Musculoskeletal Ultrasound and MRI: Which Do I Choose?

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ABSTRACT

In the diagnosis of musculoskeletal disorders, there are several applications where both ultrasound and magnetic resonance imaging (MRI) may be considered viable alternatives. Because there are advantages and disadvantages to each imaging method, often it is unclear which should be considered for a specific indication. This article reviews this topic in the following manner. First, musculoskeletal applications where there are significant advantages for the use of ultrasound are discussed, which includes evaluation of soft tissue foreign bodies, peripheral nerves, pathologies that require dynamic imaging for diagnosis, and soft tissues adjacent to metal hardware. This is followed by a discussion of indications where both ultrasound and MRI may be considered, such as evaluation of a focal tendon abnormality, focal ligament abnormality, soft tissue fluid collection, and confirmation of a probable benign cyst, such as Baker's cyst and wrist ganglion. Musculoskeletal ultrasound should be viewed as an imaging method that complements MRI rather than one that competes with MRI in the evaluation of musculoskeletal abnormalities, as it can offer important information.

KEYWORDS: Ultrasound (US), magnetic resonance (MR), soft tissues

Since its introduction in the late 1970s, musculoskeletal ultrasound has been used for many applications pertaining to the musculoskeletal system.[1] Although initially used to demonstrate the rotator cuff, other applications include evaluation of other tendons, muscles, ligaments, fractures, and bone healing.[2] Virtually any gross anatomic structure of the musculoskeletal system can be visualized with sonography. In addition, more general soft tissue abnormalities such as fluid collection, abscess, bursitis, joint effusion, and foreign bodies can be also evaluated.[3–6]

One significant reason for the increased interest and success of musculoskeletal ultrasound is improved technology. Ten years ago, a 7.5-MHz transducer was considered standard, while today transducers with frequencies up to 17 MHz are common. This improvement in transducers has resulted in significant increases in resolution with regard to superficial structures. For example, individual nerve fascicles and tendon fibers can be exquisitely demonstrated.[7] Other improvements in ultrasound include power Doppler imaging (improving detection of blood flow),[8] tissue harmonic imaging (allowing improved resolution of deeper structures),[9] compound imaging (improving real-time spatial resolution),[10] and extended field-of-view imaging (allowing more accurate display and measurement of large abnormalities).[11] In addition, ultrasound machines are smaller, more ergonomic, and more powerful.

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ULTRASOUND EXAMINATION

When evaluating the musculoskeletal system with ultrasound, proper transducer selection is important. Higher-frequency transducers have high resolution but at the expense of depth penetration; therefore, deeper structures require evaluation with lower frequency transducers (5 to 10 MHz). Normal tendons appear hyperechoic (bright echo) with a fibrillar echotexture.[2,12] Muscle appears relatively hypoechoic (low echo), although hyperechoic septae are seen.[2,12] Bone cortex is hyperechoic and due to its reflective nature, results in shadowing deep to the cortex.[12,13] Ligaments are hyperechoic and demonstrate a fibrillar echotexture that is more compact when compared with tendon.[12,14] The attachments of this structure between two osseous structures rather than muscle also indicate that a ligament is imaged. Peripheral nerves imaged in cross section produce a speckled appearance, caused by hypoechoic nerve fascicles and hyperechoic connective tissue.[7]

An important artifact with musculoskeletal sonography is due to anisotropy. When the transducer sound beam is oriented perpendicular to a tendon, the normal hyperechoic fibrillar pattern is seen.[15] If the sound beam is oblique to a tendon, it will be artifactually hypoechoic due to anisotropy and may simulate pathology.[16] It is important to focus on the segment of tendon that is perpendicular to the sound beam when evaluating for tendon abnormality. Anisotropy also involves muscle and ligaments but to lesser extent.

ULTRASOUND VERSUS MAGNETIC RESONANCE IMAGING

Because magnetic resonance imaging (MRI) is established as an effective imaging method to evaluate the musculoskeletal system, ultrasound results are often compared with MRI. There have been many studies comparing ultrasound to MRI, but unfortunately sensitivities and accuracies are quite variable.[17] This is due to the variable gold standards of these studies and the experience of the individual performing the ultrasound, which can markedly affect results. One meta-analysis of rotator cuff imaging has shown that ultrasound has an accuracy of 95%.[18] So it is obvious that there are some applications where ultrasound is quite effective. It has also been shown that for evaluation of the rotator cuff, patients prefer ultrasound to MRI.[19] With conflicting opinions about musculoskeletal ultrasound, the radiologist and the referring physician are often unsure when ultrasound can be considered as an alternative to MRI. This article will address this issue. The first segment of this article will discuss applications where ultrasound can be considered the imaging test of choice, and the second segment will review applications where both ultrasound and MRI are viable alternatives.

ULTRASOUND AS THE IMAGING METHOD OF CHOICE

Soft Tissue Foreign Bodies

Sonography is an ideal imaging method for evaluation of soft tissue foreign bodies. This is primarily related to the resolution of ultrasound, especially with superficial foreign bodies; ultrasound can demonstrate foreign bodies as small as 0.5 mm.[20] This is important for evaluation of nonradiopaque foreign bodies, such as wood and plastic as they are typically not seen on radiography.[21] Ultrasound can identify the foreign body, evaluate the adjacent structures, and give the precise location of the foreign body.[22] The skin can be marked superficial to the foreign body to aid removal, or alternatively intraoperative localization or ultrasound-guided percutaneous removal may be used.[23]

Ultrasound evaluation of foreign bodies begins with physical examination of the involved extremity, as this is a clue to the location of the foreign body. Speaking with the patient with regard to the potential type of foreign body is also helpful. It is important to begin evaluation with a lower-frequency transducer to ensure a global evaluation to include the deep soft tissues. If this is normal, then use of a high-frequency transducer (at least 12 MHz) is critical to accurately identify the foreign body. All foreign bodies are initially hyperechoic, although organic matter may decrease in echogenicity over time (Fig. 1).[22] There are two findings that greatly assist in identifying a soft tissue foreign body: the surrounding halo and artifact deep to the foreign body.[22] A hypoechoic halo forms within 12 hours after foreign body insertion, representing inflammation, edema, and hemorrhage. This increases the conspicuity of the hyperechoic foreign body and appears as a target. In addition, looking deep to the foreign body for artifact is important. One must be aware that the type of artifact depends on the surface attributes of the foreign body more than the actual composition of the foreign body. For example, a foreign body with a smooth and flat surface will produce reverberation, and an irregular surface or small radius of curvature will produce shadowing.[21] Many foreign bodies will demonstrate both artifacts. Diffraction shadowing at the edges of the foreign is also possible.

Peripheral Nerves

The advantage of ultrasound in evaluation of peripheral nerves is the resolution and the ability to examine an entire limb in a short period of time. The resolution of ultrasound and soft tissue contrast allows visualization of the individual hypoechoic nerve fascicles.[7,12] Surrounding hyperechoic connective tissue produces a speckled or honeycomb appearance in transverse dimension. Because a peripheral nerve has both hypoechoic and hyperechoic

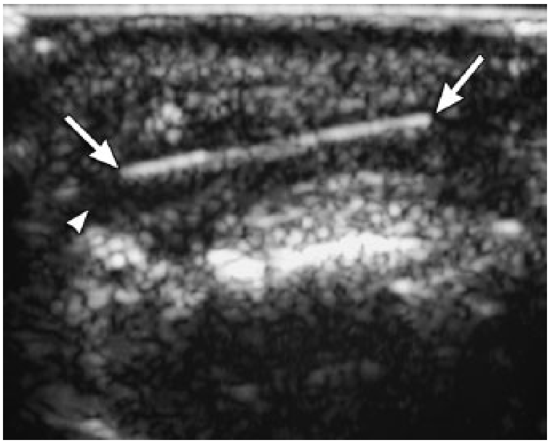


Figure 1 Wooden foreign body in the finger. Sonogram longitudinal to the foreign body shows the echogenic wood splinter (arrows), which is made more conspicuous because of the surrounding hypoechoic halo (arrowhead).

components, its appearance can vary depending on the surrounding tissues. When a peripheral nerve is imaged transversely and is surrounded by hypoechoic muscle, the hyperechoic components will appear more obvious. The opposite is true when the peripheral nerve is surrounded by hyperechoic tendon (such as in the carpal tunnel) where the hypoechoic components will be more obvious. The other advantage of ultrasound is the ability to examine an entire peripheral nerve through the extremity in a matter of minutes, which can be time-consuming with MRI. Ultrasound can effectively evaluate for nerve entrapment, transection neuroma, and peripheral nerve sheath tumor.

