Image-Guided Foot and Ankle Injections

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KEYWORDS

• Ultrasound • Injection • Foot • Ankle

KEY POINTS

- The foot and ankle is a complex anatomic region.
- Image-guided procedures should be considered over palpation-guided procedures.
- Ultrasound is a valuable tool for both soft tissue and intra-articular image-guided procedures.
- Fluoroscopy may be considered for intra-articular injections.

INTRODUCTION

The foot and ankle is a complex anatomic region that is prone to various pathologic conditions. These include intra-articular conditions, as well as acute and chronic injuries to extra-articular soft tissues. Most conditions in this region can be treated without surgical intervention, and minimally invasive options such as injection-based therapies should be considered first line as part of a comprehensive nonoperative treatment program.

Traditionally, procedures were performed based on palpation or anatomic landmarks. As fluoroscopy and ultrasound (US) have become more readily available, image-guided injections have demonstrated several benefits, including increased accuracy, improved therapeutic effect, and better clinical outcomes.[1] US demonstrates the advantage of allowing visualization of the needle within the target structure, which is necessary for injections around nerves. Fluoroscopy is very accurate for joint injections, but confers the negative of ionizing radiation, and frequently the need for contrast material.

With US-guided procedures in the foot and ankle, there are a few key points to keep in mind. Most structures in this region are small and relatively superficial. As a result, a

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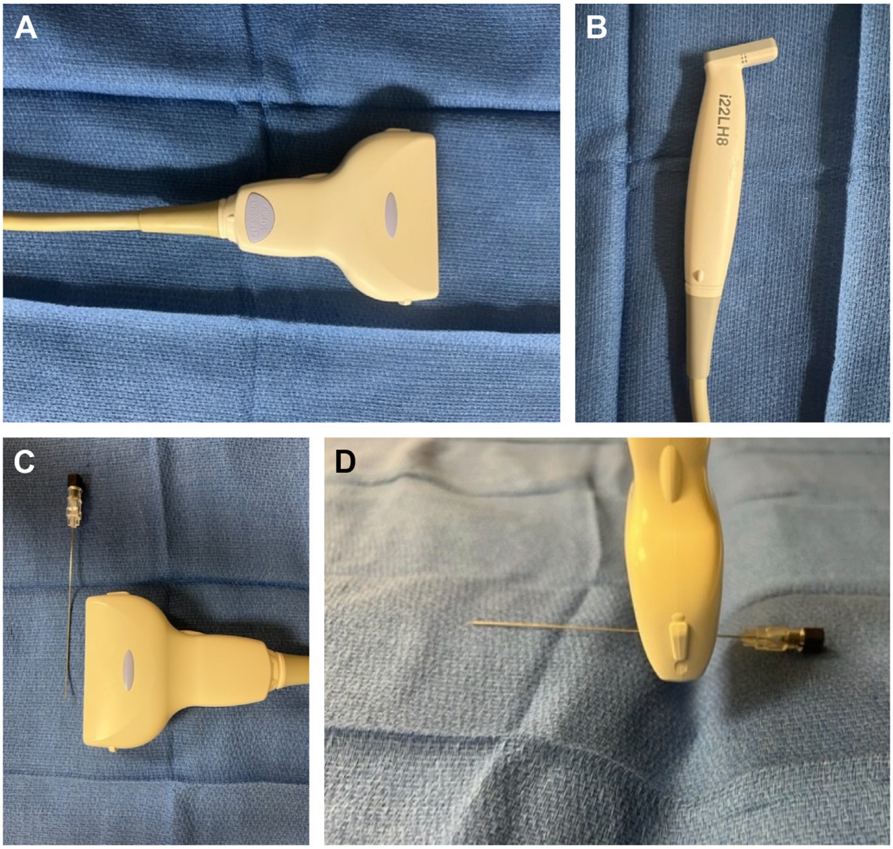

Fig. 1. (*A*). High-frequency, linear array transducer. (*B*). Hockey stick transducer. (*C*). In-plane injection approach. (*D*). Out-of-plane injection approach.

small footprint, high-frequency linear array transducer should be used (Fig. 1A). If available, a hockey stick transducer may be considered (Fig. 1B). Additionally, although in-plane (needle parallel to the transducer) injections are preferred due to improved needle visualization, out-of-plane (needle perpendicular to the transducer) injections are commonly used due to small joint spaces (Fig. 1C, D).

Injectate choice will vary based on the pathologic condition and injection goals. For therapeutic injections, corticosteroids are commonly used due to low cost and limited postprocedural restrictions. However, their safety has recently been called more into question.[2,3] Many clinicians offer alternative injection options, such as orthobiologics (OBX), which do not carry the same risks and may provide more durable pain relief.[4] Finally, anesthetic only injections are often used to confirm or refute a particular structure as a pain generator.

In this article, we describe the procedural techniques and considerations for common US-guided intra-articular, perineural, and soft tissue injections in the foot and ankle. The focus of this article is on US-guided techniques due to the authors' procedural practices; however, fluoroscopic guidance can be considered for most intra-articular injections in this region.

INTRA-ARTICULAR INJECTIONS

Intra-articular injections comprise the vast majority of foot and ankle injections. A thorough understanding of the complex anatomy in this region is critical to ensure procedural accuracy. Radiographs are essential for the evaluation of bony anatomy and the presence of anomalies such as accessory ossicles, which may result in confusion when planning the procedural approach, and potentially incorrect injection targets.

Tibiotalar Joint

The tibiotalar joint is a diarthrodial joint formed by the distal tibia, distal fibula, and talus. It functions as a hinge joint, allowing for dorsiflexion and plantarflexion of the ankle. It is stabilized by 3 ligamentous groups; anterior talofibular ligament (ATFL), the tibiofibular syndesmosis (which includes the anterior inferior tibiofibular ligament, posterior tibiofibular ligament, and the interosseous membrane), and the deltoid ligament complex.

Normal sonoanatomy

Laterally, the hyperechoic bony cortices of the distal fibula and talus are seen. The hyperechoic fibrillar structure spanning these 2 structures is the ATFL. Anteriorly, a longitudinal view of the joint demonstrates the hyperechoic talus with a thin anechoic line overlying the talus, representing the talar cartilage. In a transverse view, the hyperechoic cortices of the distal tibia and talus are in view. Medially, again seen are the distal tibia and talus with the hyperechoic deltoid ligament spanning this region.

Lateral, out-of-plane

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle inversion.

Approach

- Transducer oriented over ATFL. The needle is advanced lateral to medial, deep to the ATFL (Fig. 2A).

