Review paper

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Ultrasound-guided intervention techniques in the ankle and foot: a comprehensive guide

Elena Drakonaki[1], Georgina Allen[2], Lionel Pesquer[3]

[1] *Department of Anatomy, School of Medicine, University of Crete, Crete, Greece*
[2] *University of Oxford, Green Templeton College, United Kingdom*
[3] *Department of Radiology, Clinique du Sport, France*

Corresponding author: Elena Drakonaki; e-mail: drakonaki@yahoo.gr

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Abstract

Ultrasound-guided interventions in the ankle and foot are safe, accurate, and effective procedures for both diagnostic and therapeutic management of soft-tissue and joint diseases. They are increasingly popular due to advances in ultrasound technology and the increasing availability of ultrasound scanners. These procedures can be performed in an outpatient setting using high-resolution scanners with high-frequency linear probes under sterile conditions, using sterile equipment, supported by standardized pre- and post-treatment protocols. Interventions include simple aspirations of bursae and ganglia; intra-articular, peritendinous, intratendinous, and ligament injections; nerve blocks; injections for Morton's neuroma; and techniques such as dry needling for plantar fasciitis and stripping or high-volume injections for non-insertional Achilles tendinopathy. While corticosteroids, anesthetics, and hyaluronic acid remain the mainstay, interest is growing in the use of platelet-rich plasma for regenerative therapy to treat ankle and foot tendinopathies, as well as in more sophisticated techniques including radiofrequency ablation and cryoablation. In this comprehensive overview, we present the latest evidence regarding possible injectates and ultrasound-guided techniques for the ankle and foot. Physicians should be aware of the full spectrum of options and supporting data to be able to provide personalized advice and targeted treatment to patients as part of a clinical radiology service.

Introduction

Ultrasound (US)-guided interventions in the ankle and foot are becoming increasingly common due to advances in US technology and the wider availability of US scanners. These include simple soft-tissue aspirations/injections and nerve blocks as well as interventional techniques to treat tendinopathies such as dry needling, high-volume injections, and radiofrequency ablation. US guidance provides superior accuracy compared with landmark-guided injections, even for less experienced operators[1,2]. All procedures can be performed in an outpatient setting or ultrasound department using high-resolution US scanners with high-frequency linear array probes (15–24 MHz). Ergonomic hockey-stick probes are particularly useful, as they allow manipulation around curved areas while providing high-resolution imaging. All procedures should be performed by trained specialists under aseptic/antiseptic conditions. The use of a probe cover in procedures with low infection risk is not strictly necessary[3]. Emergency equipment is vital in the rare event of an anaphylaxis[4].

A strict pre- and post-treatment assessment protocol should be followed[4,5,6]. The indication must always be confirmed by clinical information, review of prior imaging studies, and a thorough diagnostic US examination. Therefore, competency in diagnostic scanning is essential before providing a US-guided injection service. Written or oral informed consent should be obtained prior to the procedure, including discussion of potential complications. Patients should also be advised about what to expect after the injection in terms of return to sport and activity, and about the role of physiotherapy as an adjunct. They should be warned that the procedure may not give pain relief, and an alternative management strategy should be proposed if this is the case. Basic aftercare instructions for pain management and rehabilitation should be provided. Follow-up using pain diaries is vital to ensure adequate feedback for quality audits.

In this comprehensive overview, we present the latest evidence on possible injectates and US-guided techniques for the ankle and foot.

Intra-articular injections

US-guided joint injections are safe, accurate, and effective for both diagnostic and therapeutic management of joint disease. While corticosteroids remain the mainstay of treatment due to their anti-inflammatory and analgesic effects, sodium hyaluronate (hyaluronic acid) for viscosupplementation and platelet-rich plasma (PRP) for regenerative therapy to promote healing show promise in selected patients[1,2,7]. Ozone, botulinum toxin (Botox), and dextrose (prolotherapy) are less commonly used adjunctive therapies but they may serve as efficient additional treatment options in specific situations[1,2,7].

US-guided steroid injections in the midfoot demonstrate short-term benefit, with 78% of patients reporting improvement at 2 weeks, 58% at 3 months, and <15% beyond 3 months[7,8]. The duration of effect aligns with the known six-week anti-inflammatory window of corticosteroids, and outcomes are better in non-obese patients[9]. Local steroid and anesthetic injections require caution, as there are significant contraindications and complications, especially in patients with coexisting systemic disease and medication[6,9]. Patients should be counselled regarding common systemic and local post-injection effects, typically occurring within 48 hours after steroid injection[6,10]. Local skin atrophy or depigmentation is more frequent in individuals with darker skin tones and may take up to 18 months to improve[6,10]. Most adverse effects are transient and resolve spontaneously within days to weeks. In vitro evidence demonstrates chondrotoxicity associated with all anesthetics especially if used in high concentrations particularly in arthritic joints[11]. Lidocaine should be avoided in the joint, as it is more chondrotoxic than long-acting local anesthetics[11]. Bupivacaine or ropivacaine can be used at the lowest effective concentration to minimize chondrotoxicity[11]. Subcutaneous anesthetic may obscure vision into the superficial joint due to air introduced with the injectate, so it should be avoided, unless the patient is very sensitive. Triamcinolone acetonide is preferred, though now discontinued in some regions, whereas methylprednisolone is advised for smaller, superficial joints, due to reduced risk of fat atrophy[6].

