Ultrasound-guided Interventions in the Foot and Ankle

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ABSTRACT

Both chronic as well as acute foot and ankle pain are common indications for visits to general practitioners, rheumatologists, and orthopedic surgeons. The causes for foot and ankle pain are varied and can include osseous pathology (fractures), yet the far greater majority are secondary to soft-tissue injuries and inflammation. Regional corticosteroid injections, traditionally performed using anatomic landmarks, can be inaccurate and miss intended targets. The use of ultrasound for guidance for interventional radiologic procedures is well known, including guidance for vascular as well as visceral interventions. Using sonography to guide for interventions in the musculoskeletal system, specifically the foot and ankle, yields accurate placement of the needle tip and subsequent anesthetic/steroid injection as well as diagnostic aspiration of tendon sheaths, joint spaces, and bursae.

KEYWORDS: Ultrasonography, foot, ankle

TECHNICAL CONSIDERATIONS

Diagnostic and subsequent interventional examinations are usually performed using a linear transducer. Needle selection is based on specific anatomic conditions (i.e., depth and size of the region of interest).¹ We employ a freehand technique in which the basic principle is to ensure needle visualization as a specular reflector. This relies on orienting the needle so that it is perpendicular (or nearly so) to the insonating beam. The needle then becomes a specular reflector, often having a strong ring-down artifact.² The needle can be visualized and repositioned, as necessary, in real time.³,4

Patient positioning to ensure comfort and optimal visualization of the anatomy should first be assessed. It is important to keep in mind that tendons display inherent anisotropy.⁵,6 It is, therefore, necessary to orient the transducer to maximize tendon echogenicity in order to avoid false interpretation of the tendon as being complex fluid or synovium. An offset may be required at the skin entry point of the needle relative to the transducer to allow for the appropriate needle orientation. Superficial, linearly oriented structures, such as in the ankle, are best approached using a linear array transducer with center frequencies ranging from 7.5 to 13 MHz. These factors should be assessed prior to skin preparation.

In our experience, a short axis approach affords the best opportunity to avoid intratendinous injections. The latter have been associated with collagen breakdown and potential tendon rupture.⁷ The curvature of the extremity of interest, often being greater in short axis, permits a shorter trajectory and, therefore, greater flexibility in repositioning the needle. This is particularly relevant when performing injections of superficial tendons in the ankle. Once the transducer is properly positioned, the degree of tendon sheath or bursal distension can be assessed, as well as the needle position relative to the tendon. When positioning the needle into a distended tendon sheath or bursa, the presence of surrounding fluid and/or synovium often provides a standoff to better visualize the needle tip. Alternatively, when injecting into a nonfluid distended structure, a
test injection with local anesthetic often permits improved visualization of the needle tip by introducing microbubbles, as well as providing some fluid distension of the sheath or bursa. The immiscible nature of the steroid-anesthetic mixture may likewise produce temporary contrast effect.

In most cases, unless the patient notes allergy to topical iodine solution, the area in question is cleaned with an iodine-based solution and draped with a sterile drape. The transducer is immersed into iodine-based solution and surrounded by a sterile drape; a drape is also placed over portions of the ultrasound unit. A sonologist or radiologist positions the transducer, while a radiologist positions the needle and performs the procedure. We typically use 1% Lidocaine (Abbott Laboratories, North Chicago, IL) for local anesthesia. Once the needle is in position, the injection is performed while imaging in real time. Depending on anatomic location, either a 1.5-inch or spinal needle with a stylet is used to administer the anesthesia/corticosteroid mixture or an equivalent long-acting agent. The typical mixture is 0.5 cc 1% Lidocaine, 0.5 cc 0.5% bupivacaine (Sensorcaine, Astra Pharmaceuticals, Westborough, MA), and 1 cc (40 mg) triamcinolone (Kenalog, Apothecon, a Bristol-Myers Squibb Company, Princeton, NJ).

JOINT INJECTIONS
The tibiotalar joint space can be visualized at sonography for detection of a joint effusion with subsequent diagnostic aspiration or injection, as indicated. Typically, an anterior approach provides the best visualization of the ankle joint. A medium (7.5 MHz) frequency linear transducer is typically employed. As little as 2 mL of fluid in the tibiotalar joint can be detected with sonography. An inflammatory synovitis can be distinguished from a simple joint effusion by applying power Doppler to see the hyperemic changes of the inflamed synovium. Sometimes imaging the ankle in plantar flexion can help in detecting a joint effusion. Other joints of the ankle and foot can be examined, including the tarsometatarsal and interphalangeal joints, the latter requiring a higher frequency (13 MHz) transducer (Fig. 1).