Needle

- Gauge: 25 to 27g.
- Length: 1.25 to 2.5in.

Injectate volume

- 2 to 4 mL.

Procedural considerations

- Avoid injecting into ATFL.
- “Walk down” technique can be helpful to avoid iatrogenic injury.

Medial, out-of-plane

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle eversion.

Approach

- Transducer at the medial ankle joint. The needle is advanced medial to lateral, deep to the deltoid ligament (Fig. 2B).

Needle

- Gauge: 25 to 27g.
- Length: 1.25 to 2.5in.

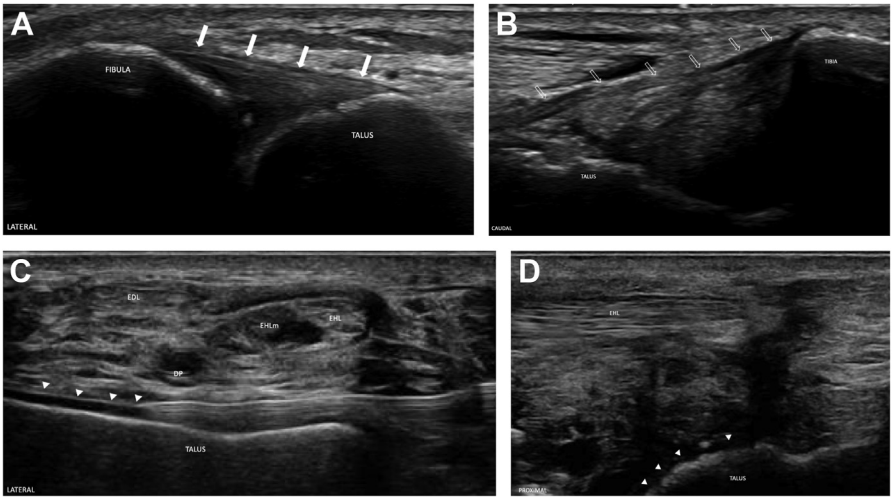

Fig. 2. Tibiotalar joint injection approaches. (*A*) Lateral, Out-of-plane. (*B*) Medial, Out-of-plane. (*C*) Anterior, In-plane. (*D*) Anterior, Out-of-plane. Closed arrowheads, talar cartilage; Closed arrows, ATFL; DP, dorsalis pedis artery; EDL, extensor digitorum longus tendon; EHL, extensor hallucis longus tendon; EHLm, extensor hallucis longus muscle; Open arrows, deltoid ligament.

Injectate volume

- 2 to 4 mL.

Procedural considerations

- Avoid nearby tibial nerve and branches.

Anterior, out-of-plane

Patient positioning

- Supine.

Approach

- Transducer over the anterior ankle joint in an anatomical sagittal plane. The needle can be advanced medial to lateral or lateral to medial (Fig. 2C).

Needle

- Gauge: 25 to 27g.
- Length: 1.25 to 2.5in.

Injectate volume

- 2 to 4 mL.

Procedural considerations

- Avoid nearby anterior ankle tendons, dorsalis pedis artery, and deep fibular nerve (DFN).

Anterior, in-plane

Patient positioning

- Supine.

Approach

- Transducer over the talus in an anatomic axial plane. The needle can be advanced medial to lateral or lateral to medial, and should be guided directly superficial to the talar cartilage (Fig. 2D).

Needle

- Gauge: 25 to 27g.
- Length: 1.25 to 2.5in.

Injectate volume

- 2 to 4 mL.

Procedural considerations

- The position of the DFN and dorsalis pedis artery needs to be considered.
- Injectate should be seen coursing medially and laterally. If injectate is seen localizing at the injection site, the needle tip is likely not intra-articular.

Subtalar Joint

The subtalar joint comprises posteriorly the talus and calcaneus (forming the posterior facet) and anteriorly the talus, calcaneus, and navicular (forming the middle and anterior facets).[5] These regions are connected by an interosseous tunnel called the sinus tarsi. Within the sinus tarsi is a complex network of ligamentous structures, small vasculature, and sensory nerve fibers.[6] The subtalar joint allows for multiplanar motion; however, the primary function of the joint is to allow inversion and eversion.

Normal sonoanatomy

The anterolateral subtalar joint can be found by identifying the hyperechoic fibular tendons and following them distally past the lateral malleolus. As they course around the lateral malleolus, the fibrillar calcaneofibular ligament (CFL) is seen underneath the tendons. Deep to the CFL, the subtalar joint is visualized as a cleft between the bony surfaces of the talus and calcaneus.

The posterolateral joint is visualized just lateral to the Achilles tendon. The hyperechoic cortices of the posterior tibial, talus, and calcaneus can be seen (and therefore the posterior tibiotalar and subtalar joints). Medially, the posteromedial joint line can be visualized by first finding the hyperechoic cortices of the medial malleolus and talus. The transducer is then translated anteriorly, and the joint space is found immediately anterior to the sustentaculum tali, deep to the flexor digitorum longus (FDL) and posterior tibialis (PT) tendons. Finally, the sinus tarsi can be readily identified at the anterolateral ankle by finding the hyperechoic cortices of the talus and calcaneus, with the transducer is a sagittal oblique orientation.

Anterolateral, out-of-plane

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle inversion.

Approach

- Transducer at the anterolateral subtalar joint, parallel to the calcaneofibular ligament. The needle is advanced anterolateral to posteromedial (Fig. 3A).

Needle

- Gauge: 25 to 30g.
- Length: 1.25 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- Avoid injecting into fibular tendons or nearby sural nerve.

