Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Ultrasound-Guided Baxter Nerve, Flexor Digitorum Brevis, or Combined Injections for Plantar Heel Pain Associated With Calcaneal Spur: A Prospective Randomized Controlled Trial

Cengiz Arslan

dr.arslancengiz@gmail.com

T.C. Ministry of Health Şanlıurfa Viranşehir State Hospital

Sabit Numan Kuyubaşı

Kütahya Health Sciences University

Turan Cihan Dülgeroğlu

Kütahya Health Sciences University

Nihat Demirhan Demirkıran

Kütahya Health Sciences University

Süleyman Kaan Öner

Kütahya Health Sciences University

Emre Çilingir

T.C. Ministry of Health Kütahya Emet Dr. Fazıl Doğan State Hospital

Research Article

Keywords: Plantar heel pain, Calcaneal spur, Baxter nerve, Ultrasonography, Corticosteroid injection, Foot Function Index

Posted Date: November 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11485559/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Plantar heel pain associated with calcaneal spur is common. This randomized controlled trial compared ultrasound-guided Baxter nerve, flexor digitorum brevis (FDB) origin, and combined injections.

Methods

A total of 210 patients with plantar heel pain associated with calcaneal spur were randomized 1:1:1 using a computer-generated block randomization sequence. Participants received ultrasound-guided injection targeting the Baxter nerve, FDB origin, or both sites. The primary outcome was longitudinal change in pain intensity measured using a 0- to 10-cm Visual Analog Scale (VAS) at 1, 3, and 6 months. The secondary outcome was longitudinal change in the Foot Function Index (FFI). Outcomes were analyzed using linear mixed-effects models with treatment, time, treatment-by-time interaction, and baseline outcome values as fixed effects and participant as a random intercept.

Results

Of 210 participants, 202 completed follow-up and were included in the analysis. Treatment-by-time interaction was significant for VAS ($\chi^2 = 155.21$, df = 4, $P < .001$) and FFI ($\chi^2 = 148.65$, df = 4, $P < .001$). At 6 months, the adjusted VAS difference was − 4.77 points (95% CI, − 5.67 to − 3.88; Holm-adjusted $P < .001$) for Baxter nerve versus FDB injection and − 4.52 points (95% CI, − 5.41 to − 3.63; Holm-adjusted $P < .001$) versus combined injection. FFI differences were − 0.343 (95% CI, − 0.412 to − 0.273; Holm-adjusted $P < .001$) and − 0.360 (95% CI, − 0.430 to − 0.290; Holm-adjusted $P < .001$), respectively. No treatment-related adverse events were observed.

Conclusions

In patients with plantar heel pain associated with calcaneal spur, ultrasound-guided Baxter nerve injection resulted in greater improvements in pain and foot function through 6 months than FDB origin or combined injection. These findings support Baxter nerve-targeted injection as an effective treatment option.

Trial registration

ClinicalTrials.gov, NCT07884695. First posted 20 October 2026. Retrospectively registered.

INTRODUCTION

Plantar heel pain is one of the most common disorders encountered in foot and ankle practice, affecting up to 10%–15% of the general population during their lifetime and accounting for approximately 11%–15% of foot-related complaints requiring medical care. Although plantar fasciopathy is considered the most common cause, calcaneal spur is frequently associated with chronic symptoms and functional disability. Persistent heel pain substantially impairs walking ability, work productivity, and quality of life, making effective nonsurgical treatment a continuing clinical challenge.[1–6]

Current nonoperative treatment includes activity modification, stretching exercises, orthoses, nonsteroidal anti-inflammatory drugs, extracorporeal shock wave therapy, and corticosteroid injection. Among these modalities, ultrasound-guided injection has gained increasing acceptance because it improves injection accuracy while reducing the risk of injury to adjacent soft tissues and neurovascular structures. Nevertheless, most published studies have focused on the injected medication rather than the optimal anatomical target, and the ideal site for corticosteroid injection remains uncertain.[2,5,7–11]

Increasing evidence suggests that plantar heel pain is not solely an enthesopathic disorder. Entrapment of the first branch of the lateral plantar nerve (Baxter nerve) has emerged as an underrecognized source of chronic heel pain and may coexist with plantar fasciopathy or calcaneal spur. Similarly, the flexor digitorum brevis (FDB) originates from the medial calcaneal tubercle, where repetitive traction may contribute to pain generation. Although ultrasound-guided Baxter nerve block has recently been described as a feasible and reproducible technique, comparative clinical evidence evaluating Baxter nerve injection against other ultrasound-guided anatomical targets remains scarce.[1,12–16]

To our knowledge, no prospective randomized study has directly compared ultrasound-guided corticosteroid injection targeting the Baxter nerve, the FDB origin, and a combination of both techniques in patients with plantar heel pain associated with calcaneal spur. Therefore, the purpose of this study was to compare the clinical effectiveness of these three ultrasound-guided injection strategies using validated pain and functional outcome measures. We hypothesized that ultrasound-guided Baxter nerve injection would provide superior pain relief and functional improvement compared with FDB origin injection or combined injection.[12,17–20]

METHODS

Study Design

This prospective, single-center, randomized controlled trial was conducted at an academic orthopaedic center in Türkiye between December 11, 2023, and December 11, 2024. The study protocol was approved by the local institutional Clinical Research Ethics Committee, and written informed consent was obtained from all participants before enrollment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The trial is reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) 2010 statement; the completed CONSORT checklist is

provided as Additional file 1. No important changes to the trial methods were made after trial commencement.

