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PICTORIAL REVIEW

Musculoskeletal infections: ultrasound appearances

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Musculoskeletal infections are commonly encountered in clinical practice. This review will discuss the ultrasound appearances of a variety of musculoskeletal infections such as cellulitis, infective tenosynovitis, pyomyositis, soft-tissue abscesses, septic arthritis, acute and chronic osteomyelitis, and post-operative infection. The peculiar sonographic features of less common musculoskeletal infections, such as necrotizing fasciitis, and rice body formation in atypical mycobacterial tenosynovitis, and bursitis will also be presented.

Introduction

Musculoskeletal infections are commonly encountered in clinical practice. Imaging is mainly used to evaluate moderate to severe infections, both as a diagnostic and therapeutic aid. Ultrasound may be used either as the primary imaging technique or as an adjunct to radiography, computed tomography (CT), magnetic resonance imaging (MRI) and nuclear medicine studies.

Ultrasound may help to (1) differentiate acute or chronic infection from tumours or non-infective inflammatory conditions with a similar clinical presentation; (2) localize the site and extent of infection (e.g. subcutaneous, muscle, bursa, tendon sheath, joint); (3) ascertain the form of infection (e.g. cellulitis, pre-abscess, abscess); (4) identify precipitating factors (e.g. foreign bodies, fistulation); and (5) provide guidance for diagnostic or therapeutic aspiration, drainage or biopsy.[1] This review focuses on the application of ultrasound in various forms of musculoskeletal infection. Infections of superficial, deep, and specific tissues (bursa, tendons, and joints) will be discussed.

Cellulitis

Cellulitis is a spreading inflammatory reaction occurring along subcutaneous and fascial planes with oedema and hyperaemia.[2] Cellulitis is probably the most common form of musculoskeletal infection encountered in hospital practice. It usually results from a *Streptococcus pyogenes* or *Staphylococcus aureus* infection.[1] Predisposing factors include stasis, poor general health, skin laceration or ulceration, venepuncture, eczema, and immunosuppression (Fig. 1).

The ultrasound appearances of cellulitis vary according to the site and severity of infection. Ultrasound appearances range from diffuse swelling and increased echogenicity of the skin and subcutaneous tissues (Figs. 1 and 2(a)), to a variable cobblestone appearance depending on the amount of perifascial fluid, the degree of subcutaneous oedema and the orientation of the interlobular fat septa. These grey-scale appearances are not, in themselves, diagnostic of cellulitis as similar appearances occur in subcutaneous oedema

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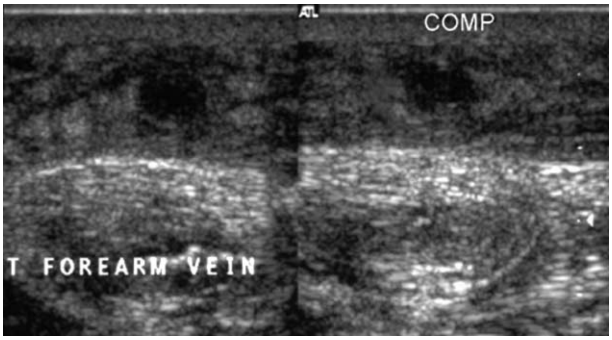
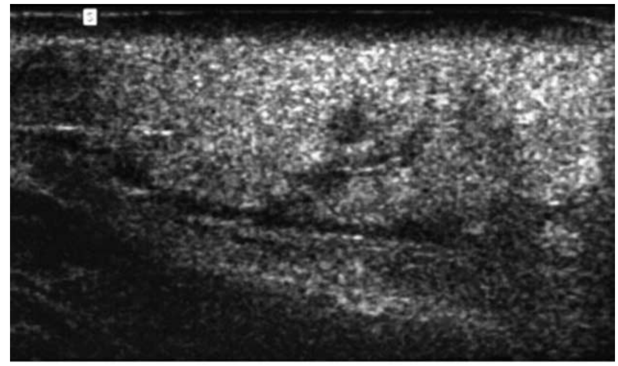


Figure 1 A 27-year-old intravenous drug abuser with left forearm swelling and fever for 1 week. Split-screen transverse ultrasound image reveals diffuse hyperechoic thickening of the subcutaneous fat interlaced with hypoechoic strands indicative of cellulitis. A subcutaneous vein is thrombosed containing non-compressible hypoechoic thrombus. The muscle is normal.

resulting from non-infective conditions such as venous insufficiency or cardiac failure. Colour or power Doppler imaging to show concurrent hyperaemia within the subcutaneous tissues is helpful in establishing an inflammatory element. Hyperaemia is not a feature of non-infective forms of oedema. Cellulitis may occur in conjunction with superficial thrombophlebitis (Fig. 1) and may progress to pre-abscess (Fig. 2(b)) or abscess (Fig. 2(c)) formation.

Necrotizing fasciitis

Necrotizing fasciitis is an uncommon, severe form of cellulitis characterized by a rapid clinical deterioration and death approaching 50% if untreated.[3,4] It usually affects the lower extremities. Patients typically experience severe pain, disproportionate to the severity of cellulitis. Dusky cutaneous discoloration with purpuric patches may occur.[5] Group A streptococci are the most common offending organisms. Pathologically, severe inflammation and necrosis of the subcutaneous tissues and the underlying investing fascia[6] characterize necrotizing fasciitis. Necrosis may be the result of microcirculation thrombosis and ischaemia.[5,7] The skin and muscle are spared in the early stage of disease.[6] Muscle necrosis occurs with involvement of the investing fascia. The accuracy of ultrasound in diagnosing of necrotizing fasciitis has not been fully established, a reflection of the relative rarity of this condition. The reported ultrasound appearances are thickened distorted fascia with perifascial hypoechoic fluid collection together with variable swelling of the subcutaneous tissues and muscle (Fig. 3). Early muscle necrosis



