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Review

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Accuracy and efficacy of tibiotalar joint injections under ultrasound guidance: A systematic review

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Abstract

Objectives: In this systematic review, we assess the accuracy and effectiveness of ultrasound (US)-guided injections compared to alternative modalities for the treatment of tibiotalar joint.

Materials and methods: A systematic review was conducted following the Cochrane process from April 2023 to August 2023 utilizing PubMed, Ovid Embase, Web of Science, and Scopus. Branched logic was used to include articles containing terms regarding the tibiotalar joint, US and injections. Studies were screened for eligibility by two authors, and any disagreements were resolved through discussion with a third reviewer. Risk of bias assessments were performed.

Results: A total of five studies were included in the review, comparing various local delivery techniques for the treatment of tibiotalar joint. Three of these studies were cadaveric, while two studies were performed in surviving patients. In general, both the cadaveric studies and studies in surviving patients demonstrated increased accuracy of US-guided compared to landmark (LM)-guided injections of the tibiotalar joint. In a randomized-controlled trial of US-guided versus LM-guided injections in patients with inflamed joints, there was a greater improvement in pain control according to Visual Analog Scale (VAS) scores at six weeks (30.6 mm *vs.* 21.2 mm; $p = 0.030$). A retrospective study demonstrated 2.3 times greater success with image-guidance (US or fluoroscopy) compared to LM, with no significant difference between US and fluoroscopy ($p = 0.09$).

Conclusion: This systematic review provides evidence that US-guided injections demonstrate a higher level of accuracy as compared with LM-guided injections. However, risk of bias concerns, the limited number of included studies, particularly *in vivo* studies, and the lack of published, high-quality randomized-controlled trials investigating efficacy limit our ability to make definitive conclusions regarding clinical outcomes of US versus LM-guided tibiotalar injections.

Keywords: Ankle pain, arthrocentesis, fluoroscopy, image-guidance, injections, systematic review, tibiotalar, ultrasound.

The tibiotalar joint, commonly referred to as the ankle joint, is a synovial hinged joint formed by the distal tibia, fibula and the talus bones. Ligaments surrounding the joint provide stability and restrict excessive movement. The tibiotalar joint belongs to the larger ankle complex

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which additionally comprises the subtalar and talocalcaneal joints.[1] The tibiotalar joint is susceptible to pathologies such as degenerative or post-traumatic osteoarthritis, inflammatory arthropathies with synovitis, repetitive overuse injuries, or impingement syndromes which may benefit from injection therapies.[2,3]

Injections of the ankle joints are used for diagnostic and therapeutic purposes in several conditions.[4-10] Accurate needle placement is critical in ensuring delivery of injectate that could potentially impact the diagnosis, treatment, and outcome.[11] Ultrasound (US), fluoroscopy, and palpation have been used to guide these injections.[12-15]

In this systematic review, we assess the accuracy and effectiveness of US-guided injections compared to alternative modalities with the aim of improving understanding of their comparative performance in guiding clinical decision-making, enhancing patient outcomes, and optimizing the delivery of musculoskeletal interventions.

MATERIALS AND METHODS

Search strategy

A systematic review was done following the Cochrane process from April 2023 to August 2023.[16] The protocol for this review was not registered. Review guidelines were established prior to the search process. 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 (Ankle OR Ankle Joint OR Tibiotalar Joint OR Tibiotalar OR Talocrural Joint OR Ankle Injury) AND (Ultrasound OR Ultrasonography OR Sonography OR Ultrasound-Guided)) AND ((Ultrasound-Guided Injection OR Injection OR Intra-Articular Injection OR Tibiotalar Injection OR Steroid Injection) OR (Anatomic Landmark OR Fluoroscopy OR Saline Solution OR Placebo OR Sucrose OR Physical Therapy OR Watchful Waiting). 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 accuracy of US- versus non-US guided tibiotalar joint injections. Accuracy was usually defined as the successful deposition of injectate within the tibiotalar joint capsule, as confirmed by imaging (US or fluoroscopy) or dissection (in cadaveric studies). The methods for assessing accuracy varied across studies, including sonographic visualization of fluid distension, fluoroscopic confirmation with contrast, or identification of injected dye within the joint during dissection. Non-US guided injections were primarily performed using anatomical LM guidance based on palpation. Due to a paucity in available research, we reviewed the efficacy of US-guided intervention in alleviating pain compared to an alternative injection modality as a secondary outcome measure.

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 of the participants, eligibility criteria outlined by the study, number of cases and controls, and results of the study. Results of these studies could include efficacy of the injection treatment, delivery method, and patient reported outcomes (Table 1).