Sample Size Calculation

An a priori sample size calculation was performed using G*Power software (version 3.1; Heinrich Heine University, Düsseldorf, Germany). VAS was prespecified as the primary outcome. Assuming Cohen's f = 0.50, a two-sided α level of 0.05, and 83% power, a minimum of 70 participants per group was required.

Patient Selection

Patients presenting to the outpatient clinic with plantar heel pain associated with a radiographically confirmed calcaneal spur were screened for eligibility. Patients who met all predefined inclusion criteria and none of the exclusion criteria and provided written informed consent were consecutively enrolled.

Inclusion criteria

1. 1. Age ≥ 18 years.
2. 2. Radiographically confirmed calcaneal spur measuring ≥ 2 mm.
3. 3. Plantar heel pain for ≥ 1 month.
4. 4. VAS pain score ≥ 2.
5. 5. Pain at the medial calcaneal tubercle or on palpation of its medial aspect.
6. 6. No clinically evident foot deformity.
7. 7. No active infection requiring medication during the preceding month.
8. 8. No corticosteroid or other injection for symptomatic calcaneal spur within the preceding 6 months.

Exclusion criteria

1. 1. Calcaneal spur measuring < 2 mm.
2. 2. Bilateral calcaneal spur.
3. 3. Known malignancy.
4. 4. Chronic kidney disease.
5. 5. Drug allergy relevant to the planned injection.
6. 6. Lower-extremity peripheral neuropathy.
7. 7. Active infection requiring treatment.
8. 8. Diabetic neuropathy or a necrotic foot wound.
9. 9. Previous open or endoscopic surgery for calcaneal spur.
10. 10. Pregnancy or breastfeeding.

Randomization and Blinding

After eligibility had been confirmed and written informed consent was obtained, patients were randomly assigned in a 1:1:1 ratio to one of three treatment groups using a computer-generated block randomization sequence with a block size of 6. The randomization sequence was generated by an investigator who was not involved in outcome assessment.

- Group 1: Ultrasound-guided Baxter nerve injection
- Group 2: Ultrasound-guided flexor digitorum brevis (FDB) origin injection
- Group 3: Combined ultrasound-guided Baxter nerve and FDB injection

Treatment allocation was performed according to the computer-generated randomization sequence. Allocation concealment was maintained by an investigator who held the randomization list and revealed the assigned treatment only after eligibility and informed consent had been confirmed. No opaque envelopes were used. The surgeon performing all injections was informed of the assigned treatment immediately before the injection procedure. Participants were blinded to treatment allocation throughout the study. Outcome assessments were performed by 3 investigators who were blinded to treatment allocation throughout follow-up.

Injection Procedure

All ultrasound-guided injections were performed by the same orthopaedic surgeon using a Logic P5 ultrasound machine (GE Healthcare, Milwaukee, WI) equipped with a 7–15 MHz linear-array transducer. Patients were positioned prone during the procedure. For each patient, a standardized injection solution consisting of 1 mL betamethasone dipropionate (6.43 mg/mL) and betamethasone sodium phosphate (2.63 mg/mL) combination (DİPROVER 2 mg + 5 mg/mL, HAVER) and 1 mL lidocaine hydrochloride (ARİTMAL 2% I.M./I.V./S.C., OSEL) was prepared (total volume, 2 mL). A 21-gauge needle was used for all injections.

Patients assigned to the Baxter nerve group received the entire injectate around the Baxter nerve. Patients in the FDB group received the injectate at the origin of the flexor digitorum brevis muscle. In the combined group, the injectate was equally divided, with 1 mL administered around the Baxter nerve and 1 mL injected at the FDB origin.

Following the procedure, all patients received identical post-injection instructions, including a standardized stretching program and activity modification.

Outcome Measures

The primary outcome was pain intensity, assessed using a 0- to 10-cm Visual Analog Scale (VAS), where 0 indicated no pain and 10 indicated the worst imaginable pain.

The secondary outcome was foot-related pain and functional disability, assessed using the Turkish version of the Foot Function Index (FFI).[21,22] FFI scores were normalized to a 0 to 1 scale, with higher scores indicating greater pain and disability.

Clinical evaluations were performed at baseline and at 1, 3, and 6 months after injection.