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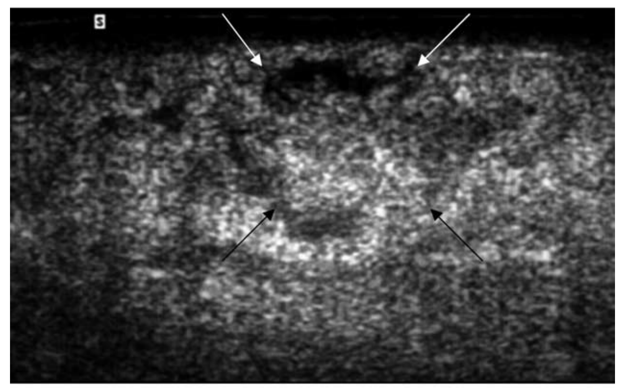

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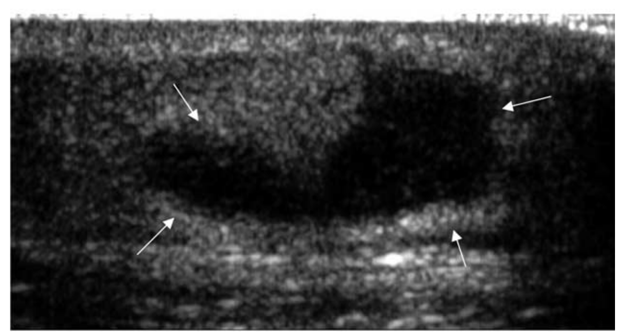


(c)

Figure 2 A three-year-old patient with painful posterior thigh swelling and erythema with central punctum for 3 days. A series of longitudinal ultrasound examinations revealed (a) increased thickening and echogenicity of the subcutaneous tissues. The muscle layer is normal. (b) Antibiotic treatment was started and 3 days later, some coalescence and fluid accumulation towards the centre of the subcutaneous tissues akin to a pre-abscess state (arrows) is apparent. (c) Two days later, there is more pronounced liquefaction (arrows) of the subcutaneous tissues. Subcutaneous swelling is less pronounced than on earlier examinations. 1 ml of purulent blood-stained fluid was aspirated.

may be apparent (Figs. 3 and 4). Parenti et al.[8] retrospectively reviewed the ultrasound appearances of 32 pathologically proven cases of necrotizing fasciitis. Ultrasound revealed changes in the

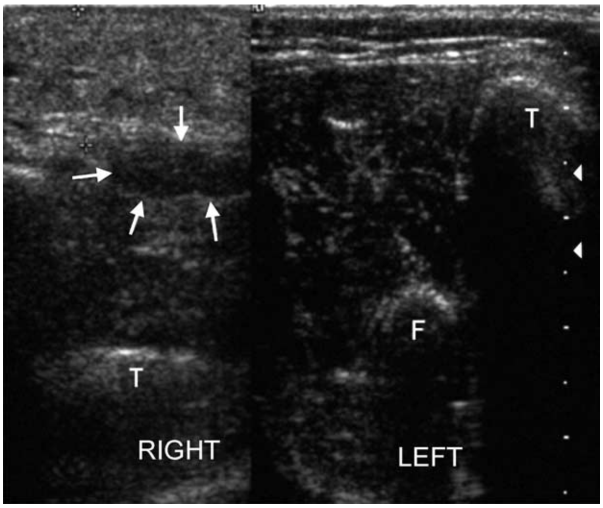


Figure 3 A four-year-old patient with fever, pain and right leg swelling for a few days. Split-screen ultrasound of right and normal left leg reveals marked subcutaneous cellulitis with thickening and increase echogenicity of subcutaneous fat (indicated by calipers). A hypoechoic abscess is present just deep to the disrupted investing fascia (arrows). The pre-tibial juxtacortical tissues are also very swollen. T = tibia. F = fibula. Surgical exploration revealed necrotic fascia, a small fascial abscess and early focal necrosis of adjacent muscle, consistent with necrotizing fasciitis. Tissue culture yielded group A streptococci. The patient responded well to debridement and antibiotic therapy.

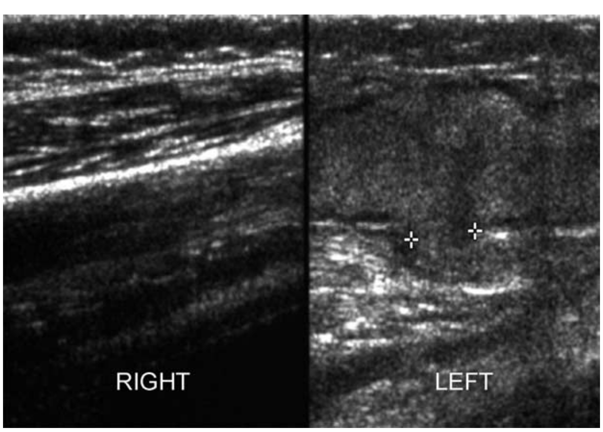


Figure 4 An eighteen-month-old patient with fever, knee pain and left distal thigh swelling for one week. Initially treated by a herbalist. Split-screen ultrasound of abnormal left and normal right distal thigh demonstrates a lobulated isoechoic abscess with a hypoechoic rim located superficial to the investing fascia. There is a focal discontinuity of the fascia with extension of the abscess into the vastus lateralis muscle. Surgical exploration confirmed necrotizing fasciitis with operative findings corresponding to the ultrasound findings. Tissue culture grew *Staphylococcus aureus*. Soon afterwards a severe osteomyelitis of the proximal tibia became apparent (not shown). This did not respond well to treatment. A residual pseudoarthrosis of the tibia remains.

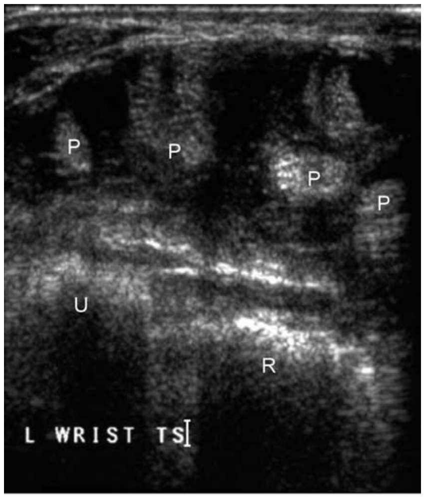
subcutaneous fat (28 of 32), investing fascia (18 of 32) and muscle (15 of 32), which correlated well with histological findings. However, in some cases ultrasound did not reveal histologically apparent inflammation in the subcutaneous tissues (three of 32) or muscle (eight of 32).[8] Ultrasound-guided aspiration of perifascial fluid can help isolate the pathogen.[9] Successful treatment requires early recognition, aggressive antibiotic therapy and adequate surgical debridement.

