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Review

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Efficacy of plantar fascia injections under ultrasound guidance versus landmark and scintigraphic guidance: A systematic review

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Abstract

Objectives: In this review, we discuss the efficacy of minimally invasive injection therapies for the treatment of plantar fasciitis (PF) using ultrasound (US)-guidance compared to landmark-guided or alternative imaging modalities.

Materials and methods: A systematic review was conducted in accordance with the Cochrane methodology from April 2023 to August 2023. A multisystem search was performed including PubMed, Ovid Embase, Web of Science, and Scopus for English published articles. Branched logic was used to include articles containing terms regarding PF, US and injections. Two authors screened studies for eligibility, and any disagreements were resolved through discussion with a third reviewer. Risk-of-bias assessments were performed.

Results: The search identified 2,068 publications; six studies were included in the review, comparing various local delivery techniques for the treatment of PF. All studies compared US- to landmark-guided local steroid injections, with one study also comparing scintigraphic-guidance. In the short- to mid-term, there was a significant improvement using all delivery methods with only one study that utilized an angle-adjustable device to aid in needle placement with US guidance showing statistical improvement compared to landmark-guided injections.

Conclusion: This systematic review demonstrates that pain outcomes are comparable between US-guided and landmark-guided injections for PF. However, US-guided techniques may offer additional practical advantages, such as improved visualization of anatomy, potentially enhancing safety and patient confidence. Clinicians should consider these procedural benefits in conjunction with efficacy outcomes when making treatment decisions.

Keywords: Plantar fasciitis, systematic review, ultrasound; injections.

Plantar fasciitis (PF) is a common and often debilitating condition characterized by inflammation of the plantar fascia, a thick band of connective tissue that supports the arch of the foot.[1,2] The majority of patients typically experience heel pain along the origin of the plantar fascia at the medial calcaneal tubercle.[3] Risk factors for developing PF are multifactorial and include obesity, excessive foot pronation, pes planus, high-heel arch (pes cavus), reduced ankle dorsiflexion (e.g., tight heel cord), or through repetitive microtrauma (e.g., prolonged standing

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or running).[3,4] Although the diagnosis can be made clinically, selected imaging modalities may aid in establishing the correct diagnosis including magnetic resonance imaging (MRI), diagnostic ultrasound (US), plain radiographs and scintigraphy.[4-7] Plantar fasciitis is typically a self-limiting condition with favorable outcomes. Nearly 80% of patients experience resolution of symptoms within one year.[4,8-11] To date, a variety of conservative treatments for PF have been described including activity modification, orthotic devices and night splints, physical therapy, anti-inflammatory drugs, and extracorporeal shock-wave therapy (ESWT), and injection therapies with limited high-quality randomized-controlled trials (RCTs).[12-15]

Patients with chronic, refractory PF persisting for more than six months may be considered for minimally invasive injection therapies or surgery aimed at alleviating pain and/or improving functional outcomes. Minimally invasive injections for the treatment of PF include corticosteroids, dry-needling, botulinum toxin A (BoNT-A), and platelet-rich plasma (PRP).[15-17] These focal injection therapies have been carried out using varying techniques for delivery of treatment utilizing landmark-, US-, and scintigraphy-guided approaches.[18-21]

In recent years, high-frequency US has emerged as a valuable diagnostic and interventional tool in the field of musculoskeletal medicine allowing for real-time imaging, dynamic evaluation of soft-tissue structures, limited radiation exposure, and accurately guiding interventional procedures.[19,22] In this review, we discuss the efficacy of minimally invasive injection therapies for the treatment of PF using US-guidance compared to landmark-guided or alternative imaging modalities.

MATERIALS AND METHODS

Search Strategy

A systematic review was conducted in accordance with the Cochrane methodology. The literature search was carried out between April 2023 and August 2023. Review guidelines were established prior to performing the search. A multisystem search was performed (PubMed, Ovid Embase, Web of Science, and Scopus) for English published articles. We utilized branched logic to include articles containing terms regarding PF (Plantar Fasciitis OR Plantar Fascia OR Plantar Fasciopathy OR Heel OR Heel Pain) AND (Ultrasound OR Ultrasonography OR Sonography OR Ultrasound-Guided)) AND ((Ultrasound-Guided Injection OR Injection OR Corticosteroid Injection OR Plantar Fascia Injection OR Corticosteroid) OR (Saline Solution OR Placebo OR Local Anesthetics OR OrthoBiologics OR Platelet-Rich Plasma OR Whole Blood OR Mesenchymal Stem Cells OR Amnion OR Adipose Tissue OR Fat Injection OR Dextrose OR Botulinum Toxins OR Fasciotomy OR Tenotomy OR Tenex OR Prolotherapy OR Electrolysis OR High-Energy Shock Waves OR Palpation OR Anatomic Landmarks OR Physical Therapy). Two researchers screened studies for eligibility, and any disagreements were resolved through discussion with a third reviewer.