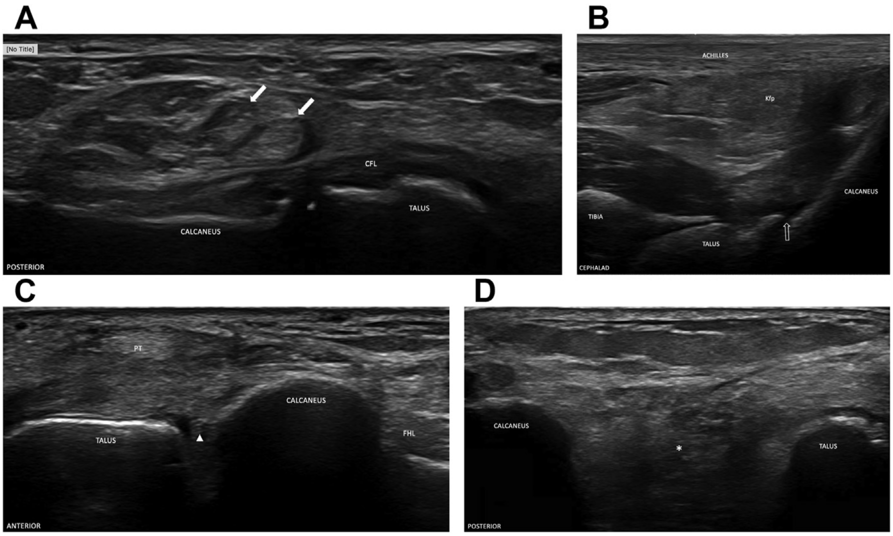

Fig. 3. Subtalar joint injection approaches. (*A*) Anterolateral, Out-of-plane. (*B*) Posterolateral, In-plane. (*C*) Posteromedial, Out-of-plane. (*D*). Sinus tarsi injection, Out-of-plane. Asterisk, Sinus tarsi; CFL, calcaneofibular ligament; Closed arrowhead, posteromedial subtalar joint; Closed arrows, fibular tendons; FHL, flexor hallucis longus tendon; Kfp, Kager's fat pad; Open arrow, posterolateral subtalar joint; PT, posterior tibialis tendon.

Posterolateral, in-plane

Patient positioning

- Prone with ankle in dorsiflexion.

Approach

- Transducer oriented in an anatomic sagittal plane, directly lateral to the Achilles tendon, angled slightly medially. The needle is advanced posterolateral to anteromedial (Fig. 3B).

Needle

- Gauge: 25 to 30g.
- Length: 1.25 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- This is a very steep approach and visualization can be challenging. Care should be taken to visualize the needle tip at all times.
- The nearby sural nerve should be identified and avoided.

Posteromedial, out-of-plane

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle eversion.

Approach

- Transducer is oriented over the sustentaculum tali and the talus, with the spring ligament spanning the 2 bony cortices. The needle is advanced medial to lateral (Fig. 3C).

Needle

- Gauge: 25 to 30g.
- Length: 1.25 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- The tibial neurovasculature is nearby and should be identified.

Sinus tarsi

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle inversion.

Approach

- Transducer is oriented in an anatomic coronal oblique plane, spanning the anterior process of the calcaneus and the talar neck. The needle is advanced in a posteromedial direction (**Fig. 3**D).

Needle

- Gauge: 25 to 30g.
- Length: 1.25 to 2in.

Injectate volume

- 1 to 2 mL

Procedural considerations

- This injection approach can also be used in cases of soft tissue/sinus tarsi impingement.

Talonavicular Joint

The talonavicular joint is functionally and anatomically connected to 2 separate joint complexes.[7] It contributes to the subtalar joint complex as part of the talocalcaneonavicular joint, and also articulates with the calcaneocuboid joint to form the transverse tarsal (Chopart's) joint. The joint primarily allows inversion and eversion.

Normal sonoanatomy

The talonavicular joint is identified by following the PT tendon distally to its insertion on the navicular. The transducer is then rotated in a clockwise manner, and the hyperechoic cortex of the talus should come into view.

Out-of-plane

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle eversion.

Approach

- Transducer is oriented in an anatomic sagittal oblique plane. The needle is advanced medial to lateral (**Fig. 4**).
- Alternatively, an in-plane, proximal to distal approach may be used.

Needle

- Gauge: 27 to 30g.
- Length: 0.75 to 1.5in.

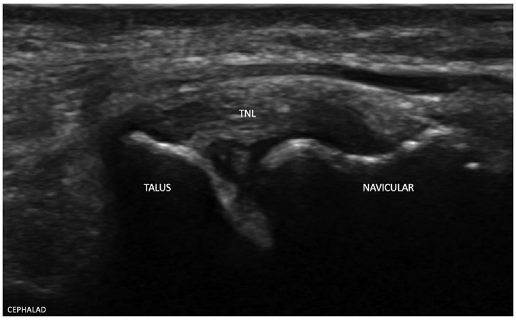

Fig. 4. Talonavicular joint injection approach. TNL, dorsal talonavicular ligament.

Injectate volume

- 0.5 to 1 mL.

Procedural considerations

- Be mindful of an os naviculare because a synchondrosis between it and the navicular could be confused for the talonavicular joint.

Calcaneocuboid Joint

The calcaneocuboid joint, along with the talonavicular joint, forms the transverse tarsal joint.[8] The calcaneocuboid joint is a modified saddle joint, with minimal motion except slight translation during inversion and eversion. The joint is stabilized plantarly by the short and long plantar ligaments, medially by the medial calcaneocuboid ligament, and dorsally by the dorsal calcaneocuboid ligament.

Normal sonoanatomy

In an anatomic sagittal plane, the hyperechoic bony cortices of the calcaneus and cuboid are seen, with the hyperechoic dorsal calcaneocuboid ligament spanning the 2 structures.

Out-of-plane

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle inversion.
- Alternatively, patient may lay supine.

Approach

- Transducer oriented in an anatomic sagittal plane, with the needle advanced lateral to medial (Fig. 5).
- Alternatively, an in-plane, proximal to distal approach may be used.

Needle

- Gauge: 27 to 30g.
- Length: 0.75 to 1.5in.

Injectate volume

- 0.5 to 1 mL.

Procedural considerations

- The nearby fibular tendons should be identified and avoided.

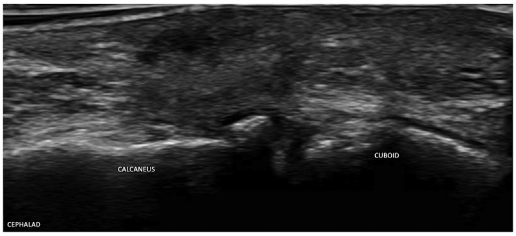

Fig. 5. Calcaneocuboid joint injection approach.

Naviculocuneiform Joint

The naviculocuneiform joint is formed by the articulations between the navicular and the 3 cuneiform bones.[9] Motion is minimal across the joint. The joint is primarily stabilized by both dorsal and plantar ligaments, with the plantar ligaments being further supported by small slips from the PT tendon.

Normal sonoanatomy

The hyperechoic bony cortices of the navicular and each cuneiform bone are seen, typically with a small joint space.

Out-of-plane

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle eversion.

Approach

- Out-of-plane, medial to lateral (**Fig. 6**).

Needle

- Gauge: 27 to 30g.
- Length: 0.75 to 1.5in.

