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Authors

Joines, Melissa
Motamedi, Kambiz
Seeger, Leanne
et al.

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Musculoskeletal Interventional Ultrasound

Melissa M. Joines, M.D.,¹ Kambiz Motamedi, M.D.,² Leanne L. Seeger, M.D.,²
and John P. DiFiori, M.D.³

ABSTRACT

Ultrasound is a nonionizing, low-cost, portable imaging technique for the evaluation of tendons, muscles, joints, soft tissue masses, and cysts, especially in patients unable to tolerate computed tomography or magnetic resonance imaging. These advantages make ultrasound an ideal modality for guiding musculoskeletal interventions. Its real-time capabilities allow continuous observation of needle placement into the targeted area and direct visualization of interventions such as injection of medication while avoiding other soft tissue structures or nearby neurovascular bundles. After a brief overview of the technical factors involved in performing ultrasound-guided musculoskeletal interventions, this article reviews commonly performed percutaneous procedures in the musculoskeletal system.

KEYWORDS: Musculoskeletal, ultrasound, intervention, injection, aspiration, biopsy

Musculoskeletal ultrasound is rapidly growing in importance and utility in the United States. The advantages of ultrasound make it an ideal adjunct for guiding musculoskeletal interventions.

TECHNICAL CONSIDERATIONS

When performing musculoskeletal sonography, the proper equipment must be used to optimize image quality, the diagnostic examination, and subsequent intervention. A linear array transducer (7.5 to 17 MHz) is recommended for imaging superficial joints such as in the wrist or ankle; a curved array transducer (3 to 5 MHz) generally is reserved for imaging deeper joints such as the hip in patients with a larger body habitus.^{1,2} The choice of needle is based on specific anatomy, with the general principle of using a small-gauge needle for injections and a larger size needle for aspirations (e.g., an 18-gauge versus a 22-gauge needle, respectively).³

Patient positioning should accommodate both the patient's and the interventionalist's comfort, thus optimizing the outcome of the procedure. A preliminary

sonographic evaluation locates the intended target structure and approach route, as well as defines the relationship of the lesion to surrounding anatomical structures. Color Doppler interrogation is critical to assess for vascular structures close to the lesion.^{2,4}

Ultrasound-based musculoskeletal interventions, as with other image-guided procedures, are performed in a sterile fashion. The skin is cleansed and draped. The tip of the transducer may be cleansed by immersing it in colorless sterilizing liquid such as alcohol or by using a sterile probe cover to avoid staining or damaging the transducer tip. Lidocaine 1% is generally used for local anesthesia. Most musculoskeletal procedures employ a free-hand technique because it allows for greater flexibility and needle movement during the procedure. The needle must be visualized via ultrasound as it progresses through the soft tissues. When the transducer is oriented longitudinally along the same plane as the needle track axis, the needle appears as a bright echogenic linear structure. Alternatively, positioning the transducer transverse to the needle depicts the needle as a bright echogenic dot. Gently wobbling

¹Department of Radiology, UCLA, Los Angeles, California; ²Department of Radiology, Musculoskeletal Imaging, UCLA, Los Angeles, California; ³Department of Family Medicine, Sports Medicine Division, UCLA, Los Angeles, California.

Address for correspondence and reprint requests: Kambiz Motamedi, M.D., Department of Radiology, Musculoskeletal Imaging, UCLA, 10833 Le Conte Ave., Los Angeles, CA 90095 (e-mail: kmotamedi@

mednet.ucla.edu).

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the needle or injecting a small amount of anesthetic or saline and observing the moving echoes may assist in identifying the needle position.^{2,4-6}

SOFT TISSUE BIOPSY

Ultrasound-guided core needle biopsy of musculoskeletal soft tissue tumors is a well-established reliable alternative to computed tomography (CT) and fluoroscopy.⁷⁻⁹ CT-guided biopsy of lesions involving the feet, hands, and wrists is often challenging because the lesions may be too small for adequate CT visualization or are located in the periphery of the field of view where beam-hardening artifact may degrade image quality. In addition, when optimal patient positioning on the CT table is impossible (e.g., hand overhead extension, the so-called mighty mouse or swimmer's position), sonography provides an easy and elegant alternative.

