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REVIEW

Injection Techniques for Common Chronic Pain Conditions of the Foot: A Comprehensive Review

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ABSTRACT

Purpose of Review: This is a comprehensive literature review of the available evidence and techniques of foot injections for chronic pain conditions. It briefly describes common foot chronic pain syndromes and then reviews available injection techniques for each of these syndromes, weighing the available evidence and comparing the available approaches.

Recent Findings: Foot and ankle pain affects 20% of the population over 50 and significantly impairs mobility and ability to participate in activities of daily living (ADLs), as well as increases fall risk. It is commonly treated with costly surgery, at times with questionable efficacy. Injection therapy is challenging when the etiology is anatomical or compressive. Morton's neuroma is a budging of the interdigital nerve. Steroid, alcohol, and capsaicin injections

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provide some benefit, but it is short lived. Hyaluronic acid (HA) injection provided long-term relief and could prove to be a viable treatment option. Achilles tendinopathy (AT) is most likely secondary to repeat tendon stress—platelet-rich-plasma (PRP) and prolotherapy have been trialed for this condition, but more evidence is required to show efficacy. Similar injections were trials for plantar fasciitis and achieved only short-term relief; however, some evidence suggests that PRP injections reduce the frequency of required therapy. Tarsal tunnel syndrome, a compressive neuropathy carries a risk of permanent neural injury if left untreated. Injection therapy can provide a bridge to surgery; however, surgical decompression remains the definitive therapy. When the etiology is inflammatory, steroid injection is more likely to provide benefit. This has been shown in several studies for gout, as well as osteoarthritis of the foot and ankle and treatment-refractory rheumatoid arthritis. HA showed similar benefit, possibly due to anti-inflammatory effects. Stem cell injections may provide the additional benefit of structure restoration.

Summary: Chronic foot pain is common in the general population and has significant associated morbidity and disability. Traditionally treated with surgery, these are costly and only somewhat effective. Injections provide an effective alternative financially and some evidence exists that they are effective in pain alleviation. However, current evidence is limited and the benefit described from injection therapy has been short-lived in most cases. Further studies in larger populations are required to evaluate the long-term effects of these treatments.

Keywords: Achilles tendinopathy; Ankle arthritis; Foot pain; Gout; Injection techniques; Morton neuroma; Plantar fasciitis; Tarsal tunnel syndrome

Key Summary Points

This is a comprehensive literature review of the available evidence and techniques of foot injections for chronic pain conditions. It briefly describes common foot chronic pain syndromes and then reviews available injection techniques for each of these syndromes, weighing the available evidence and comparing the available approaches.

Foot and ankle pain affects 20% of the population over 50 and significantly impairs mobility and ability to participate in ADLs, as well as increases fall risk. It is commonly treated with costly surgery, at times with questionable efficacy.

Injections provide an effective alternative financially and some evidence exists that they are effective in pain alleviation. However, current evidence is limited and the benefit described from injection therapy has been short-lived in most cases. Further studies in larger populations are required to evaluate the long-term effects of these treatments.

INTRODUCTION

Foot and ankle pain is a common ailment in the general population but frequently affects one in five people over the age of 50 [1]. People with foot pain often have limited mobility and decreased ability to do everyday activities [2, 3]. In addition to this, people with foot pain are often at a higher risk for falling and locomotive disability due to their pain [1]. In addition to chronic foot pain being physically debilitating, Belatti et al. calculated that since 2000, foot and ankle surgery for chronic pain has cost the Medicare population around 11 billion dollars [4]. This review discusses non-surgical injection techniques for common foot pain conditions: Morton's neuroma, Achilles tendinopathy,

tarsal tunnel syndrome, plantar fasciitis, gout, ankle osteoarthritis, rheumatoid arthritis, and posterior tibial tendon dysfunction. The selection of which injection technique would be most beneficial should be done by the clinical practitioner on an individual patient basis. This article is based on previously conducted studies and does not contain any studies with human participants or animals performed by any of the authors.