Calcaneal spur length was measured on standardized weightbearing lateral foot radiographs using the method previously described by Johal et al.[3]

Statistical Analysis

The primary outcome was the longitudinal change in VAS across the 1-, 3-, and 6-month follow-up assessments, and the secondary outcome was the longitudinal change in FFI over the same follow-up period. Statistical analyses were performed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation or median (interquartile range [IQR]), as appropriate, and categorical variables as frequencies and percentages. Baseline characteristics were compared across the three randomized groups using the Kruskal–Wallis test for continuous variables and the Pearson chi-square or Fisher–Freeman–Halton exact test for categorical variables, as appropriate. Because VAS and FFI were measured repeatedly within the same participant at baseline and at 1, 3, and 6 months, longitudinal outcomes were analyzed using linear mixed-effects models with a random intercept for participant. Each model included treatment group, follow-up time, the treatment-by-time interaction, and the corresponding baseline outcome value as a fixed-effect covariate. The treatment-by-time interaction was considered the principal test of whether the pattern of change over time differed among the three treatment groups. Estimated between-group differences at each follow-up time point were obtained from the fitted models with 95% confidence intervals. Pairwise comparisons were adjusted for multiplicity using the Holm method. Mixed-effects models used all available outcome observations without imputing missing follow-up values. All statistical tests were two-sided, and $P < .05$ was considered statistically significant. Analyses were conducted according to participants' original randomized group assignments.

No changes were made to the prespecified primary or secondary outcomes after trial commencement.

No interim analysis or formal stopping rule was used.

The trial ended as planned after completion of the prespecified recruitment and follow-up period.

RESULTS

Patient Flow

Between December 11, 2023, and December 11, 2024, a total of 720 patients presenting with plantar heel pain were assessed for eligibility. Of these, 510 patients did not meet the inclusion criteria and were excluded. The remaining 210 patients were randomized and allocated equally to the Baxter nerve

injection group (n = 70), flexor digitorum brevis (FDB) origin injection group (n = 70), or combined injection group (n = 70). During follow-up, 8 patients were lost to follow-up because they did not attend any scheduled follow-up visits, including 3 in the FDB group and 5 in the combined injection group. No patients were lost to follow-up in the Baxter nerve group. The study was completed with 202 patients who had follow-up data: 70 in the Baxter nerve group, 67 in the FDB group, and 65 in the combined injection group (Fig. 1).

Baseline Characteristics

Baseline demographic and clinical characteristics are summarized in Table 1. The treatment groups were generally comparable with respect to age, sex, body mass index, comorbidity, symptom duration, affected side, previous treatments, and calcaneal spur length (all P > .05). Baseline FFI scores were also comparable among the groups (P = .998). However, baseline VAS scores differed statistically among the groups (P = .044), and baseline VAS was therefore included as a covariate in the longitudinal mixed-effects analysis.

Table 1
Baseline Demographic and Clinical Characteristics

Characteristic	Overall (n = 202)	Baxter (n = 70)	FDB (n = 67)	Combined (n = 65)	P value
Age, years	50 (42–56)	50 (42–55)	51 (44–60)	48 (41–54)	0.171
Female sex, n (%)	171 (84.7)	57 (81.4)	54 (80.6)	60 (92.3)	0.114
Body mass index, kg/m²	31 (27–35)	31 (29–35)	32 (26–35)	30 (27–33)	0.319
Any comorbidity, n (%)	75 (37.1)	22 (31.4)	28 (41.8)	25 (38.5)	0.439
Right side, n (%)	98 (48.5)	36 (51.4)	30 (44.8)	32 (49.2)	0.731
Symptom duration, months	8 (4–22)	12 (4–24)	10 (4–22)	6 (3–12)	0.228
Previous NSAID use, n (%)	171 (84.7)	62 (88.6)	52 (77.6)	57 (87.7)	0.146
Previous ESWT, n (%)	54 (26.7)	18 (25.7)	15 (22.4)	21 (32.3)	0.424
Previous injection > 6 months before enrollment, n (%)	57 (28.2)	20 (28.6)	20 (29.9)	17 (26.2)	0.892
Calcaneal spur length, mm	6.7 ± 2.3	6.5 ± 2.3	7.0 ± 2.3	6.6 ± 2.2	0.476
Baseline VAS	10.00 (9.00–10.00)	10.00 (9.00–10.00)	10.00 (7.00–10.00)	10.00 (9.00–10.00)	0.044
Baseline FFI	0.74 (0.61–0.82)	0.76 (0.62–0.82)	0.72 (0.55–0.85)	0.76 (0.63–0.80)	0.998

VAS scores decreased in all groups at 1 month, with the Baxter nerve group having the lowest scores at 3 and 6 months.

Primary Outcome: Pain Intensity (VAS)

Median VAS scores are reported in Table 2. VAS scores decreased in all groups at 1 month, with the Baxter nerve group having the lowest scores at 3 and 6 months. The baseline-adjusted linear mixed-effects model demonstrated a significant treatment-by-time interaction for VAS ($\chi^2 = 155.21$, df = 4, P < .001), indicating significantly different longitudinal pain trajectories among the treatment groups. At 6 months, the adjusted VAS difference was − 4.77 points (95% CI, − 5.67 to − 3.88; Holm-adjusted P < .001) for Baxter nerve versus FDB injection and − 4.52 points (95% CI, − 5.41 to − 3.63; Holm-adjusted P < .001) for Baxter nerve versus combined injection.