NERVE ENTRAPMENT

Ultrasound can evaluate several nerve entrapment syndromes, including carpal tunnel syndrome,[24] cubital tunnel syndrome,[25] and Morton's neuroma.[26] The common feature to these syndromes is abnormal hypoechoic swelling of the affected nerve at the site of compression. With regard to the carpal tunnel, median nerve area greater than 9 mm^2 using circumferential trace correlates with carpal tunnel syndrome (Fig. 2).[24] Distally, the median nerve will be compressed with bowing of the flexor retinaculum.[27] With regard to cubital tunnel syndrome, this diagnosis is suggested with ulnar nerve area greater than 7.5 mm^2 (Fig. 3).[25] Morton's neuromas will appear as a hypoechoic mass greater than 5 mm between the metatarsal heads of the forefoot, often showing digital nerve continuity and coexisting bursa.[26,28]

TRANSECTION NEUROMAS

Ultrasound can also evaluate for transection neuromas. This becomes important in the setting of limb amputation, where multiple painful neuromas may exist. At sonography, a transection neuroma commonly appears as a hypoechoic mass in continuity with the transected nerve (Fig. 4). It is important to realize that a neuroma is a normal and expected response to nerve transection; however, it is important to identify which neuroma is symptomatic.[29] Although MRI can show neuromas, it cannot determine which is symptomatic. With ultrasound, once a neuroma is identified, simple pressure on the neuroma with the transducer will identify the symptomatic neuroma. The skin over the neuroma may be marked or a guide wire placed to assist in surgical removal.[30]

PERIPHERAL NERVE SHEATH TUMORS

Peripheral nerve sheath tumors can also be demonstrated with ultrasound.[31] Although the appearance of a hypoechoic mass is nonspecific, it is the resolution of ultrasound that will demonstrate the peripheral nerve entering the mass, which indicates neural origin (Fig. 5). One must be aware of the potential pseudocyst appearance of some neuromas, as the hypoechoic neuroma may show posterior acoustic enhancement simulating a complex cyst.[32] The presence of flow on color or power Doppler imaging will suggest solid mass to aid in this

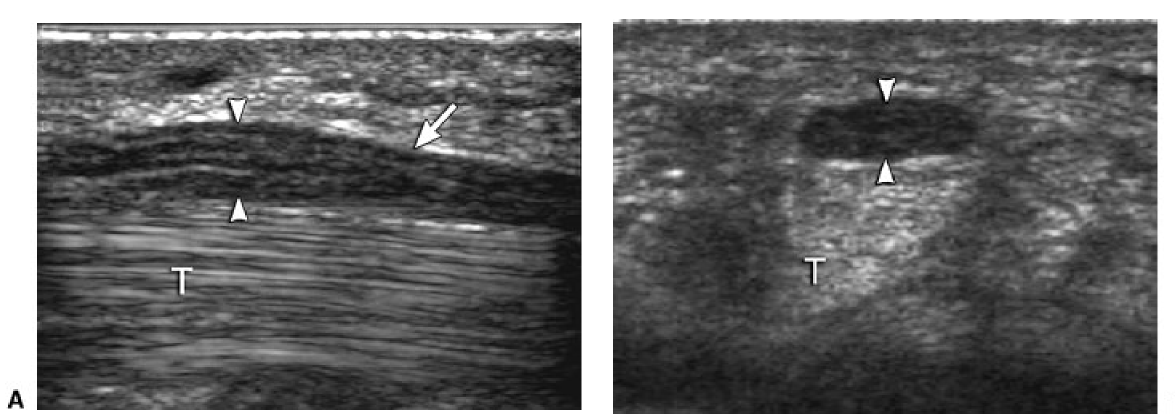


Figure 2 Carpal tunnel syndrome. Sonograms longitudinal (A) and transverse (B) to the median nerve at the wrist shows hypoechoic swelling of the median nerve (arrowheads) just proximal to the carpal tunnel and flattening more distally (arrow). Note hyperechoic and fibrillar echotexture of normal flexor tendon (T).

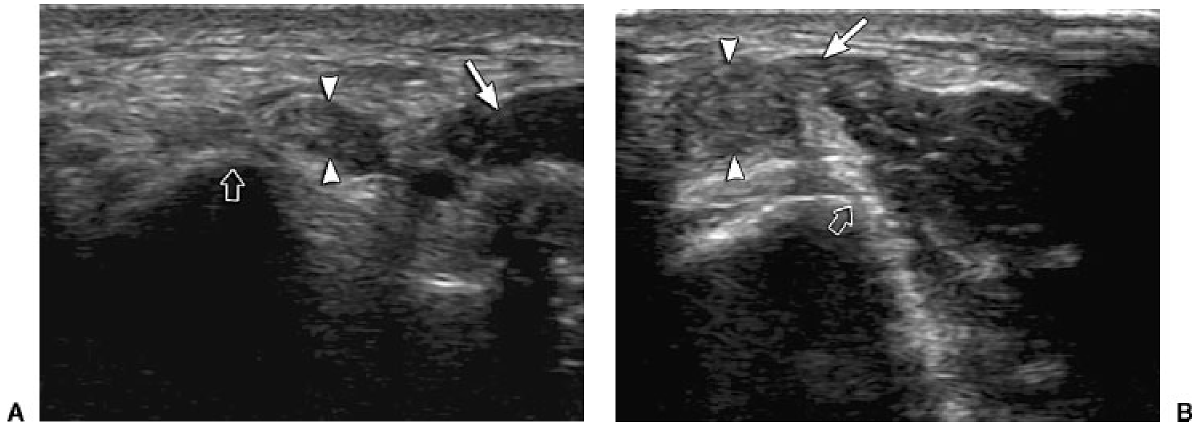


Figure 3 Cubital tunnel syndrome secondary to snapping triceps syndrome. Sonograms transverse to the ulnar nerve in the cubital shows abnormal hypoechoic enlargement of the ulnar nerve (arrowheads). In elbow extension (A), the ulnar nerve is normally located posterior to the apex of the medial epicondyle of the humerus (open arrow). In elbow flexion (B), both the ulnar nerve (arrowheads) and medial head of the triceps muscle (arrow) move anterior to the medial epicondyle apex (open arrow).

differentiation. Although schwannomas have classically been described as being located eccentric to the involved nerve, they may also be central with respect to the peripheral nerve similar to a neurofibroma.[32] A target appearance has also been described in neurofibromas with a hyperechoic fibrous center and surrounding hypoechoic myxoid tissue.[33]

Dynamic Imaging

Another area where musculoskeletal ultrasound is considered the imaging method of choice is in the evaluation of musculoskeletal disorders where dynamic imaging is required. This includes situations where specific joint movement or positioning, or muscle contraction, is needed for the pathology to appear or to become more conspicuous. Currently, routine MRI is unable to effectively diagnose these types of pathology. Ultrasound technique for providing these diagnoses is specific to each application, which includes tendon subluxation and dislocation, nerve subluxation and dislocation, muscle hernia, and differentiating partial- versus full-thickness tendon and ligament tear.

TENDON SUBLUXATION AND DISLOCATION

Tendon subluxation or dislocation can involve specific tendons, such as the long head of the biceps tendon in the shoulder,[34] snapping triceps syndrome in the elbow,[35] snapping iliopsoas and gluteus maximus tendons in the hip,[36,37] and the peroneal tendons in the ankle.[38] In many of the conditions, the patient's symptoms can be directly related to the abnormal tendon motion seen at ultrasound, and often an abnormal snap can be felt through the transducer. With regard to dislocation of the long head of biceps tendon in the shoulder, when present in neutral position, this diagnosis can be made with any cross-sectional imaging and may coexist with subscapularis tendon tear. However, medial

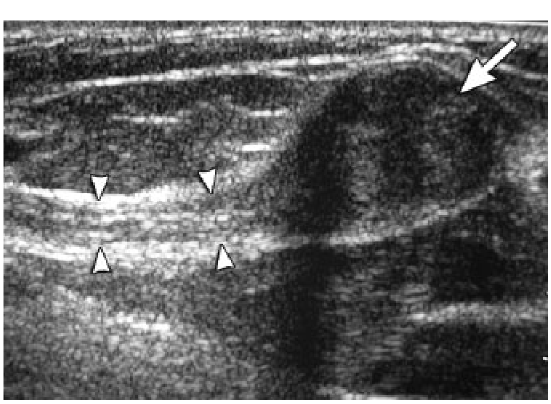


Figure 4 Transection neuroma of ulnar nerve. Sonogram longitudinal to the ulnar nerve in the wrist shows the hypoechoic neuroma (arrow) in continuity with the ulnar nerve (arrowheads).