Assessment of study quality

For our systematic review, we employed two assessment tools: the Newcastle-Ottawa Quality Assessment Scale (NOS) and the Revised Cochrane Risk of Bias Tool for Randomized Trials (RoB 2).[16,17]

The NOS is tailored for evaluating the quality of non-randomized studies, such as observational, cohort, and case-control studies, in the context of systematic reviews and meta-analyses. It evaluates studies across three main domains: selection bias, the comparability for addressing confounding variables, and the assessment of outcomes or exposures. Higher scores on the NOS typically indicate lower risk of bias and higher study

Table 1. Characteristics of studies included

S. No.	Study	Objective	Design	Country	Age in years (range) and country	Eligibility Criteria	Number of cases and controls	Results
1.	Berona et al.,[18] 2017	To compare the success of a landmark-guided (LMG) approach with an ultrasound-guided (USG) technique for hip, ankle and wrist arthrocentesis, and compare change in provider confidence with landmark (LM) and ultrasound (US) arthrocentesis.	Prospective, non-blinded study of EM resident physicians conducted using a cadaver model	USA	Cadaver	Study investigators assessed whether an effusion was present or absent in the joint after saline injection into joints under US guidance and ensured only one side had an effusion and that fluid was only present inside the joint.	17 ankle joints	Success with arthrocentesis: US-17/17 (100%) LM-16/17 (94%) $p = 0.31$ Median number of attempts: US-mean = 1.7 LM-mean = 2.2 $p = 0.36$ Median time to arthrocentesis: US-24 seconds (mean = 55) LM-35 seconds (mean = 77) $p = 0.62$ For ankle joints, US was 88% (15/17) sensitive and 94% (17/18) specific. Resident confidence after the training was higher with US arthrocentesis than LM arthrocentesis 4.3 *vs.* 3.8 ($p < 0.001$). Furthermore, the increase in confidence was greater for US than LM arthrocentesis (2.0 to 4.3, delta 2.3 *vs.* 2.3 to 3.8, delta 1.5) ($p < 0.001$).
2.	Bossert et al.,[20] 2016	To assess whether performing HA injections with the use of an imaging guidance helps to optimize the success rate of viscosupplementation in patients suffering from ankle OA.	Retrospective	France	Mean age (range) was 59.8 years (26-85 years)	Fifty consecutive patients referred for symptomatic ankle OA to 11 physicians and who received a single injection of HANOX-M-XL into the tibiotalar joint within the previous 12 months were included in the survey.	50 total patients: US injections-9 Fluoroscopy injections-29 No guidance injections -12	Satisfaction and efficacy were significantly better in patients injected under imaging guidance than in those injected using anatomical landmarks ($p = 0.03$). Success rate was 2.3 times higher in the imaging-guided group than in the LM-guided group. Patients rated efficacy as "very good or good": Anatomical LM-4/12 Fluoroscopy-20/29 Ultrasonography-9/9 However, the difference between US and fluoroscopy did not reach the level of significance ($p = 0.09$).
3.	Cunnington et al.,[19] 2010	To investigate whether US guidance improves the accuracy and clinical outcome of joint injections as compared with clinical examination (CE) guidance in patients with inflammatory arthritis	Randomized double blind controlled study	USA	US-57.9 ± 14.5 CE-58.4 ± 13.9	Patients with evidence of an inflamed joint (satisfying 2 of the following 3 criteria: exacerbation of pain, exacerbation of stiffness, or local findings of synovitis) involving either the shoulder (glenohumeral joint), elbow, wrist, knee, or ankle. Patients were excluded if they required an immediate change in their treatment (nonsteroidal anti-inflammatory drugs, DMARDs, or corticosteroids, whether via oral, IA, or intramuscular route), if they had had a change in their treatment within 28 days prior to study entry, if they had a second joint requiring IA injection, or if they had evidence of potential sepsis or allergy to corticosteroids or contrast agent.	184 patients/ joints: US-92 (13 ankle) CE-92 (12 ankle)	Number of joints accurately injected: Ankle US-11/13 (85%) CE-7/12 (58%) $p = 0.131$ Accurate injections led to greater improvement in joint function, as determined by VAS scores, at 6 weeks, as compared with inaccurate injections (30.6 mm versus 21.2 mm; $p = 0.030$). Clinicians who used US guidance reliably assessed the accuracy of joint injection ($p < 0.001$), whereas those who used CE guidance did not ($p = 0.29$).