Outcome Measures

The main outcome for this systematic review was to evaluate the efficacy of the US-guided intervention in alleviating pain compared to an alternative injection modality. There were insufficient/unavailable studies for the comparison of injection accuracy.

Data Abstraction

Data abstraction was completed by a standardized approach for each study. In our data abstraction, we included the following fields where appropriate: first author, study objective, study design, country location of the study, age in terms of years of the participants, eligibility criteria outlined by the study, number of cases and controls, and results of the study. The outcomes reported in these studies included the efficacy of the injection treatment, the delivery method, and patient-reported outcome measures. A summary of the included studies is presented in Table 1.

Assessment of Study Quality

The revised Cochrane Risk-of-Bias Tool for Randomized Trials (RoB 2) was utilized to assess the studies included in our systematic review. The RoB 2 is a comprehensive and widely adopted tool designed to assess the risk of bias in RCTs

Table 1. Characteristics of studies included

No.	Study	Design	Country	Level of evidence	Age in Years (range) and country	Eligibility criteria	Number of cases and controls	Risk Factors values in cases and controls (Presented as number of participants (%) or mean values (SD) unless otherwise noted)	Results
1	Ball et al.,[26] 2013	Randomized controlled trial	UK	II	Mean 49 years (SD 11.3 years) med range of duration of symptoms 6 month (range 2.5–60 month)	Inclusion criteria were a history of heel pain combined with point tenderness over the medial tubercle of the calcaneus, and failure to respond to at least 8 weeks of conservative therapy. Exclusion criteria were a diagnosis of inflammatory arthritis, prior surgery or trauma to the heel, or a previous steroid injection into the heel pad.	65 patients, 22 US steroid injection, 21 PG steroid injection, 21 US placebo injection	Values listed in or-der of US, blind, US placebo Age, mean (SD) years 49.0 (12.9), 49.1 (10.7), 50.1 (10.6), Duration of symp-toms, median (IQR) months 6 (6–10), 6 (5–11), 7 (5–18) BMI, mean (SD) kg/m^2 30.7 (5.1), 31.8 (5.0), 32.4 (5.7), Male sex, n (%) 10 (45%), 8 (36%), 11 (52%), Baseline plantar fascia thick-ness, mean (SD), mm 6.1 (1.6), 6.2 (1.4), 5.8 (1.4), Positive power Doppler signal, n (%) 5 (23%), 7 (32%), 4 (19%), Calcification, n (%) 5 (23%), 5 (23%), 3 (14%), Decreased echogenicity, n (%) 12 (55%), 7 (32%), 8 (38%), Pronated foot score >+6, n (%) 17 (77%), 13 (59), 14 (67), Supinated foot score <−1, n (%) 2 (9%), 0 (0%), 1 (5%), Baseline heel tenderness index, mean (SD) 1.7 (0.8), 2.0 (0.7), 1.9 (0.7), Baseline heel pain VAS score, mean (SD) 62.0 (19.2), 65.5 (19.6), 56.0 (27.9)	Significant difference in VAS scores between the groups at 6 and 12 weeks (p = 0.018 and p=0.004, respectively). There was a 19.7 (95% CI 2.5 to 37.0) difference in mean VAS scores at 6 weeks between the ultrasound guided steroid group and the placebo group and a 24.0 (95% CI 6.6 to 41.3) difference between the unguided steroid group and the placebo group at 6 weeks. At 12 weeks, the mean difference was 25.1 (95% CI 6.5 to 43.6) and 28.4 (95% CI 11.1 to 45.7) respectively between both steroid injection groups and the placebo group. There was no difference in VAS scores following steroid injection between the ultrasound guided and the unguided groups at either time point. Plantar fascia thickness was significantly reduced after injection in both active treatment groups (p = 0.00).
2	Chen et al.,[24] 2013	Randoized controlled trial	Taiwan	II	55.69 ± 9.38 years in the US group, 54.25 ± 11.70 years in the palpation guided	The inclusion criteria were as follows: (1) 20 years or older; (2) unilateral inferior foot pain with tenderness to pressure at the origin of the plantar fascia on the medial tubercle of the calcaneus for at least 8 week; (3) worsening of inferior foot pain with activity and/or upon arising in the morning; and (4) failure after at least 4 weeks of conservative treatments such as orthoses, stretch exercises, nonsteroidal anti-inflammatory drugs, ultrasound diathermy, or transcutaneous electrical stimulation. The exclusion criteria were (1) previous local invasive procedures such as injection or operation and (2) systemic inflammatory disease, connective tissue disease, lumbar spine herniated disc, or previous local trauma	33 total patients, 16 US and 17 Palpation guided	Age, years: US 55.69 ± 9.38, PG 54.25 ± 11.70, Body height, m US 1.61 ± 0.06 PG 1.63 ± 0.07, Body weight, kg US 70.13 ± 10.33, PG 75.25 ± 11.26 Body mass index, kg/m^2 US 27.09 ± 2.58, PG 28.27 ± 3.04, Sex US M-5 (31.3) F-11 (68.7), PG M-8 (50) F-8 (50)	Thirty-three patients who received either device-assisted ultrasound guided or palpation-guided injection had significantly lower visual analog scale scores (P G 0.001) and higher tenderness threshold (P G 0.01) postinjection. However, the device-assisted group had higher tenderness threshold (9.02 T 1.38 *vs.* 7.18 T 2.11 kg/cm^2; p = 0.007), lower visual analog scale score (1.88 T 2.13 *vs.* 3.63 T 2.60; p = 0.046), and lower hypoechogenicity incidence in the plantar fascia (3/16 *vs.* 9/16; p = 0.033) than the palpation-guided group did at 3 mos. postinjection. The heel pad was significantly thinner (p = 0.004) in the palpation guided group postinjection.