MORTON'S NEUROMA

Morton's neuroma (MN), a form of metatarsalgia, is pain in the forefoot region usually located in the third intermetatarsal region of the foot [5]. MN is the result of a bulging of the interdigital nerve distal to the metatarsal transverse ligament and can result in sharp burning pain and numbness either diffused throughout the foot or localized to a specific section [5, 6]. The pain can be exacerbated by wearing tight shoes or high heels and is often described as "walking on marbles" or "walking on piece of stone or pebble" [5, 6]. MN more commonly presents in women in their 50s that perform activities such as running, walking, and dancing [7]. Diagnosis of MN is often done clinically by first examining the patient's shoes for wear and tear locations towards the distal end of the foot [5]. Diagnosis of MN can also be confirmed with the Mulder maneuver, where pressure and tightening is exerted on the metatarsals, resulting in pain and a distinct clicking or the Silfverskiöld test to assess gastrocnemius muscle tightness are useful in diagnosing MN [5–7]. Surgical treatment of MN is traditionally a neurectomy; however, non-surgical treatments first are now becoming more recommended [5, 8]. A non-surgical option is preferred due to the large spectrum of potential causes of MN, patients declining surgical options, or not being suitable for surgery due to contraindications [5, 8].

Steroid

Steroid treatment is commonly used to alleviate symptoms along with changes in footwear and stretching [9]. Principal findings by Lizano-Diez et al. showed that corticosteroid injections with local anesthetics did improve symptoms temporarily between the experimental and control groups ($P = 0.012$). However, the beneficial effects diminished over a short period of time [10]. In addition to the short-term effects, Perini et al. also noted diminished short-term pain after injection in 73% of their patients ($P < 0.001$) [11]. However, there were side effects that resulted in pain in the injection site, skin lesions, tissue alterations consist with "steroid flare," tissue atrophy, and pigment alterations [9, 11].

Alcohol

Alcohol injections are another method to treat MN instead of corticosteroid injections. Alcohol is usually mixed with a local anesthetic and guided via ultrasound into the neuroma [11]. The concentration of alcohol that is injected for MN varies, although the beneficial results are amplified as the concentration of alcohol increases [9]. There is local transient pain at the site of injection as the concentration of alcohol is increased from 30 to 50%, but it is short lived [9]. More research needs to be conducted on alcohol-based treatments and this therapy should only be used if more evidence-based treatments fail to produce beneficial results [9, 11].

Capsaicin

Capsaicin, the chemical found in hot peppers, is a selective transient receptor potential vanilloid 1 (TRPV1) receptor agonist that results in the reversible loss of nociceptor afferents [12, 13]. In high doses (20 μg/20 μl), it can be applied topically to the neuroma to treat the pain for at least 12 weeks [12]. Due to activation of the TRPV1 receptors, patients usually experience a burning, stinging sensation at the site of application [13]. To avoid this, capsaicin can be injected directly into the neuroma with similar beneficial results and localized pain at the injection site that usually subsided after 4 h [12].

Hyaluronic Acid

Hyaluronic acid (HA) injection treatment has anti-inflammatory properties and promotes cell proliferation that are used in the treatment of tendon injuries and osteoarthritis [14]. Hyaluronic acid can have positive effects on facilitating the regeneration and organization of damaged axons due to its chemical properties [15]. Lee et al. used these properties for treatment of MN via injection of HA directly into the neuroma [14]. Results showed that MN pain was reduced for over a year and was able to lessen inflammation at the site [14]. However, there was no evidence of its ability to help regenerate the nerve and further studies need to be conducted [14].

ACHILLES TENDINOPATHY

The Achilles tendon is formed when the gastrocnemius muscle merges with the soleus muscle [16]. This merging can occur in two different ways: Type 1 (the most common one) has the aponeuroses of the gastrocnemius and soleus muscles merge 12 cm proximal to the calcaneal insertion [16]. Type 2 has the gastrocnemius aponeuroses directly insert into the aponeuroses of the soleus [16]. The exact cause of AT is currently unknown; however, the main cause is thought to be excessive and receptive stress to the tendon itself [16, 17]. Excessive heel striking while running is believed to cause a "whipping action" on the tendon that causes inflammation and/or degenerative damage to the tendon, predisposing it to tendinopathy [18]. Besides repetitive exertion to the tendon, other intrinsic factors that might cause AT are vascularization of the tendon, age, sex, body weight, height, and ankle stability [16, 18]. Patients with AT typically complain of tenderness at the posterior aspect of their heel and difficulty wearing footwear [19]. Clinical diagnosis of AT shows tenderness and swelling at the insertion point of the Achilles tendon with palpation then ultrasound (US) or magnetic resonance imaging (MRI) can be used to determine the extent of the degeneration of the tendon [19, 20].