Infective bursitis

Although chronic bursitis is common, in our experience it is usually non-infective.[10] Bursitis usually comprises a sterile inflammation of the bursal wall as a result of chronic repetitive trauma or undue mechanical stress. When infection is present, *S. aureus* is usually the offending organism and a superficial bursa, such as the olecranon or prepatella bursa, the most commonly affected.[1,5] Ultrasound reveals peribursal oedema, bursal wall thickening and distension by fluid or gelatinous material of mixed echogenicity. Occasionally internal debris and calcification may be apparent. Colour Doppler imaging may reveal bursal wall hyperaemia. The ultrasound appearances of infective bursitis are considered identical to those of a chronic inflammatory non-infective bursitis, (which may be accompanied by intra-bursal bleeding), especially if a relatively non-virulent pathogen such as tuberculosis is responsible. Rice body, comprised of aggregates of fibrin, may be a feature of typical or atypical tuberculous burstitis (Fig. 5).[11,12] When bursal inflammation cannot be adequately explained by the clinical history, bursal aspiration for culture is recommended to exclude an infective element.

Infective tenosynovitis

Infective tenosynovitis is most commonly the result of penetrating trauma and as such occurs predominantly affects the hands and wrists.[10] The flexor tendons are more commonly affected.[5] Familiarization with tendon sheath anatomy and communication is essential to understanding the spread of tendon sheath infection in the hand and wrist.[13] The flexor tendon sheaths of the thumb and little finger communicate, respectively, with the radial and ulnar bursa on the volar aspect of the wrist and carpus. In half of cases, the radial and ulnar bursa communicate via an intermediate bursa. There are



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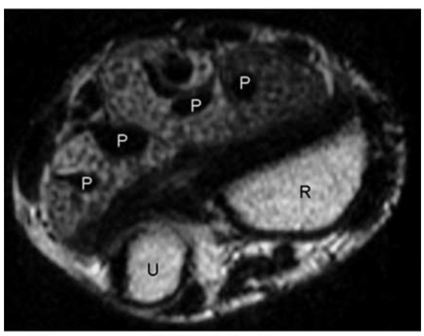


(b)

Figure 5 A 50-year-old man with left wrist swelling for 1 year. Transverse ultrasound of wrist shows low-level internal echoes without acoustic shadow located in deeper portion of the radio-ulnar bursa and surrounding flexor digitorum superficialis and profundus (P) tendons. Discrete rice bodies cannot be appreciated. R = radius, U = ulna. (b) Axial fast spin-echo MR image (repetition time 3800/echo time 105) demonstrates multiple small hypointense rice bodies (short arrows). These rice bodies almost completely fill the radioulnar bursa and are much more readily appreciable than on ultrasound (a). P = flexor digitorum profundus tendons. R = radius, U = ulna.

six discrete extensor tendon synovial sheaths that communicate neither with each other or the flexor tendons.[14] Acute suppurative tenosynovitis is usually caused by *S. aureus* and *S. pyogenes*.

Ultrasound can demonstrate variable thickening of the tendon and tendon sheath with hyperaemia most commonly of the tendon sheath though also occasionally within the substance of the tendon. Tendon sheath thickening is usually hypoechoic and as such may resemble viscous fluid (Fig. 6). Colour Doppler is particularly helpful in this instance allowing one to differentiate synovial sheath thickening from a synovial sheath effusion.

Figure 6 A 37-year-old intravenous drug addict with history of recurrent lung abscess and septic arthritis of knee with wrist pain for 1 week. Ultrasound revealed marked tenosynovitis affecting the extensor carpi ulnaris tendon with moderate tendon thickening, severe tendon sheath thickening and moderate peritendinous soft-tissue oedema. Colour Doppler (not shown) revealed diffuse hyperaemia of the tendon sheath (indicating that it represents synovial inflammation rather than an echogenic effusion) and peritendinous tissues.

This distinction is important as the demonstration of an effusion allows one to consider diagnostic aspiration (for culture and sensitivity) and may also influence decision making as to whether urgent surgery should be undertaken. Surgery may potentially be less beneficial in those patients without visible tendon sheath effusion. Unequivocal tendon sheath effusions are usually not a dominant feature though small pockets of fluid may be present with more pronounced fluid accumulation being a feature of severe acute suppurative tenosynovitis (Fig. 7). Occasionally

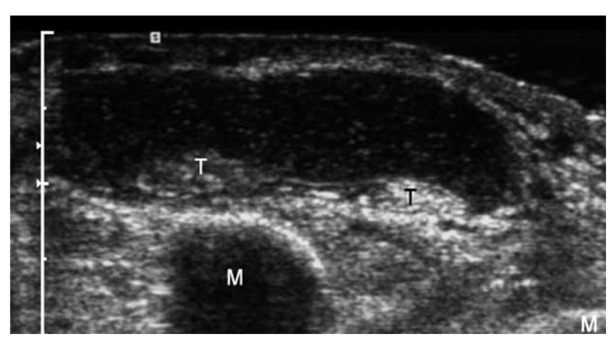
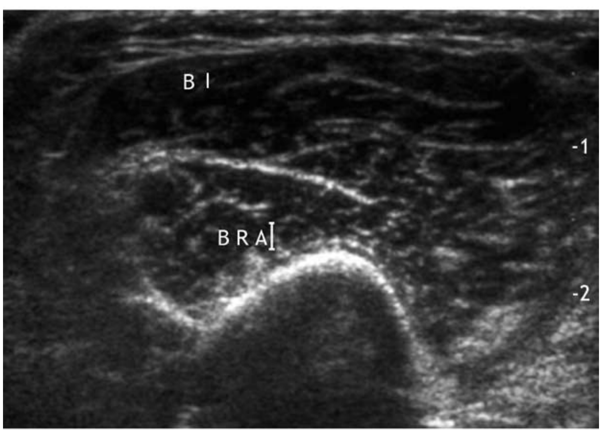


Figure 7 A 74-year-old man with chronic renal failure who presented with wrist swelling for 8 days. Ultrasound revealed a severe suppurative-type tenosynovitis of the extensor digitorum tendons from the wrist joint to the metacarpophalangeal joints. Note the echogenic fluid collection located superficial to the thickened extensor tendons (T). No tendon sheath encases the extensor tendons normally at this location. The extensor carpi radialis brevis and longus tendons (not shown) were also involved. Percutaneous aspirate grew group G streptococci. M, metacarpal shafts.