Table 1. Continued

No.	Study	Design	Country	Level of evidence	Age in Years (range) and country	Eligibility criteria	Number of cases and controls	Risk Factors values in cases and controls (Presented as number of participants (%) or mean values (SD) unless otherwise noted)	Results
3	Kane et al.,[19] 2001	Randomized controlled trial	Ireland	II	Mean age 58 ± 2.19 years	Consecutive patients presenting to a rheumatology out-patient clinic with idiopathic plantar fasciitis unresponsive to conservative treatment were assessed. Exclusion criteria included any history of acute heel trauma preceding the onset of plantar fasciitis, previous surgical intervention to the heel or corticosteroid injection of the heel within 6 weeks prior to assessment.	14 US heels (13 patients), 10 heels palpation guided	There was no significant difference in the duration of symptoms, BMI, mean VAS or mean HTI at baseline in the two randomized groups.	Ultrasound- and palpation-guided injection resulted in significant mean improvements in VAS [39.6 ± 9.2 (ultrasound) *vs.* 41.5 ± 8 (palpation)] and HTI [1.35 ± 0.2 (ultrasound) *vs.* 1.3 ± 0.4 (palpation)]. There was no significant difference in the response rate following corticosteroid injection by either modality (ultrasound=13/14, palpation=8/10). Following injection, the mean thickness of the plantar fascia decreased from 5.7 ± 0.3 mm to 4.65 ± 0.4 mm ($p < 0.01$).
4	Saba and El Sherif[23] 2016	Randomized controlled trial	Egypt	II	40 (45.20 ± 11.75) US, 46 (46.45 ± 8.84) Palpation, 45.5 (45.90 ± 7.55) control	Inclusion criteria were chronic unilateral PF unresponsive to conservative treatment for at least 3 months. Patients were excluded from the study if they had received a previous cortico-steroid injection for PF, or if they had any of the following: a known hypersensitivity to corti-costeroids, current pregnancy, current skin or soft tissue infection at or near the injection site, heel fat pad atrophy, posterior heel pain, rheumatologic disorders, endocrine disorders, metabolic disorders, peripheral arterial insufficiency in the lower limbs, previous local surgery, or a history of local heel trauma and neurological disorders as peripheral neuropathy or tarsal tunnel syndrome.[16] Patients with a diagnosis of bilateral PF were also not enrolled in the study to exclude any potential systemic disease.[4]	10 US patients, 11 Palpation guided, 20 control feet from 10 individuals	Age, weight, height, BMI (all patients and controls were female) Values listed in order of US, PG, and control Age (year) 40 (45.20 ± 11.75), 46 (46.45 ± 8.84) 45.5 (45.90 ± 7.55) Weight (kg) 92.50 (92.45 ± 6.89), 96.00 (91.27 ± 14.81), 91.50 (89.50 ± 11.72) Height (cm) 160.25 (159.40 ± 3.57), 161.00 (158.45 ± 6.23), 160.50 (160.80 ± 7.49 BMI (kg/m^2) 36.60 (36.37 ± 2.55), 36.50 (36.45 ± 6.05), 34.50 (34.79 ± 5.31) Occupation (house-wife/employed) 6/4 (60/40), 7/4 (63.6/36.4), 10/10 (50/50), Side (right/left) 6/4 (60/40) 5/6 (45.5/54.5) 10/10 (50/50) Duration of the condition (months) 14.00 (25.20 ± 23.21) 15.00 (24.54 ± 22.24) NA	There was a statistically significant reduction in VAS, Plantar Fasciitis Pain/Disability Scale, plantar fascia thickness and improvement in plantar fascia echogenicity after treatment in both patient groups; however, there were no statistically significant differences between both groups. The plantar fascia thickness was statistically significantly thicker in both groups in relation to control group before injection and after it by 2 weeks and 4 weeks. The plantar fascia hypoechogenicity was found exclusively among patient groups before injection. At 4 weeks after injection, the hypoechogenicity disappeared in all patients of both groups.