Table 2
Changes in Pain Intensity (VAS) During Follow-up

Time Point	Baxter (n = 70)	FDB (n = 67)	Combined (n = 65)	P value
Baseline	10.00 (9.00–10.00)	10.00 (7.00–10.00)	10.00 (9.00–10.00)	0.044
1 Month	2.00 (0.00–6.00)	6.00 (3.00–8.00)	3.00 (1.00–5.00)	< .001
3 Months	2.00 (0.00–7.75)	7.00 (5.00–9.50)	5.00 (4.00–9.00)	< .001
6 Months	3.00 (1.00–8.00)	9.00 (7.00–10.00)	10.00 (8.00–10.00)	< .001

Table 3
Changes in Foot Function Index (FFI) During Follow-up

Time Point	Baxter (n = 70)	FDB (n = 67)	Combined (n = 65)	P value
Baseline	0.76 (0.62–0.82)	0.72 (0.55–0.85)	0.76 (0.63–0.80)	0.998
1 Month	0.17 (0.01–0.48)	0.36 (0.18–0.62)	0.18 (0.07–0.45)	0.003
3 Months	0.15 (0.00–0.59)	0.55 (0.35–0.71)	0.40 (0.27–0.65)	< .001
6 Months	0.20 (0.07–0.59)	0.69 (0.49–0.77)	0.71 (0.56–0.79)	< .001
LEGENDS				

FFI scores decreased in all groups at 1 month, with progressively greater separation between the Baxter nerve group and the other groups at 3 and 6 months (P = .003 at 1 month; P < .001 thereafter).

Secondary Outcome: Foot Function Index (FFI)

No adverse events or procedure-related complications were observed in any treatment group during the 6-month follow-up period. Specifically, no infection, neurovascular injury, allergic reaction, bleeding, injection-site complications, transient paresthesia, or other treatment-related adverse events were reported. No patient required additional intervention because of treatment-related complications.

The baseline-adjusted linear mixed-effects model demonstrated a significant treatment-by-time interaction for FFI ($\chi^2 = 148.65$, df = 4, P < .001), indicating significantly different longitudinal functional trajectories among the treatment groups. At 1 month, Baxter showed a lower adjusted FFI than FDB (adjusted difference, − 0.137; 95% CI, − 0.206 to − 0.067; Holm-adjusted P < .001), whereas Baxter and combined injection did not differ significantly (0.015; 95% CI, − 0.055 to 0.085; P = 1.000). At 3 months, Baxter was superior to FDB (− 0.267; 95% CI, − 0.336 to − 0.197; Holm-adjusted P < .001) and combined injection (− 0.161; 95% CI, − 0.231 to − 0.091; Holm-adjusted P < .001). At 6 months, Baxter remained superior to FDB (− 0.343; 95% CI, − 0.412 to − 0.273; Holm-adjusted P < .001) and combined injection (− 0.360; 95% CI, − 0.430 to − 0.290; Holm-adjusted P < .001), while FDB and combined injection did not differ significantly (− 0.018; 95% CI, − 0.088 to 0.053; Holm-adjusted P = 1.000).

Adverse Events

Values are presented as median (IQR), mean ± SD, or n (%), as appropriate. BMI, body mass index; ESWT, extracorporeal shock wave therapy; FFI, Foot Function Index; NSAID, nonsteroidal anti-inflammatory drug; VAS, Visual Analog Scale.

Values are presented as median (IQR). Overall P values are from Kruskal–Wallis tests at each time point.

Values are presented as median (IQR). Overall P values are from Kruskal–Wallis tests at each time point.

DISCUSSION

In this randomized controlled trial, ultrasound-guided Baxter nerve injection was associated with greater improvements in pain intensity and foot function through 6 months than FDB origin injection or combined injection in patients with plantar heel pain associated with calcaneal spur. The treatment-by-time interactions were statistically significant for both VAS and FFI, and the adjusted between-group comparisons at 3 and 6 months showed greater improvement in the Baxter nerve group.

Comparison With Previous Studies

Chronic plantar heel pain is challenging because multiple anatomical structures may contribute to symptoms. Most randomized trials have focused on injections directed at the plantar fascia or perifascial tissues, whereas relatively few have investigated the Baxter nerve. Current evidence supports individualized treatment according to the suspected pain generator, and anatomical and imaging studies indicate that a calcaneal spur should not necessarily be regarded as the sole source of pain.[1,2,12,13]

Recent reports have described ultrasound-guided Baxter nerve blockade and favorable outcomes after nerve block or decompression, but the available evidence has largely been technical, noncomparative, or case-based.[9,10,12,15–19,23,24] In contrast, this randomized trial directly compared three ultrasound-guided injection strategies and found greater pain and functional improvement with selective Baxter nerve injection, particularly at 3 and 6 months.