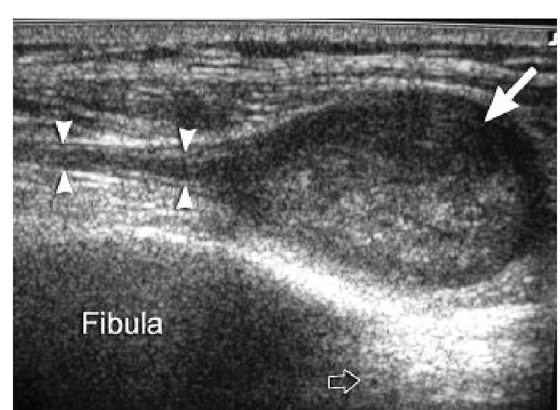


Figure 5 Schwannoma of superficial peroneal nerve branch. Sonogram longitudinal to the intermediate dorsal cutaneous nerve shows the predominately hypoechoic schwannoma (arrow) with posterior acoustic enhancement (open arrow). Note continuity with entering nerve (arrowheads).

tendon subluxation or dislocation may only occur when the arm is held in external rotation.[34] This is easily diagnosed with ultrasound when the tendon is imaged transversely at the level of the bicipital groove of the humerus with active external arm rotation. Snapping triceps syndrome at the elbow (Fig. 3) will be discussed below with nerve dislocation. Snapping hip syndrome may be caused by several conditions. One cause of medial snapping is abnormal motion of the iliopsoas tendon over the iliopectineal eminence of the pelvis during extension of an externally rotated and abducted hip.[37] Abnormal snapping motion of the iliopsoas tendon is seen with the transducer placed in the oblique transverse plane over the inferior margin of the bony pelvis. Another cause is abnormal snapping of either the gluteus maximus or iliotibial band over the greater trochanter.[36] This latter condition may only occur with a patient standing and shifting their weight. Abnormal snapping is identified with the transducer placed in the transverse plane over the greater trochanter. Peroneal tendon subluxation or dislocation may occur after ankle trauma when there is injury to the superior peroneal retinaculum (Fig. 6). This abnormal tendon movement is often only seen with dynamic motion, when the ankle is moved into dorsiflexion and eversion.[38] At ultrasound, the transducer is placed in the transverse plane over the inferior aspect of the fibula, and peroneal tendon movement over the lateral margin of the fibula indicates dislocation. Coexisting peroneal tendon tear may also be present.

NERVE SUBLUXATION AND DISLOCATION

Abnormal nerve motion has been described in the elbow, where the ulnar nerve may dislocate from the cubital tunnel with elbow flexion.[39] This finding has been described in up to 20% of an asymptomatic study population.[39] However, ulnar nerve subluxation may predispose to nerve injury, and repetitive subluxation and relocation can predispose to direct irritation and cause cubital tunnel syndrome. A condition called "driver's elbow" has been described, where an individual with ulnar nerve subluxation will experience transient ulnar neuropathy when resting their flexed elbow out the window of a vehicle.[40] For ultrasound examination, the transducer is placed between the olecranon process and medial epicondyle with elbow extension.[35] The patient then flexes the elbow while keeping the transducer fixed on the humerus. Medial dislocation over the medial epicondyle apex is considered abnormal. A somewhat related condition is snapping triceps syndrome, seen in muscular individuals and after trauma (Fig. 3).[35] In this condition, in addition to dislocation of the ulnar nerve, the medial head of the triceps tendon also dislocates over the medial epicondyle apex. Both the medial triceps and ulnar nerve displace together with elbow flexion, and two snaps may be experienced.

MUSCLE HERNIA

Ultrasound is an ideal imaging method to diagnose muscle hernia.[41] This typically involves muscles of the lower extremity, most commonly the anterior tibialis. A fascial defect may develop after injury at the site of a perforating vessel, which allows herniation of muscle tissue. A patient will present with a painful soft tissue mass. It is important to ask the patient if there is a specific joint position or muscle contraction that produces the soft tissue mass. At ultrasound, discontinuity of the thin hyperechoic muscle fascia may be seen, and often the herniated muscle tissue in continuity with the underlying muscle may only be seen with muscle contraction (Fig. 7).

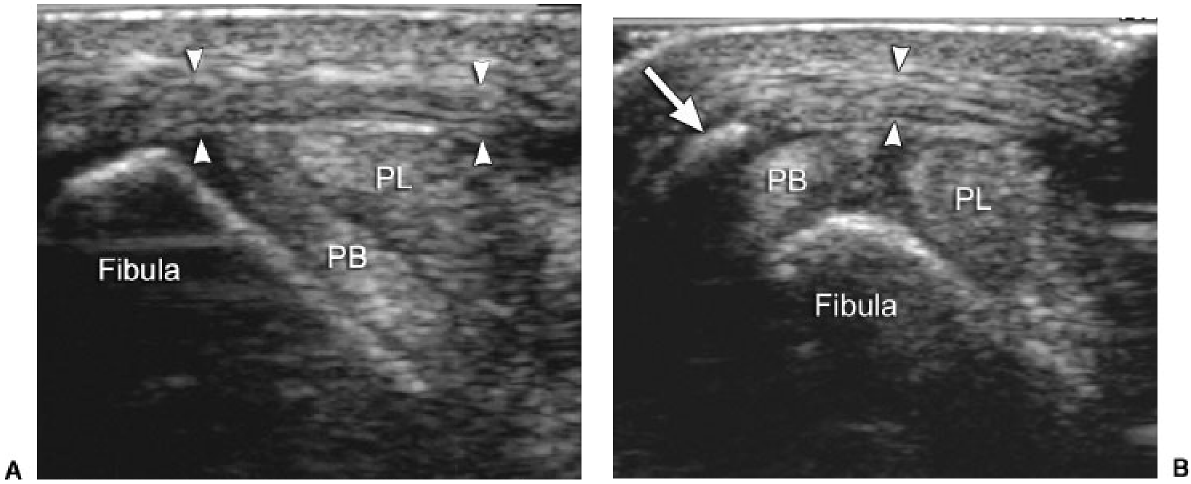


Figure 6 Peroneus brevis tendon dislocation and superior peroneal retinaculum avulsion. Sonogram transverse to the distal peroneal tendons with the ankle in neutral position (A) shows normal location of the peroneus brevis (PB) and peroneus longus (PL) tendons. Note thickened superior peroneal retinaculum at the fibula (arrowheads). In ankle dorsiflexion and eversion (B), the peroneus brevis tendon dislocates anteriorly and laterally between the fibula and avulsion fragment (arrow) at the superior peroneal retinaculum attachment.

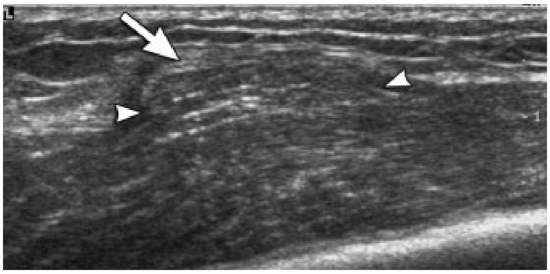


Figure 7 Muscle hernia. Sagittal sonogram over the lower leg with muscle contraction shows peroneus brevis muscle herniation (arrow), which reduced with muscle relaxation. Note defect in retinaculum (arrowheads).

PARTIAL- VERSUS FULL-THICKNESS TENDON AND LIGAMENT TEAR

Dynamic sonography also has an important role in differentiating partial- from full-thickness tears of tendons and ligaments. With regard to tendon tears, a subacute tear may be associated with significant heterogeneous hemorrhage that may simulate intact fibers. In addition, partial tendon healing may be present. To differentiate partial- from full-thickness tear, this is easily accomplished by passively moving the affected muscle-tendon unit. For example, in diagnosing Achilles tendon tear, either the calf can be squeezed or the foot passively dorsiflexed. Lack of tendon translation across the abnormal area and retraction of a torn tendon stump indicates full-thickness tear (Fig. 8). A similar maneuver can be used with quadriceps and patellar tendon tears by either squeezing the thigh, moving the patella, or flexing the knee. These maneuvers are only helpful when evaluating an isolated tendon; evaluation of a tendon that converges with other tendons such as the supraspinatus and infraspinatus tendon is not very helpful. The other situation where dynamic imaging helps to differentiate partial- from full-thickness tear is in the setting of ligament injury. At times, hemorrhage and partial healing of a ligament tear makes evaluation difficult; however, by placing stress across the joint spanned by the abnormal ligament, full-thickness tear can be suggested. For example, with regard to ulnar collateral ligament tear of the elbow, application of valgus stress to the joint will show asymmetric widening of the joint and possibly separation of torn ligament fibers (Fig. 9).[42,43] This maneuver can also be applied to the anterior talofibular ligament of the ankle imaged with anterior translation of the talus relative to the tibia and fibula.

