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Dextrose prolotherapy versus radial extracorporeal shock wave therapy in the treatment of chronic plantar fasciitis: A randomized, controlled clinical trial

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ABSTRACT

In the recent years, prolotherapy is increasingly being used in the field of musculoskeletal medicine. However, few studies have investigated its effectiveness in plantar fasciitis (PF). The purpose of this study was to compare the effectiveness of ultrasound-guided dextrose prolotherapy with radial extracorporeal shock wave therapy (ESWT) in the treatment of chronic PF. This randomized controlled trial was conducted on 59 patients with chronic PF. Patients were randomly assigned into two groups receiving three sessions of radial ESWT (29 patients) vs. two sessions of ultrasound-guided intrafascial 2 cc dextrose 20% injection (30 patients). The following outcome measures were assessed before and then six weeks and 12 weeks after the treatments: pain intensity by visual analog scale (VAS), daily life and exercise activities by Foot and Ankle Ability Measure (FAAM), and the plantar fascia thickness by ultrasonographic imaging. The VAS and FAAM scales showed significant improvements of pain and function in both study groups 6 weeks and 12 weeks after the treatments. A significant reduction was noted for plantar fascia thickness at these intervals (all $p < .05$). The inter-group comparison revealed that except for the FAAM-sport subscale which favored ESWT, the interaction effects of group and time were not significant for other outcome measures. Dextrose prolotherapy has comparable efficacy to radial ESWT in reducing pain, daily-life functional limitation, and plantar fascia thickness in patients with PF. No serious adverse effects were observed in either group.
Level of evidence: Level I, randomized controlled trial.

1. Introduction

Plantar fasciitis (PF) is one of the common causes of medial heel pain in the general population. The pathogenesis of PF is not fully understood, but it is generally thought to result from repetitive micro-trauma to the plantar fascia at its origin on the tuberosity of the calcaneus. Patients commonly complain of heel pain when they first wake up in the morning as well as start-up pain after prolonged inactivity. Palpation typically reveals tenderness at the antero-medial side of the heel, where the plantar fascia attaches to the calcaneus [1,2]. Plantar fasciitis is generally diagnosed on a clinical basis. However, imaging modalities like ultrasonography and x-ray may be required when the presentation is atypical [1,3].

Conservative management is generally suggested in the initial treatment of PF. These measures include correction of biomechanical imbalances, modification in daily activities, application of proper orthotics and therapeutic physical agent modalities [4]. Extracorporeal shock wave therapy (ESWT) is an effective and safe therapeutic modality in patients with PF. The effectiveness of ESWT has been established in large randomized clinical trials and several meta-analyses [5–9]. It has also found to be an effective treatment when other non-surgical treatments have failed [5,9].

In recent years, the practice of prolotherapy in the treatment of musculoskeletal disorders is trending [10]. Prolotherapy is an injection-based procedure where a small volume of an irritant or sclerosing solution is injected at the sites of tissue injury or in the

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joint space. The mechanism of action for prolotherapy is not yet fully elucidated, but it is known to inhibit the release of substance P, induce vascular growth and fibroblast activity, and promote tissue repair and regeneration [11,12]. Promising results have been published in the recent literature on the effectiveness of dextrose prolotherapy in patients with PF [13–15]; however, the available data is scarce. This topic is currently an ongoing area of research; and as in most novel therapies, more well-designed clinical trials are needed to substantiate its effectiveness in the treatment of PF.

The need to compare novel treatments with existing therapies, as opposed to placebos, has always been emphasized in the literature. To the best of our knowledge, to date, no study has compared the effectiveness of dextrose prolotherapy and ESWT in patients with chronic PF. In this study, we compared the effectiveness of ultrasound-guided dextrose prolotherapy with ESWT on pain intensity, functional status, and ultrasonographic findings of patients with chronic PF.

2. Patients and methods

2.1. Study design, setting and ethics

This prospective, randomized controlled trial was conducted from July 2019 to January 2020 on patients with plantar fasciitis presenting to physical medicine and rehabilitation out-patient clinics affiliated to Baqiyatallah University of Medical Sciences, Tehran, Iran. This research followed the tents of the Declaration of Helsinki and the protocol of the study was approved by the regional ethics committee of Baqiyatallah University of Medical Sciences. A written informed consent was obtained from all patients before enrollment in the study. The process of the treatment was fully explained to the patients, and they were advised that they could withdraw from the study at any time. The trial was registered in Iranian Registry of Clinical Trial (registration ID: IRCT20140306016865N2).

2.2. Participants

We consecutively recruited 62 patients with a clinical diagnosis of chronic plantar fasciitis in this study. The inclusion criteria were: (i) age between 18 and 75 years; (ii) heel pain at the antero-medial side of the heel consistent with a diagnosis of plantar fasciitis; (iii) exacerbation of the pain by manual compression of the plantar fascia attachment to the medial border of the calcaneus; and (iv) chronic recalcitrant heel pain for more than 8 weeks with failed conservative management. The exclusion criteria were: a history of any injection into the plantar fascia, ESWT or surgery to the heel, history of bleeding disorders or systemic inflammatory diseases like rheumatoid arthritis, history of trauma to the heel and calcaneus, a history of uncontrolled diabetes mellitus, Achilles tendinopathy, S1 radiculopathy, crystal arthropathy or neuropathy related heel pain.