Table 1. Continued

No.	Study	Design	Country	Level of evidence	Age in Years (range) and country	Eligibility criteria	Number of cases and controls	Risk Factors values in cases and controls (Presented as number of participants (%) or mean values (SD) unless otherwise noted)	Results
5	Tsai et al.,[25] 2006	Randomized control trial	Taiwan	II	Palpation group mean age 49.8 ± 10.8 years US group 53.0 ± 11.4 years	Twenty-five consecutive, otherwise healthy individuals with the diagnosis of unilateral plantar fasciitis seen at the outpatient clinic of a university hospital were enrolled in this study. Patients with systemic inflammatory disease, connective tissue disease, herniated intervertebral disc of the lumbar spine, or previous local trauma and those with bilateral plantar fasciitis were excluded from the study. All patients received conservative treatment of plantar fasciitis, including nonsteroidal anti-inflammatory drugs, ultrasound diathermy, transcutaneous electric nerve stimulation, or stretching exercise for at least 2 months without significant improvement.	12 US patients and 13 palpation guided	Age (years) PG 49.8 ± 10.8, US 53.0 ± 11.4 Sex (M/F) PG 3/10, US 5/7 Height (cm) PG 1.60 ± 0.07, US 1.64 ± 0.09 Weight (kg) PG 67.7 ± 13.0, US 67.8 ± 3.5 BMI (kg/m^2) PG 26.9 ± 4.8, US 25.1 ± 1.3	Both VAS- and TT-measured levels of pain improved significantly after steroid injection in both groups ($p < 0.001$). Also, the thickness decreased significantly after injection ($p < 0.01$ in the palpation guided group; $p < 0.001$ in the sonographically guided group). The number of patients with hypoechogenicity at the proximal plantar fascia decreased after steroid injection in both groups ($p < 0.01$ for both groups). The recurrence rate of plantar fasciitis in patients of the palpation-guided group (6/13) was significantly higher than that of the sonographically guided group (1/12) ($p < 0.05$).
6	Yucel et al.,[21] 2009	Randomized controlled trial	Turkey	II	Mean age 45.8 ± 12 years	Between 2003 and 2006, 27 patients admitted to the Orthopaedics and Traumatology Department with the diagnosis of plantar fasciitis were included in this study. The enrolled patients had undergone unsuccessful conservative treatment with nonsteroidal anti-inflammatory drugs, foot orthoses, and stretching exercises. The diagnosis of plantar fasciitis was based on tenderness localized to the medial tubercle of the calcaneus and pain, which started with the first step in the morning, receded thereafter, and worsened with weight-bearing activity. The exclusion criteria were surgical intervention, corticosteroid injection within 6 weeks of the start of the study, acute heel trauma, systemic inflammatory disease, connective tissue disease, lumbar herniated nucleus pulposus, local infections, coagulation disorders, and pregnancy.	35 heels of 27 patients 11 UG patients, 10 Palp, 6 scintigraphy guided	Values listed in order US, PG, SG Age: 41.9 (10.5), 49.7 (15.5), 47.4 (8.4) Sex (M/F): 2/9, 3/7, 0/6 Weight: 78.5 (8.5), 78.3 (14.1), 74.5 (12.6) Height: 164.8 (7.0), 164.8 (9.5), 156.5 (1.5) BMI: 28.7 (3.6), 28.5 (4.1), 30.1 (5.1)	VAS values before treatment, the VAS values were 5.6 ± 2.5, 6.4 ± 2.7, and 4.9 ± 2.0 in the UG, PG, and SG groups, respectively. After treatment, the VAS values were 1.3 ± 1.2, 2.2 ± 2.5, and 0.8 ± 1.0 in the UG, PG and SG groups, respectively. The VAS value for all the groups decreased from 5.1 ± 2.6 to 1.1 ± 1.7. The average plantar fascia thicknesses before