Possible Mechanisms

The superior outcomes following Baxter nerve injection are biologically plausible. The inferior calcaneal nerve traverses a narrow fibro-osseous tunnel between the abductor hallucis and quadratus plantae before supplying the abductor digiti minimi; chronic compression or irritation in this corridor has been proposed as a contributor to persistent medial heel pain.[12–16,25]

Ultrasound-guided perineural injection may reduce local inflammation, facilitate hydrodissection, decrease mechanical compression, and improve neural mobility. In contrast, FDB-origin injection may address local myofascial pain without directly treating neural entrapment, potentially explaining the smaller and less durable response observed here.[8–11,18,26,27]

Clinical Implications

The terminology surrounding the Baxter nerve warrants consideration. Although the term “first branch of the lateral plantar nerve” is widely used in the clinical literature, recent anatomical evidence has questioned whether the nerve should consistently be classified as the first branch of the lateral plantar nerve. In the present study, the term “Baxter nerve” is used for consistency with the clinical and ultrasound-guided intervention literature and should not be interpreted as implying a uniform anatomical origin in all individuals. Future anatomical and imaging studies may further clarify the nomenclature and anatomical variability of this nerve.

The findings suggest that Baxter nerve involvement should be considered in selected patients with persistent plantar heel pain, particularly when conventional treatment fails. Ultrasound-guided Baxter nerve injection is minimally invasive and can be performed under real-time imaging. The greater pain relief and functional recovery observed with selective perineural treatment support an individualized, image-guided approach when a specific pain generator is suspected.[2,5,9–12,17,20,27]

Interpretation of Findings

These findings should be interpreted within the study design and study population. The observed benefit of Baxter nerve-targeted injection does not establish that the participants had objectively confirmed Baxter neuropathy or that neural entrapment was the mechanism responsible for the treatment effect. Patient selection, anatomical localization, clinical evaluation, and ultrasound findings may influence the choice of injection target.

Strengths and Limitations

Strengths include the prospective randomized design, 1:1:1 block randomization, blinded outcome assessment, standardized ultrasound-guided techniques, validated pain and functional outcomes, and a high follow-up rate of 96.2%.

Several limitations should be acknowledged. First, the absence of a placebo or sham-injection control means that the study evaluates the relative effectiveness of different anatomical injection targets rather

than the efficacy of injection therapy itself. Second, although the total injectate volume was standardized at 2 mL, the combined group received 1 mL at each target, whereas the single-target groups received the full 2 mL at one site; therefore, the effects of anatomical target and injectate volume at each site cannot be completely separated. Third, Baxter nerve involvement was not independently confirmed using magnetic resonance imaging, electrodiagnostic testing, or predefined sonographic criteria, so the findings should not be interpreted as evidence specifically in patients with objectively confirmed Baxter neuropathy. Fourth, the single-center design and use of a single experienced operator may limit generalizability, although this approach reduced procedural variability. The predominantly female population and relatively high body mass index may also limit applicability to other populations. Fifth, the 6-month follow-up does not establish longer-term durability or recurrence. Sixth, post-treatment imaging was not performed to evaluate structural or neural changes. Finally, 8 participants were lost to follow-up; although the follow-up rate was high and mixed-effects models used all available observations without imputation, attrition bias cannot be completely excluded.

CONCLUSION

In patients with plantar heel pain associated with calcaneal spur, ultrasound-guided Baxter nerve-targeted injection was associated with greater improvements in pain and foot function through 6 months than FDB origin or combined injection. These findings support Baxter nerve-targeted injection as a potential treatment option in selected patients.

This randomized controlled trial was registered retrospectively on ClinicalTrials.gov (NCT07884695; first posted 20 October 2026).

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Clinical Research Ethics Committee of Kütahya Health Sciences University (Approval No. 2023-14/07; December 5, 2023). Written informed consent was obtained from all participants before enrollment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Consent for publication

Written informed consent for publication of the ultrasound images was obtained from the participants whose images are included in the manuscript.

Funding

The authors received no financial support for the research, authorship, or publication of this article.

Author Contribution

C.A. conceived and designed the study, coordinated the research, performed the statistical analysis, and drafted the manuscript. S.N.K., T.C.D., N.D.D., and S.K.Ö. contributed to patient recruitment, clinical assessment, and data collection. E.Ç. contributed to data collection and clinical follow-up. All authors critically reviewed the manuscript, approved the final version, and agree to be accountable for the work.

Acknowledgements

Not applicable.

Use of AI-assisted technologies

During manuscript preparation, ChatGPT (OpenAI) was used for English language editing, sentence restructuring, journal formatting, and refinement of the title and abstract. The authors independently reviewed and approved all AI-assisted text and remain fully responsible for the accuracy, integrity, and interpretation of the manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

References

1. Rosenbaum AJ, DiPreta JA, Misener D. Plantar heel pain. Med Clin North Am. 2014;98(2):339–52. 10.1016/j.mcna.2013.10.009.
2. Martin RL, Davenport TE, Reischl SF, McPoil TG, Matheson JW, Wukich DK, et al. Heel Pain–Plantar Fasciitis: Revision 2023. J Orthop Sports Phys Ther. 2023;53(12):CPG1–39. 10.2519/jospt.2023.0303.
3. Johal KS, Milner SA. Plantar fasciitis and the calcaneal spur: fact or fiction? Foot Ankle Surg. 2012;18(1):39–41. 10.1016/j.fas.2011.03.003.
4. Kirkpatrick J, Yassaie O, Mirjalili SA. The plantar calcaneal spur: a review of anatomy, histology, etiology and key associations. J Anat. 2017;230(6):743–51. 10.1111/joa.12607.
5. Thomas JL, Christensen JC, Kravitz SR, et al. The diagnosis and treatment of heel pain: a clinical practice guideline–revision 2010. J Foot Ankle Surg. 2010;49(3 Suppl):S1–19. 10.1053/j.jfas.2010.01.001.
6. Agyekum EK, Ma K. Heel pain: a systematic review. Chin J Traumatol. 2015;18(3):164–9. 10.1016/j.cjtee.2015.03.002.