US Imaging

While clinicians are able to diagnose AT clinically, the use of radiography imaging is beneficial to determine the severity of the tendinopathy [21]. When comparing US vs. MRI, both are able to diagnose AT; however research shows that US diagnosis is more accurate compared to MRI [22, 23]. In addition to being more accurate, US is more cost-effective and has the ability to dynamically assess muscles compared to MRI [21].

Injection Techniques

Injection techniques are a relatively newer treatment method for AT pain. However, there is not a sufficient amount of evidence to support it being recommended as a treatment option [24]. One form of treatment currently being researched is platelet-rich plasma (PRP) injections, which is thought to reduce chronic pain in patients with AT [24]. PRP treatment involves injection of a solution of increased platelet count compared to baseline of the body to promote platelet-derived growth factor levels (TGF-beta) to increase and promote healing [25]. In 2017, Chen et al. looked at PRP treatment in various tendon and ligament injuries and found that there was a significant decrease in short-term pain in PRP injection groups compared to control groups [26]. They saw an overall mean decrease in pain for rotator cuff injuries, anterior cruciate ligament (ACL) injuries, and lateral epicondylitis injuries between the experimental and control groups (MD = − 0.72, 95% CI − 1.10 to − 0.34; $P < 0.01$) [26]. However, in 2018 a study conducted by Zhang et al. looked at PRP injection benefits in AT treatment and they saw that there was no difference in mean improvements of Victorian Institute of Sport Assessment—Achilles scores (VISA-A) between the PRP and saline control groups (MD: 5.3, 95% CI [− 0.7 to 11.3] $P = 0.085$) [25]. Overall, both research groups state that there needs to be more research done on PRP therapy before it is recommended for treatment purposes [25, 26].

Prolotherapy

Another promising therapy is prolotherapy injection treatment. Yelland et al. reported in 2011 an increase in mean VISA-A score by 79% compared to eccentric loading exercises (ELE) at 73% (MD 27.5; 95% CI 12.8 to 42.2; $P < 0.0005$) [27]. There was a decrease in pain and limitation of activity after injection compared to ELE treatment for the first 12 months ($P < 0.0005$) [27]. However, the difference between the prolotherapy treatment group and ELE group was not significant overtime overall ($P = 0.105$) [27].

TARSAL TUNNEL SYNDROME

Tarsal tunnel syndrome (TTS) is a compressive neuropathy of the posterior tibial nerve or its branches within the tarsal tunnel, a fibro-osseous space located deep to the flexor retinaculum and postero-inferior to the medial malleolus [28, 29]. Causes of nerve entrapment include soft tissue irregularity (i.e., hypertrophic flexor retinaculum), space-occupying (i.e., osteophyte, tumor), inflammatory (i.e., rheumatoid arthritis), trauma, biomechanical, obesity, or lower leg edema [30]. Symptoms include paresthesia or hyperesthesia in the areas of the distal tibial nerve exacerbated by standing, walking, or foot eversion and dorsiflexion, which can progress to irreversible nerve injury, weakness, or muscle atrophy [30–32]. TTS is relatively uncommon with an unknown incidence, although it is more prevalent in adults, females, athletes, and individuals with prolonged standing or walking [30]. Diagnosis is based on clinical history and physical exam findings including a positive Tinel sign at the tarsal tunnel, and can be confirmed with MRI and nerve conduction studies [28, 31, 33].

In TTS, injection therapy with anesthetics or corticosteroids is considered a conservative measure often used as initial therapy, especially in cases in which nerve pain is not accompanied by a persistent neurological deficit [30, 31]. Decompression of the tibial nerve through surgical tarsal tunnel release is a frequently used treatment when conservative therapy fails [31, 34].

No randomized controlled studies on injection techniques in TTS have been conducted to date, attributable to the low incidence of the condition and the high frequency of surgical release. A study on electrophysiology outcomes in TTS noted that of the nine patients who received local tibial nerve steroid injections, six experienced symptomatic relief, while only two demonstrated nerve conduction improvement. Because all nine patients were treated by different providers, type and dosage of steroid injection was not included [35]. In a case report, a pediatric patient with TTS was treated by tibial nerve block performed under ultrasound guidance with 20 mg of tetracaine and 40 mg of methylprednisone acetate suspension. There was complete resolution of symptoms after two blocks 90 days apart [36].