Injectate volume

- 0.5 to 1 mL.

Procedural considerations

- A far lateral approach should be avoided due to the nearby superficial and deep fibular nerves.

Tarsometatarsal Joints

The tarsometatarsal (TMT) joints are arthrodial joints, formed by the articulations between the proximal metatarsals and the cuneiforms and cuboid. Although each TMT joint is considered a separate entity, there is a normal communication between the second and third TMT joints.[10] The joints are stabilized by dorsal, plantar, and interosseous ligaments, the most important of which is the Lisfranc ligament, which connects the medial cuneiform to the base of the second metatarsal.

Normal sonoanatomy

In a transverse plane, the metatarsals, cuneiforms, and cuboid all seem as hyperechoic, relatively flat structures. Hyperechoic, fibrillar extensor tendons may be seen in long axis dorsal to the joints.

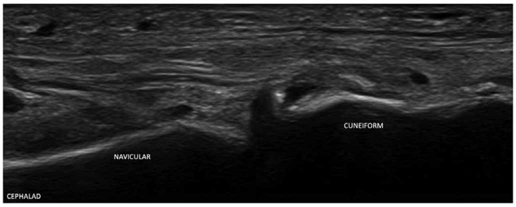

Fig. 6. Naviculocuneiform joint injection approach.

Out-of-plane

Patient positioning

- Supine, knee flexed, foot flat on bed.

Approach

- Anatomic sagittal orientation over dorsal foot. The needle is advanced medial to lateral or lateral to medial (Fig. 7).

Needle

- Gauge: 27 to 30g.
- Length: 0.75 to 1.5in.

Injectate volume

- 0.5 to 1 mL.

Procedural considerations

- Avoid overlying neurovasculature, including dorsal pedis artery and superficial/ deep fibular nerves.
- To identify which TMT joint is visualized, it can be helpful to trace the metatarsals in an axial plane to the TMT joint and rotate the transducer.

Metatarsophalangeal Joints

The metatarsophalangeal (MTP) joints are formed by the articulations of the metatarsal heads and proximal phalanges. They are condyloid joints, which allow for flexion, extension, abduction, and adduction. The joints are stabilized by collateral ligaments, plantar ligaments, deep transverse metatarsal ligaments, and plantar plate.

Normal sonoanatomy

From a dorsal view, the metatarsal head has a characteristic rounded, hyperechoic appearance. The hyperechoic dorsal joint capsule is easily visualized, with the hyperechoic, fibrillar extensor tendons seen in long axis dorsal to the joints.

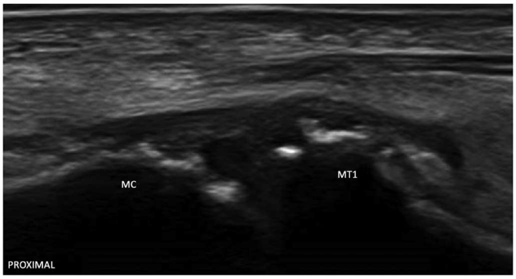

Fig. 7. TMT joint injection approach. MC, medial cuneiform; MT1, first metatarsal.

Out-of-plane
Patient positioning

- Supine, knee flexed, foot flat on bed.

Approach

- Anatomic sagittal orientation over dorsal foot, with a transverse view of joint. The needle is advanced medial to lateral or lateral to medial (**Fig. 8**).

Needle

- Gauge: 27 to 30g.
- Length: 0.75 to 1.5in.

Injectate volume

- 0.25 to 0.5 mL.

Procedural considerations

- Small volume injectate preferred to avoid overdistension of the joint.

Interphalangeal Joints

The interphalangeal joints are small joints formed by the articulations of the proximal and middle phalanges as well as the middle and distal phalanges. They are hinge joints, allowing for flexion and extension. Stabilization is provided by plantar and collateral ligaments.

Normal sonoanatomy
Bony margins seem as hyperechoic, well-corticated structures, with a small joint space between. Hyperechoic, fibrillar extensor tendons are seen dorsal to the joint.

Out-of-plane
Patient positioning

- Supine, knee flexed, foot flat on bed.

Approach

- Anatomic sagittal orientation over dorsal foot, with a transverse view of joint. The needle is advanced medial to lateral or lateral to medial (**Fig. 9**).

Needle

- Gauge: 27 to 30g.
- Length: 0.5 to 1.5in.

Injectate volume

- 0.5 to 1 mL.

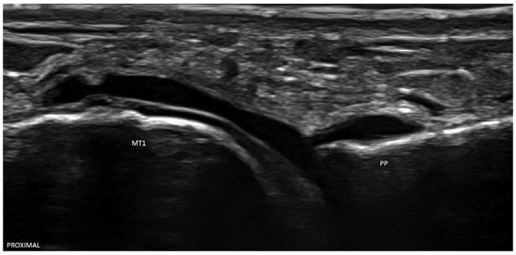

Fig. 8. MTP joint injection approach. MT1, first metatarsal; PP, proximal phalanx.

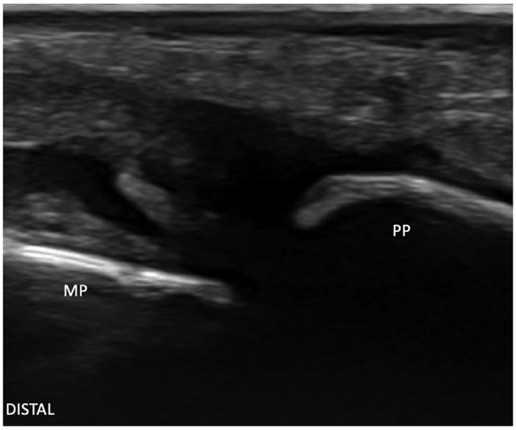

Fig. 9. Interphalangeal joint injection approach. PP, proximal phalanx; MP, middle phalanx.

Procedural considerations

- Identify and avoid nearby interdigital nerves.
- Consider rotating the transducer into an in-plane view to confirm depth of the needle to avoid intracapsular injection.

PERINEURAL INJECTIONS

Nerve pathology about the foot and ankle is common and can have primary or secondary causes. When performing perineural injections, there are a few key points to consider. Injecting slowly with local anesthetic while advancing the needle toward the neve can help prevent penetrating the nerve because it will start to push away from the needle tip when the needle enters the perineural space. It is also important to ensure circumferential, perineural spread of injectate to limit the chance of a false-negative response, especially when injecting for diagnostic purposes. Finally, the authors recommend the use of a nonparticulate steroid to reduce the chance of a thromboischemic injury to the nerves.