(a)



(b)

Figure 8 An 11-year-old patient with fever and left elbow region swelling of a few days, 3 weeks after sustaining blunt trauma to this area. (a) Transverse ultrasound reveals a very swollen hyperechoic brachialis muscle compatible with acute myositis. The overlying biceps muscle is only mildly swollen. No biopsy or surgical intervention was performed. (b) Follow-up ultrasound at 4 months after completion of antibiotic treatment, at a slightly proximal level to 8a. The brachialis (Bra) and distal biceps (Bi) muscles are now normal.

infection can spread from the tendon sheath into the peritendinous tissues.

Mycobacterial tuberculous tenosynovitis

Both typical and atypical mycobacterial tuberculous tenosynovitis may be associated with rice body formation.[11,12] If rice bodies are small, ultrasound may reveal low-level internal echoes but may fail to resolve individual rice bodies (Fig. 5(a)). In that situation, MRI is recommended for better delineation (Fig. 5(b)).[12] Whenever the possibility of an infective tensosynovitis exists and a tendon sheath effusion is visible, ultrasound-guided aspiration of tendon sheath fluid is helpful in differentiating infective from non-infectious causes of tenosynovitis. If moderate to severe tendon sheath thickening is present, percutaneous biopsy may be undertaken.

Pyomyositis

Pyomyositis is a suppurative bacterial infection of muscle,[1,5] most commonly affecting the larger muscles of the lower limbs.[5] Pyomyositis is more prevalent in the tropics and in immunocompromised patients.[5] Muscle trauma and haematoma may be precipitating factors. Clinically, there is fever, myalgia and localized muscle tenderness. *S. aureus* is the causative organism in more than 90% of cases.[1,5]

Ultrasound of pyomyositis reveals diffuse muscle swelling with oedema, the latter manifested by either diffuse muscle hyperechogenicity with or without localized hypoechogenicity (severe muscle oedema or early necrosis) and diffuse hyperaemia.[1] At this stage, pyomyositis will usually response to antibiotic treatment (Fig. 8). If untreated, muscle abscess formation will often subsequently occur requiring surgical or percutaneous drainage (Fig. 9).

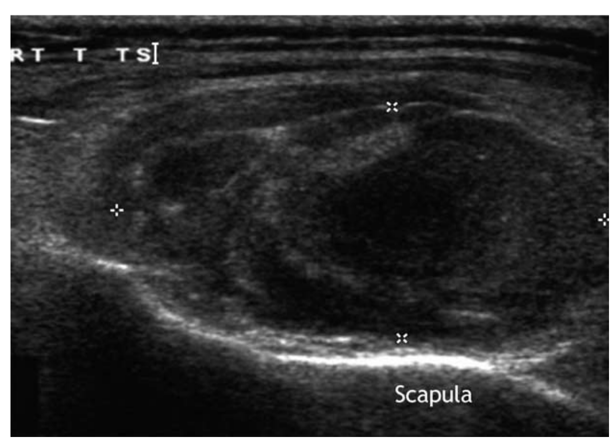
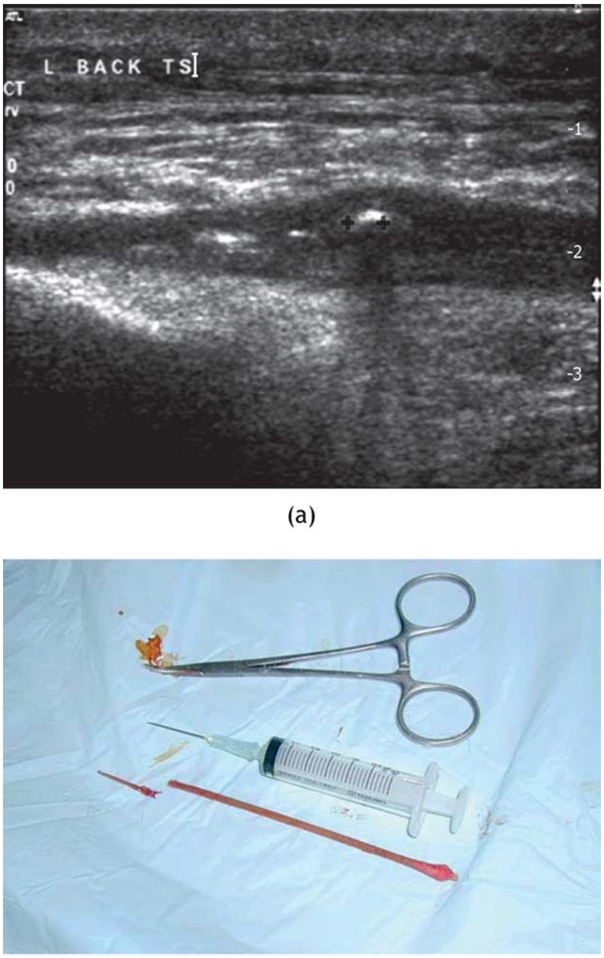


Figure 9 A 73-year-old woman with fever and right shoulder pain. Transverse ultrasound of the right infraspinatus muscle. There is large well-defined heterogeneous hypoechoic abscess collection within the infraspinatus muscle. Although the abscess appears reasonably solid, percutaneous aspiration yielded 10 ml of purulent material. Culture revealed *Enterobacter cloacae*.