The evidence for PRP and hyaluronic acid intra-articular foot applications is continuously increasing[12–14]. PRP and hyaluronic acid may serve as adjunctive therapies for acute ankle sprains, talus osteochondral lesions, and ankle osteoarthritis[12–14]. Treatment efficacy can be influenced by many additional factors such as injection timing, volume, co-medication, and absolute platelet count[13]. Furthermore, a distinction must be made between leukocyte-poor and leukocyte-rich PRP, as leukocyte-poor PRP appears to be more effective for intra-articular uses[14].

Joint-specific step-by-step instructions for US-guided ankle and foot injections are available[6]. There are two different US-guided injection techniques: the indirect technique, following a pre-interventional US examination to mark the skin entry point, and the direct technique, where there is real-time visualization of needle, but it is more technically demanding as it requires bimanual coordination. As a rule, an in-plane technique is advised for needle placement, as it allows needle visualization when using a transverse probe plane to the joint for injection (Fig. 1). For more technically challenging joints, such as the subtalar joint, or in the presence of significant joint remodeling, US -CT/MR fusion imaging can be of value. Ankle and foot joint injections can be performed without interruption of

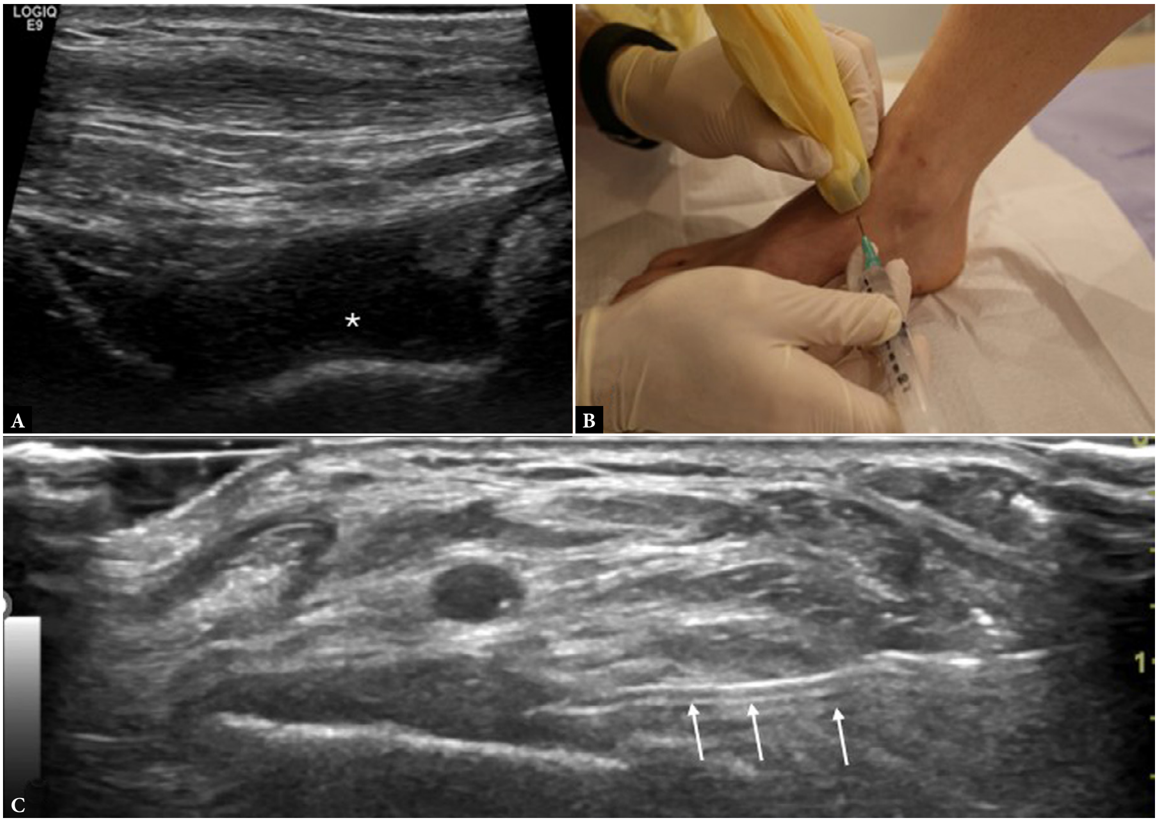

Fig. 1. *US-guided injection in the ankle joint.* **A.** *US imaging of the anterior recess of the ankle joint starts in the longitudinal plane, showing a significant joint effusion (asterisk).* **B.** *The transducer is then rotated perpendicular to the plane in image (***A***), and the injection is performed in the axial plane, with the needle entering from the side, parallel to the transducer.* **C.** *The needle is visualized on the screen entering the anterior joint recess in the axial plane*

direct oral anticoagulants; however, for patients on warfarin, an INR <1.5 is preferred. Practical tips include identifying surrounding vascular and neural structures by thorough prior scanning and marking the skin with a needle hub impression before needle insertion. The needle tip should be visualized within the joint prior to injection. It is advised to aspirate any joint effusion prior to injecting and pause injection if resistance increases to avoid exceeding the joint's fluid capacity. Steroids (ideally non-crystalline) should only be used when the tendon is intact to minimize the risk of tendon rupture.