Prior to the actual biopsy of a soft tissue mass, ultrasound may be used in evaluating the intrinsic structure of the mass. The cystic portions may be aspirated and the fluid sent for cytologic investigation. The solid elements should be targeted selectively to obtain core biopsies.¹⁰ The vascular nature of a lesion can readily become apparent using power or color Doppler sonography. Avoiding the vascular portions is critical to prevent excessive bleeding during or after the procedure, which is of utmost importance in patients with coagulopathies.¹¹ Immediate or delayed scanning after the procedure may be performed to evaluate for possible complications.

Following localization of the lesion on ultrasound, a suitable point of needle entry should be selected. The distance of the lesion from the point of skin entry can be measured for choosing the appropriate needle length. Because the majority of surgeons would like to include the biopsy site in the surgical incision to avoid needle track recurrences, a discussion with the orthopaedic surgeon regarding an appropriate puncture site is suggested.^{8,12} Core biopsies may then be taken with or without a guiding needle as needed. Using a guiding trocar needle would secure obtaining a core within a lesion after penetrating a fibrous or partially calcified capsule. The biopsy needle without a guide may merely push the lesion in front of the needle instead of penetrating it. This is in contrast to a CT-guided biopsy in which direct visualization of the core biopsy process is not possible. The exact location and orientation of the core can be visualized and adjusted accordingly (Fig. 1).

ASPIRATION OF JOINTS AND CYSTS

Ultrasound provides a fast and convenient method for visualization of fluid containing lesions and for guiding aspiration of cysts, joints, hematomas, and abscesses.

Traditionally, aspiration of a superficial joint has been performed without imaging guidance. However, when only a small joint effusion is suspected, the anatomy is distorted due to joint replacement, or periarticular soft tissue swelling is present, ultrasound guidance provides a safe and successful alternative.^{10,13} Almost any joint space can be targeted and aspirated as indicated. Prior literature has reported a high success rate using ultrasound-guided joint aspiration of the shoulder, hip, knee, and ankle.^{2,6,11}

Aspiration of a knee joint is best achieved with the patient supine, with mild flexion of the knee. Scanning longitudinally over the distal quadriceps tendon just proximal to the patella evaluates the suprapatellar recess. The skin is marked adjacent to the quadriceps tendon, ~3 cm superior to its attachment site on the superior patellar pole. The space between the posterior aspect of the patella and the anterior aspect of the distal femur is targeted. Aspiration may be performed via a superolateral or superomedial approach into the distended suprapatellar recess.¹² When using this approach, no major neurovascular bundles are encountered. The aspirated fluid can be sent for laboratory examination as necessary.

The smaller superficial joints, such as the sternoclavicular or acromioclavicular articulations, can be visualized and aspirated under ultrasound guidance, such as in cases with suspected septic arthritis. This is especially useful during a pregnancy when radiation exposure can be entirely eliminated. The sternoclavicular joint is best approached anteriorly in a transverse axis.¹² Depending on the width of the joint space and the amount of fluid present, a large needle may be inserted into the joint space under direct visualization to avoid penetration beyond the joint and thus injuries to the deeper vascular structures. A synovial biopsy may be performed at this point with a cutting needle as well (Fig. 2).

Cystic and fluid-containing lesions of the extremities include ganglion cysts, paralabral cysts, meniscal cysts, synovial cysts, and Baker cysts (recess). These cysts may be painful due to mechanical impingement of adjacent nerves or tendons or from increased internal pressure.^{2,4} Prior to aspiration of a cystic lesion, ultrasound should be performed to confirm its cystic nature. Cysts appear anechoic or hypoechoic on ultrasound with posterior acoustic enhancement.⁵ Color Doppler should be performed to ensure the lesion is not a vascular structure such as a pseudoaneurysm.¹⁰

When aspirating a Baker cyst, the patient should be positioned prone. The cyst is identified within the popliteal fossa, between the medial head of the gastrocnemius muscle and the semimembranosus tendon.¹⁴ The popliteal vessels are identified using Doppler sonography. Using a transverse orientation, a suitable point of entry is selected, usually in the midportion of the