(a)

(b)

Figure 10 A 51-year-old diabetic man with left tuberculosis empyema, complicated (after removal of percutaneous chest drain) by fistula to chest and abdominal wall with abscess formation. During cleaning, a wooden probe was accidentally retained inside the abscess cavity. (a) Transverse ultrasound image of the abscess reveals the echogenic wooden probe (indicated by calipers) with acoustic shadowing. Adjacent small echogenic gas locules show no acoustic shadowing. Post-contrast abdominal CT (not shown) revealed a left posterior muscle abscess cavity and a wooden probe (the latter with a similar attenuation to gas). (b) The wooden probe, including a small broken fragment, is shown after removal with a forceps under ultrasound guidance.

Abscess formation

An abscess is a localized collection of necrotic tissue, bacteria, inflammatory exudate and polymorphs.[15] Abscesses most commonly occur within either muscle or subcutaneous tissue. Abscesses are usually round in shape though may be tubular or geographical. Depending on location, maturity and contents, abscess echogenicity can vary from hypoechoic to isoechoic or hyperechoic.[16] Posterior acoustic enhancement is characteristic. Internal debris is a common feature while gas loculations may be seen with gas-forming organisms or if there is open communication with bowel or skin (Fig. 10). Internal septa are a feature of more chronic, low-grade infection. Colour Doppler imaging usually reveals variable hyperaemia of the abscess wall and immediate surrounding tissues. Arslan et al.[17] reported that 19 out of 21 soft-tissue abscesses displayed wall hyperaemia apparent on by power Doppler imaging. Breidahl et al.[18] found hyperaemia to be a feature of inflammatory rather than non-inflammatory collections. Movement of the part under examination or dynamic compression, if tolerated, can help identification of the fluid component of the abscess. The threshold for aspiration should be low particularly as muscle abscesses may appear quite solid with no clearly discernible fluid yet still yield pus on aspiration (Figs. 9 and 11). The extent of the abscess, especially with respect to the adjacent bone, joint and internal structures (Figs. 12 and 13) should be carefully assessed. Therapeutic intervention (single or repeated aspiration, or catheter drainage) can be readily performed under ultrasound guidance.

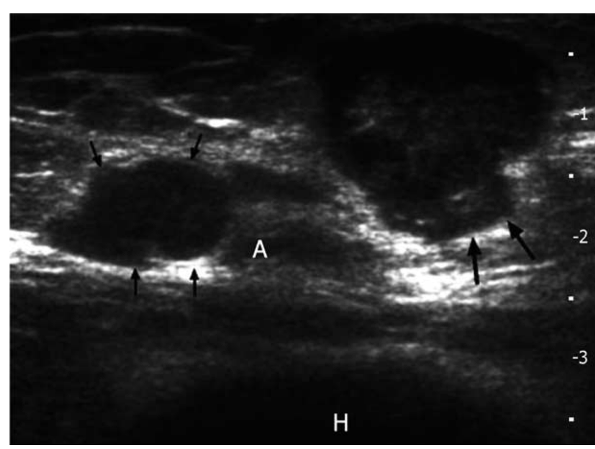


Figure 11 A 72-year-old woman with a right arm mass for 1 year that was slowly increasing in size. Oblique longitudinal ultrasound reveals an irregular lobulated subcutaneous mass with internal echoes and posterior acoustic enhancement (large arrows). There was moderate vascularity throughout the mass, though particularly at the periphery (not shown). There is also a small lymph node (small arrows) present alongside the brachial neurovascular bundle. Percutaneous guided biopsy of the mass revealed caseating granuloma with mycobacteria. A = brachial artery.

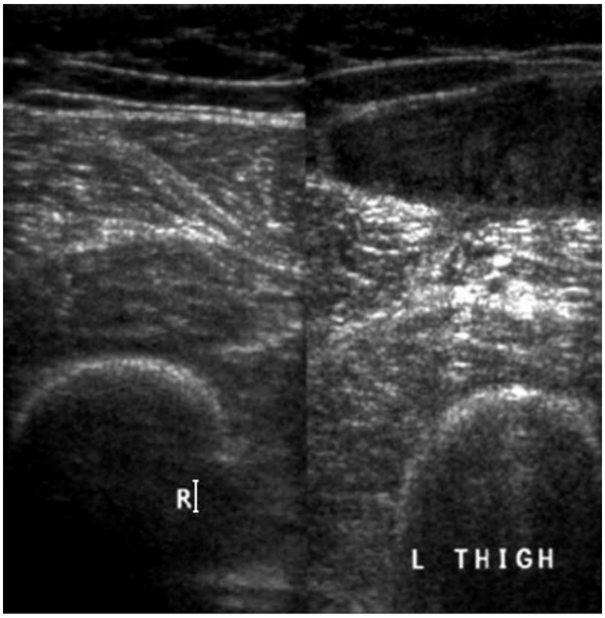


Figure 12 A 36-year-old woman with systemic lupus erythematosus and mixed connective tissue disease on steroid treatment presented with a left thigh mass of 3 months duration. Split-screen ultrasound of abnormal left and normal right thigh reveals well-defined subfascial hypoechoic collection with posterior acoustic enhancement. Surgical excision revealed this to be a mycobacterial tuberculous abscess.

Septic arthritis

Joint infection is a particularly serious condition given the propensity for long term morbidity if not recognized and treated early. Septic arthritis most commonly affects the hip, knee, shoulder, elbow and ankle.[19] *S. aureus* is the most common causative organism, followed by group A streptococci and streptococcal pneumonia. In neonates, group B streptococci and coliform bacteria are important causes. In children of 3 months to 5 years, *Haemophilus influenzae* used to be a common causative organism, but the incidence has declined significantly because of vaccination.[20,21] Radiographic changes comprise peri-articular soft-tissue swelling, effacement and blurring of peri-articular fat planes, effusion, and peri-articular osteopenia (the latter reflecting peri-articular hyperaemia and increased osteoclastosis). By the time joint-space narrowing becomes apparent radiographically, articular cartilage lysis is already well-established and severe morbidity with premature osteoarthritis, limitation of joint movement, and limb shortening is likely to ensue.