Peritendinous, intratendinous, and ligament injections

Peritendinous injections with steroid and anesthetic are an effective and safe way to manage degenerative or inflammatory tendinopathy in both adults and children[8,15–17]. The tibialis posterior tendon is the most commonly injected tendon in the ankle and foot, followed by the peroneus longus and brevis tendons[8,16,17]. US findings such as fusiform hypoechoic thickening, loss of normal fascicular echostructure, effusion with or without synovial tissue proliferation, and peri- and intratendinous neovascularity confirm the diagnosis of tendinosis and indicate the need for injection[5].

Real-time, direct US guidance allows accurate placement of the needle tip to allow injection into the synovial tendon sheath and avoid intratendinous injection, which is associated with collagen breakdown and tendon rupture[5]. A preliminary test injection using only anesthetic may be useful in cases without significant sheath distension by effusion to allow confirmation of correct needle-tip placement. The injection is performed under sterile conditions using a 23-G needle oriented under direct US-guidance, preferably longitudinally to the transducer (in-plane technique) (Fig. 2). If there is significant synovial sheath effusion, it should be aspirated before injection. Synovial fluid should be analyzed, including polarization microscopy, cell count determination, and cell differentiation, with further microbiological examinations only in the presence of corresponding clinical findings. The injectate usually consists of 1 mL of steroid and 1–2 mL long-lasting anesthetic.

Steroid injections in weight-bearing tendons are generally considered to carry a risk of rupture. Interestingly, US-guided corticosteroid injections into the posterior tibial tendon sheath have been found to be safe and effective[16]. Nevertheless, if a steroid injection is needed, informed consent by the patient and immobilization in a boot for three weeks after steroid injection are advised[5,7].

Peritendinous hyaluronic acid injections have been reported for impingement tendinopathies and post-operative peritendinous adhesions, however, only scarce evidence is available[5,18]. Most literature focuses on the Achilles tendon, where one or two peritendinous injections of 25–40 mg/2 mL of high-molecular-weight hyaluronic acid, with or without 10 mg mannitol, are injected without local anesthetic at the tendon attachment site[18]. In our practice, these injections can be very effective for midportion Achilles tendinopathy, and patients do not require a boot.

Intratendinous PRP infiltration combined with walking-cast immobilization has been assessed as an alternative to steroids in cases of insertional tibialis anterior tendinopathy and found to be safe and effective[19]. In general, PRP injections are indicated for tendinopathy associated with a tear[20]. Tendons have low vascularity and limited exposure to growth factors and cytokines, which may result in delayed or prolonged healing. Platelet-rich plasma is defined as a blood-derived product with a platelet concentration at least 2.5 times the number of platelets in peripheral blood. When PRP comes into contact with collagen, platelet activation occurs, releasing 95% of platelet growth factors along with cytokines (chemokines, interleukins) during the first hour of degranulation[21]. PRP acts on the different phases of tendon healing (inflammation, repair, remodeling) by providing growth factors and cytokines. PRP exerts multiple effects on tendons: anti-inflammatory, analgesic, promoting angiogenesis, recruitment of mesenchymal cells, differentiation into fibroblasts, and collagen synthesis. PRP is obtained by centrifuging peripheral venous blood (blood volume depends on the system used). Ideally, a cell count is performed to determine the platelet concentration and the near absence of red blood cells in the resulting injectate[22]. A minimum dose of 4.5 billion platelets is recommended for optimum efficacy, but a cumulative dose of 10–12 billion across multiple treatments is considered the most effective[23]. For this reason, it must always be decided individually how often and how many injections are necessary. In the era of individualized precision medicine, measuring platelet counts has already become standard practice. However, laboratory testing of individual specimens may not be available in all clinical settings; instead, commercially available kits are widely used in many clinical practices. Injections are performed under US guidance within the areas of tendinosis, along the long or short axis of the tendon depending on the location of the lesions. If the injection is expected to be painful, a nerve block may be performed, as local anesthesia is generally avoided. Relative rest for eight days, followed by a rehabilitation protocol including home exercises, may be recommended. The efficacy of PRP injection is debated across different studies, depending on preparation techniques, injection protocols, and post-treatment rehabilitation[22,24,25].

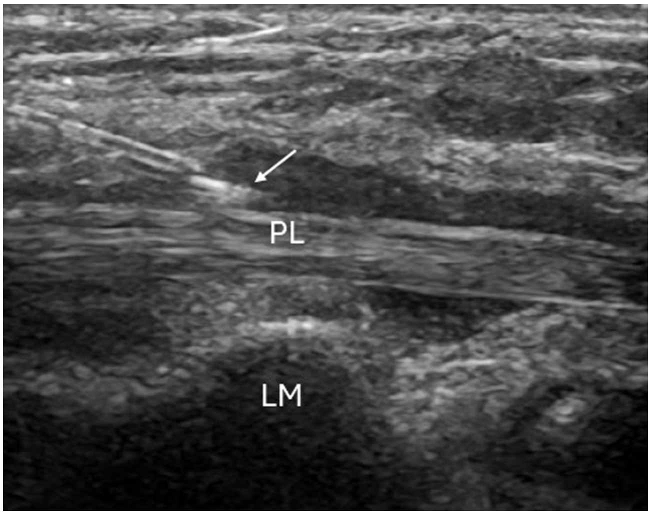

Fig. 2. *Peritendinous injection at the peroneal longus tendon in a patient with tenosynovitis. Note the position of the needle (arrow) inside the distended tendon sheath, away from the tendon fibers*

PRP and dextrose/sucrose injections into sprained anterior inferior tibiofibular ligaments have been shown to accelerate a safe and successful return to play[6]. However, evidence remains limited to a small number of studies and cases.