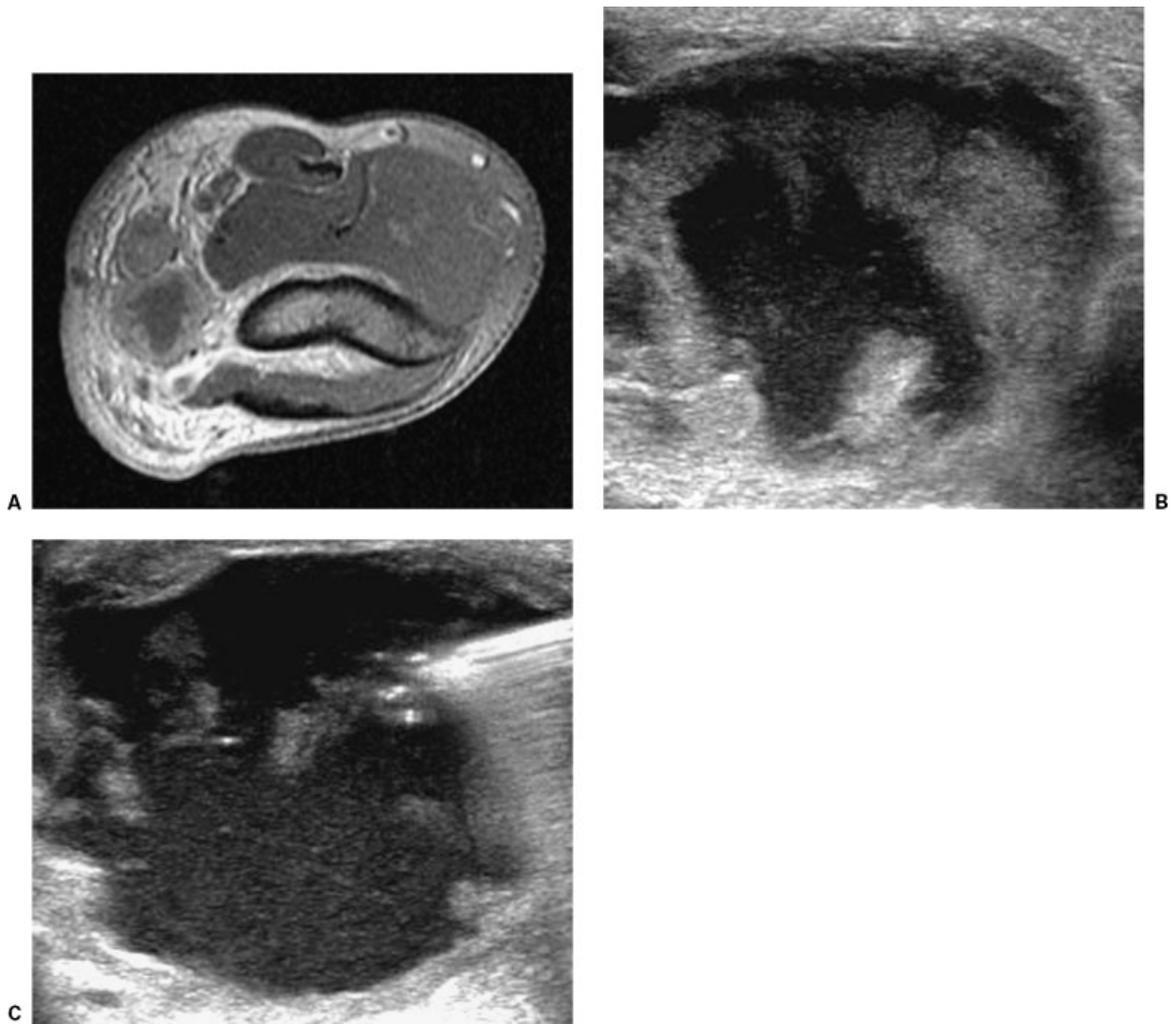


Figure 1 A 58-year-old man with a history of melanoma with new epitrochlear lymphadenopathy. (A) Fat-saturated T1 axial images illustrating a lesion with central necrosis and peripheral enhancement of the medial epitrochlear region. (B) Longitudinal ultrasound of the epitrochlear region reveals a hypoechoic mass with low-level internal echoes and several nodular masses at the periphery. (C) The needle tip is directly visualized within the peripherally located solid masses.