One of the main indications of ankle sonography is to identify other possible causes for pain (periarticular bursae, tendon sheath effusions, etc.). In patients with inflammatory arthropathies, bursitis and/or tenosynovitis (such as in rheumatoid arthritis) may be the primary abnormality or may coexist with the arthritis. Ultrasound can localize active sites of inflammation in patients with nonspecific ankle swelling and thus identify the appropriate site and provide guidance for steroid in-
Ultrasound-Guided Interventions

Determining the exact source of infection in patients presenting with a swollen ankle and clinical signs of sepsis can be difficult, as the sites of infection can include soft-tissue, osseous, or articular sites. Ultrasound can be used to further characterize and provide guidance for needle aspiration in cases of cellulitis, abscess, pyomyositis, septic bursitis and arthritis, infectious tenosynovitis, and, in some cases, osteomyelitis, with depiction of a subperiosteal fluid collection.\textsuperscript{13–16}

**ACHILLES TENDON AND RETROCALCANEAL BURSA**

Patients with chronic Achilles tendonitis can have inflammation with or without involvement of the paratenon. Ultrasound-guided injection of the Achilles paratenon is typically performed using a high frequency (13 MHz) linear transducer, oriented transversely relative to the tendon, with a short needle used to access the paratenon from a lateral approach.

In addition to diagnosing intrinsic abnormalities of the Achilles tendon, the retrocalcaneal bursa, a frequent cause of heel pain, can be evaluated at ultrasound examination. Fluid distending the bursa to greater than 3 mm is generally considered abnormal.\textsuperscript{17} Moreover, the presence of significant inflammatory change can be confirmed with power Doppler. During real-time evaluation, the injected medication (with low-level echoes) can be seen to fill the bursa (Fig. 2).

**PLANTAR FASCIA**

Ultrasound diagnosis of plantar fasciitis includes thickening of the plantar fascia and fat pad edema.\textsuperscript{18} One treatment option for severe plantar fasciitis is regional corticosteroid injection, typically performed using anatomic landmarks. Blind injections into the heel, however, have been associated with rupture of the plantar fascia.
Figure 4  (A) Paired short axis images of the posterior tibial tendon demonstrating an enlarged hypoechoic tendon consistent with tendinosis (arrow). Power Doppler imaging reveals marked inflammation surrounding the tendon and tendon sheath. (B) (Left) The linear echogenic needle is seen with the tendon sheath (arrow) with (right) subsequent steroid injection distending the tendon sheath (curved arrow).

Figure 5  (A) Longitudinal extended field-of-view image demonstrating a large multilobulated dorsal ganglion in the midfoot originating from the talonavicular joint capsule (arrow). (B) (Left) A short axis view demonstrating the needle tip within the ganglion cyst (arrow). (Right) A short axis view illustrating the appearance of the cyst postaspiration. Note that the cyst has nearly completely decompressed (curved arrow).
and failure of the longitudinal arch. Ultrasound can be used to guide a needle along the plantar margin of the fascia and thus avoid direct intrafascial injection.

**TENDON SHEATH INJECTIONS**

The normal sonographic appearance of tendons includes a hyperechoic band of tissue with fine intrasubstance hypoechoic fibrils. Tendinosis can be diagnosed as decreased echogenicity and enlargement of the tendon, sometimes with a tendon sheath effusion (Fig. 3). Examination of the tendon in question with power Doppler preinjection or aspiration is useful not only for identifying the proximity of regional vascular structures but also to evaluate for areas of possible inflammation, indicating areas that might benefit from therapeutic injection (Fig. 4). Power Doppler sonography is useful in further characterizing tendon sheath effusions from thickened synovium.

**MISCELLANEOUS**

Ultrasound can be used to localize and inject soft-tissue ganglia, common in the midfoot (Fig. 5). In addition, ultrasound has proven useful not only in localizing but also providing guidance for retrieval of foreign bodies.

Interdigital (Morton’s) neuromas, a common cause of forefoot pain especially in women, have been described at sonography as hypoechoic masses replacing the normal hyperechoic fat in the interdigital web spaces (Fig. 6). Occasionally, a dilated hypoechoic tubular structure can be seen associated with the neuroma, reflecting the enlarged feeding interdigital nerve. As with other sites in the musculoskeletal system, power Doppler may be helpful in distinguishing symptomatic from noninflamed interdigital neuromas. This can aid in the decision-making process of which neuroma to inject with corticosteroids in cases of multiple neuromas, which is not infrequent.

**SUMMARY**

In summary, the role of ultrasound in diagnosing conditions of the foot and ankle is expanding not only with respect to diagnosis, but also to provide imaging guidance for aspirations and injections. Sonography can be used to guide for procedures involving the regional soft tissues as well as the articular spaces and, on occasion, the osseous structures.

**REFERENCES**


**Figure 6** (Top) A longitudinal image of the second web space demonstrating a bilobed hypoechoic mass consistent with an interdigital neuroma (curved arrow). (Bottom) The linear echogenic needle (arrow) with the tip directed into the center of the neuroma during therapeutic injection. Increased echoes within the neuroma are evident during infiltration with the steroid-anesthetic mixture.
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