Achilles tendon injection techniques

Achilles tendinopathy is classified into midportion and insertional types, with different anatomical features, clinical presentations, treatment strategies, and rehabilitation protocols[26]. In midportion Achilles tendinopathy, findings are localized >2 cm above the distal attachment, whereas insertional tendinopathy affects the first 2 cm of the tendon at its calcaneal attachment and may be associated with Haglund's deformity and retrocalcaneal bursitis[27]. Mechanical insertional tendinopathy must be differentiated from inflammatory Achilles enthesitis, which can occur, among other causes, in spondyloarthritides or in endocrinopathies. In these clinical situations, systemic therapy under specialist supervision should be preferred over local treatment. US evaluation shows an enlarged tendon with altered echostructure, variable degree of neovascularity within the tendon and Kager's fat, and thickening or effusion of the paratenon in cases of paratenonitis[28]. When conservative treatment fails, US-guided injections may include tendon stripping and high-volume injections, dry needling, prolotherapy, radiofrequency ablation, sclerosing polidocanol injections, aprotrinin (a broad-spectrum protease inhibitor), hyaluronic acid, and various autologous blood/PRP preparations[5,29–32]. All techniques are safe and feasible, though with variable levels of evidence[2,29–32]. There is an accepted consensus about avoiding intra- and peritendinous steroid injections due to the risk of complications, including tendon rupture[2,5].

High-volume saline injections, also called brisement or saline stripping, are injections of saline and local anesthetic with/without steroid between the mid-portion of the Achilles tendon and Kager's fat pad. The technique has a mechanical effect on disrupting neurovascular ingrowth and adhesions, allowing for improvement in pain and function (Fig. 3)[5,29]. It is a simple, minimally invasive US-guided procedure similar to surgical stripping for Achilles midportion tendinopathy using a suture[5,26,29,32]. Using an aseptic technique, a 21-G needle attached to a connecting tube is inserted in the axial plane between the anterior aspect of the Achilles tendon and Kager's fat pad. A medial-to-lateral approach is preferred to avoid the superficially located sural nerve[5–7,29]. A 10 mL syringe containing 2–3 mL of lidocaine is initially injected. The injection may be followed by saline. Some authors suggest 50 mL but 20–25 mL in practice is successful, and larger volumes increase the risk of compartment syndrome[5–7,29]. The procedure is performed under direct real-time US guidance to allow smooth dissection of Kager's fat from the Achilles tendon. Based on a recent meta-analysis of 10 studies, high-volume saline stripping is safe and effective, leading to improvements in pain and function, and reduction in tendon thickness and neovascular-