7. McMillan AM, Landorf KB, Gilheany MF, Bird AR, Morrow AD, Menz HB. Ultrasound guided corticosteroid injection for plantar fasciitis: randomised controlled trial. BMJ. 2012;344:e3260. 10.1136/bmj.e3260.
8. Crawford F, Atkins D, Young P, Edwards J. Steroid injection for heel pain: evidence of short-term effectiveness. A randomized controlled trial. Rheumatology (Oxford). 1999;38(10):974–7. 10.1093/rheumatology/38.10.974.
9. Chen CM, Chen JS, Tsai WC, Hsu HC, Chen KH, Lin CH. Effectiveness of device-assisted ultrasound-guided steroid injection for treating plantar fasciitis. Am J Phys Med Rehabil. 2013;92(7):597–605. 10.1097/PHM.0b013e318278a831.
10. Ata AM, Altunay BS. Treatment optimization with ultrasound for chronic heel pain. J Am Podiatr Med Assoc. 2024;114(4):22160. 10.7547/22-160.
11. Yucel U, Kucuksen S, Cingoz HT, et al. Full-length silicone insoles versus ultrasound-guided corticosteroid injection in the management of plantar fasciitis: a randomized clinical trial. Prosthet Orthot Int. 2013;37(6):471–6. 10.1177/0309364613478328.
12. Presley JC, Maida E, Pawlina W, Murthy N, Ryssman DB, Smith J. Sonographic visualization of the first branch of the lateral plantar nerve (Baxter nerve): technique and validation using perineural injections in a cadaveric model. J Ultrasound Med. 2013;32(9):1643–52. 10.7863/ultra.32.9.1643.
13. Chundru U, Liebeskind A, Seidelmann F, Fogel J, Franklin P, Beltran J. Plantar fasciitis and calcaneal spur formation are associated with abductor digiti minimi atrophy on MRI of the foot. Skeletal Radiol. 2008;37(6):505–10. 10.1007/s00256-008-0455-2.
14. Rodrigues RN, Lopes AA, Torres JM, Mundim MF, Silva LLG, Silva BRC. Compressive neuropathy of the first branch of the lateral plantar nerve: a study by magnetic resonance imaging. Radiol Bras. 2015;48(6):368–72. 10.1590/0100-3984.2013.0028.
15. Baxter DE, Pfeffer GB. Treatment of chronic heel pain by surgical release of the first branch of the lateral plantar nerve. Clin Orthop Relat Res. 1992;(279):229–36.
16. Louisia S, Masquelet AC. The medial and inferior calcaneal nerves: an anatomic study. Surg Radiol Anat. 1999;21(3):169–73. 10.1007/BF01630895.
17. Yildizgoren MT, Ekici B, Bagcier F. How to perform Baxter’s nerve blockage easily by ultrasound in chronic heel pain: four simple steps. Ultrasound. 2024;32(3):164–7. 10.1177/1742271X231225095.
18. Sahoo RK, Peng PWH, Sharma SK. Ultrasound-guided hydrodissection for Baxter's neuropathy secondary to plantar fasciitis: a case report. Pract. 2020;14(13):e01339. 10.1213/XAA.0000000000001339.
19. Coles IR, Vieira CL, Gouveia IB, Rebelo T, Agualusa L. Ultrasound block of first branch of the lateral plantar nerve (Baxter nerve): case report of a promising and effective treatment for heel chronic pain. Braz J Anesthesiol. 2021;71(6):664–6. 10.1016/j.bjane.2020.11.007.
20. Chen JSC, Abbott M, Landorf KB. Association of Baxter's neuropathy and fatty infiltration of the abductor digiti minimi muscle on magnetic resonance imaging: a systematic review. J Foot Ankle Res. 2025;18(3):e70075. 10.1002/jfa2.70075.