Evaluation of Soft Tissues Adjacent to Hardware

The soft tissues immediately adjacent to metal hardware are often evaluated for fluid collection, bursa, and tendon abnormalities such as tendon tear, tenosynovitis, and tendon impingement.[44] Although there are methods to reduce artifact from metal when imaging with MRI and computed tomography (CT), ultrasound is able to evaluate adjacent soft tissues without obscuration from artifact. This is most effective with more superficial aspects of extremities where resolution is optimal. For example, hypoechoic infected fluid can be seen immediately adjacent to a metal plate, as reverberation artifact is deep to the hardware away from the fluid (Fig. 10). In addition, ultrasound-guided aspiration may be immediately completed to evaluate for infection. Another situation where ultrasound is helpful after hardware placement is when a patient has point tenderness at the operative site. Although radiography can show hardware loosening, ultrasound is able to evaluate adjacent soft tissues. Even when a structure such as tendon is in direct contact with hardware, such as a screw head or tip, the individual tendon fibers are still visible, enabling an accurate evaluation without artifact (Fig. 11). In addition, dynamic imaging by moving the affected tendon can demonstrate whether a tendon slides normally over the hardware or whether there is irregular movement suggesting impingement.

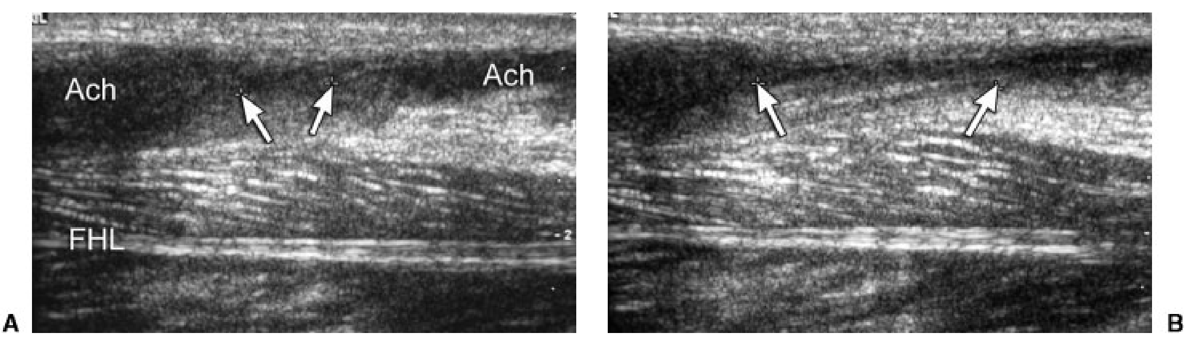


Figure 8 Full-thickness Achilles tendon tear. Sonogram longitudinal to Achilles tendon with foot in neutral position (A) shows discontinuity (between arrows) between the swollen and hypoechoic Achilles tendon stumps (Ach). With passive dorsiflexion, the torn tendon gap widens (between arrows) confirming suspected full-thickness tear.

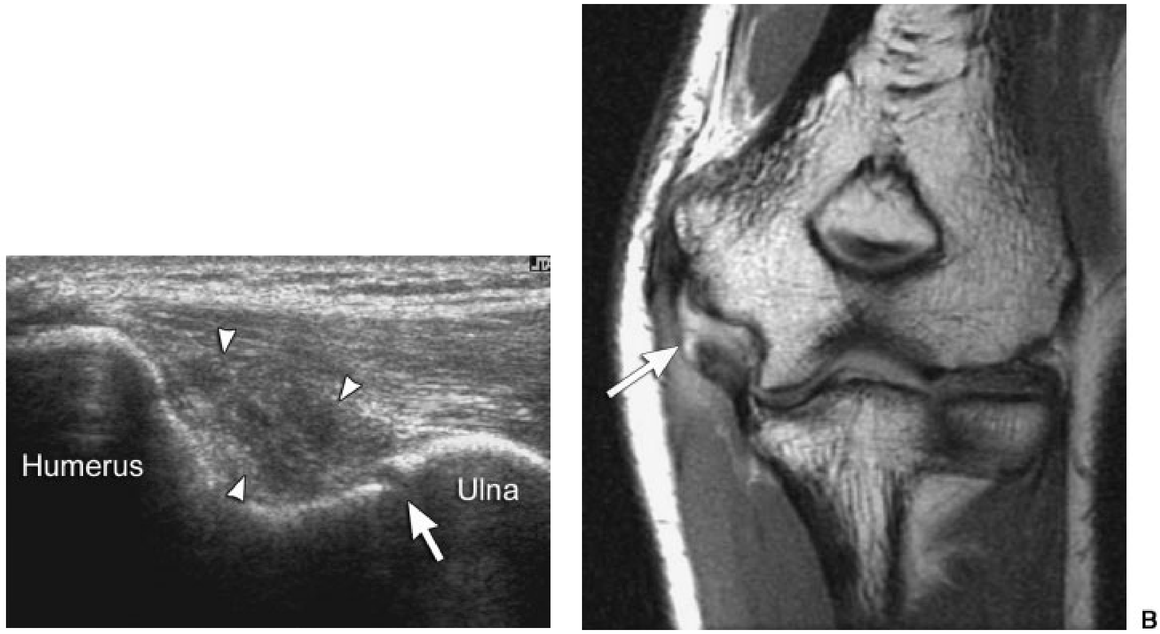


Figure 9 Partial-thickness ulnar collateral ligament tear of elbow. Sonogram longitudinal to anterior bundle of ulnar collateral ligament (A) shows abnormal thickening and hypoechogenicity (arrowheads). With valgus stress, the joint space between the trochlea of the humerus and ulna (arrow) did not widen, excluding full-thickness tear. Note (B) corresponding abnormal signal on intermediate-weighted coronal MRI (arrow).

ULTRASOUND AND MRI: BOTH VIABLE ALTERNATIVES

Focal Tendon Abnormality

The evaluation of a tendon abnormality can be accomplished with both MRI and ultrasound.[17] Of course there are intrinsic advantages and disadvantages to both imaging methods. One significant advantage of MRI is the ability to globally assess a joint, diagnosing tendon, ligament, cartilage, and bone abnormalities. Therefore, an algorithm can be devised to take this into account. If a clinician has suspicion for a focal tendon abnormality, such as rotator cuff tear, then ultrasound can be considered. If the clinician is suspecting something more than a focal tendon problem then MRI should be considered. In addition, with patient's less than 40 years of age and in the correct clinical setting where there is significant concern for cartilage or ligament injury, magnetic resonance arthrography should be considered. The drawback of this algorithm is that the decision on choice of imaging relies on the clinicians' suspicions of specific pathology. As an alternative algorithm, sonography may be considered the first line of imaging for joint problems after radiography,

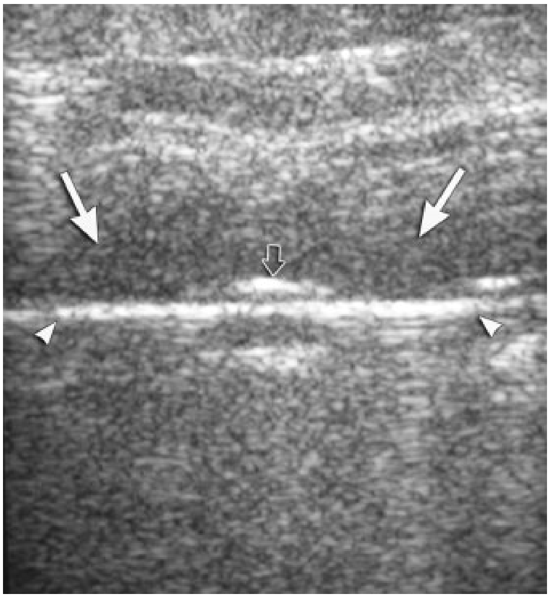


Figure 10 Infected fluid collection adjacent to metal plate. Sonogram sagittal to humeral shaft shows hypoechoic infected fluid (arrows) superficial to metal plate (arrowheads). Note screw head (open arrow) and posterior reverberation artifact away from adjacent hypoechoic fluid.