Table 1. Continued

S. No.	Study	Objective	Design	Country	Age in years (range) and country	Eligibility Criteria	Number of cases and controls	Results
4.	Reach et al.,[15] 2009	To evaluate the accuracy of US guided injections for common injection sites in the foot and ankle	Prospective human cadaveric study	USA	Cadaver	10 fresh cadaver feet with methylene blue-saline mixture injected under US guidance.	10 feet	US-guided tibiotalar injection was 100% accurate
5.	Wisniewski et al.,[2] 2010	To compare the relative accuracy rates of US-guided versus nonguided ankle (tibiotalar) joint and sinus tarsi injections in a cadaveric model.	Prospective human cadaveric study	USA	Cadaver	The cadavers were free from obvious deformity, trauma, and surgical changes	Twelve embalmed and 8 fresh cadavers (40 ankles)	Accuracy of US-guided tibiotalar joint injections was 100% (20/20) versus 85% (17/20) for nonguided injections. $p = 0.1154$

EM, emergency medicine; HA, hyaluronic acid; OA, osteoarthritis; HANOX-M-XL, mannitol-modified cross-linked hyaluronic acid; DMARDs, disease-modifying antirheumatic drug; VAS, Visual Analog Scale.

quality (e.g., a score of 7 or higher is often considered high quality). Meanwhile, the RoB 2 tool is a comprehensive and widely recognized method for evaluating the risk of bias in randomized-controlled trials (RCTs) included in systematic reviews and meta-analyses. It focuses on five key areas: the risk of bias from the randomization process, deviations from the intended interventions, missing outcome data, bias in outcome measurement, and bias in the selection of reported results. Reviewers use a series of guiding questions within each domain to assess and categorize the risk of bias as "low" (minimal risk of bias), "some concerns" (some doubt about the reliability of the result due to potential bias) or "high" (substantial risk of bias likely to affect the result) for each study based on responses to the signaling questions. The overall risk of bias for a result is the least favorable domain-level judgement.

RESULTS

The initial search found 2,871 manuscripts excluding any duplicated (Figure 1). Of those manuscripts, 56 were found to meet the eligibility criteria for screening. From that point, the authors excluded 19 studies due to incorrect study design, 27 studies due to wrong intervention, three studies due to wrong indication and two studies due to wrong setting. After completion of the review, a total of five studies met the inclusion criteria (Table 1). Those studies were, then, analyzed by the NOS (Table 2a) and ROB 2 (Table 2b). The single RCT notably showed a low risk of bias, while the other four studies exhibited moderate to high risk of quality bias.

Of the five studies selected for this review, a broad nonblinded cadaveric study assessed provider confidence and accuracy in LM guidance and US for arthrocentesis in the hip, ankle, and wrist.[18] In that study, saline was injected into tibiotalar joint of cadavers by emergency medicine residents and success was denoted by a sonographically visualized effusion post injection. Ultrasound-guidance demonstrated 100% accuracy, while LM guidance demonstrated 94% (p = 0.31). Additionally, an increase in post-training confidence while comparing US

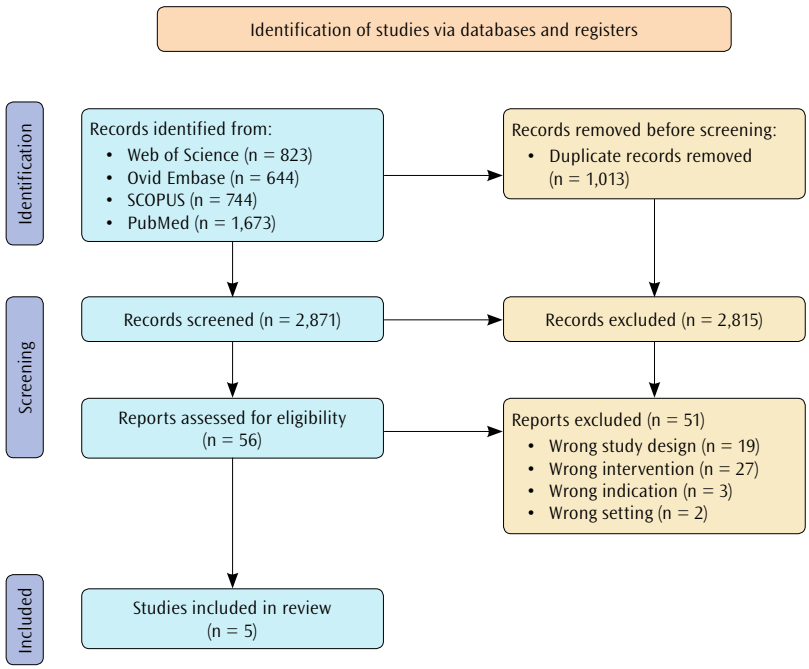

Figure 1. Identification of studies.

to LM (2.0 to 4.3, delta 2.3 *vs.* 2.3 to 3.8, delta 1.5; $p < 0.001$) was noted. A second follow-up comparative cadaveric study demonstrated a similar finding.[2] The aforementioned study found 100% accuracy with US compared to 85% accuracy with LM ($p = 0.1154$). To further establish the increased accuracy of US, an additional study demonstrated an accuracy of 100%.[15] These three cadaveric studies showed that US was more accurate than LM for tibiotalar arthrocentesis. While compiling these cadaveric studies, US demonstrated an accuracy of 100% of the 47 tibiotalar joints injected compared to 89% of the 37 tibiotalar joints injected by LM.