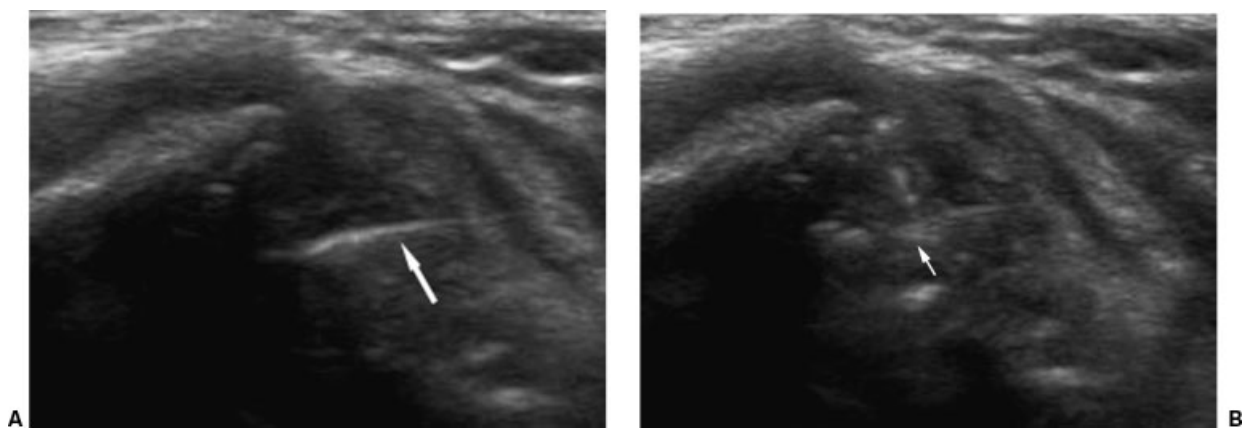


Figure 2 A 65-year-old woman with osteoarthritis of the right sternoclavicular joint. (A) A 25-gauge needle (white arrow) is identified within the sternoclavicular joint. (B) Echogenic steroid/anesthetic mixture (white arrow) is visualized at the needle tip.

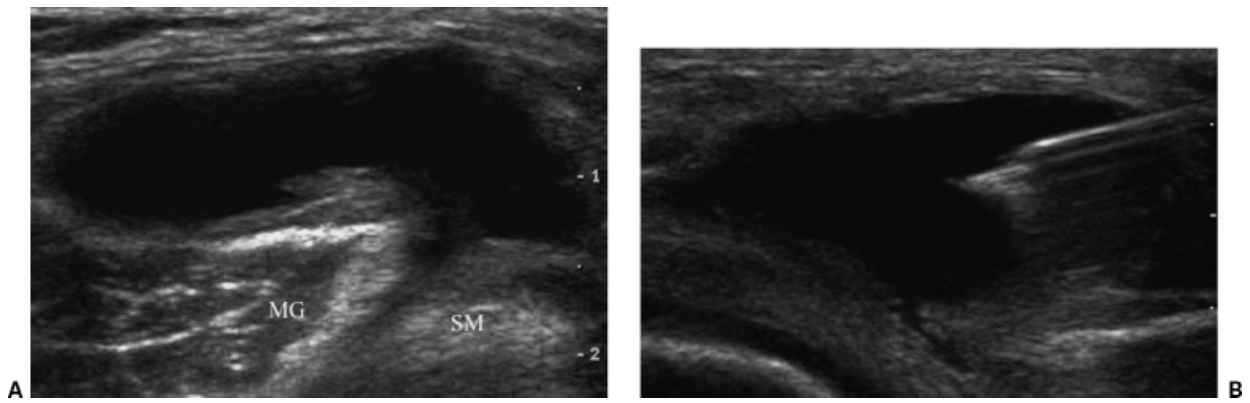


Figure 3 A 65-year-old woman with a large Baker cyst on previous magnetic resonance imaging. (A) Longitudinal ultrasound of the posteromedial aspect of the knee shows an elongated fluid collection between the medial head of the gastrocnemius (MG) and semimembranosus tendon (SM). (B) A needle is visualized within the cyst.