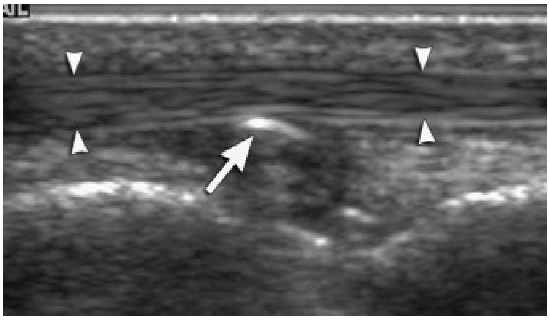


Figure 11 Normal extensor hallucis longus tendon in contact with screw head. Sonogram longitudinal to extensor hallucis longus tendon (arrowheads) shows normal fibrillar echotexture. Note direct impingement from adjacent screw head (arrow) with posterior reverberation artifact away from adjacent tendon.

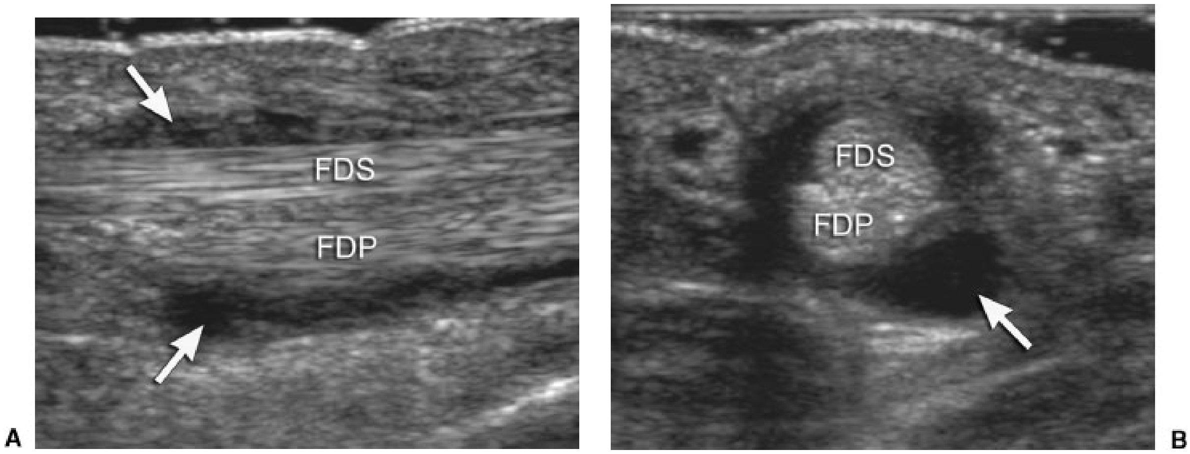


Figure 12 Tenosynovitis of flexor digitorum superficialis and profundus tendons. Sonograms longitudinal (A) and transverse (B) to flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) tendons show surrounding anechoic fluid (arrows).

especially in the proper clinical setting, such as evaluating for rotator cuff tear in patients over 40 years of age. If the ultrasound is negative, then MRI may be considered.

Tendon abnormalities include tenosynovitis, tendinosis, and tendon tear. Tenosynovitis will appear as anechoic or hypoechoic fluid distending a tendon sheath (Fig. 12). Synovitis can appear hypoechoic, isoechoic, or even hyperechoic. The presence of flow on color and power Doppler imaging supports the diagnosis of synovitis over complex fluid.[45] Tendinosis will appear as heterogeneous hypoechoic swelling of tendon, without disruption of tendon fibers (Fig. 13).[46] Partial-thickness tears of a tendon may appear as an anechoic or hypoechoic surface defect or discontinuity as is seen in the rotator cuff (Fig. 14),[46] or an anechoic or hypoechoic longitudinal split as seen in the ankle tendons about the malleoli (Fig. 15).[47–49] Full-thickness tear is characterized by anechoic or hypoechoic tendon fiber disruption, with tendon retraction (Fig. 16).[46]

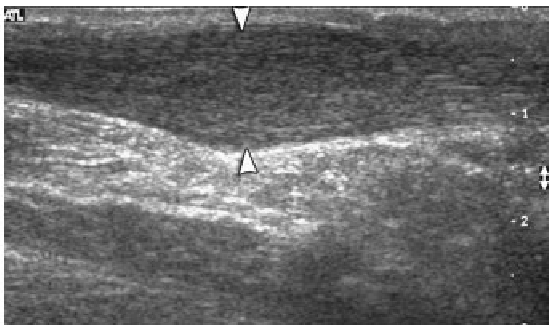
Focal Ligament Abnormality

Similar to what was described above with a focal tendon abnormality, ultrasound may also be considered to evaluate a focal ligament abnormality. Although it has been shown that MRI, and in particular magnetic resonance arthrography is very effective in the diagnosis of partial- and full-thickness ligament tear, ultrasound has not been adequately evaluated in the literature. It has been shown that ultrasound can evaluate specific ligaments, such as the ulnar collateral ligament of the elbow,[42,50,51] the scapholunate ligament of the wrist,[52] collateral ligaments about the knee,[53] and the lateral ankle ligaments[54,55]; however, it is the use of dynamic imaging in the evaluation of ligament tears that will enable ultrasound to compete with MRI. Because many individuals with ligament tears have other internal derangement problems, such as cartilage injuries, this is one argument to use magnetic resonance arthrography to evaluate for ligament tears. Ultrasound can still be considered the first line of imaging after radiography, and then MRI considered if normal or if other pathology is expected. One must keep in mind that many patients with suspected ligament injury may not need surgery depending on the patient's age and activity level. It is this population where ultrasound can easily characterize a ligament tear and exclude other adjacent pathology.

A ligament abnormality is characterized at sonography as abnormal hypoechoic swelling and loss of the normal hyperechoic compact fibrillar echotexture in the setting of a partial-thickness tear or sprain (Fig. 9). With a full-thickness tear, there will be abnormal hypoechoic or anechoic areas disrupting the ligament fibers (Fig. 17). Application of stress to the joint at the location of the ligament (for example, valgus elbow stress to evaluate the ulnar collateral ligament) is helpful in that retraction of torn ligament ends and asymmetric widening of the affected joint indicates full-thickness tear.[42] Bone irregularity and small bone fragments can indicate bony avulsion.

Soft Tissue Fluid Collection

When there is concern for soft tissue infection, CT, MRI, and ultrasound may be considered to evaluate for abscess, joint effusion, and bursitis.[17] There are several advantages and disadvantages for each. Both CT and MRI can show joint effusion and abscess, with the latter facilitated by the use of intravenous contrast. With regard to ultrasound, this is often the first imaging method of choice after radiography because of availability and low cost. Ultrasound can effectively evaluate for joint effusions and bursitis. Patient symptoms and physical examination findings are often a clue to underlying abscess when evaluating with ultrasound. One significant advantage of ultrasound is the ability to immediately aspirate a fluid collection to exclude infection.[56] The disadvantages of ultrasound include limited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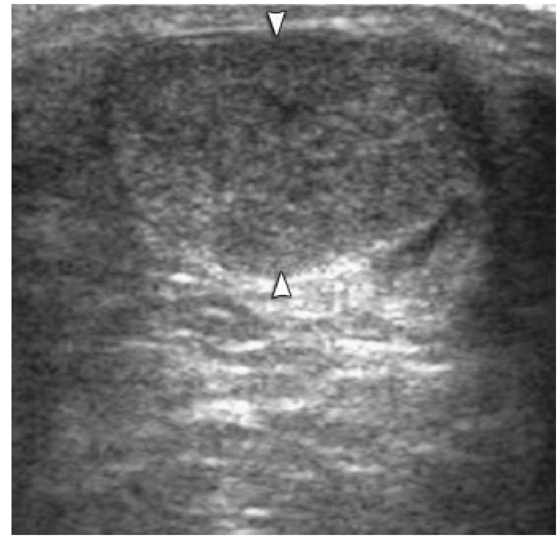
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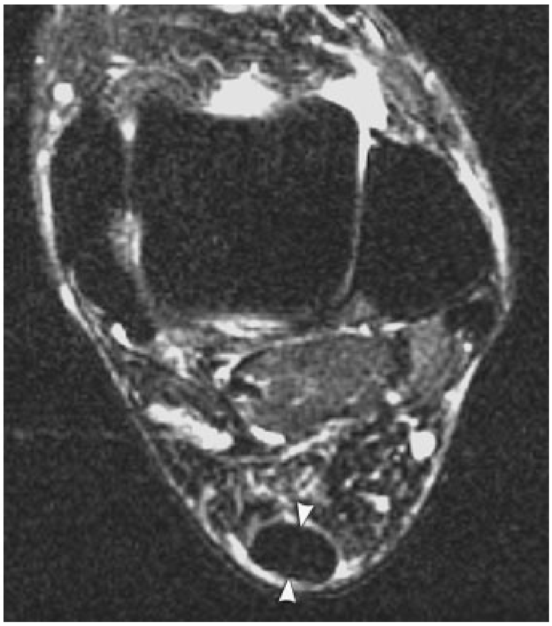
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Figure 13 Tendinosis of Achilles tendon. Sonograms longitudinal (A) and transverse (B) to the distal Achilles tendon shows fusiform hypoechoic enlargement (arrowheads). Note tendon fiber continuity excluding tendon tear and corresponding T2-weighted transverse MRI (C).