treatment were 4.2 ± 1.1, 5.4 ± 1.1, and 3.5 ± 1.4 mm in the UG, PG and SG groups, respectively. After treatment, the corresponding values were 3.0 ± 1.2, 3.7 ± 1.4, and 3.3 ± 1.1 mm, respectively. The average fat pad thicknesses before treatment were 6.9 ± 1.3, 8.3 ± 2.4, and 8.7 ± 1.8 mm in the UG, PG and SG groups, respectively. After treatment, the corresponding values were 8.9 ± 1.2, 9.6 ± 3.5, and 9.5 ± 1.1 mm in the UG, PG and SG groups, respectively. Plantar fascia hypoechogenicity decreased from 7/15 (46.7%) to 0/15 (0%), from 10/11 (90.9%) to 2/11 (18.2%), and from 2/9 (22.2%) to 1/9 (11.1%) in the UG, PG and SG groups, respectively. The hypoechogenicity of all the groups decreased from 19/35 (54.3%) to 3/35 (8.6%). In the UG group, there was a statistically significant difference between the before-injection and follow-up values for plantar fascia thickness, fat pad thickness, and VAS ($p < 0.05$). In the PG group, there was a statistically significant difference between the before-injection and follow-up values for plantar fascia thickness and VAS ($p < 0.05$), and a weak statistically significant difference in fat pad thickness ($p = 0.056$). In the SG group, there was a statistically significant difference in VAS ($p < 0.05$) but the differences between the before-injection and follow-up values for plantar fascia thickness and fat pad thickness were not statistically significant ($p > 0.05$). Comparisons of the plantar fascia and fat pad thicknesses and VAS value between groups Between the UG and PG groups, there was a difference only in plantar fascia thickness before injection ($p = 0.017$, MWU = 36.5). Between the UG and SG groups, there was a difference only in fat pad thickness before injection ($p = 0.023$, MWU = 29.5). Between the PG and SG groups, there was a difference only in plantar fascia thickness before injection ($p = 0.006$, MWU = 13).

SD, standard deviation; US: Ultrasound; IQR, interquartile range; BDI: Body mass index; HTI, Heel Tenderness Index; VAS, Visual Analog Scale; TT, tenderness threshold; UG, ultrasound-guided; PG, palpation-guided; SG, scintigraphy-guided.

included in systematic reviews and meta-analyses. The tool covers five primary domains: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result. Each domain is assessed through a series of signaling questions that guide reviewers in evaluating the risk of bias for each included study. The incorporation of the RoB 2 tool allows for a nuanced examination and appraisal of RCTs and aids in determining whether a study is at risk of "low", "some concerns", or "high risk" for bias.

RESULTS

Overview

Initially, a total of 2,068 articles were identified to include our search terms: 644 articles from PubMed, 505 articles form Ovid Embase, 464 articles from Web of Science, 455 articles from Scopus, and two systematic review bibliographies. There were 617 duplicate records which were removed prior to screening. A total of 1,452 articles were screened across all databases. Of them, 1,420 were excluded based on their title and abstract. A total of 29 articles underwent a full text review for eligibility. Out of these articles that had a full text review, 24 articles were excluded, as they had the wrong intervention, wrong study design (such as case report or case series or open letter to the editor), incomplete data, or did not include a comparison group. Six studies were ultimately included for final review after meeting the established criteria (Figure 1).