21. Budiman-Mak E, Conrad KJ, Roach KE. The Foot Function Index: a measure of foot pain and disability. J Clin Epidemiol. 1991;44(6):561–70. 10.1016/0895-4356(91)90220-4.
22. Külünkoğlu BA, Fırat N, Yıldız NT, Alkan A. Reliability and validity of the Turkish version of the Foot Function Index in patients with foot disorders. Turk J Med Sci. 2018;48(3):476–83. 10.3906/sag-1705-143.
23. Montes-Salas R, Mahillo-Durán R, Gómez-Carrión Á, Gómez-Aguilar E, Fernández-Gibello A, Castillo-Lopez JM. Ultrasound-guided procedures for plantar fasciitis: a randomized clinical study. J Orthop Surg Res. 2024;19(1):436. 10.1186/s13018-024-04946-y.
24. Choi JW, Lee HJ, Nam YS, Shin MY, Kim SH, Kim JH, et al. Optimizing injection accuracy for Baxter's nerve entrapment: an ultrasonography-guided approach based on anatomical surface landmarks. Ann Med. 2025;57(1):2450525. 10.1080/07853890.2025.2450525.
25. Williams NH, Senatore JR, Dellon AL, Williams EH. Baxter's nerve exists but is usually NOT the first branch of the lateral plantar nerve. Microsurgery. 2026;46(3):e70215. 10.1002/micr.70215.
26. Maida E, Presley JC, Murthy N, Pawlina W, Smith J. Sonographically guided deep plantar fascia injections: where does the injectate go? J Ultrasound Med. 2013;32(8):1451–9. 10.7863/ultra.32.8.1451.
27. Erden T, Toker B, Cengiz O, Ince B, Asci S, Toprak A, et al. Outcome of corticosteroid injections, extracorporeal shock wave therapy, and radiofrequency thermal lesioning for chronic plantar fasciitis. Foot Ankle Int. 2021;42(1):69–75. 10.1177/1071100720949469.
28. Chen JSC, Osborne JWA, Menz HB, Abbott M, Munteanu SE, Entwisle T, et al. Plantar heel pain is not associated with fatty infiltration of the abductor digiti minimi muscle on magnetic resonance imaging: a cross-sectional observational study. J Foot Ankle Res. 2026;19(2):e70155. 10.1002/jfa2.70155.
29. Schulz KF, Altman DG, Moher D, CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ. 2010;340:c332. 10.1136/bmj.c332.

Figures

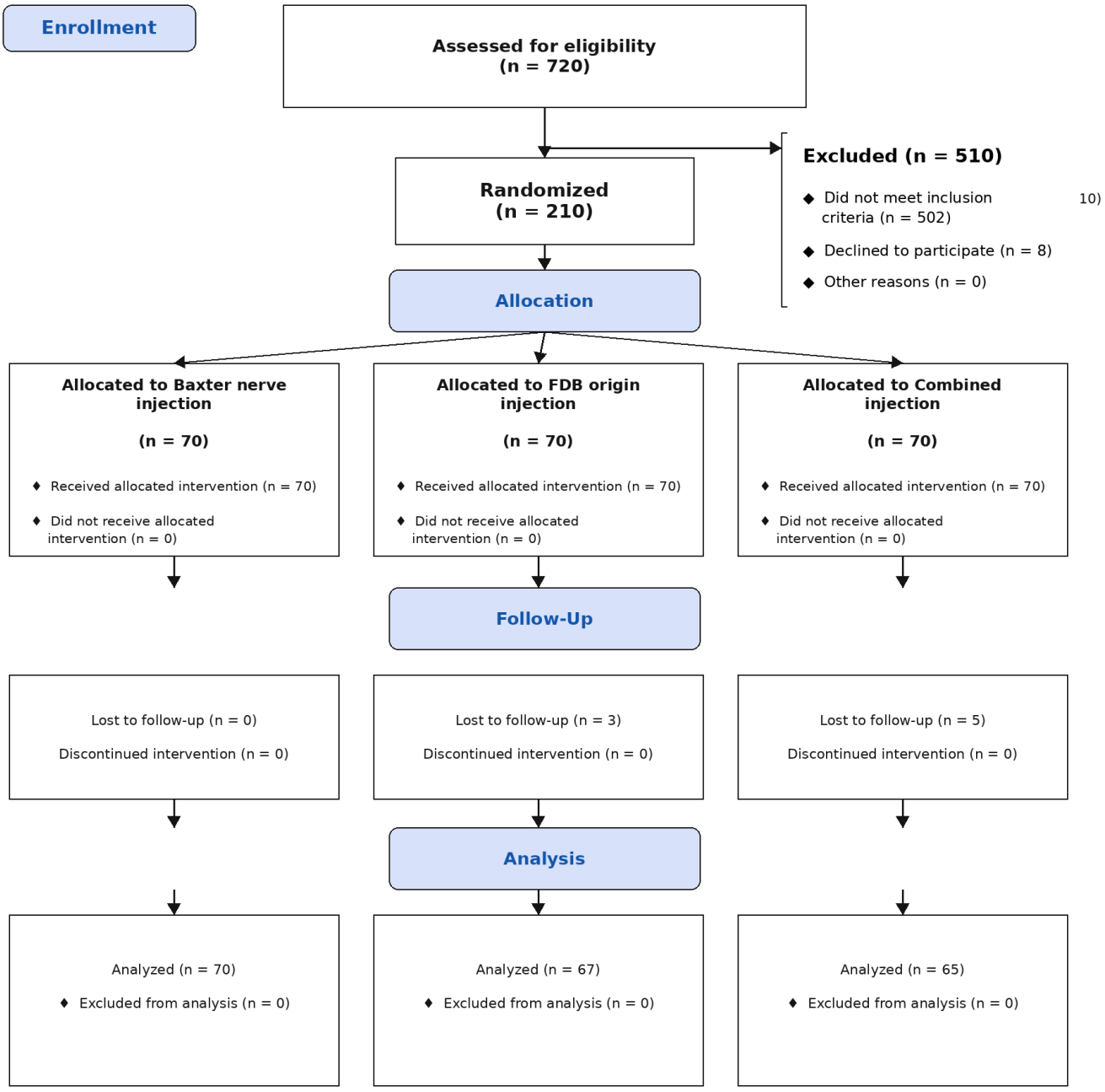


Figure 1

CONSORT 2010 flow diagram illustrating patient screening, eligibility assessment, randomization, allocation, follow-up, and final analysis.[29]



Figure 2

Ultrasound-guided injection entry site on the medial aspect of the heel.