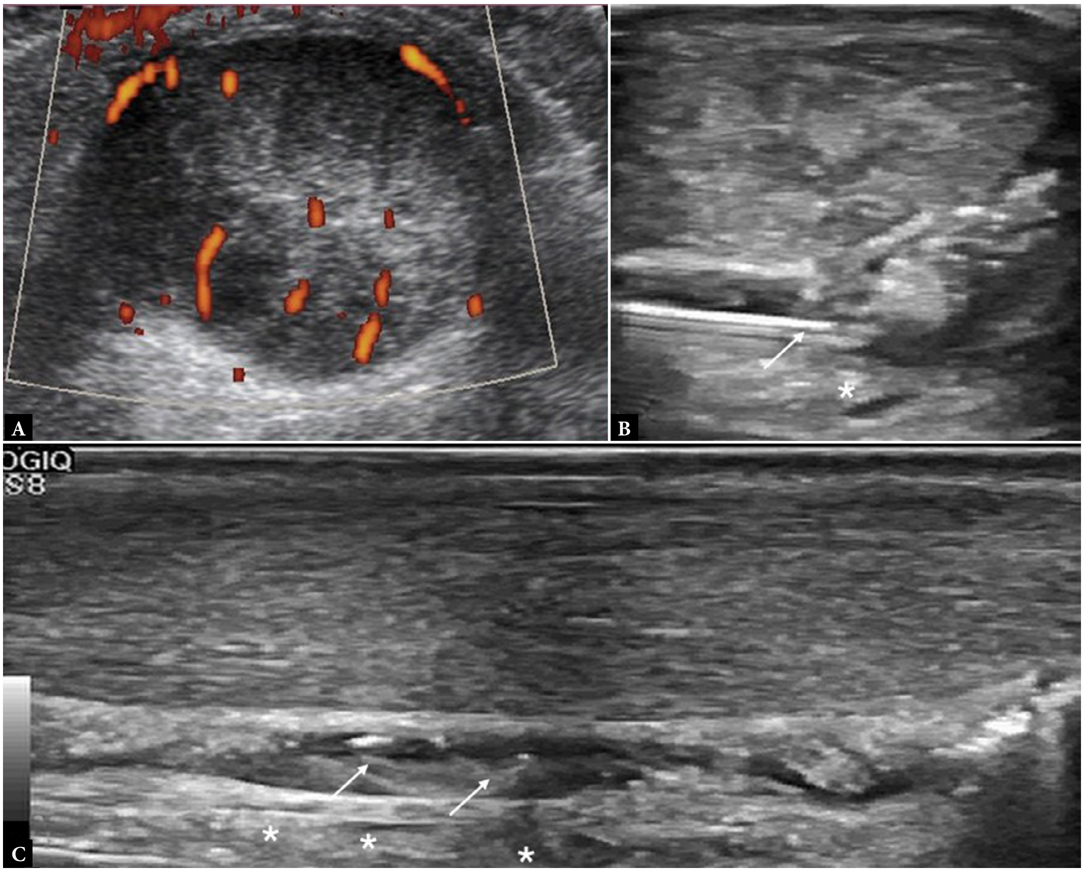

Fig. 3. *A 35-year-old man with midportion Achilles tendinopathy treated with saline stripping.* **A.** *Axial US image of the Achilles free tendon showing tendon enlargement and neovascularity consistent with Achilles tendinopathy.* **B.** *Under US guidance in the axial view, a 21-G needle (arrow) was inserted using the in-plane technique, and 20 mL of fluid (2 syringes of saline with 4 mL of local anesthetic each) was injected between Kager's fat (asterisk) and the Achilles tendon. An extension was connected to the needle to allow easier change of the syringes during the injection.* **C.** *The injectate creates a fluid collection between Kager's fat (asterisks) and the Achilles tendon that disrupts neovessels and neural tissue from extending from fat into the tendon. The patient was instructed to wear a boot for one week, use paracetamol as needed, and then gradually return to normal activity*

ity[33]. Steroid injections around the Achilles tendons are strongly discouraged as they may predispose to rupture[33].

PRP can be effective as dry needling in relieving pain for up to six months in various tendinopathies including Achilles tendinopathy[7,34,35].

Despite the large numbers of studies on the use of PRP for Achilles tendinopathy, a fundamental limitation is that there are too many different systems and no consensus, leading to publication bias, variability in preparations, treatment protocols, and patient selection. Unless all contraindications are considered, patients are properly selected, adequate platelet concentrations are achieved, and follow-up care in a specialized center is ensured, there will be discrepancies in published evidence leading to a lack of definite guidance[24,25,36].

The most recent meta-analysis focusing on randomized clinical trials comparing PRP with placebo or other treatments for Achilles tendinopathy found no benefit of PRP over placebo at three months and showed that PRP was less effective in the short term compared with high-volume injections[25]. Additional limitations of PRP include less favorable outcomes in patients with diabetes[37] and higher rates of post-injection pain associated with PRP versus comparison treatments[38]. Preliminary animal studies show that local use of PRP exosomes promotes tendon cells differentiation in insertional Achilles tendinopathy, so PRP with or without dry needling could be an option for insertional Achilles tendinopathy where saline stripping is not feasible[39]. (Fig. 4) Until larger trials with standardized protocols in PRP preparations and doses are available, the above limitations must be addressed in the informed patient's consent.

Plantar fascia injection techniques

US-guided injections of steroids or autologous blood/PRP preparations, with or without dry needling, are commonly performed in recalcitrant cases of plantar fasciopathy[32,40]. Pre-treatment US examination confirming the diagnosis demonstrates increased plantar fascia (PF) thickness (>4.5–5 mm) and a hypoechoic appearance, with or without calcifications. PF tears at the enthesis and calcaneal enthesophytes may also be evident[40]. Increased vascularity and thinning of the plantar fat pad may occasionally be present, and elastography can confirm increased PF stiffness[40]. A normal-appearing PF in a patient with heel pain should raise suspicion of entrapment of the muscular branch of lateral plantar nerve (Baxter neuropathy), tarsal tunnel syndrome, or plantar fat pad syndrome.

US-guided corticosteroid injections for PF are avoided, as they provide only short-term benefit (<12 weeks) and may be associated with local complications, including fat pad atrophy[5,6,41,42].

US-guided dry needling of the PF, with or without PRP injection, has been used as an alternative to steroid therapy. Research has shown that dry needling in rat tendons increases gene expression associated with collagen regeneration and tissue remodeling without further histological damage[43]. The procedure is also considered safe in human tendons, resulting only in mild post-needling soreness, bruising, and transient post-procedural pain exacerbation that resolves spontaneously[44]. Nonsteroidal anti-inflammatory drugs, administered either prior to or after the procedure, may negate the effects of dry needling and should be avoided[7]. Based on a few randomized controlled trials, dry needling in plantar fasciitis results in improvements in pain and disability in the long term (>6 months), while the combination with stretching exercises is more effective in improving symptoms and US findings compared to stretching alone[45–47]. However, evidence is limited due to the small number of trials, heterogeneity in published series, confusion between US-guided and palpation-guided dry needling, and a lack of detailed data concerning the technique (i.e., number of passes)[42]. Dry needling is usually performed in the axial US plane following a perifascial local anesthetic injection using a 21-G needle (Fig. 5). Plantar fascia injections are painful, especially when fenestration is used. A tibial nerve root block can help make the procedure more tolerable. The needle is introduced directly into the fascia, into the most hypoechoic/degenerative areas, and PRP preparations can be delivered using a fenestration technique with multiple passes. The procedure can be repeated if necessary, but there is no consensus on the optimal timing or number of PRP injections[29]. The insertion of the needle using a lateral-to-medial approach avoids puncturing through the medial fat pad and potential injury to the medially located posterior tibial nerve branches and the lateral plantar nerve[48]. If a medial approach is used, the needle should not be inserted more anteriorly than the plantar fascia insertion on the calcaneus to avoid this complication.

