes thin with low echogenicity in partial thickness tear. In full thickness tear, tendon ends are retracted and have a wavy outline. The gap between the torn ends is filled with hypoechogenic fluid and haematoma (figure 2). Calcium deposition in tendon can present as calcific tendinosis, especially in the rotator cuff. When calcium irritates the adjacent subacromial bursa, it produces severe pain and limitation of shoulder movements. Ultrasound guided barbotage can be performed in which the calcium deposit is punctured, fragmented and aspirated with wide bore needle (figure 4).

Bursae
Ultrasound can efficiently show pathological changes in the paraarticular bursae. In acute bursitis, a variable amount of fluid is noted with or without bursal wall thickening. Fluid content decreases in chronic bursitis but bursal wall becomes thickened and irregular in outline.

Post-operative joint
Following arthroplasty, joint assessment can be quite challenging, as CT and MR imaging can be difficult to interpret due to artifacts. Ultrasound should be the first line of investigation in cases of suspected aseptic loosening or infection. Ultrasound can detect large amounts of fluid in the joint pseudocapsule, extracapsular soft tissue collection and local inflammatory change. Ultrasound can easily detect collections around the hip joint in metal on metal prostheses due to hypersensitivity to chromium and cobalt particles. Ultrasound-guided intervention can be used to precisely approach these collections without any damage to adjacent structures.

Further reading

References

FIGURE 1
First MTP joint: (a) Synovial thickening with erosions over the metacarpal head. (b) Neovascularity at the periphery of thickened synovium.

FIGURE 2
US medial knee: Parameniscal cyst, connected with medial meniscal tear (arrow) through a narrow pedicle.
**FIGURE 3**
(a) Normal patellar tendon, (b) Traumatic full thickness avulsion tear of proximal patellar tendon. Gap between torn tendon is filled with fluid and haematoma (arrow).

**FIGURE 4**
US shoulder: Calcification in the supraspinatus tendon (arrow). Needle in position for barbotage (arrow-heads).