Sural Nerve

The sural nerve is a sensory nerve that provides sensation to the posterolateral aspect of the distal one-third of the leg as well as the lateral foot and ankle. It is formed by the confluence of the lateral and medial sural cutaneous nerves. Distally, the nerve terminates as the lateral sural cutaneous nerve.

Normal sonoanatomy

The nerve can be readily identified at the posterior leg, superficial to the distal gastrocnemius muscles. It seems as a multifascicular, hyperechoic, honeycomb structure. It courses directly adjacent to the anechoic lesser saphenous vein. At the ankle, it can be seen lateral to the Achilles tendon and posterior to the fibular tendons.

Fascial exit

Patient positioning

- Lateral decubitus or prone.

Approach

- In-plane (Fig. 10A).

Needle
- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume
- 1 to 2 mL.

Procedural considerations
- Avoid intravascular injection of the lesser saphenous vein.

Foot/ankle
Patient positioning
- Lateral decubitus, pillow or bolster under ankle to promote inversion.

Approach
- In-plane (Fig. 10B).

Needle
- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume
- 1 to 2 mL.

Procedural considerations
- Avoid intravascular injection of the lesser saphenous vein.

Superficial Fibular Nerve

The superficial fibular nerve (SFN) is 1 of 2 branches of common fibular nerve (CFN), originating just distal to the fibular head. It is a mixed nerve. It supplies sensation to most of the lateral leg and dorsum of the foot (with the exception of the first web space), as well as motor innervation to the lateral compartment musculature. Distally, it bifurcates into 2 terminal sensory branches—the medial and intermediate dorsal cutaneous nerves.

The most common site of nerve compression is at the distal one-third of the leg as it pierces the crural fascia. Posttraumatic compression can be seen at the foot and ankle after sprains, fractures, or surgical intervention.

Normal sonoanatomy
The nerve seems as a small, hyperechoic, honeycomb structure coursing between the fibularis longus (FL) and brevis muscle bellies. At the distal one-third of the leg, it is

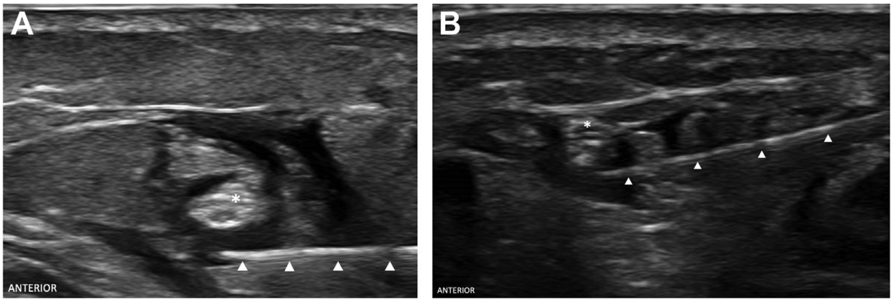

Fig. 10. Sural nerve injection approaches. (*A*) Fascial exit. (*B*) Foot and ankle region. Closed arrowheads, needle; Asterisk, sural nerve.

seen piercing the crural fascia because it becomes cutaneous before it bifurcates further distally.

Fascial exit

Patient positioning

- Lateral decubitus.

Approach

- In-plane, posterior to anterior or anterior to posterior (Fig. 11A).

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- If injecting for diagnostic purposes, important to ensure injectate spreads just proximal to fascial exit as well.

Foot/ankle

Patient positioning

- Lateral decubitus, pillow or bolster under ankle to promote inversion.
- Alternatively, supine.

Approach

- In-plane (Fig. 11B).

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- Follow terminal branches distally to confirm identification of nerve.

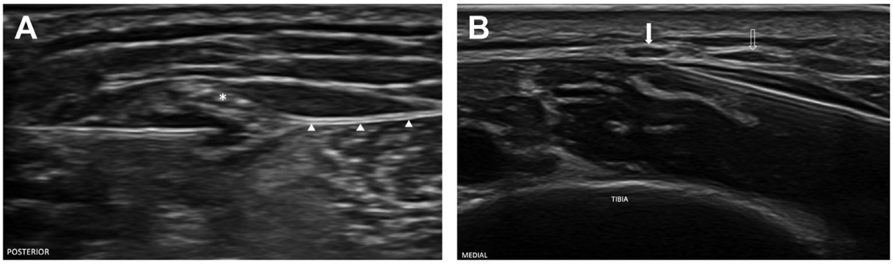

Fig. 11. SFN injection approaches. (*A*) Fascial exit. (*B*) Foot and ankle region. Closed arrow, medial dorsal cutaneous nerve; Open arrow, intermediate dorsal cutaneous nerve; Asterisk, SFN; Closed arrowheads, crural fascia.

Deep Fibular Nerve

The DFN is a mixed nerve and is 1 of 2 terminal branches of the CFN. At the CFN bifurcation, the nerve enters the anterior compartment of the leg and travels distally adjacent to the anterior tibial artery. Within the leg, the nerve provides motor innervation to the anterior compartment musculature. At the level of the tibiotalar joint, the nerve bifurcates into medial and lateral terminal branches. The medial terminal branch is a sensory nerve, which provides sensation to the first web space. The lateral terminal branch is a mixed nerve, providing motor innervation to the extensor digitorum brevis and extensor hallucis brevis muscles and sensory innervation to the second to fourth TMT and MTP joints.

There DFN can become entrapped deep to the inferior extensor retinaculum, otherwise known as “anterior tarsal tunnel syndrome.” Additionally, the medial sensory branch can be compressed from tight-fitting shoe wear, dorsal osteophytes secondary to osteoarthritis (OA), or as it courses deep to the extensor digitorum brevis muscle/tendon unit.

Normal sonoanatomy

The nerve is a small, hyperechoic, honeycomb structure. After piercing the extensor digitorum longus muscle, it can be challenging to visualize because it is located deep within the anterior compartment. At the distal leg, it can be seen within the anterior tarsal tunnel before it bifurcates at the tibiotalar joint. Distally, the medial terminal branch is seen immediately adjacent to the dorsalis pedis artery.

Anterior Ankle/Anterior Tarsal Tunnel

Patient positioning

- Supine.

Approach

- In-plane, lateral to medial (Fig. 12A).

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- A lateral to medial approach is preferred as the dorsalis pedis artery most often lies medial to the nerve.