PRP administration has been increasingly used for managing patients with chronic PF[35,49]. Compared with steroids, autologous blood/PRP preparations have been reported to provide better treatment outcomes in the mid and long term, with a more fa-

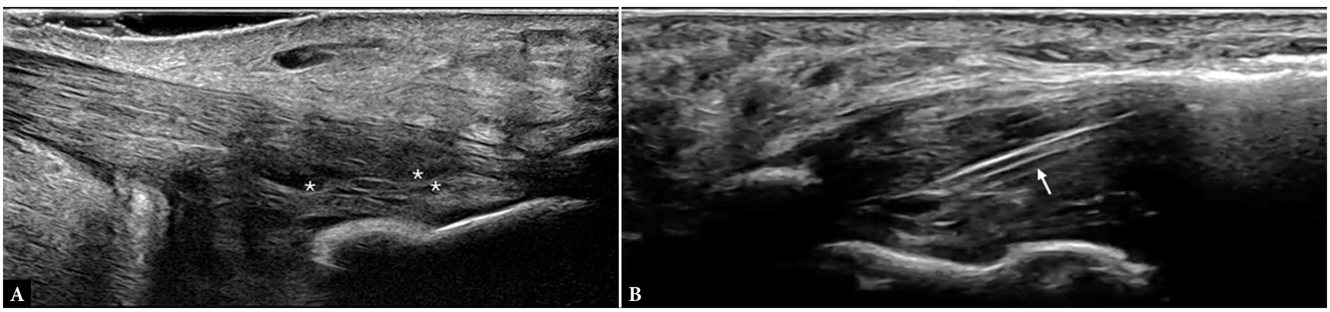

Fig. 4. *A 55-year-old man with insertional Achilles tendinopathy treated with PRP injection.* **A.** *US shows a Haglund's deformity with a prominent calcaneal spur and considerable inhomogeneity, hypoechoic appearance, and fissures/microtears at the tendon insertion (asterisk).* **B.** *Using a 23-G needle (arrow), PRP was injected inside the fissures. After one week of worsening pain, the patient experienced gradual improvement in pain and function, lasting up to eight months, when the patient was lost to follow-up*

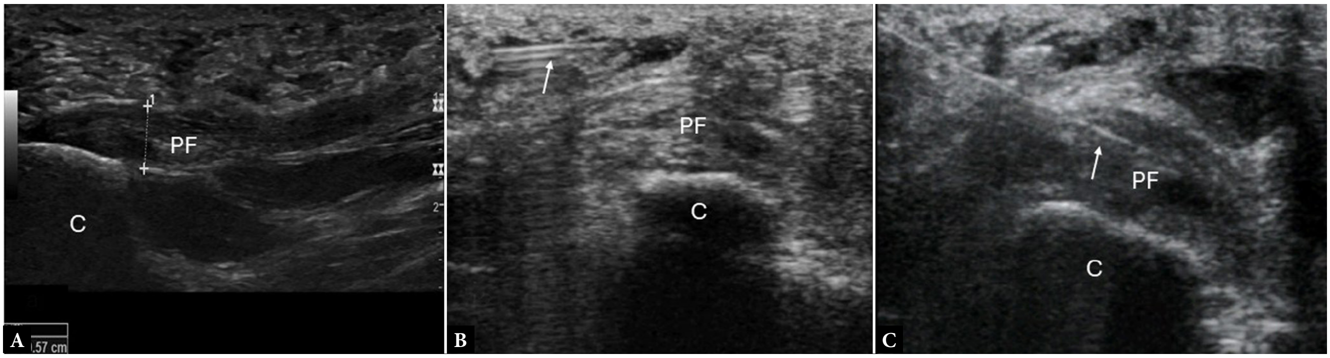

Fig. 5. *A 56-year-old woman with plantar fasciitis treated with dry needling.* **A.** *US scanning in the longitudinal axis confirmed the presence of a thick plantar fascia at the calcaneal insertion (5.7 mm, measured with calipers).* **B.** *Axial view of the plantar fascia insertion: a 21-G needle (arrow) is inserted parallel to the transducer, and local anesthetic is injected superficial to the plantar fascia (PF).* **C.** *The same needle (arrow) is redirected without retracting into the plantar fascia (PF), and multiple passes (6–10) are performed*

vorable safety profile[2,46,49], with no difference between PRP and autologous whole-blood preparations[50]. Complication rates are five times lower than with steroids, including only pain at the injection site and a few cases of superficial infection[46]. Based on a randomized controlled trial, adding 3 mL of autologous blood to PF dry needling had no additional effect compared to a dry-needling procedure alone; both approaches were equally effective in improving pain by 25% by six weeks and by 50% at six months[46].

Combined treatment protocols including US-guided radiofrequency ablation together with steroid injections seem to provide superior and more durable improvements in pain and function, with lowest relapse rates compared with either technique alone[51,52]. Various other US-guided therapeutic options for recalcitrant PF have been evaluated in studies with small patient numbers, including TOPAZ® coblation (ArthroCare, Sunnyvale, CA), radiofrequency ablation of the calcaneal branches of the inferior calcaneal nerve, percutaneous needle electrolysis (EPI), and percutaneous ultrasonic tenotomy (Tenex) via phacoemulsification; however, the available evidence is still insufficient to allow any recommendations [32,53–55]. According to the European Society of Musculoskeletal Radiology (ESSR) consensus statements, the effectiveness of US-guided injections with ozone, hyaluronic acid, or botulinum toxin type A has not yet been sufficiently proven[2].