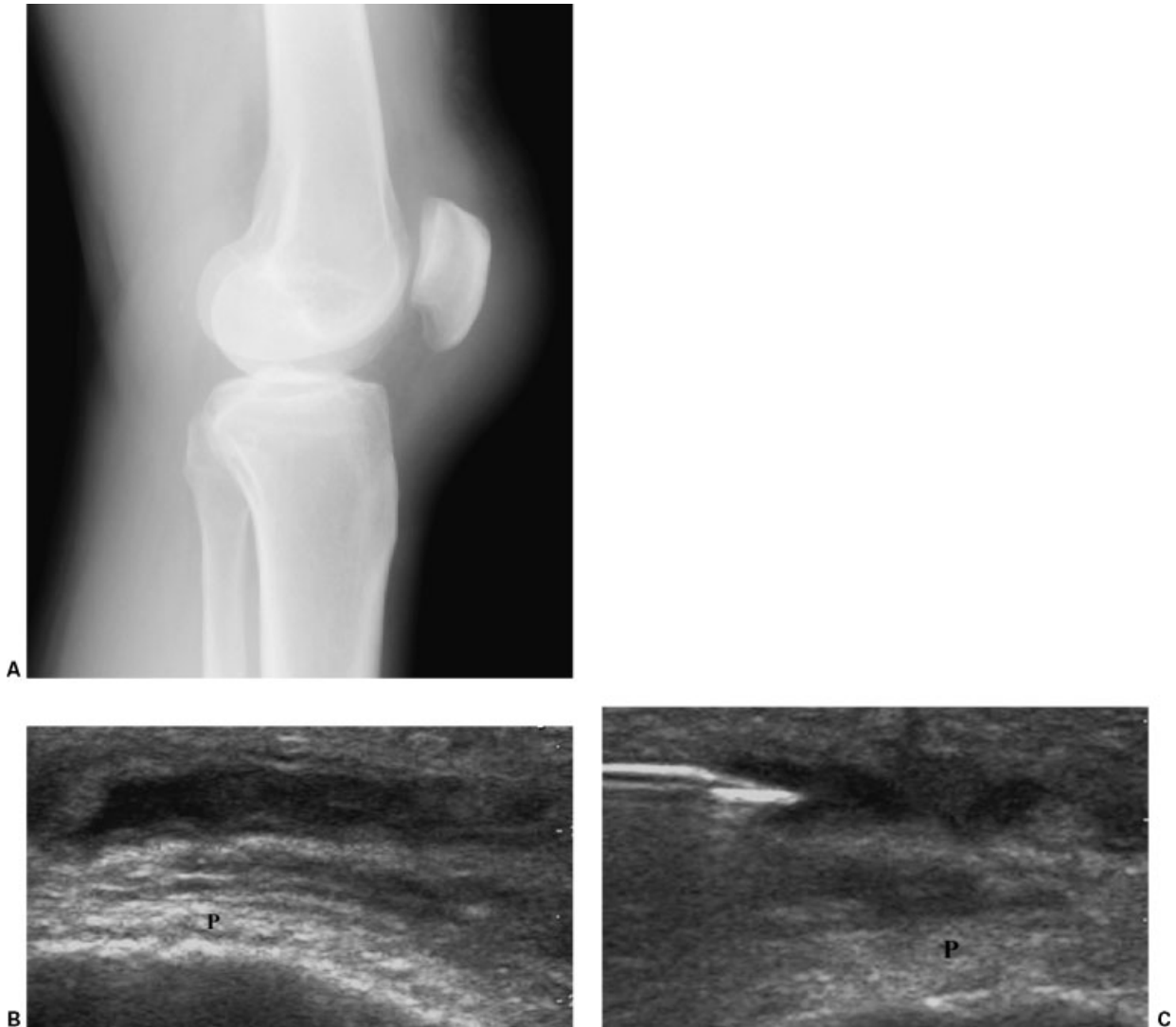


Figure 4 A 45-year-old man with prepatellar right knee swelling and tenderness. (A) Lateral radiograph of the knee demonstrating significant prepatellar soft tissue swelling. (B) Longitudinal ultrasound shows a hypoechoic fluid collection anterior to the patella (P) within the prepatellar bursa. The bursal wall appears thick secondary to an associated inflammatory/infective synovitis. (C) A needle is seen within the prepatellar space.

fossa or more laterally depending on the size of the cyst, while carefully avoiding the popliteal vessels (Fig. 3). The aspirated fluid can be sent for microbiology, cytology, and crystal analysis.