Lipografting has shown initial potential as an adjunct to surgical tarsal tunnel release. Morandi et al. described a patient who, after an initial unsuccessful surgical tarsal tunnel release, presented with excess scar tissue, nerve compression, and distal denervation. During the revision tunnel release procedure, abdominal fat collected with liposuction was grafted to the released tarsal tunnel in an attempt to prevent repeat nerve compression. At follow-up, the patient had decreased pain and electromyogram showed signs of distal reinnervation. A concern with lipografting is the unpredictable fat graft resorption rate of between 30 and 80% in the first 3 months [37]. Overall, considering the frequent use of injections as conservative treatment for TTS despite a paucity of data on the subject, future randomized studies would be beneficial to determine optimal injection regimen and ensure safety for these patients.

PLANTAR FASCIITIS

Plantar fasciitis is characterized by heel pain due to tissue degeneration along the plantar fascia as a result of biomechanical overuse [38–40]. The prevalence is approximately 10% of the population, with an increased incidence in the middle aged, the elderly, and runners [41]. Risk factors include reduced ankle dorsiflexion,

prolonged standing in the workplace, and obesity [42]. Diagnosis is based on clinical symptoms, including pain along the medial tubercle of the calcaneus that is worse upon taking the first steps in the morning and weight bearing [43].

Multiple reviews and clinical studies have investigated injection techniques for plantar fasciitis. A review exploring the efficacy of injected corticosteroids (ICS) compared to placebo found that while ICS improved heel pain within 1 month of injection, they had no effect on average heel pain between 1 and 6 months after injection [44].

Platelet-rich plasma (PRP) contains growth factors that stimulate healing through angiogenesis and cell proliferation [38]. A meta-analysis found that PRP injections were associated with better outcomes than ICS only at 3-month follow-up, but not at 1, 6, or 12 month follow-up. Upon limiting analysis to only RCTs or high-sensitivity analyses, no difference existed between the two groups in function or pain at any time point [40]. More recently, one randomized study indicated that though both treatments improved outcomes for 18 months, corticosteroids had a greater improvement than PRP within 1 month of injection, and PRP had a more positive effect than ICS at 6-, 12-, and 18-month follow-ups [38]. Conversely, two other studies found that ICS and PRP both improved outcomes up to 16 weeks and 6 months, respectively, with no difference between level of improvement due to the two treatments [8, 9].

Shock wave therapy (SWT) is a pulsed sound wave that improves outcomes in plantar fasciitis by an unclear mechanism [47]. One meta-analysis found SWT and ICS both effectively improved pain and function with no intergroup difference at 3-month follow-up except a more improved visual analog scale (VAS) score in the SWT group. However, another meta-analysis suggested that pain improvement and success rate correlated with energy intensity level, with outcomes improved most by high-intensity SWT, followed by ICS, and lastly low-intensity SWT [47, 48]. A different study indicated that SWT provided better outcomes than placebo at 24-month follow-up [49].

To determine the longer-term effects of these treatments, Ugurlar and colleagues directly compared ICS, PRP, SWT, and prolotherapy with 36-month follow-up. PRP and prolotherapy were effective between the 3- and 12-month follow-up points. Pain was most effectively treated with ICS in the first 3 months, and was treated by SWT for the first 6 months. Notably, at the 36-month follow-up, there was no difference in VAS score among the four groups from before treatment, indicating that no treatment option produced long-term improvement in outcome [39].

Comparison of these conflicting results indicates that there is still significant ambiguity regarding the extent and duration of effects of each therapy. ICS, PRP, and SWT have all been reported as safe with side effects limited to brief erythema or throbbing pain at the therapy site [38, 39, 46, 47, 49]. Studies have shown that PRP is associated with decreased requirement for reinjection or surgery in the long term and positive effects on soft tissue regeneration and inflammation reduction, but its higher cost must also be considered when choosing a treatment [38, 45]. Considering that the study by Ugurlar and colleagues with longest follow-up for plantar fasciitis treatment found no difference in pain or function at 36 months compared to baseline, it would be beneficial to conduct further long-term studies directly comparing these treatments to elucidate outcomes.