Morton's neuroma injections

The misnomer "Morton's neuroma" (MN) is still widely used instead of "interdigital neuralgia" to describe the fusiform enlargement of a digital branch of the medial or lateral plantar nerve caused by excessive intraneural and perineural fibrosis[56]. Many patients with interdigital neuralgia may not primarily have neuropathy but rather interdigital bursitis with secondary neuralgia, due to deformities, overuse, or systemic diseases such as rheumatoid arthritis. In these cases, the underlying pathology and the bursitis should be treated first before performing US-guided injection around the nerve itself.

US-guided injection therapies are a cost-effective strategy compared with proceeding directly to surgical neurectomy and are indicated as a first-line treatment for patients with symptomatic Morton's neuromas when conservative management fails[57]. Corticosteroids reduce inflammation and induce tissue atrophy in the intermetatarsal space, thereby decreasing compression of the neuroma[58] and treating the associated web-space bursitis. Under direct US guidance, a 23-G blue needle is inserted through the interdigital fold parallel to the long axis of the transducer, and a maximum of 1 mL steroid and 1 mL anesthetic is injected (Fig. 6). A dorsal approach to the area can also be performed with the probe on the plantar aspect of the foot[6], which is much less painful for the patient. The procedure has a combined diagnostic and therapeutic role.

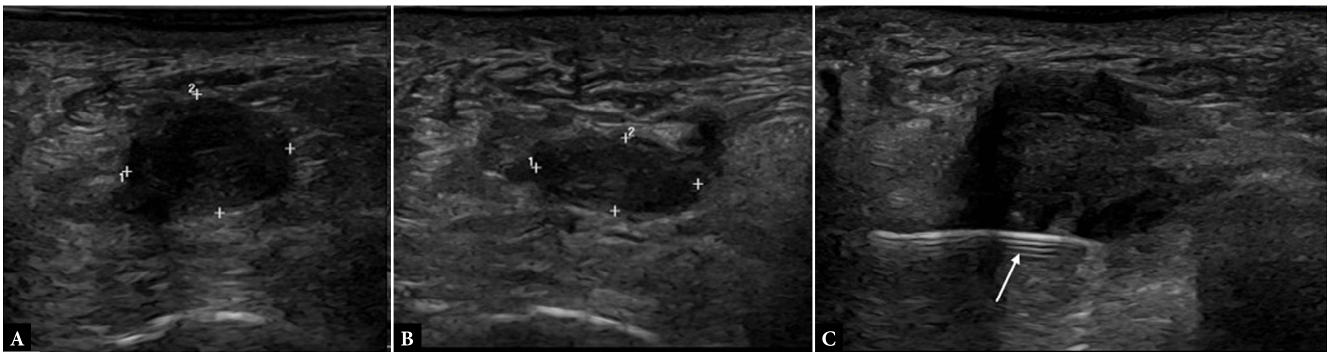

Fig. 6. *A 34-year-old woman with a Morton's neuroma in the third web space of the left foot treated with steroid injection.* **A.** *A 1.16 x 0.86 cm hypoechoic lesion (calipers) was identified in the web space.* **B.** *Manual compression at the dorsal side of the webspace while scanning with the transducer in the long axis at the plantar side displaced fluid in the interdigital bursa, revealing a 1.15 × 0.52 cm Morton's neuroma (calipers).* **C.** *Injection was performed using a 23-G needle (arrow) inserted through the interdigital space parallel to the transducer*

Steroid injections result in significant pain improvement, ranging from 40–70% between six months and three years, with maximal pain reduction between one week and three months after injection[58–60]. Triamcinolone yields better results than methylprednisolone with the expense of higher rates of skin depigmentation at the injection site and/or atrophy of the plantar fat pad[58].

US-guided alcohol ablation has been used in the treatment of MN, leading to a reduction in symptoms after 12 months. However, exacerbation of pain despite the use of local anesthetic, prolonged pain lasting several weeks, or paresthesia in adjacent toes has been reported with alcohol concentrations between 30% and 50%[58]. There is also a risk of digital ischemia and necrosis of the skin and subcutaneous tissue[61]. Corticosteroid injections demonstrate variable effectiveness; therefore, clinical evaluation with various tests remains crucial, as neuroma size alone may not reliably predict symptoms or treatment response[62]. US-guided injections of hyaluronic acid are generally safe but less effective in functional and pain outcomes than steroids[60]. A few studies also suggest that capsaicin, the pungent component of hot peppers, is a safe and effective injection treatment for MN; however, evidence is still very limited[58].

There is growing evidence that US-guided radiofrequency ablation and cryoablation are safe and effective, suggesting a promising role in the comprehensive management algorithm for this condition[63]. However, US-guided pulsed radiofrequency ablation does not guarantee complete nerve ablation, and neurophysiological monitoring may be necessary to improve treatment efficacy and prevent recurrences[64]. Cryoneurolysis, which creates an ice ball with accurately controlled dimensions, has high rates of clinical efficacy and can be combined with US-guided nerve blocks to improve post-procedural symptomatic pain relief[32,65].