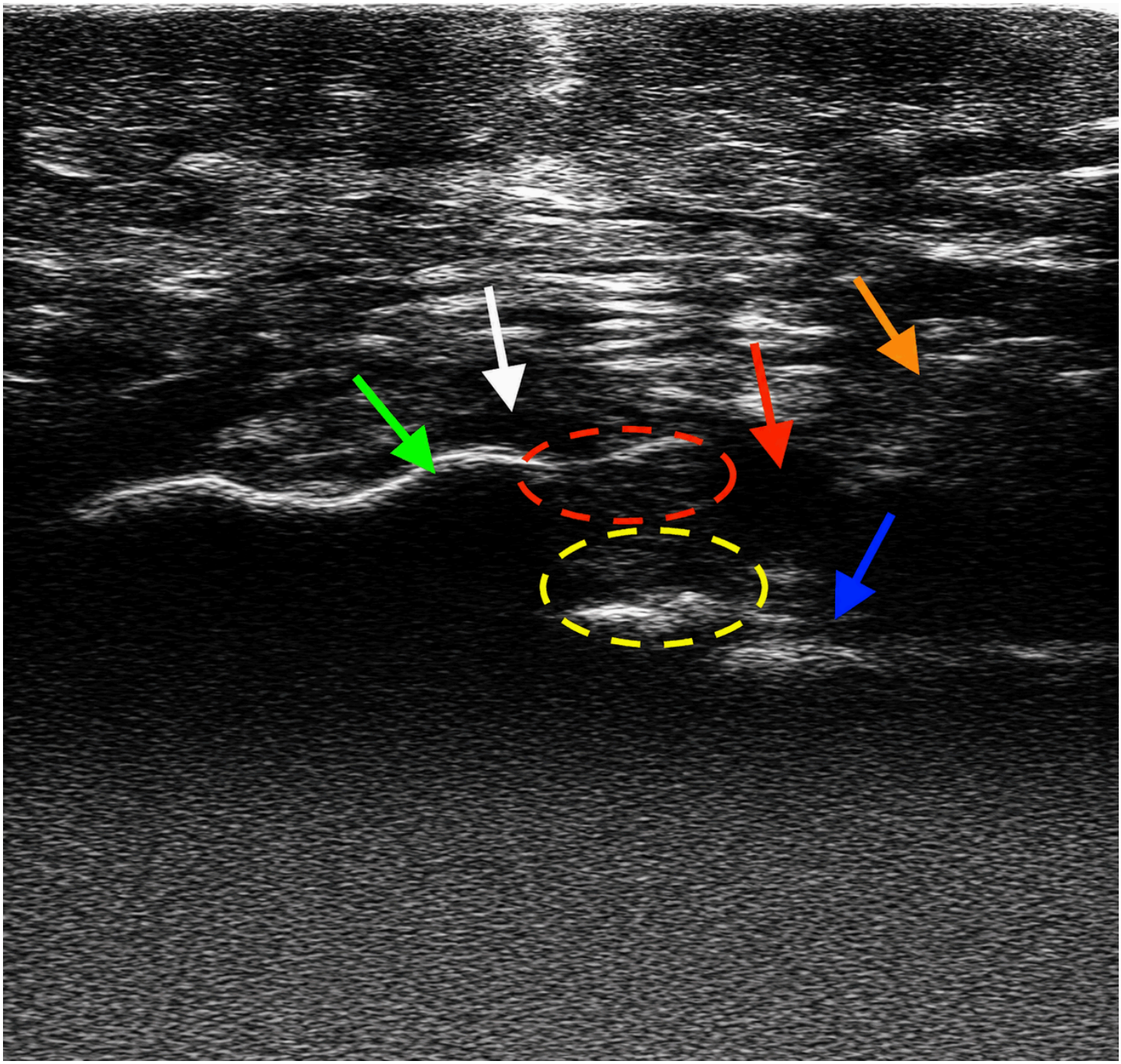


Figure 3

Ultrasound image demonstrating the anatomical structures of the plantar heel and the injection target sites. The green arrow indicates the calcaneal spur; the orange arrow, the injection needle; the white arrow, the plantar fascia; the red arrow, the flexor digitorum brevis (FDB) muscle; and the blue arrow, the inferior cortex of the calcaneus. The red dashed circle indicates the FDB injection target, whereas the yellow dashed circle indicates the Baxter nerve injection target.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CONSORT2010ChecklistFINAL.docx