Ultrasound more than any other imaging technique has enabled septic arthritis to be identified early before significant cartilage lysis occurs. The hallmark of septic arthritis on ultrasound is the presence of a joint effusion in a patient with clinical signs of joint infection. Ultrasound enables recognition and guided-aspiration of joint fluid at an early stage thereby allowing early diagnosis and treatment of septic arthritis (Fig. 14). Joint fluid in septic arthritis may be hypoechoic and clearly demarcated from joint synovium and capsule (Fig. 14) or hyperechoic and less clearly demarcated from joint synovium or capsule (Figs. 15 and 16). Particular attention has been paid to the paediatric

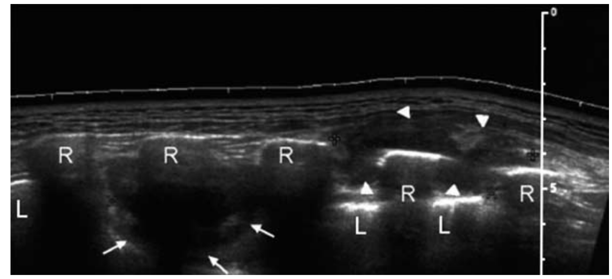


Figure 13 A 50-year-old man with right posterior chest wall mass and fever for 5 days. Longitudinal ultrasound of chest wall reveals a hypoechoic abscess in the chest wall (arrowheads), extending in the intercostal space to communicate with an empyema (arrows) ("empyema necessitans"). Post-contrast thoracic CT (not shown) confirms the right pleural empyema. Percutaneous aspiration yielded a small amount of purulent fluid. No growth was obtained on culture. The patient responded to antibiotic treatment. R = ribs, L = lung.

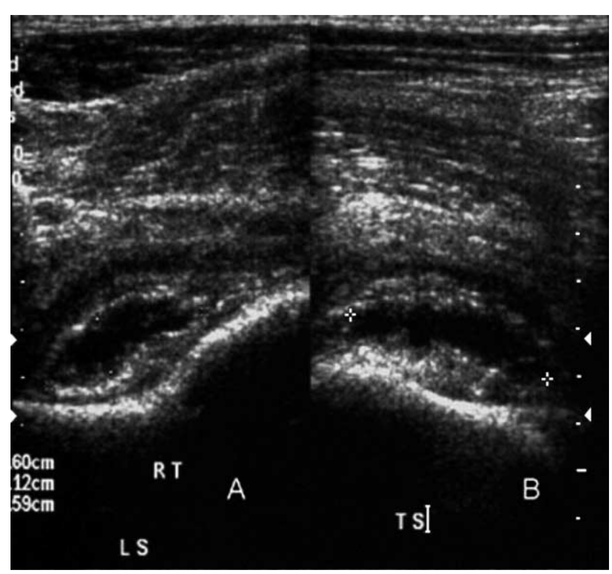


Figure 14 A 36-year-old intravenous drug abuser with right hip pain of 1 week. Longitudinal (a) and transverse (b) ultrasound of the hip reveals moderate capsular, synovial thickening and a small joint effusion. Ultrasound-guided aspiration yielded purulent fluid that grew *Micrococcus* sp.

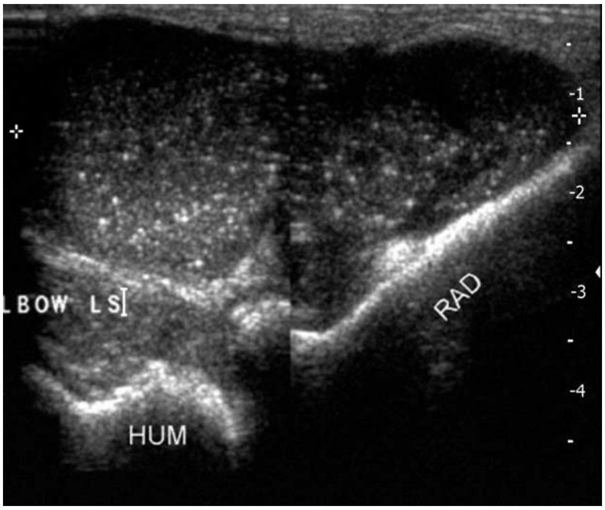
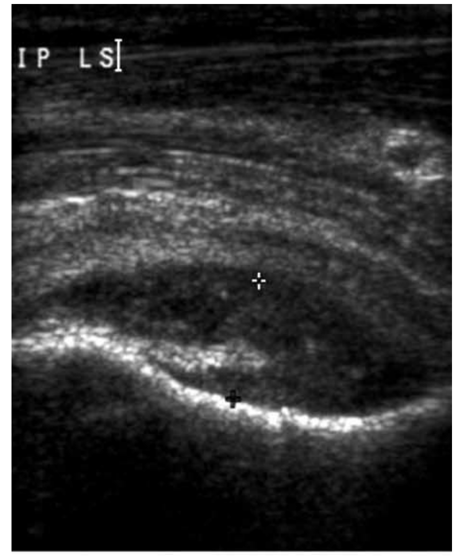


Figure 15 A 83-year-old woman with a right elbow mass of 2 weeks' duration. Longitudinal ultrasound of radiohumeral joint demonstrates a large echogenic elbow joint effusion. (H = humerus, Rad = radius). 3 ml of pus was aspirated under ultrasound guidance. Culture yielded tuberculous mycobacterium. Subsequently, symptoms resolved with operative drainage and anti-tuberculous medication.

hip. The anterior joint capsule of the normal paediatric hip consists of anterior and posterior layers, mainly composed of fibrous tissue with only a thin synovial membrane.[22] In children, the distance between the cortex of the femoral neck and the outer margin of the hip capsule should not be greater than 5 mm or more than 2 mm thicker than the contralateral normal side.[22] In adults, a thickness of 9 mm or more than 2 mm thicker than the contralateral normal hip is considered abnormal.[23] For most joints, a normal ultrasound examination has a strong negative predictive value for septic arthritis.[24] In a study of 96 children by Zawin et al.,[24] all 15 surgically proven cases of septic arthritis of the hip had hip joint effusions demonstrable by ultrasound. Increased capsular vascularity can be seen on colour or power Doppler imaging. In an animal study, Strouse et al.[25] demonstrated increased synovial vascularity in about 50% of septic arthritis cases by power Doppler imaging. No knees with aseptic arthritis demonstrated increased vascularity. In clinical practice, demonstrable synovial hypervascularity proved a less useful marker of septic arthritis being demonstrable in only one of 11 patients in one recent study.[26] Contrast-enhanced imaging may improve the sensitivity of ultrasound in this respect. In most instances, ultrasound cannot reliably differentiate infective from non-infective causes of arthritis, and, in the appropriate clinical setting, aspiration of joint fluid for analysis