Ultrasound guidance may also be used for aspiration of ganglion, meniscal, synovial, or labral cysts. Injection of steroids into the cyst following decompression has been reported with recurrence rates similar to surgical excision.^{4,15} Using ultrasound guidance allows one to avoid intratendinous steroid injections. A large-caliber needle, ≥ 18 gauge, should be used because the ganglion cyst contents tend to be very viscous, and the accumulated fluid of synovial cysts can be difficult to aspirate using a smaller gauge needle.^{2,3,5,13} For a posterior acetabular labral cyst, a posterior approach may be selected, carefully avoiding the course of the sciatic nerve. Attention should be paid to the depth of the cyst and appropriate needle length because the buttock musculature and soft tissues need to be penetrated.

INJECTIONS OF TENDON SHEATHS, BURSAE, AND JOINTS

Ultrasound-guided injections into various joints have been described widely in the literature. In cases of intraarticular gadolinium injection of the shoulder for subsequent MR arthrography, it is more common to perform the procedure using fluoroscopic guidance. Replacing fluoroscopy with ultrasound eliminates radiation exposure and can also be performed in a preparation room next to the magnetic resonance imaging (MRI) suite. Using an anterior approach, an entry point is selected lateral to the coracoid process and anteromedial to the humeral head, puncturing the joint capsule along the medial border of the humeral head.^{6,16} On axial scanning, the needle tip should be visualized adjacent to the cartilage of the humeral head.



Figure 5 A 65-year-old woman with rheumatoid arthritis and right buttock pain. A 22-gauge spinal needle advanced to the right ischial tuberosity with an injection of steroid/anesthetic mixture (white arrow).

The often thin stripe of bursal tissue may be difficult to locate with fluoroscopy, especially in cases where only a small amount of bursal fluid is present. Ultrasound provides convenient access to bursae for decompression and injection.^{13,17} The injection of the subdeltoid/subacromial bursa can be performed from an anterolateral approach.^{4,6,12} Access to the olecranon bursa is typically from a posterior approach, with the elbow in a flexed position.⁶ Ultrasound guidance allows one to avoid injections into the triceps tendon. The prepatellar bursa is also easily accessed with ultrasound (Fig. 4). Less common sites include the ischial bursa, which may be performed from a posterior approach with the patient in a prone position. This bursa is superficial to the ischial tuberosity. Injection of a steroid/local anesthetic mixture into the bursa or into the area of the ischial bursa is generally done using a 22-gauge needle (Fig. 5).¹⁸