Risk of Bias Assessment

Out of the six studies, all were assessed using the RoB 2. The summary of these evaluations is shown in Tables 1 and 2. Six trials compared different techniques (US, palpation, scintigraphy) to guide local steroid injections for the treatment of PF.[19,21,23-26]

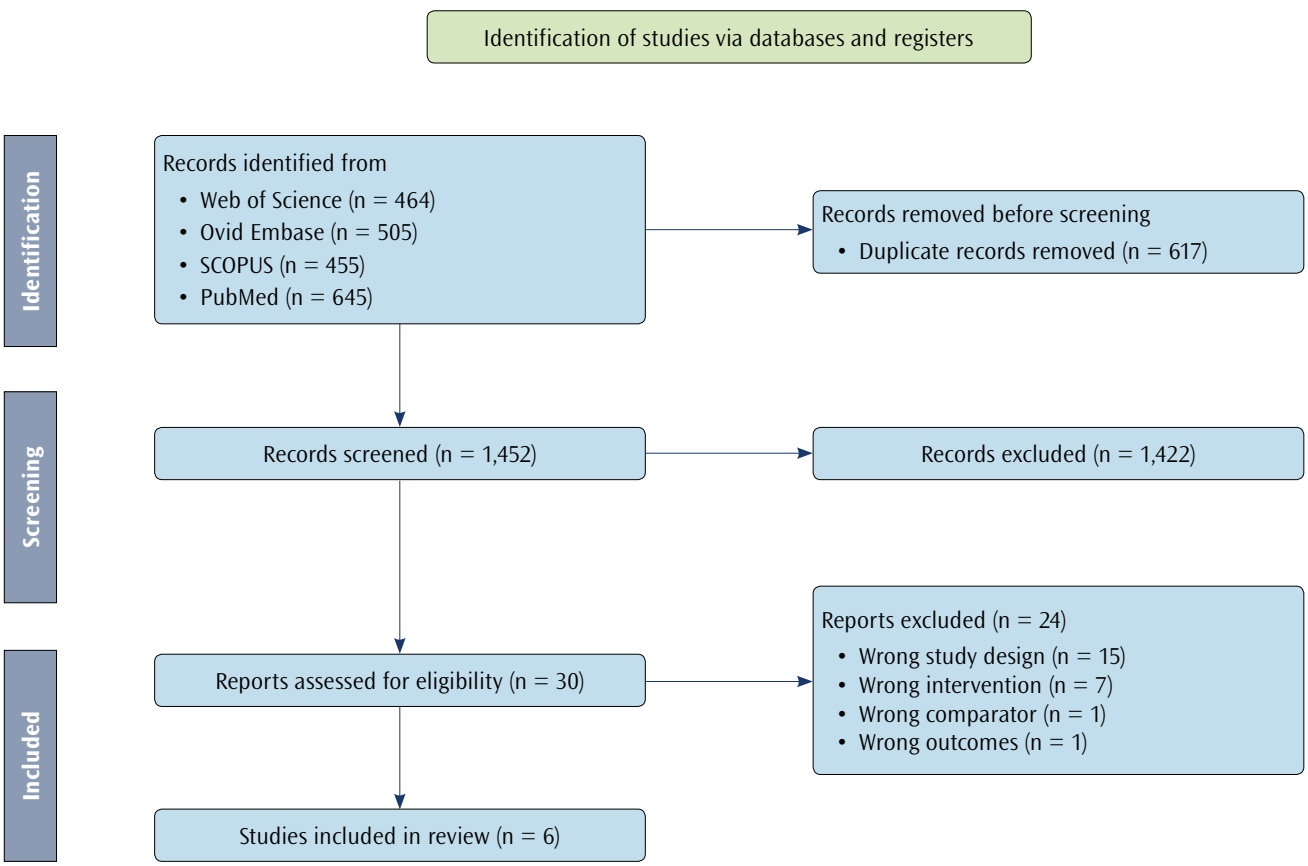

Figure 1. PRISMA flow diagram illustrating identification, screening, eligibility, and inclusion of studies.