resolution in deep soft tissues and limited evaluation of bone, although ultrasound diagnosis of osteomyelitis has been extensively described, especially in children.[57] As a potential imaging algorithm, sonography should be considered after radiography, especially in the peripheral aspects of the extremities. If the site of a suspected abnormality is in the deeper structures, such as the hip and pelvis or axillary regions, then CT or MRI should be considered if the ultrasound examination is normal. If a fluid collection is adjacent to bone, then MRI should be considered to evaluate for osteomyelitis, especially if the bone cortex is irregular.

At sonography, a joint effusion is characterized by anechoic or hypoechoic distention of a joint recess.[56] Important sites of evaluation include the biceps long head tendon sheath (Fig. 18) and posterior recess in the shoulder, the posterior olecranon recess in the elbow (with elbow flexion), the volar and dorsal joint recesses of the wrist, the anterior hip joint recess over the femoral neck, the suprapatellar recess of the knee, and the anterior ankle joint recess (with foot in plantarflexion). If joint distention is not anechoic, considerations include complex fluid or synovitis. Compressibility of the joint recess and lack of flow on color or power Doppler imaging would suggest complex fluid over synovitis. Ultrasound-guided aspiration may be needed to exclude infection, especially as septic and aseptic effusion cannot be differentiated at sonography. A bursal fluid collection and abscess may also be anechoic or hypoechoic with possibly hyperemia (Fig. 19). Knowledge of the common bursae about the body, such as the subacromial-subdeltoid bursa in the shoulder (Fig. 20), the olecranon bursa

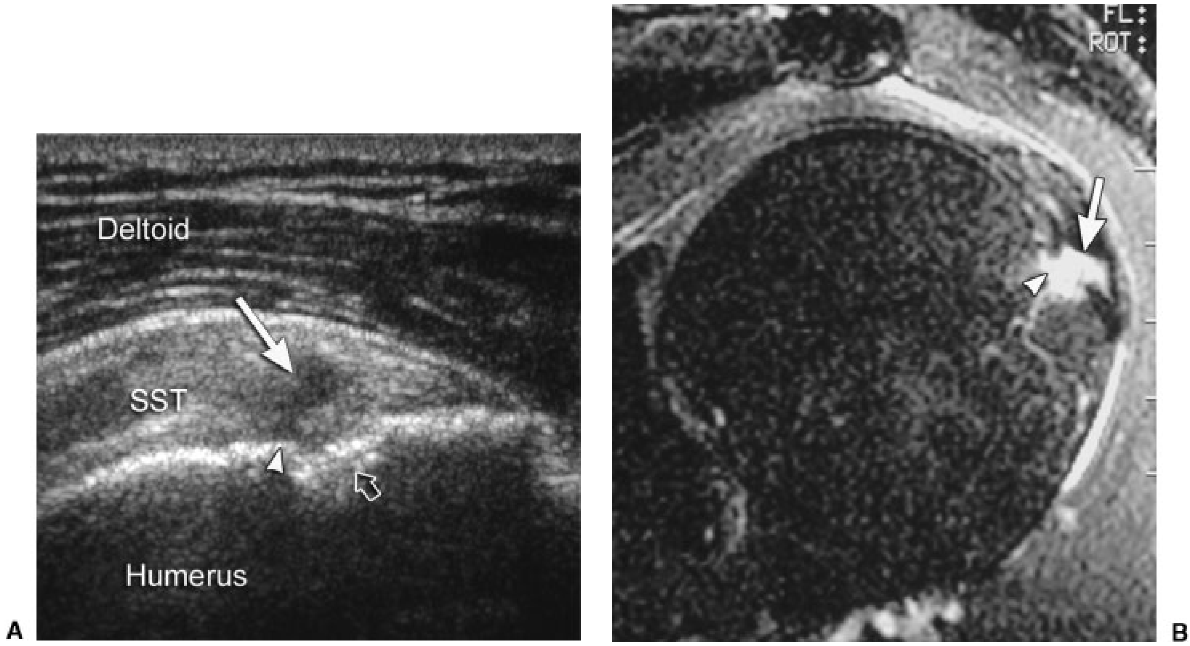


Figure 14 Partial-thickness, articular side supraspinatus tendon tear. Sonogram (A) longitudinal to the supraspinatus tendon (SST) shows hypoechoic fiber discontinuity (arrow) representing tear. Note extension to articular surface (arrowhead) and adjacent bone irregularity of the greater tuberosity (open arrow). Intact fibers superficial to the tear excludes full-thickness tear. Note corresponding findings on T2-weighted coronal-oblique MRI (B).

in the elbow, and the prepatellar bursa in the knee, help distinguish bursal fluid from nonspecific soft tissue abscess. Because an abscess may appear isoechoic or hyperechoic to adjacent soft tissues and can be difficult to identify, the use of secondary signs such as posterior acoustic enhancement and swirling of internal echoes with transducer pressure assists in the diagnosis (Fig. 19).[58,59]