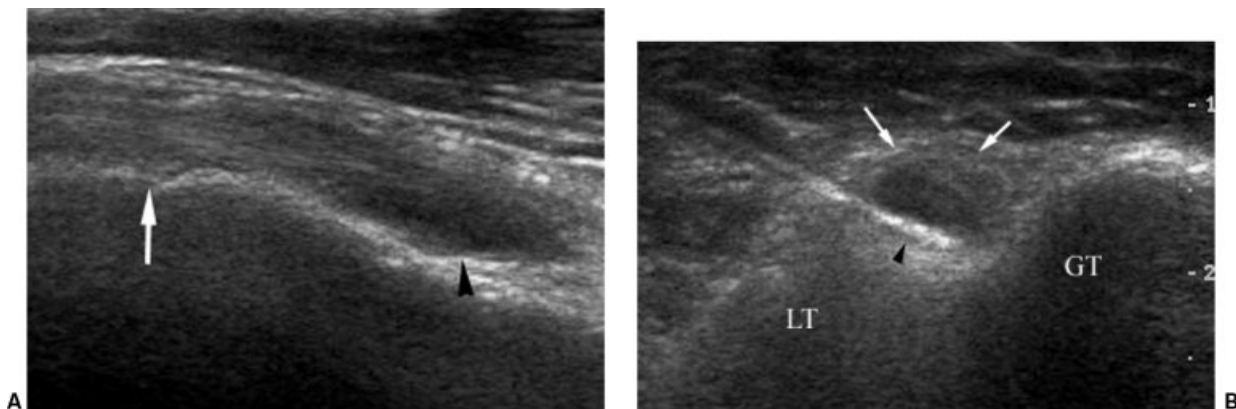


Figure 6 A 62-year-old man with chronic biceps tenosynovitis. (A) Longitudinal ultrasound demonstrates a thickened biceps tendon (white arrow) with a loculated tendon sheath fluid (black arrowhead). (B) The biceps tendon (white arrows) is seen in the bicipital groove between greater (GT) and lesser tuberosities (LT). A needle (black arrowhead) is seen along the peripheral aspect of the tendon for the purpose of aspiration and steroid injection.

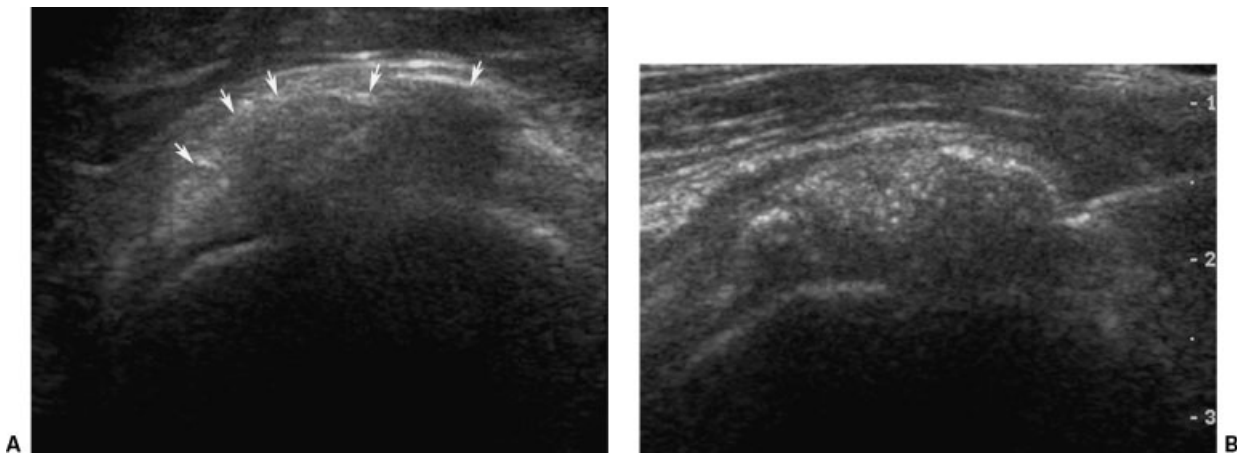


Figure 7 A 59-year-old woman with calcific tendinopathy of the supraspinatus tendon. (A) Longitudinal ultrasound of the supraspinatus tendon (SS) reveals extensive calcifications (white arrows) within the tendon consistent with calcific tendinitis. (B) Fragmentation of the calcium was performed using a 20-gauge spinal needle.

Ultrasound guidance may be used for superficial and deep peritendinous injections for a wide variety of clinical indications such as a sports-related injuries or underlying inflammatory disorders like rheumatoid arthritis. Superficial and deep tendons can be easily identified using a short-axis approach. Tendons appear as a hyperechoic band of tissue with fine intrasubstance hypoechoic fibrils.^{1,10} A thorough sonographic study using color Doppler prior to the injection should be performed to identify adjacent neurovascular bundles and areas of hyperemia within the tendon because this commonly represents sites of inflammation that may benefit from a therapeutic injection.^{1,4,12} Preexisting fluid may or may not surround the tendon sheath. Tendon sheath fluid helps facilitate needle placement and visualization. Needle confirmation into the tendon sheath may be accomplished by a preliminary injection of anesthetic with the free flow of material within the sheath and away from the needle (Fig. 6).^{1,4}