A double-blind RCT in 2010 attempted to investigate whether US could improve accuracy and clinical outcomes in patients with inflamed joints.[19] The aforementioned study found that, while injecting the tibiotalar joint, there was an accuracy of 85% with US compared to 58% with LM ($p = 0.131$). Additionally, with increased accuracy, there was a greater improvement in

Table 2a. Quality Assessment using the Newcastle-Ottawa Quality Assessment scale of included studies

	Selection				Comparability	Outcome/exposure			Total score
Articles	1	1	1	1	2	1	1	1	
Berona et al.,[18] 2017	0	0	0	0	2	1	0	1	4
Bossert et al.,[20] 2016	1	1	0	0	2	1	1	1	7
Reach et al.,[15] 2009	0	0	0	0	2	1	1	1	5
Wisniewski et al.,[2] 2010	0	0	0	0	2	1	1	1	5

Table 2b. Quality assessment using the Revised Cochrane Risk-of-Bias Tool for Randomized Trials

Articles	Domain 1	Domain 2[1]	Domain 2[2]	Domain 3	Domain 4	Domain 5	Assessment
Cunnington et al.,[19] 2010	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk of bias

[1], effect of assignment to intervention; [2], effect of adhering to intervention.

pain control according to Visual Analog Scale (VAS) scores at six weeks (30.6 mm *vs.* 21.2 mm; $p = 0.030$).

A high-quality retrospective study assessed the success of hyaluronic acid injections into the ankle joint comparing US, LM, and fluoroscopic guidance.[20] In this study, success was defined based on patient satisfaction and efficacy outcomes rather than sole needle positioning. That study demonstrated 2.3 times greater success with image-guidance compared to LM, with no significant difference between US and fluoroscopy ($p = 0.09$). This study also demonstrated increased accuracy and efficacy of imaged guidance, compared to LM guidance ($p = 0.03$).

DISCUSSION

In this systematic review, we identified five studies, which met criteria to assess for accuracy as well as efficacy of the US-guided tibiotalar joint interventions. It is important to note that efficacy was not evaluated as a primary outcome in all included studies. All the studies compared tibiotalar joint interventions to either image-guided interventions (US and fluoroscopy) or LM-guided interventions. The results of this systematic review showed high accuracy of US tibiotalar joint injections, with all included studies reporting superior accuracy compared to LM injections. While US demonstrated improved precision in needle placement, evidence on its impact on clinical efficacy, such as pain relief and functional improvement, remains limited. One study, indicated that increased accuracy of US correlated with better pain control in patients with inflammatory arthritis of the tibiotalar joint,[19] but this finding has not been consistently replicated across other patient populations or conditions due to a paucity of studies investigating this correlation.

Nonetheless, one of the major limitations to this review is the relatively small number of studies that focus on both accuracy and efficacy in a clinical setting, particularly those assessing long-term outcomes such as sustained pain relief and functional improvement. Also, most of the available studies, including the cadaveric investigations, are limited to short-term assessments of accuracy. Furthermore, only two studies assessed patient-reported outcomes, which are critical for understanding the full clinical benefit of US. This highlights the need for future research to prioritize high-quality, RCTs that not only evaluate injection accuracy, but also incorporate patient-centric outcomes such as quality of life and long-term joint function. Finally, the heterogeneity of studies included in this review precluded the ability to perform a meta-analysis.

In conclusion, this systematic review provides evidence that US injections demonstrate a higher level of accuracy as compared to LM injections. However, risk of bias concerns, the limited number of included studies, particularly *in vivo* studies, and the lack of published, high-quality RCTs investigating efficacy limit our ability to make definitive conclusions regarding clinical outcomes of US-versus LM-guided tibiotalar injections. Nevertheless, considering a consistent demonstration of increased accuracy with US injections, clinicians should weigh the benefits of increased accuracy against the lack of definitive evidence for improved long-term clinical outcomes when selecting between US and alternative guidance methods.

Declaration of Conflicting Interests

The authors declare that there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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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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