Table 2. Quality Assessment using the Revised Cochrane Risk-of-Bias Tool for Randomized Trials (RoB 2)

Articles	Domain 1	Domain 2[1]	Domain 2[2]	Domain 3	Domain 4	Domain 5	Assessment
Ball et al.,[26] 2012	Low risk	Low risk	Low risk	Some concerns	Some concerns	Low risk	Some concerns
Chen et al.,[24] 2013	High risk	Some concerns	High risk	Low risk	High risk	Low risk	High risk of bias
Tsai et al.,[25] 2006	High risk	High risk	High risk	Low risk	Some concerns	Low risk	High risk of bias
Yucel et al.,[21] 2009	High risk	High risk	High risk	High risk	High risk	High risk	High risk of bias
Kane et al.,[19] 2001	High risk	High risk	High risk	Low risk	Some concern	Low risk	High risk of bias
Saba and El Sherif[23] 2016	Some concerns	High risk	High risk	High risk	High risk	Low risk	High risk of bias

1 (effect of assignment to intervention); 2 (effect of adhering to intervention).

One of the earlier studies by Kane et al.[19] compared US-guided versus palpation-guided injections of 23 patients (28 heels) who failed at least eight weeks of conservative treatment. The authors evaluated the Visual Analog Scale (VAS) and the Heel Tenderness Index (HTI) scores from baseline to follow-up (median = 14.3 weeks). Fourteen heels were assigned to receive US-guided injections, 10 heels were allocated to the palpation-guided injection group, and four heels did not receive any injections. Both the US- and palpation-guided injections led to significant improvements in the mean VAS scores [39.6 ± 9.2 (US) *vs.* 41.5 ± 8 (palpation)] and HTI [1.35 ± 0.2 (US) *vs.* 1.3 ± 0.4 (palpation)]. While both groups experienced a significant improvement in the mean VAS and HTI scores, there was no significant difference by either mode of delivery. The RoB 2 was judged to be 'high-risk' for bias given lack of clear participant or assessor blinding. There were also baseline patient characteristic imbalances which could produce additional source of biases.[27]

Ball et al.[26] compared US-guided steroid injections to placebo injections, as well as, landmark-guided steroid injections. Sixty-five patients with PF were followed at 6 and 12 weeks with no difference in VAS scores following steroid injection between the US-guided and unguided groups at either time point. At six weeks post-treatment, the mean VAS scores were 33.1 ± 28.4 for the US-guided steroid injection group, 30.3 ± 27.3 for the unguided steroid injection group, and 50.9 ± 31.4 for the placebo group. By 12 weeks, the VAS scores were 28.4 ± 24.9, 28.2 ± 24.8, and 53.8 ± 33.8, respectively. The RoB 2 was noted to be of 'some concern' given potential bias in lack of reporting adverse events for patients that dropped out of the US-guided steroid group.[26,27]

In a study by Chen et al.,[24] patients with PF (n=33) received either device-assisted US-guided or palpation-guided steroid injections. An angle-adjustable device was used to aid needle position along with US-guidance. At three months of follow-up, the device-assisted group had higher tenderness threshold (TT) (9.02 T 1.38 *vs.* 7.18 T 2.11 kg/cm^2; p = 0.007), lower VAS score (1.88 T 2.13 *vs.* 3.63 T 2.60; p = 0.046), and lower hypoechogenicity incidence in the plantar fascia (3/16 *vs.* 9/16; p = 0.033) compared to the palpation-guided group. The RoB 2 assessment was deemed to be 'high risk' for bias given multiple factors including no clear mention of randomization method, assessor, or participant blinding.

Tsai et al.[25] compared the effectiveness of US-guided versus palpation-guided steroid injections for the treatment of proximal PF. Twenty-five patients underwent treatment evaluating VAS scores and TT up to one-year follow up after injection. In both groups, VAS- and TT-measured levels of pain improved significantly after steroid injection ($p < 0.001$). The RoB 2 assessment was judged to be 'high risk' for bias given multiple factors including lack of clear randomization, and lack of participant or assessor blinding.

Yucel et al.[21] compared the efficacy of US-, palpation-, and scintigraphy-guided injections. Twenty-seven patients (35 heels) were randomly assigned to the treatment groups after failed conservative treatment. The VAS was evaluated from baseline to follow-up (median: 25.3 months).