CALCIFIC TENDONITIS AND TENDINOSIS

Calcific tendinopathy can be extremely painful and can occur in any tendon. Common sites include the Achilles tendon, the elbow extensor or flexor tendons, and the rotator cuff tendons, with the supraspinatus tendon the most common symptomatic location.^{19,20} Not only can ultrasound detect the presence of calcium, it can also be used to guide the treatment of calcific tendinitis.¹⁹⁻²² Ultrasound can detect the presence of calcium deposits within the tendons more accurately than plain film or MRI.¹² Calcific deposits appear as echogenic arcs, fragments, or nodular masses with variable degrees of posterior shadowing.^{19,21}

The procedure is usually performed using a 20-gauge needle. A single- or dual-needle technique has been described in the literature.^{4,12,19-21} The dual technique involves using one needle as an inflow for anesthetic or saline and the other one as an outflow for the calcium solution. After puncturing the

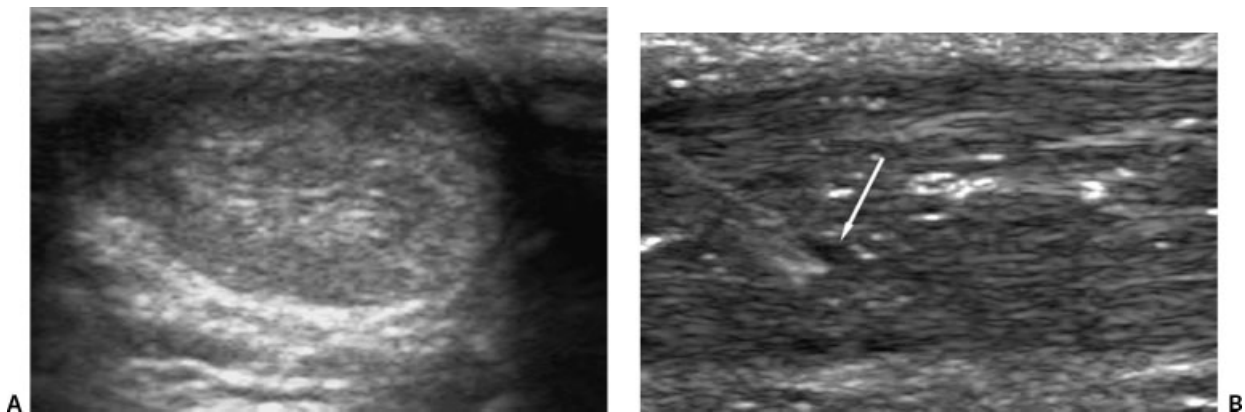


Figure 8 A 55-year-old man with chronic Achilles tendinopathy. (A) Transverse ultrasound reveals a thickened Achilles tendon. (B) Longitudinal image with a 20-gauge needle within the Achilles tendon; on infiltration with anesthetic, a small interstitial tear was exposed (white arrow) and debrided.

calcification under ultrasound guidance, gentle agitation of the needle along the longitudinal axis of the tendon fibers promotes calcium dispersion, with aspiration of the calcium into the syringe. Following lysis, a small quantity of steroid may be injected locally into the peritendinous space (Fig. 7).¹²

This procedure may also be performed for foci of tendinosis without calcific tendonitis, (e.g., thickened tendon fibers). During careful movement of the needle tip along the longitudinal axis of the tendon fibers, a small amount of saline may be injected to visualize possible intrasubstance tears, defined as linear hypoechoic foci associated with discontinuity of tendon fibers. These then can be treated by gentle needle movements and lysis of the adjacent fibers to promote healing.^{23,24} Doppler sonography may be used to detect foci within the tendon substance corresponding to granulation tissue, which then can be scratched off the healthy fibers under ultrasound guidance (Fig. 8).

CONCLUSION

Not only is ultrasound a readily available diagnostic technique for evaluating cysts, tendons, soft tissue masses, and joints, it has proved to be a valuable tool in guiding percutaneous procedures within the musculoskeletal system. Using ultrasound guidance for musculoskeletal interventions is rapidly growing in popularity within the United States because its utility and ease is becoming increasingly recognized not only by radiologists, but also by other clinicians such as orthopaedic surgeons, rheumatologists, sports medicine, and physical medicine and rehabilitation physicians.

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