Nerve blocks

High-resolution US using high-frequency (>15 Mhz) hockey-stick probes allows for imaging the small oligofascicular nerves of the ankle and foot, and facilitates injections around nerves that may be locally thickened or subject to extrinsic compression, such as in idiopathic tarsal tunnel syndrome or at the site of a posttraumatic or postoperative neuroma[66,67]. The most frequently affected nerves are the tibial nerve and its calcaneal and plantar branches, the sural nerve, and the superficial and deep peroneal nerves[68]. Perineural injections are usually performed using betamethasone (6 mg/cc) mixed with either short- or long-lasting anesthetic (lidocaine 1%, bupivacaine 0.75%, or ropivacaine 0.5%, respectively) in volumes ranging from 0.75 to 5 mL, depending on the anatomical area being injected[68]. For the posterior tibial nerve block specifically, 3.5 mL of anesthetic is injected using a 25-G needle around the nerve at the level of the medial malleolus[68]. The technique is especially valuable in cases of iatrogenic complications, in the postoperative setting, or in cases of a sonographically normal nerve with clinical suspicion of injury, as the injection of local anesthetic allows for a diagnostic test before further intervention, such as neurolysis or neurectomy (Fig. 7)[67,68].

US-guided nerve hydrodissection is a technique used to treat nerve entrapments by injecting anesthetic, saline, or 5% dextrose around a nerve to mechanically separate it from surrounding tissues. This approach is safe and has many applications in cases of neuropathic pain due to postsurgical scar tissue, friction/compression during nerve movement, or altered gait post-injury resulting in nerve irritation[69].

Aspiration/injection in ganglia and bursae

Ganglion cysts and bursae in the ankle and foot are common, and US-guided aspiration and injection can reduce swelling and pain, and prevent recurrence[70]. Subcutaneous anesthesia with a fine 23- or 25-G needle is generally administered before cyst aspiration to minimize discomfort during the procedure. Aspiration is performed with an 18- to 20-G needle under US guidance. Aspiration should be as complete as possible, using a large syringe for suction; saline may be added to make the content less viscous, if needed. The procedure can be followed by a corticosteroid injection, the volume of which is adjusted according to the size of the cyst[71], though this is not essential, depending on the degree of inflammation within the cyst. The effectiveness of aspiration with injection of ganglion cysts

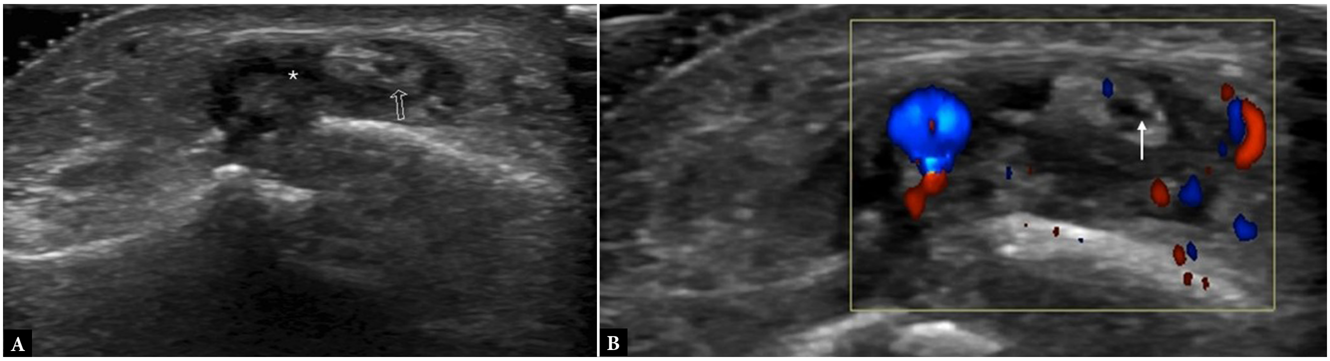

Fig. 7. *A 67-year-old woman with a small painful palpable lump at the dorsal foot causing numbness of the big toe during pressure from shoes and walking.* **A.** *Diagnostic US showed hypoechoic tissue (asterisk) around the medial branch of the deep peroneal nerve (arrow), located just lateral to the dorsalis pedis artery in close relation to the navicular-medial cuneiform joint.* **B.** *Note the enlarged hypoechoic fascicles (arrow) and surrounding intensely echogenic connective tissue, the artery visualized on color Doppler and the hypoechoic tissue between them. Impingement of the nerve by the hypoechoic tissue was suspected and reported. The surgeon asked for a diagnostic nerve block before deciding on surgical management. Using a 23-G needle, an injection of a long-lasting anesthetic (ropivacaine) was performed with a high-resolution 18 MHz hockey-stick probe. Following relief of symptoms for a few hours, surgical debridement of the nerve was performed*

is variable. The recurrence rate after aspiration and corticosteroid injection is 29%, compared with 17% after surgery[72]. The use of a pressure bandage can also be useful initially.

Conclusion

US-guided interventions in the ankle and foot are safe and accurate procedures that enable both diagnostic and therapeutic management of soft tissue and joint diseases. The essential requirements for successful US-guided interventions include thorough US training in sonoanatomy and sonopathology, knowledge of rheumatic diseases, orthopedic conditions, traumatology and differential diagnosis, as well as ongoing training, continuous medical education, and experience with US-guided techniques. Physicians should be aware of the requirements, scope, and existing evidence for these US-guided techniques to be able to provide personalized advice and targeted treatment as part of clinical care.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

Author contributions

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