GOUT

Gout is the most common form of inflammatory arthritis. It is characterized by disruptions in purine metabolism and urate excretion leading to increased serum uric acid levels, causing monosodium urate (MSU) crystal formation and deposition mainly in and near joints [50–52]. The four phases of the disease course are asymptomatic hyperuricemia, acute gouty attack, an intercritical period, and chronic tophaceous gout [51]. Risk factors include increased age, purine-rich diet including high consumption of meat and alcohol, obesity, hypertension, diabetes, and genetic

predisposition [50, 51, 53]. In the United States, the prevalence is 3.9% among adults with men more affected than women [54]. In 43–76% of patients, acute arthritis of the first metatarsophalangeal (MTP) joint is the first symptom of gout [55]. Gout is diagnosed by clinical findings and can be confirmed by MSU crystals in synovial fluid visualized under polarized light [51].

Although intra-articular corticosteroid injections are used frequently for plantar gout, there are no randomized controlled trials on the topic [56–58]. Kang and colleagues published a trial with 21 patients evaluating the safety and efficacy of intra-articular corticosteroid injections for acute gout flare of the first MTP joint. Under ultrasound guidance, the affected joint was injected with 0.5 ml (20 mg) triamcinolone with 0.5 ml of 2% lidocaine. All 21 patients experienced significant improvement in pain, general disability, and walking disability within 48-h post-treatment with average reduction on visual analog scale (VAS) of 48 mm (SD 27), 35 mm (SD 26), and 39 mm (SD 26), respectively. No adverse events occurred within the first 7 days post injection, the duration of the study [59].

Fernandez and colleagues reported on a case series of 19 patients who received intra-articular triamcinolone acetonide for acute gout attacks. The affected joints included 11 knees, four first MTP joints, three ankles, and two wrists. Patients were given 10 mg in knees and 8 mg in small joints. Based on VAS, 11 joints were resolved within 24 h and the remaining nine joints were resolved by 48 h, and no patients presented for return of pain in the initial joint within the next 30 days [60].

Despite the lack of randomized trial data on intra-articular corticosteroid injections for gout, they are generally considered to have good safety profiles. Intra-articular glucocorticoids have been shown to be safe and effective in treating knee osteoarthritis and rheumatoid arthritis compared to placebo, and these findings have been generalized to gout treatment as well [57, 61, 62]. Intra-articular steroid injections are recommended by both European League Against Rheumatism and the American College of Rheumatology for the treatment of gout [58, 63]. They are often used when systemic steroids, colchicine, or non-steroidal anti-inflammatory drugs are contraindicated [59]. The ACR recommends that dosing be based on the size of the affected joint [63]. Further testing should be specifically conducted in patients with gout to generate both acute and long-term data about efficacy, symptom recurrence, and safety.

ANKLE OSTEOARTHRITIS

Introduction

Recent estimates predict that 10–15% of all adults over the age of 60 suffer from some form of osteoarthritis (OA), making it a leading cause of disability worldwide [64]. Various factors contribute to this high incidence of OA including increasing population age, trauma, exercise, genetics, and obesity [64]. It is predicted that as the population ages and incidence of obesity continues to rise, the disease burden of osteoarthritis will rise with it [64].

OA of the foot and ankle is not as well studied as OA of the knee and hip, although data suggests that the incidence of foot OA is comparable to knee OA in some populations [65–67]. Pain in foot and ankle OA is largely managed conservatively, with physical therapy, foot orthotics, non-steroidal anti-inflammatory medications, and intra-articular (IA) injections [68]. Given the recent understanding of the high prevalence of foot and ankle OA, a more in-depth understanding of conservative treatment options for these joints is needed.

Injection Technique

When considering the treatment of foot and ankle OA with IA injections, it is important to first establish the appropriate injection technique. In a comparison between use of superficial landmarks alone vs. ultrasound-guided injection into cadaveric midfoot joints, accuracy of injection was found to be significantly better in US-guided injection (64 vs. 24% in landmark only) [69]. The results of this study were put into practice by Dankarini et al.,

showing significant clinical improvement of foot pain following US-guided injections for up to 3 months in the majority of those treated [70]. As the use of ultrasound in clinical practice continues to rise, US-guided injections could prove to be a safe way to manage foot and ankle OA pain non-surgically, however more data is needed to assess its efficacy and cost-effectiveness [71].

INJECTION SUBSTRATES

Corticosteroids

Corticosteroids (CS) have been widely used as non-surgical treatment for OA in clinical practice, yet very few studies have been done to prove its efficacy in foot and ankle OA [72]. The use of IA corticosteroids for ankle OA is limited to two studies [73]. Sarkin studied the effects of IA injections in 100 patients with ankle OA and found significant evidence that patients with less severe OA benefit more from corticosteroid injections [74]. More recently, Fox et al. found a significant reduction in pain following injection of triamcinolone acetonide and bupivacaine into the tibiotalar joint, although there was no follow-up pain assessment after the initial injection so the effects of the steroids vs. anesthetic is unclear [75].