There were no statistically significant differences observed among the three groups (US-palpation guided, US-scintigraphy guided, and palpation-scintigraphy guided) after treatment, with p-values of 0.017 (MWU = 36.5), 0.023 (MWU = 29.5), and 0.006 (MWU = 13), respectively. The RoB 2 assessment was considered to be 'high risk' for bias due to lack of blinding for participants and outcome assessors, as well as, selection bias and no clear mention of randomization sequence.[27]

In the most recent study, Saba and El-Sherif[23] performed a prospective study in which 21 patients with PF received a local corticosteroid injection either with landmark- or palpation-guidance. At Weeks 2 and 4 of follow-up, outcome measures were statistically significant in VAS for pain, Plantar Fasciitis Pain/Disability Scale, and US evaluation assessment of PF thickness and echogenicity for both groups; however, there was no statistically significant difference between groups. The RoB 2 assessment was considered to be 'high risk' for as there was no clear mention of randomization, as well as, lack of blinding of participants and outcome assessors.

DISCUSSION

In this systematic review, we discuss the efficacy of US-guided injections compared to different techniques to deliver local medications. Of the six reviewed studies involving 173 heels of 165 participants, all compared US-guided steroid injections to palpation-guided steroid injections,[19,21,23-26] with one study by Yucel et al.[21] also comparing scintigraphy-guided steroid injections. All studies showed improvement with treatment of local corticosteroid injections; however, with the exception of the study by Chen et al.[24] using device-assisted US-guidance, there was no statistically significant difference in efficacy based on injection technique.

Plantar fasciitis is the most common cause of chronic heel pain.[28] Multiple risk factors may contribute to chronic PF including obesity, repetitive overuse, excessive loading, structural foot deformities, or tight heel cords and foot muscles.[16] Chronic degenerative processes may, indeed, contribute more to plantar 'fasciosis,' rather than, inflammatory 'fascititis'.[29] Clinical presentation is often unilateral; however, up to 30% of patient may experience bilateral symptoms.[28] The diagnosis of PF can be made with a thorough history and physical examination with various imaging modalities that can assist in further evaluation.[4-7] In the setting of recalcitrant chronic PF which does not resolve or respond to conservative measures, minimally invasive injection therapies may be considered.

Several factors may have contributed to the improved clinical outcomes between the groups. One likely scenario is the local dispersion of the injectate providing benefit which would not require precise placement of the needle. A common consideration while injecting the PF, particularly with corticosteroids, is the concern for fat pad atrophy or PF rupture. In one study, up to 10% of patients injected with corticosteroid suffered from PF rupture.[30,31] In the study performed by Tsai et al.,[25] there was no disruption of the PF noted up to one-year following injection. Another possibility is the systemic effects of corticosteroids providing improvement in treatment.

While there was no superiority in the use of US-guided procedures, the use of US as both a diagnostic and interventional modality may enhance the clinical decision-making process in patient management.[32] By accurately visualizing the surrounding structures, such as neurovascular anatomy, practitioners can avoid unintentional complications or trauma while providing precise needle placement. Ultrasound provides real-time feedback on the distribution of medication within the target tissue. Clinicians may also be able to tailor injections to each patient's specific anatomy and condition, adjusting the injection technique, medication, and dose accordingly to maximize the therapeutic benefits while minimizing unwanted effects. Compared with other image-guided procedures, US offers several advantages, including lower relative cost, absence of ionizing radiation, real-time imaging capability, and portability.[22]

Nonetheless, there are some limitations that should be acknowledged. All the studies include

the low quality of evidence, as most included RCTs were judged to have a high risk of bias. Key sources of bias included inadequate blinding of participants and assessors, unclear randomization methods, and small sample sizes, all of which could affect the reliability of the reported results. Additionally, studies largely reported only short- to mid-term outcomes, with limited or no data on long-term efficacy or recurrence rates. Functional outcomes, including mobility and quality-of-life measures, were infrequently evaluated.

In conclusion, this systematic review demonstrates that pain outcomes are comparable between US-guided and landmark-guided injections for PF. However, US-guided techniques may offer additional practical advantages, such as improved visualization of anatomy, potentially enhancing safety and patient confidence. Taken together, clinicians should consider these procedural benefits in conjunction with efficacy outcomes when making treatment decisions.

Declaration of Conflicting Interests

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Author Contributions

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Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

AI Disclosure

The authors declare that artificial intelligence (AI) tools were not used, or were used solely for language editing, and had no role in data analysis, interpretation, or the formulation of conclusions. All scientific content, data interpretation, and conclusions are the sole responsibility of the authors. The authors further confirm that AI tools were not used to generate, fabricate, or 'hallucinate' references, and that all references have been carefully verified for accuracy.

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