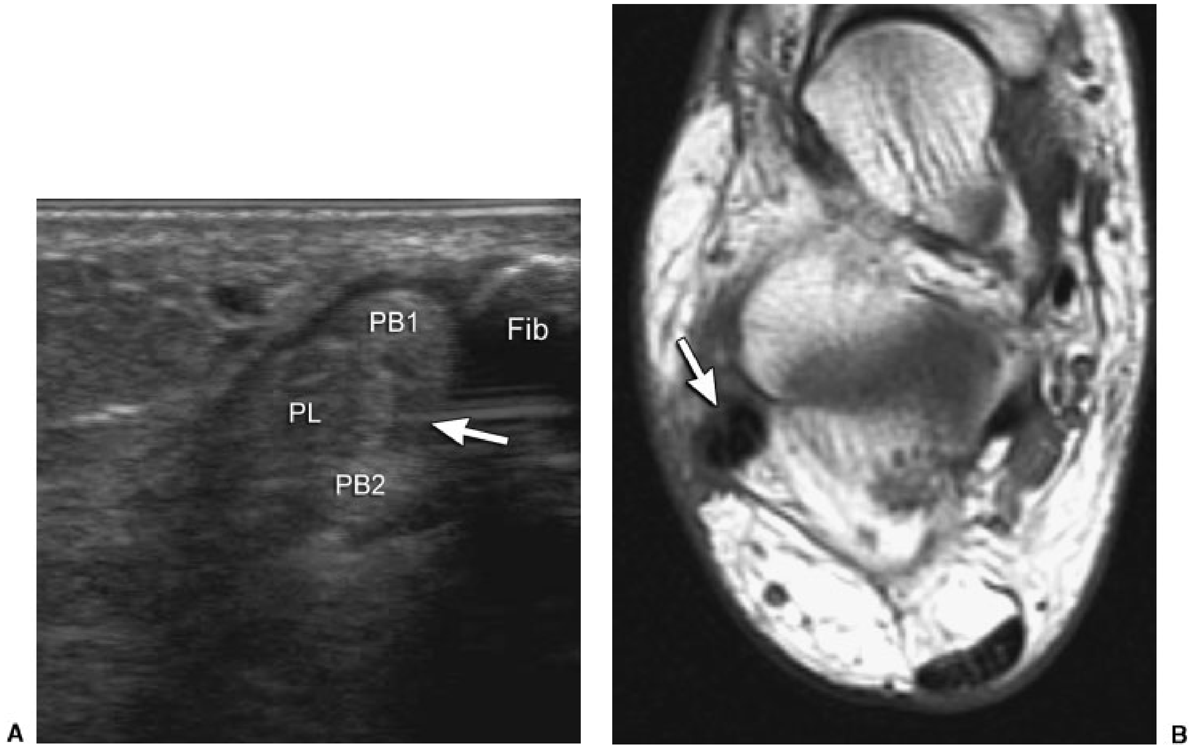
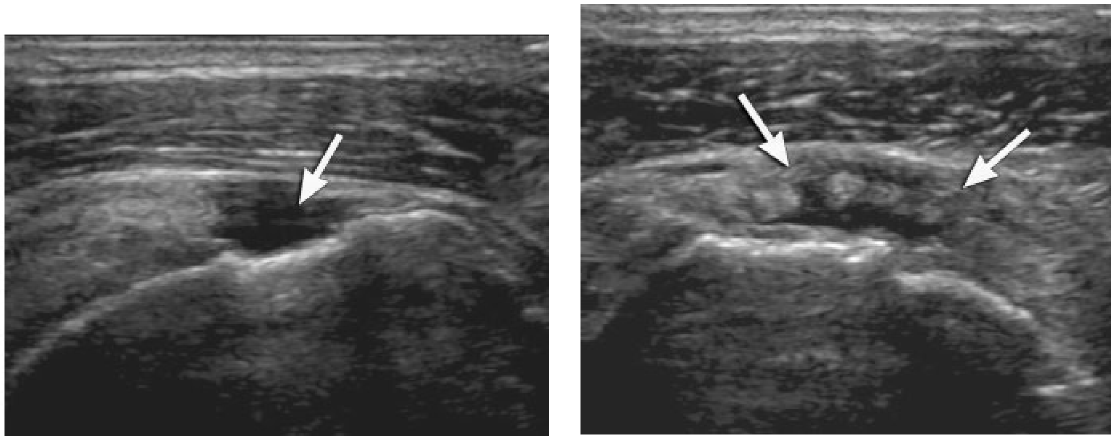
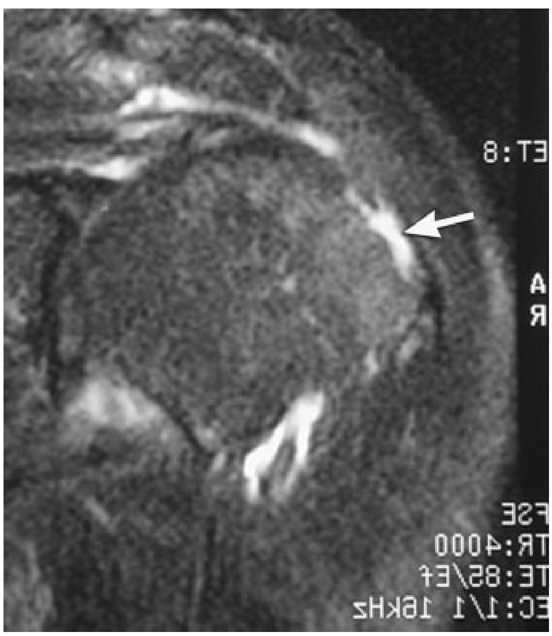


Figure 15 Partial-thickness peroneus brevis tendon tear. Sonogram (A) transverse to the peroneal tendons show a longitudinal split (arrow) separating the peroneus brevis tendon into two (PB1 and PB2). Note peroneus longus tendon (PL), fibula (Fib), and corresponding finding on T1-weighted transverse MRI (B).



A B



C

Figure 16 Full-thickness supraspinatus tendon tear. Sonograms longitudinal (A) and transverse (B) to the distal supraspinatus tendons show the anechoic fluid-filled tendon tear (arrows). Note extension from articular to bursal surface, with flattening or loss of normal superior convexity of the supraspinatus tendon. Also note corresponding findings on T2-weighted coronal-oblique MRI (C), which is in the same plane as the longitudinal sonogram (A).

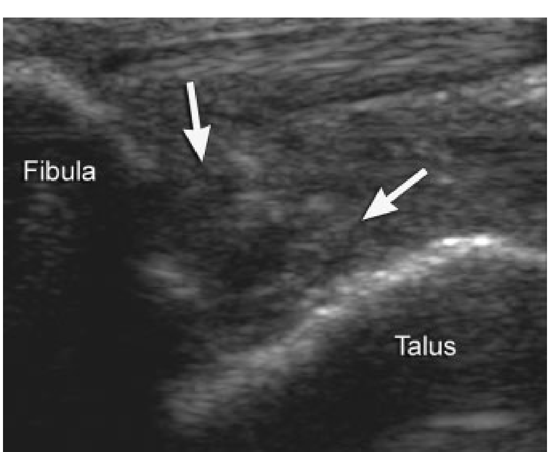


Figure 17 Full-thickness anterior talofibular ligament tear. Sonogram longitudinal to the anterior talofibular ligament shows abnormal heterogeneous hypoechogenicity in the expected location of the anterior talofibular ligament (arrows). No normal fibrillar ligament fibers were identified.

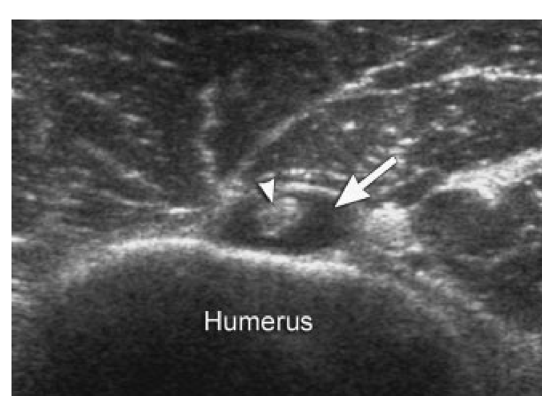


Figure 18 Shoulder joint effusion. Sonogram transverse to the proximal long head of the biceps brachii tendon (arrowhead) shows anechoic distention of the tendon sheath (arrow), which communicates with the shoulder joint.

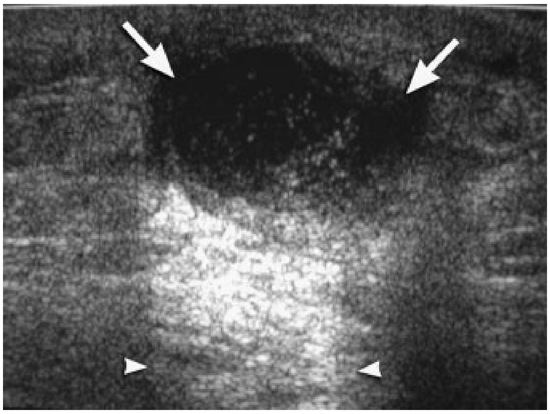


Figure 19 Soft tissue abscess. Sonogram anterior to the shoulder joint shows a heterogeneous but predominately hypoechoic abscess (arrows). Note posterior acoustic enhancement (arrowheads).

Evaluation of a Probable Benign Cyst

In the presence of a palpable soft tissue mass, sonography is often used to differentiate between solid mass and cyst. This often assists in the diagnostic workup and differential diagnosis. One problem is that once a cystic mass is identified, it may still remain nonspecific, and benign versus malignant cannot always be diagnosed. Ultrasound may be used to provide percutaneous aspiration or biopsy to assist. However, there are two situations where ultrasound is very effective in providing a diagnosis: Baker's cyst and wrist ganglion cyst. These types of cyst occur in a very characteristic location and have a typically history; therefore, ultrasound is used to confirm the presence of a probable benign cyst.

BAKER'S CYST

A Baker's cyst is distention of the semimembranosus-medial gastrocnemius bursa.[60] Over 50% of individuals over the age of 50 years have a communication between the knee joint and this bursa, likely due to degeneration of the capsule and increased intra-articular pressures related to internal derangement common in this age group.[60] The workup of a probable Baker's cyst depends on the patient's age, as both ultrasound and MRI can effectively provide an accurate diagnosis.[60] For example, if a patient is over 50 years old and has a suspected Baker's cyst, ultrasound should be considered. This will effectively diagnose Baker's cyst and exclude other causes for medial posterior knee mass such as tumor and exclude deep venous thrombosis. In a patient of this age, osteoarthrosis and internal derangement are likely, and the patient is more likely to have a knee arthroplasty rather than arthroscopy to repair meniscal pathology. In a patient less than 50 years of age who will likely have arthroscopy to repair any meniscal pathology, MRI should be used as this will diagnose Baker's cyst and the internal derangement.