The only RCT involving the use of IA corticosteroid for foot OA was done by Pons et al., who compared treatment of foot OA with hyaluronic acid (HA) vs. CS injection in 40 patients. While both patient populations had significant improvement in pain for up to 56 days following injection, patients who received HA had significantly improved pain with walking when compared to CS patients [76]. The only other three clinical studies involving IA corticosteroids for foot OA have supported its clinical efficacy, with each finding a majority of patients achieving significant pain relief for up to 3 months following injection ($n = 180$) [70, 72, 77]. Importantly, one study noted that patients with a BMI < 30 had sustained pain relief for up to 12 months following treatment [72].

Hyaluronic Acid

Currently, there are a total of 18 studies assessing the effectiveness of IA injections of HA in the treatment ankle OA, seven RCTs, nine case series, and two prospective cohort studies [73, 78]. Each case series and the two prospective cohort studies concluded that intra articular HA was an effective and tolerable in the treatment of osteoarthritic ankle pain, with some studies noting pain relief for up to 12–-18 months following injection [73, 78]. All seven RCTs concluded that intra-articular HA injections lead to significant relief of ankle pain. Of note, three RCTs observed the effects of HA vs. saline injection. Two of the three found a significant improvement in pain relief with HA compared to saline, however DeGroot et al. did not [79–81]. Despite this discrepancy, pooled data between these three studies did show a significant difference in pain relief at 6 months with HA over saline injection [73].

Two RCTs have been done assessing the use of HA in treatment of foot OA, comparing HA to either saline [82] or corticosteroid injection [76]. Both trials showed clinical improvement of pain for 3 months following injection. As previously mentioned, Pons et al. found that HA had significantly better results than CS injection, although both resulted in significant pain reduction [76]. Munteanu et al. found that HA was no better than saline in reducing pain, although both treatment groups did report significant pain relief for up to 6 months [82].

Platelet-Rich Plasma (PRP)

Three studies have been done to assess the efficacy of IA PRP in ankle OA [83–85]. The first study assessing PRP in ankle OA was conducted on five patients with OA and found no benefit in treatment on 3- or 6-month follow-up [85]. More recently, both Fukawa et al. and Repetto et al. found that injections of PRP were safe and efficacious in ankle OA, with significant pain reduction for up to 24 weeks for Fukawa and an average of 17.7 months for Repetto [83, 84].

Mesenchymal Stem Cells (MSC)

One study exists using MSCs in the treatment of ankle OA [86]. Emadedin et al. studied six patients with ankle OA and found dramatic improvement in ankle pain and function. Patients improved from an average walking distance of 1010 m at baseline to 2333 m at 30 months and an average Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain score of 40.0 at baseline to 8.3 at 30 months.

RHEUMATOID ARTHRITIS

Introduction

Rheumatoid arthritis (RA) is a chronic autoimmune synovitis characterized by swelling, tenderness, and destruction of synovial joints leading to severe disability [87]. It has proven to be the most common cause of autoimmune arthritis in adults with an estimated 1.3 million Americans currently affected [88]. Several treatments exist for the treatment for symptomatic RA including disease-modifying antirheumatic drugs (DMARDs), biologics, tofacitinib, and glucocorticoids [89]. However, when pharmacological treatment fails, or when one joint remains symptomatic despite medical treatment, further methods of treatment should be considered. Intra-articular glucocorticoids have shown to exert their effects in patients with RA by reducing synovial perfusion and volume, increasing joint fluid viscosity, and decreasing erythema, heat, and tenderness in affected joints [90].

Injections

Intra-articular steroids have been used to treat synovitis for over 60 years [91] and since then have remained a mainstay of treatment in patients with RA despite a relative paucity of controlled studies assessing its effectiveness [92]. One of the few controlled studies, the CIMESTRA trial, showed that treatment of early RA with oral methotrexate combined with intra-articular injections of corticosteroid resulted in significant symptomatic improvement by ACR20 criteria [93].

Multiple studies assessed the efficacy of US-guided injections in patients with RA of the ankle and found significant evidence suggesting that US-guided injection was significantly more accurate than clinically examined injection [92, 94] with one study noting the accuracy of the injection was correlated significantly with improvement of joint function up to 6 weeks following injection [94].