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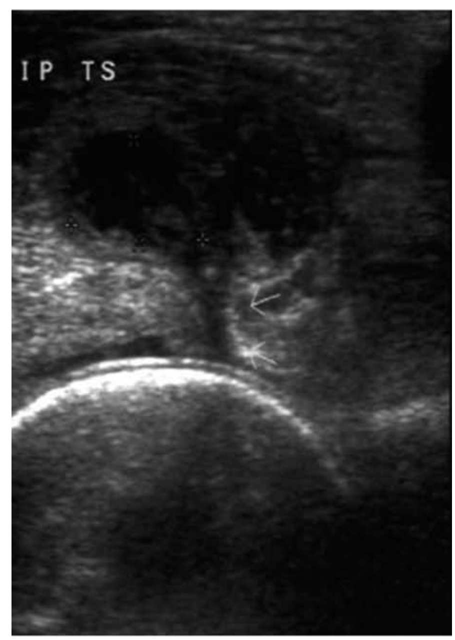


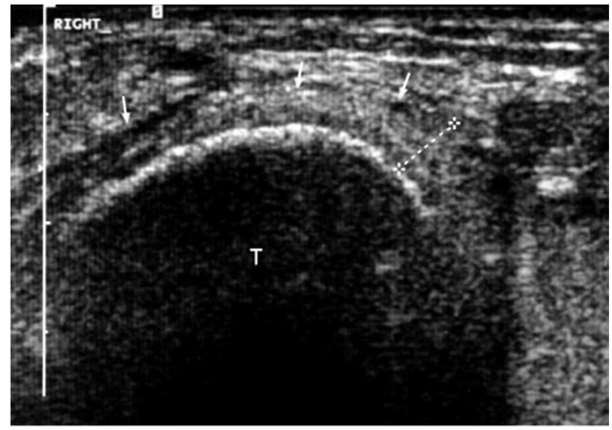
(b)

Figure 16 A 57-year-old man post renal transplant on immunosuppressant and steriod treatment. Intermittent right hip pain for several months. (a) Transverse ultrasound of hip joint reveals a hypoechoic joint effusion containing echogenic debris. The joint capsule is thickened. (b) Transverse ultrasound of hip joint also reveals a distended hypoechoic ilioposas bursa containing echogenic debris. Ultrasound-guided aspiration of the joint effusion was performed. Culture was negative. Crystal analysis was not performed. The patient was treated with non-steroidal anti-inflammatory drugs with alleviation of symptoms. No antibiotic treatment was given. The final diagnosis was a non-infective inflammatory arthropathy. Periarticular extension does not always imply the presence of a septic arthritis.

is helpful (Figs. 14–16). For joints with non-distensible capsules (sacroiliac, sternoclavicular, acromoclavicular joints), the absence of a visible joint effusion cannot be used to exclude septic arthritis and, if suspected, MRI (or CT) examination together with guided joint aspiration should be undertaken.

Osteomyelitis

Acute osteomyelitis occurs more commonly in the skeletally immature. Osteomyelitis is usually caused by *S. aureus* in young patients, and by Gram-negative bacteria in the elderly. Radiographically apparent osteolysis or periosteal new bone formation may not become apparent for up to 2 weeks after the onset of infection. Ultrasound examination may show features of osteomyelitis several days earlier than radiographs.[27] Juxtacortical soft-tissue swelling together with early periosteal thickening is the earliest sign of acute osteomyelitis on ultrasound (Fig. 17(a)). This is followed by increased periosteal thickening accompanied by, in up to two-thirds of cases, a layer of subperiosteal exudate, and more rarely, abscess formation.[28,29] Finally, cortical erosion can become apparent[30] (Fig. 18). Sympathetic joint effusions (Fig. 17(b)) or co-existent inflammation of juxtacortical tissues can occur. Ultrasound examination is likely to be most sensitive in children with suspected acute osteomyelitis of the tubular bones where the propensity to develop a periosteal reaction is greatest. Although the sensitivity and specificity of ultrasound examination at diagnosing osteomyelitis has not been determined, it is not likely to be as high as MRI or nuclear medicine studies as visualization is limited to outer cortical and juxtacortical tissues only.[19,31,32] Therefore, if there is clinical suspicion of osteomyelitis, especially when infection of a non-tubular bone or the intra-articular portion of a tubular bone is suspected, either MRI (or phosphonate bone scintigraphy) should be considered on an urgent basis. In patients with sickle cell disease, subperiosteal fluid collections similar to those found in acute osteomyelitis may occur with medullary infarction, although they are tend to be less pronounced than in acute osteomyelitis.[28] Ultrasound-guided aspiration is helpful in confirming an infective aetiology.[28] Reactivation of chronic osteomyelitis may be associated with soft-tissue abscess, fistula or sinus tract formation, all of which may be apparent on ultrasound (Fig. 19).



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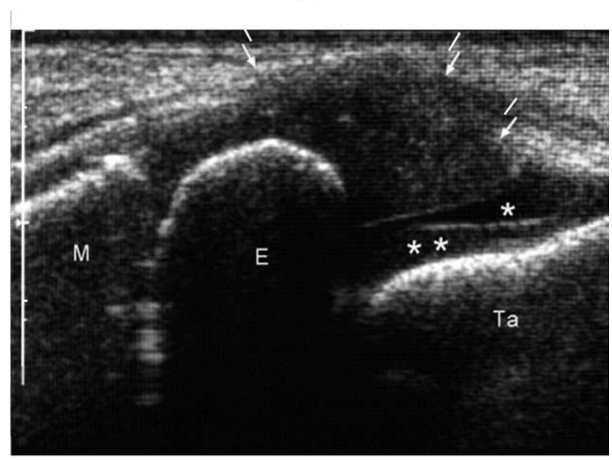

(b)

Figure 17 A 7-year-old patient with fever, right ankle pain and swelling. (a) Transverse ultrasound of the distal tibia reveals isoechoic juxtacortical soft-tissue thickening (arrows). T = tibia. (b) Longitudinal ultrasound of the ankle joint reveals small sympathetic-type joint effusion (*). Medial malleolus is outlined by arrows. M = metaphysis, E = epiphysis, ** = articular cartilage. Ta = talus. The patient responded well to antibiotic treatment. MRI examination was not undertaken in this case.