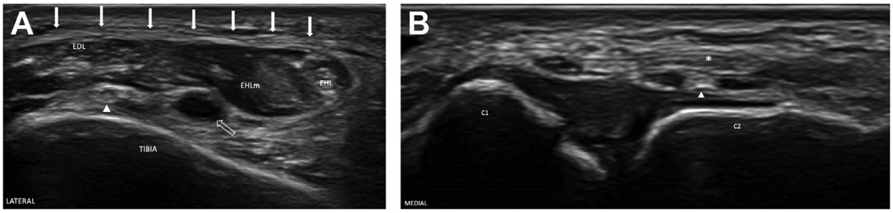

Fig. 12. DFN injection approaches. (*A*) Anterior tarsal tunnel. (*B*) Deep to extensor digitorum brevis tendon. Asterisk, extensor digitorum brevis tendon; C1, first cuneiform; C2, second cuneiform; Closed arrow, inferior extensor retinaculum; Closed arrowhead, DFN; EDL, extensor digitorum longus tendon; EHL, extensor hallucis longus tendon; EHLm, extensor hallucis longus muscle; Open arrow, anterior tibial artery.

Medial branch deep to extensor digitorum brevis tendon

Patient positioning

- Supine.

Approach

- In-plane, lateral to medial (Fig. 12B).

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- Ensure careful needle placement to avoid intravascular injection of the dorsalis pedis artery.

Tibial Nerve

The tibial nerve is a mixed nerve and is 1 of 2 terminal branches of the sciatic nerve. It provides sensory innervation to the posterior heel and most of the plantar foot. It provides motor supply to the deep and superficial posterior compartment musculature as well as the foot intrinsic muscles. The nerve courses deep within the posterior leg before entering the tarsal tunnel at the medial ankle. Here, the nerve most typically trifurcates into the medial calcaneal, medial plantar, and lateral plantar nerves; however, the branching pattern is highly variable. The medial calcaneal nerve is a sensory nerve, while the medial and lateral plantar nerves are mixed nerves.

Within the foot and ankle, the most common site of compression is the tarsal tunnel. The medial plantar nerve can be compressed because it courses between the abductor hallucis muscle and the navicular. Additionally, the inferior calcaneal nerve can become compressed because it courses between the abductor hallucis and quadratus plantar muscles.[11] Finally, the common digital plantar nerves can be chronically compressed, which may give rise to focal nerve enlargement, also known as a "Morton neuroma."

Normal sonoanatomy

The nerve seems as a large, hyperechoic, fascicular structure that can be easily identified within the distal leg. As it enters the tarsal tunnel, it is often posterior to the anechoic posterior tibial vasculature. The characteristic hyperechoic, fibrillar architecture of the flexor hallucis longus (FHL) tendon is seen deep to the tibial nerve.

Tarsal tunnel

Patient positioning

- Prone, foot hanging off the edge of the bed.

Approach

- In-plane, posterolateral to anteromedial, deep to the Achilles tendon (Fig. 13A).

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 3 mL.

Procedural considerations

- Avoid the nearby posterior tibial vasculature.
- Ensure differentiation of the tibial nerve from the FHL tendon because these can have a similar echotexture.

Medial plantar nerve

Patient positioning

- Prone or lateral decubitus.

Approach

- In-plane (Fig. 13B).

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- Avoid nearby flexor tendons.

Inferior calcaneal nerve

Patient positioning

- Prone or lateral decubitus.

Approach

- In-plane (Fig. 13C).

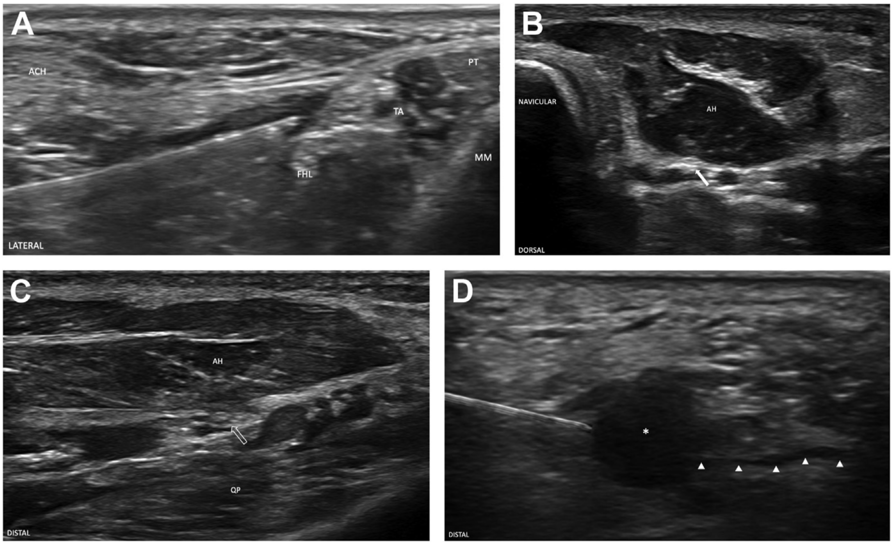

Fig. 13. Tibial nerve injection approaches. (*A*) Tarsal tunnel. (*B*) Medial plantar nerve at the abductor hallucis/navicular interval. (*C*) Inferior calcaneal nerve at the abductor hallucis/quadratus plantae interval. (*D*) Common digital plantar nerve. Closed arrow, medial plantar nerve; Open arrow, inferior calcaneal nerve; Closed arrowheads, common digital plantar nerve; Asterisk, common digital plantar nerve neuroma; ACH, Achilles tendon; AH, abductor hallucis muscle; FHL, flexor hallucis longus tendon; MM, medial malleolus; PT, posterior tibialis tendon; QP, quadratus plantae muscle; TA, posterior tibial artery.

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- Circumferential spread should be seen as the nerve is separated from the surrounding tissues.

Common digital plantar nerve (Morton neuroma)

Patient positioning

- Supine.

Approach

- In-plane, plantar approach, distal to proximal (Fig. 13D)
- Alternatively, in-plane, dorsal approach, proximal to distal

Needle

- Gauge: 25 to 30g.
- Length: 0.75 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- The nerve is located plantar to the intermetatarsal bursa, so a plantar approach may provide a more "superficial" needle trajectory.
- Avoid injecting into the plantar fat pad due to the risk of fat pad atrophy.

SOFT TISSUE INJECTIONS

Soft tissue injections in the foot and ankle region are primarily limited to peritendinous and intratendinous targets, as well as the plantar fascia (PF). As mentioned previously, corticosteroid should be reserved for peritendinous/perifascial injections and never injected directly into these structures. If an intratendinous/intrafascial procedure is required, a noncorticosteroid such as an OBX should be considered.