Current studies examining the effects of intra-articular steroids for patients with RA affecting the ankle have been limited. Lopes ($n = 54$), Cunnington ($n = 25$), and Furtado ($n = 45$) all found significant improvement in VAS score for ankle pain following IA corticosteroid injection, although length of significant pain relief varied vastly from 1 week to 12 weeks following injection [92, 94, 95].

One study compared the effects of IA injections of methotrexate (MTX) to IA corticosteroids in 100 patients with RA of multiple medium-sized joints (58 ankles) and found that both groups achieved significant pain relief up to 20 weeks following injection, however MTX had a significantly longer anti-inflammatory effect than corticosteroids as confirmed by degree of synovial inflammation on power Doppler [96]. While the results of these trials are promising, more randomized controlled trials are needed assessing IA injections for the treatment of ankle RA.

POSTERIOR TIBIAL TENDON DYSFUNCTION

Posterior tibial tendon dysfunction (PTTD), also known as flatfoot, is a collapse of the medial longitudinal arch of the foot [97]. The posterior tibial tendon is the main tendon that provides dynamic support of the longitudinal arch of the foot. If this tendon is damaged, it will result in flattening of the foot [98]. PTTD is the result of a multifactorial process: hypo-vascularization of the tendon, obesity, and genetics [97]. Its severity is graded by the Johnson and Strom classification system from I–III, which was

expanded upon by Myerson by adding stage IV to the system in 1997 [97]. Stage I consists of posterior tibial tendon tenosynovitis with no arch collapse; stage II will have arch collapse and be unable to perform a single leg heel raise; stage III has fixed deformity with hindfoot valgus and forefoot abduction; and finally stage IV will have fixed foot deformity with degenerative changes in the ankle joint [97–99]. PTTD affects around 3.3–10% of the population, most commonly in elderly women over the age of 40 [97, 100, 101]. Diagnosis of PTTD is typically done with an anteroposterior (AP), lateral, and hindfoot weight-bearing radiography [97, 100]. Simmons angle, increased talo-first metatarsal angle, will be present on the AP footage, foot abduction at the talonavicular joint, and access the degree of arch collapse [97, 100]. Magnetic resonance imaging (MRI) is not as useful in evaluating PTT; however, it can be helpful to determine any ligamentous involvement for surgical purposes [97].

Injection

Non-surgical treatment of PTTD is often injection of anesthesia directly into the PTT under US imagining guidance [102]. Cooper et al. conducted a trial to determine the effectiveness of 1% lidocaine treatment on PTT symptoms and noted that 100% of the ankles injected with anesthesia initially had complete relief of symptoms [102]. However, it was also noted that 88% of the ankles had abnormal increased fluid signals within the sheath and mild tendinosis [102]. In the past, clinicians typically inject anesthesia blindly into the upper third of the anterior portion of the tibia due to the large "safety window" compared to the posterior portion [103]. However, there was a risk of improper injection location in the posterior tibial tendon (11%) or neurovascular injury [103, 104]. Rha et al. used US to greatly increase the effectiveness and accuracy of injection of anesthesia into the upper third of the tibialis posterior muscle ($p < 0.01$) [103]. They concluded that compared to conventional needle injection techniques, US guidance was able to increase the accuracy of the placement in the "safety window" and lower the incidence of neurovascular injury [103]. Botulinum toxin, another potential treatment for PTTD, also requires precise and proper injection into the tendon due to the diffuse-adverse side effects that result from a large dose [105]. US guidance showed an increased rate of accurate injection of botulinum toxin into the posterior tibial tendon and increase the effect of the treatment on the patient.

CONCLUSIONS

Chronic foot and ankle pain is a common ailment in the general population and causes limited mobility and pain that can put patients at a higher risk of falling and decreased ability to perform activities of daily living. Traditional management of this pain is surgical intervention that can be costly, have long recovery times, and have variable degrees of efficacy. To combat this, minimally invasive injection-based treatments have been in development with the goal to decrease pain, improve mobility, and increase overall quality of life. Injection therapy may provide pain relief and improvement in the clinical condition but they do not come without certain limitations including potential failure. In the event that injections are not beneficial for the discussed syndromes, evaluation for surgical intervention may need to be obtained. While there appears to be positive outcomes due to injection-based treatment in small-scale trials, further studies are needed to evaluate the positive effects of injection-based treatment for chronic foot and ankle pain.

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