Post-operative infection

Examination of the soft tissues adjacent to orthopaedic hardware by CT and MRI is often limited by metallic artefacts. Similarly, the effects of post-operative repair tissue, altered mechanical stresses in bone and the photopenic areas resulting from metallic shielding may impair the specificity of nuclear medicine studies. Ultrasound is less hampered in many of these respects and as such is often the preferred investigation in this situation provided transducer access is possible (Fig. 20). Infection is a complication of 0.5–2% of hip and knee replacements. Early-onset infection is usually the result of pre-operative wound contamination.

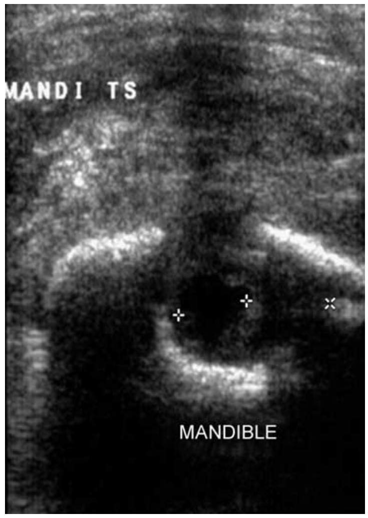

Figure 18 A 28-year-old woman with on and off left side face swelling for 3 weeks with trismus. Clinically a parotid abscess was suspected. Transverse ultrasound of angle of mandible reveals focal cortical defect containing a hypoechoic abscess (callipers). There is moderate degree of adjacent soft-tissue cellulitis. Lateral radiograph for the parotid (not shown) revealed a well-defined multiloculated lytic lesion in the right angle of mandible. Incision and drainage was performed. Culture grew *S. aureus*.

Late-onset infections (i.e. more than 3 months after surgery) are usually the result of haematogenous seeding.[3,33] Ultrasound examination is able to detect small increases in joint fluid or juxtacortical fluid collection after arthroplasty or internal fixation and guide needle aspiration. After tendon repair, ultrasound can help to differentiate tendon re-rupture from other causes of impaired mobility such as infection.

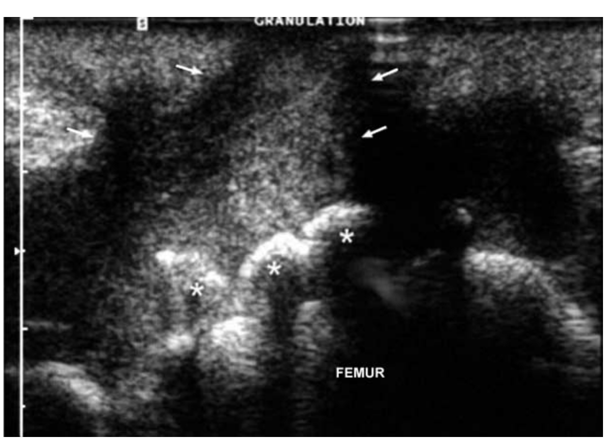

Figure 19 A 54-year-old man with acute exacerbation of chronic osteomyelitis of left femur. Transverse ultrasound of femur reveals a band of hypoechoic granulation tissue (arrows) extending from femur to the cutaneous surface. Echogenic gentamicin beads (*) are present.

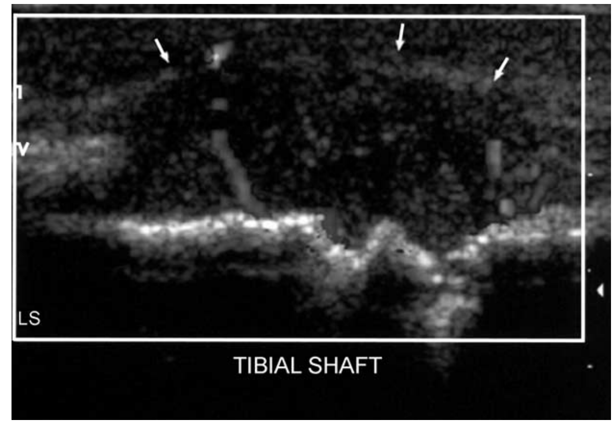

Figure 20 A 52-year-old man with a fracture of the right tibia sustained during a road traffic accident 3 months earlier and treated by ring external fixator. He sustained a minor fall 2 weeks earlier which was followed by persistent swelling of the wound. Colour Doppler ultrasound examination reveals increased vascularity of a hypoechoic abscess collection (arrows) overlying the fracture site. Subsequent surgical debridment confirmed the presence of an abscess cavity. Culture was negative.

Foreign body detection

Ultrasound can demonstrate wood, bamboo, glass or fishbone foreign bodies in soft tissues that may not be apparent radiographically.[34] Foreign bodies may be a cause of persistent infection. They are often more clearly demarcated at a later stage when surrounded by hypoechoic reparative granulation tissue and, as such, if clinical suspicion remains high or if the infection fails to settle, a repeat ultrasound in about 3 weeks or sooner should be performed. Ultrasound can demonstrate wooden fragments as small as 2.5 mm with 87% sensitivity and 90% specificity.[34,35] Ultrasound can also be used to assist percutaneous removal of foreign bodies by forceps[36] (Fig. 10(b)).

Conclusion

Musculoskeletal tissues are, for the most part, accessible to examination by ultrasound, allowing its deployment as a first-line investigation in a wide range of musculoskeletal infections. Ultrasound examination, often coupled with ultrasound-guided aspiration, frequently provides sufficient information to enable a firm diagnosis and guide treatment. The judicious and appropriate use of ultrasound should allow earlier recognition and treatment of musculoskeletal infections, thereby helping to minimize long-term morbidity. MRI (or CT) can be reserved for situations where ultrasound access is limited or whenever extensive soft-tissue infection is present.

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