At sonography and any imaging method, a Baker's cyst has a characteristic comma shape in the transverse plane as it wraps around the medial margin of the medial gastrocnemius muscle and tendon (Fig. 21).[60] A Baker's cyst echogenicity can range from anechoic to hyperechoic, depending on the presence of synovitis and hemorrhage. Because this variable echogenicity may cause it to appear as a complex or solid mass, it is very important to identify the communication between the Baker's cyst and the posterior knee joint. This channel located between the tendons of the medial gastrocnemius and semimembranosus tendons will effectively exclude other causes for posterior knee cyst.[60] This is quite important in the situation of a Baker's cyst rupture or dissection, where a complex cyst or mass in the calf actually represents extension from an adjacent cephalad Baker's cyst. Irregular inferior margin of a Baker's cyst with adjacent soft tissue edema extending over the medial gastrocnemius muscle indicates rupture.

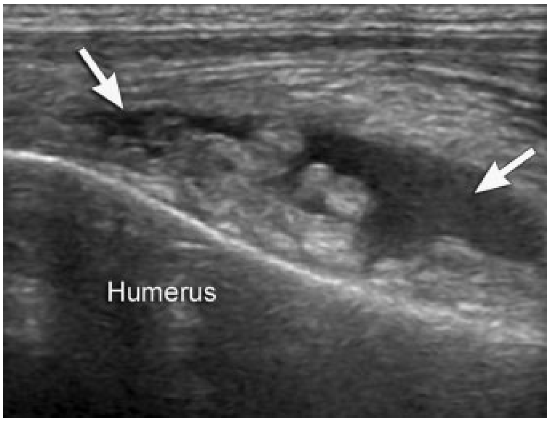
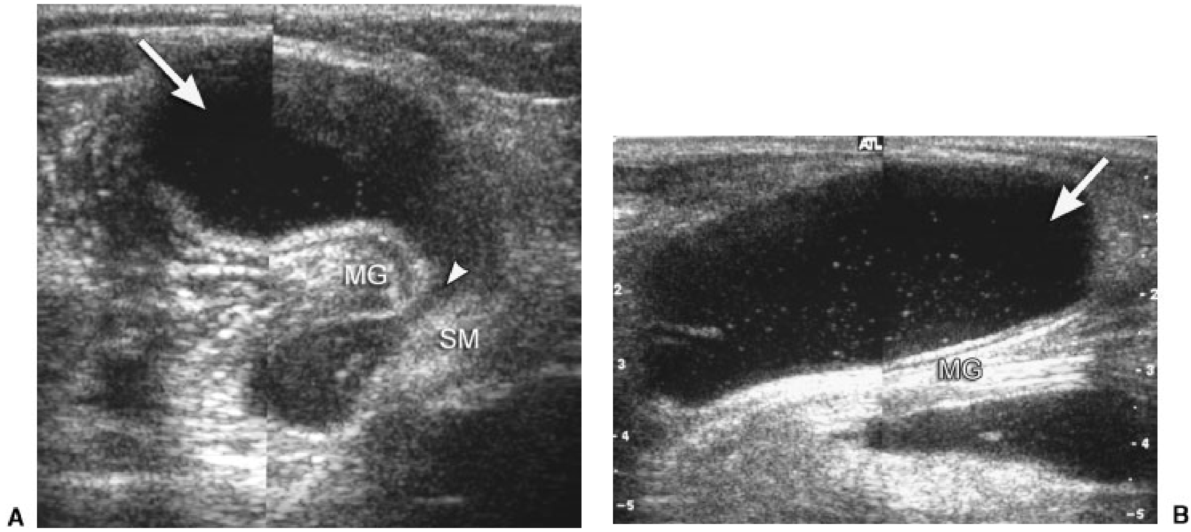


Figure 20 Subacromial-subdeltoid bursal fluid collection. Sonogram in the coronal plane distal to the greater tuberosity of the humerus shows distention of the subacromial-subdeltoid bursa (arrows) with anechoic fluid and hyperechoic synovitis or hemorrhage.

WRIST GANGLION CYST

Most wrist masses are benign, and the majority of these represent ganglion cysts.[61] One of the most important features of a ganglion cyst is the location. Up to 70% of these cysts are found dorsally, superficial to the dorsal aspect of the scapholunate ligament.[61] Most remaining ganglion cysts are located between the radial artery and flexor carpi radialis tendons, with extension from the adjacent radiocarpal joint.[62] These locations are so important that these sites should be evaluated for ganglion cysts, regardless of the type of cross-sectional imaging. Both ultrasound and MRI can effectively evaluate wrist ganglion cysts.[61] One pitfall in MRI is the presence of multiple normal vascular structures about the wrist that are very bright on fluid-sensitive sequences and may make small ganglion cysts less conspicuous.

At sonography, ganglion cysts are hypoechoic or anechoic, often with a multilocular appearance (Fig. 22).



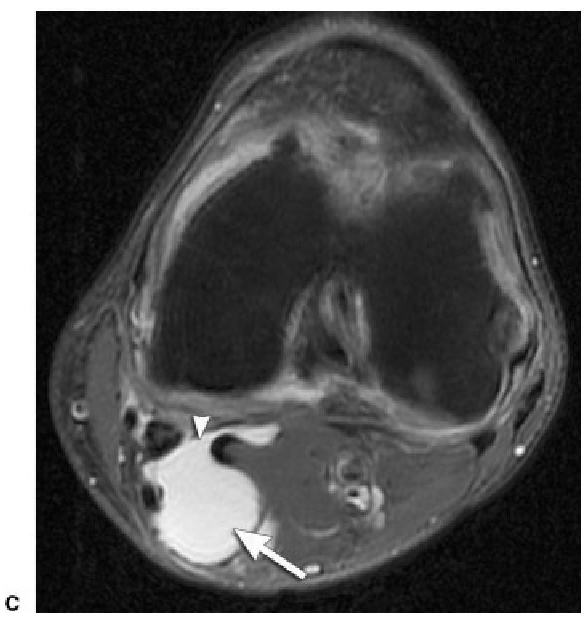


Figure 21 Baker's cyst. Axial (A) and sagittal (B) sonograms over the posteromedial knee show hypoechoic distention of the medial gastrocnemius-semimembranosus bursa (arrow). Note communication to the posterior knee joint via a channel (arrowhead) between the medial gastrocnemius tendon (MG) and semimembranosus tendon (SM). Note corresponding findings on intermediate-weighted fat-saturated axial MRI (C).

Posterior acoustic enhancement is typically present. However, when a ganglion cyst is small, it may appear hypoechoic without posterior acoustic enhancement. In this situation, it is the location of the cyst and possible extension from the radiocarpal joint that suggests the correct diagnosis. Ultrasound-guided injection of ganglia with corticosteroids has been described.[63]

SUMMARY

Similar to other imaging methods such as radiography, CT, and MRI, ultrasound also has a role in the diagnosis of musculoskeletal disorders. Ultrasound should not be viewed as a competing imaging method but rather as a complementary imaging method. For specific applications (foreign body, peripheral nerve, dynamic imaging, soft tissues adjacent to hardware), there are significant advantages to ultrasound over other imaging methods because of its resolution, its ability to image an entire extremity over a short period of time, its ability to image around hardware without artifact, and its ability to image dynamically. There are other areas of musculoskeletal pathology where both ultrasound and MRI work equally well. In these situations, we are fortunate that an imaging method choice can be made based upon the individual circumstances, such as availability and cost. Ultrasound can be viewed as an alternative to MRI when there are contraindications for MRI or when a patient cannot tolerate MRI. In summary, a radiologist who

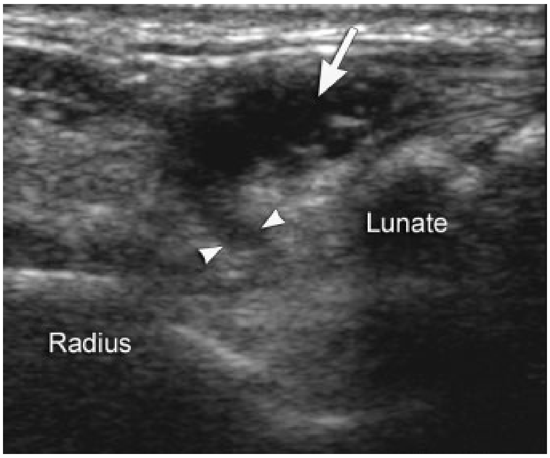


Figure 22 Dorsal wrist ganglion. Sagittal sonogram over the dorsal radiocarpal joint shows an anechoic ganglion cyst (arrow) with lobular margins and communication to the adjacent radiocarpal joint (arrowheads).

understands the potential roles of musculoskeletal ultrasound will be able to consider this complementary imaging method in the diagnosis of musculoskeletal abnormalities.

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