Posterior Tibialis Tendon

The PT originates from the deep posterior compartment and passes through the tarsal tunnel, posterior to the medial malleolus. The tendon turns anterior and plantar, ultimately inserting on tuberosity of the navicular, the plantar cuneiforms, and plantar second-fourth metatarsal bases.

Normal sonoanatomy

In the posterior lower leg, the PT is visualized deep and lateral to the FDL muscle, adjacent to the posterolateral border of the tibia and the interosseous membrane. As the hyperechoic PT passes below the medial malleolus, the tendon frequently fans out for a broad distal insertion. The tendon always inserts on the navicular but the remainder of the insertion sites is highly variable.[12]

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle eversion.

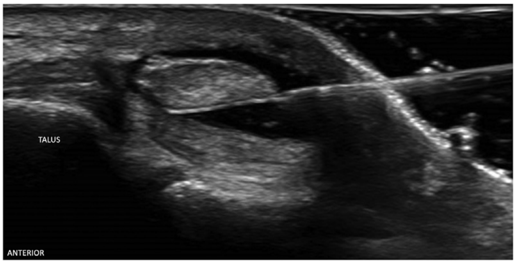

Fig. 14. PT tendon sheath injection approach.

Approach

- In-plane. The target is between the tendon sheath and PT tendon (Fig. 14).

Needle

- Gauge: 25 to 30g.
- Length: 1 to 2in.

Injectate volume

- 1 to 3 mL.

Procedural considerations

- Care should be taken to avoid the medial calcaneal nerve, which passes superficial to the PT and flexor retinaculum.

Flexor Hallucis Longus Tendon

The FHL sits anterior to the soleus and posterior to the PT muscle in the lower leg. The tendon passes posteromedial to the groove for the FHL in the talus, and subsequently the groove for the FHL in the calcaneus. The tendon courses deep to the FDL tendon at the Master Knot of Henry before continuing to its insertion at the great toe.

Normal sonoanatomy

In the distal posterior leg, the FHL seems as a hypoechoic muscle with a hyperechoic tendon forming in the posteromedial muscle belly. As it approaches the talus, the hyperechoic ovoid tendon sits within a crescentic groove in the talus, subsequently passing adjacent to the calcaneus in a slightly shallower groove. At these locations, the tibial or medial and lateral plantar nerves are visualized adjacent to the tendon and may seem similar in echotexture to the tendon.

At ankle

Patient positioning

- Prone, with the ankle at the edge of the bed and in a neutral position.

Approach

- In-plane, posterolateral to anteromedial, deep to the Achilles tendon (Fig. 15A).

Needle

- Gauge: 25 to 27g.
- Length: 1.5 to 2in.

Injectate volume

- 1 to 2 mL.

Procedural considerations

- The medial and lateral plantar nerves pass posterior to the FHL tendon and care should be taken to avoid these nerves.

Foot region

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle eversion.

Approach

- In-plane, medial to lateral.
- The target is adjacent to the FHL tendon at the level of the FHL/FDL intersection (Fig. 15B).

Needle

- Gauge: 25 to 27.
- Length: 1.25 to 2in.

Injectate volume

- 1 to 3 mL.

Procedural considerations

- Identify and avoid the medial plantar nerve, which sits adjacent to the FDL/FHL intersection in the foot.

Fibularis longus and fibularis brevis tendons

The FL muscle originates from the fibular head and lateral border of the fibula, as well as the intramuscular septum. Distally, it inserts on the plantar medial cuneiform and base of the first metatarsal. The fibularis brevis tendon originates from the lateral aspect of the fibula and adjacent intramuscular septum. It courses between the lateral malleolus and FL before inserting on the fifth metatarsal.

Normal sonoanatomy

At the level of the midfibula, the typical hypoechoic muscular architecture and a notable superficial hyperechoic FL tendon can be seen. At the lateral malleolus, 2 hyperechoic ovoid tendons are seen, which wrap along the posterior/inferior lateral malleolus, superficial to the CFL and deep to the fibular retinaculum. In the inframalleolar region, they are separated by an osseous prominence on the calcaneus called the fibular tubercle, before they diverge to their distal insertions.

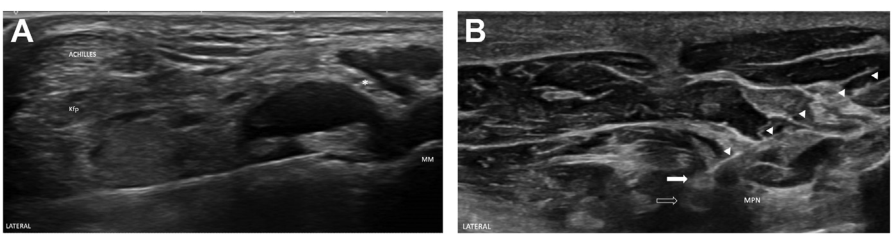

Fig. 15. FHL tendon sheath injection approaches. (*A*) Ankle, deep to Achilles tendon. (*B*) Foot region, Master Knot of Henry. Closed arrow, FDL tendon; Open arrow, FHL tendon; Closed arrowheads, needle; Asterisk, tibial nerve; Kfp, Kager's fat pad; MM, medial malleolus; MPN, medial plantar nerve.

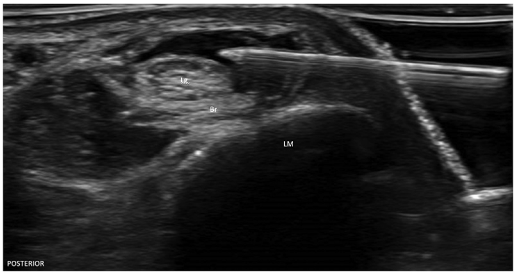

Fig. 16. Fibular tendon sheath injection approach. Br, fibularis brevis tendon; Lg, fibularis longus tendon; LM, lateral malleolus.

Patient positioning

- Lateral decubitus, with pillow or bolster underneath ankle to promote ankle eversion.

Approach

- In-plane, anterior to posterior or posterior to anterior (**Fig. 16**).

Needle

- Gauge: 25 to 30.
- Length: 1 to 2in.

Injectate volume

- 1 to 3 mL.

Procedural considerations

- A gel standoff can help with needle entry location.

Anterior Ankle Tendons

In the lower leg, the anterior tibialis (AT), extensor hallucis longus (EHL), and extensor digitorum longus (EDL) originate from the lateral tibia and interosseous membrane; medial fibula and interosseous membrane; and lateral tibia, medial fibula, and interosseous membranes, respectively. In most individuals, a separate muscle, the fibularis tertius, is seen lateral to the EDL, inserting on the fifth metatarsal. The AT inserts on the inferomedial cuneiform and base of the first metatarsal. The EHL inserts dorsally on the base of the first toe distal phalanx. The EDL tendon diverges into separate tendinous slips in the anterior ankle, inserting on the dorsal aspect of the distal phalanges of toes 2 to 5.

Normal sonoanatomy

The AT and EDL are identified proximally in the anterior compartment as hypoechoic muscle bellies. Approximately halfway down the lower leg, the EHL muscle arises. As the tendons approach the superior extensor retinaculum, they hypoechoic muscles give way to hyperechoic, ovoid tendons, with the AT slightly larger than the EHL. The EDL begins to form into separate tendinous slips as it approaches the tibiotalar joint.

Patient positioning

- Supine, with the ankle comfortably plantarflexed.

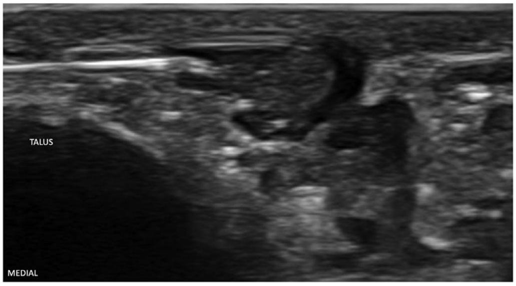

Fig. 17. AT tendon sheath injection approach.

Approach

- In-plane, medial to lateral or lateral to medial for peritendinous injections (Fig. 17).
- Mixed in-plane/out-of-plane, distal to proximal for intratendinous injections.

Needle

- Gauge: 22 to 25.
- Length: 0.5 to 1.5in.

Injectate volume

- 1 to 3 mL.

Procedural considerations

- The positions of the SFN and DFN branches should be identified, as the SFN crosses the EHL and EDL, whereas the DFN courses deep to the EHL.

Plantar Fascia

The PF is a thick fascial band arising from the calcaneus, with terminal slips to the toes distally. It is composed of central and lateral cords and a much smaller medial band.

Normal sonoanatomy

The PF seems as a fibrillar, hyperechoic structure, which typically measures less than 4 mm thick at its origin.[13] The distal bands become thin and fan out, making the distal PF sometimes difficult to follow.

Patient positioning

- Prone, with the ankle comfortably plantarflexed.
- Alternatively, lateral decubitus, in neutral ankle position with the medial ankle facing the ceiling.

Approach

- In-plane, medial to lateral for the superficial target (Fig. 18A).
- Mixed in-plane/out-of-plane for the deep PF or intrafascial injections (Fig. 18B).

Needle

- Gauge: 22 to 27.
- Length: 1.25 to 2in.

Injectate volume

- 1 to 3 mL.

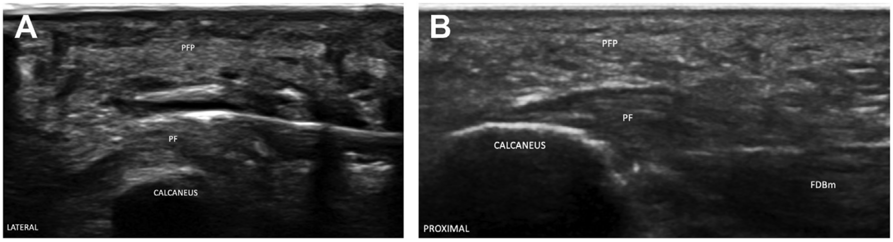

Fig. 18. PF injection approaches. (*A*) In-plane, superficial perifascial. (*B*). Out-of-plane, intrafascial or deep perifascial. FDBm, flexor digitorum brevis muscle; PF, plantar fascia; PFP, plantar fat pad.

Procedural considerations

- A superficial PF injection target with corticosteroid faces the risk of atrophy of the plantar fat pad.

Retrocalcaneal Bursa

The retrocalcaneal bursa is a synovial lined space, bordered by the calcaneus, Kager's fat pad, and Achilles tendon.

Normal sonoanatomy

The retrocalcaneal bursa is a potential space and is not well visualized sonographically in the absence of bursal fluid. With dynamic motion, the differential motion among Kager's fat pad, the Achilles, and the calcaneus can identify this space. In the normal state, a small rim of anechoic fluid can be seen.

Patient positioning

- Prone, or side-lying.

Approach

- In-plane, medial to lateral or lateral to medial (Fig. 19).

Needle

- Gauge: 25 to 27.
- Length: 1.25 to 1.5in.

Injectate volume

- 0.5 to 2 mL

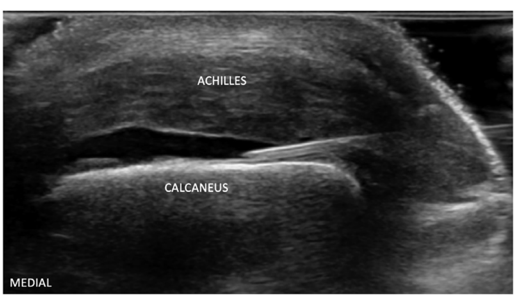

Fig. 19. Retrocalcaneal bursa injection approach.

Pearls/pitfalls

- The position of the tibial, medial calcaneal, and sural nerves must be considered.

SUMMARY

Foot and ankle pathologic condition is ubiquitous, and injection-based treatments are an effective, low risk, treatment option. A thorough understanding of the complex anatomy in this region is critical to ensure procedural accuracy. Due to the high-resolution, real-time imaging capabilities of US, it should be considered as a first-line imaging modality for procedural guidance, whereas fluoroscopy can also be considered for intra-articular injections.

CLINICS CARE POINTS

- Image-guided injections are more accurate and result in better clinical outcomes compared to palpation-guided injections.
- Although in-plane injections are preferred to out-of-plane due to easier needle tracking, an out-of-plane technique is often required due to the small joint spaces in the foot and ankle.
- Nonparticulate corticosteroids should be considered for perineural injections in order to reduce the risk of thromboembolic injury.
- Corticosteroids should never be injected directly into a tendon due to the risk of tendon rupture.

DISCLOSURES

The authors declare no conflicts of interest and do not have any financial disclosures relevant to this study.

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