2.3. Randomization and blinding

The eligible subjects who met the inclusion criteria were randomly allocated into two treatment groups by block randomization method. This method is designed to randomize subjects into the treatment groups with equal sample sizes [16]. We used an online randomizer software program for this purpose: https://www.randomizer.org/. Given the nature of the interventions, blinding of participants and clinicians to treatment allocations was not possible. Therefore, blinding only applied to data analysts and the statistician.

2.4. Study groups and interventions

According to the randomization method, patients were assigned into the following study groups:

2.5. Group A (ESWT)

Patients in this group received three sessions of radial ESWT at weekly intervals for 3 consecutive weeks. The shockwave probe was placed perpendicularly on the plantar surface of the patient's heel, over the point of maximal tenderness after application of the coupling gel. The procedure was performed without using local anesthesia. Shockwaves were administrated using a radial shockwave device (MP 100, Storz Medical, Switzerland) for all patients. In each session, patients received 2000 shocks at a pressure of 2 Bars and a frequency of 10 Hz. Due to pain and intolerance of a high energy protocol in 3 patients, we used a painless lowest intensity protocol as a pilot, and then increased the intensity level gradually to the study protocol. All ESWT sessions were performed by a single expert physiatrist.

2.6. Group B (Prolotherapy)

Patients in this group received two sessions of ultrasound-guided prolotherapy treatments, with a one-week interval. Prior to

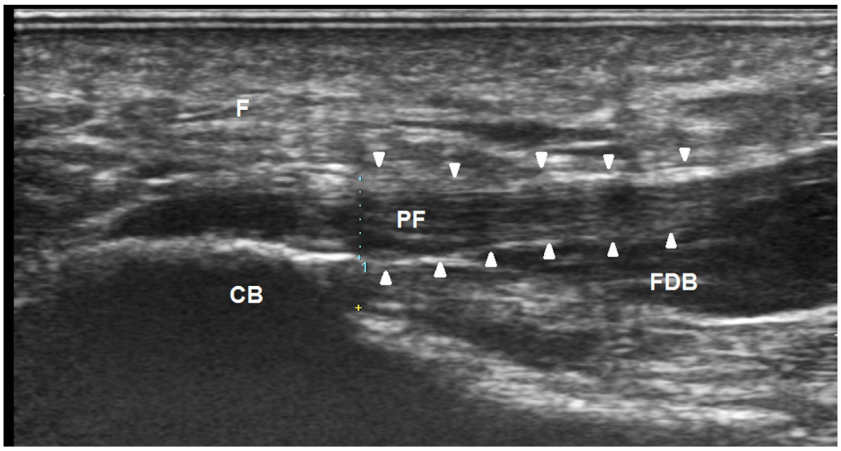

Fig. 1. A longitudinal sonogram view of a patient with plantar fasciitis, showing the measurement of the plantar fascia thickness (arrowhead). CB: calcaneus bone; F: fat pad; FDB: flexor digitorum brevis muscle; PF: Plantar fascia.

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the injection, an ultrasonographic evaluation of the plantar fascia was performed using a Hitachi ARIETTA V60 (Hitachi Aloka Medical Systems, Tokyo, Japan) ultrasound device with a 5–18 MHz linear transducer. Patients were placed in the prone position with their feet hanging over edge of the table in the neutral ankle position. The transducer was placed longitudinally over the medial aspect of the heel and the plantar fascia was visualized in a long-axis view. The plantar fascia was followed to its origin on the medial tuberosity of the calcaneus. In this area, the plantar fascia thickness was measured from the hyperechogenic border of the calcaneus bone vertically to the inferior hyperechogenic rim of the plantar fascia (Fig. 1). The ultrasound-guided injection procedure was as follows: Under sterile measures (transducer covered with a sterile barrier and applying sterile ultrasound transmission gel), the transducer was positioned transversely along the antero-medial side of the heel, and a short-axis view of the plantar fascia and the underlying calcaneus bone was obtained. Under ultrasound guidance and using in-plane injection technique, the needle was inserted on the medial side of the heel and it was visualized as it was approaching from the medial to lateral aspect of the field, targeting the hypoechogenic and mixed echogenic region of the plantar fascia (Fig. 2). In each session, an intrafascial injection of 2 cc dextrose 20% was performed using a Luer-lock syringe with a 25 gauge 1.5-inch needle. All injections were performed by a single physiatrist with 8 years of experience in ultrasound-guided musculoskeletal interventions.

2.7. Patients' instructions

All patients were asked to avoid using braces, non-steroidal anti-inflammatory drugs, local steroid injections, or physiotherapy for 12 weeks after the first treatment session. They were also asked to limit physical activity and refrain from high impact running. All patients in both groups were instructed to perform calf muscle and plantar fascia stretching exercises and intrinsic foot muscle strengthening. Patients also had access to the project's physician in case they experienced adverse side effects of the treatments.

2.8. Outcome measures

All outcome measures were evaluated at baseline and the follow-ups by the same physician. These evaluations were performed before treatment and at 6 and 12 weeks after the first session of the treatment. The outcome measures were the following:

2.9. Pain intensity

The intensity of the first-step pain was evaluated by means of visual analogue scale (VAS) consisting of a 100-point Likert-type scale. Zero represented no pain and 100 represented most severe pain.

2.10. Functional outcome measures

The Foot and Ankle Ability Measure (FAAM) was used to evaluate the functional limitation caused by plantar fasciitis. The FAAM is a validated and widely used self-administered questionnaire for quantifying functional limitations in patients with varying musculoskeletal disorders of the foot and ankle, including plantar fasciitis [17]. This questionnaire is divided into two subscales: a) the Activities of Daily Living (ADL) subscale, which consists of 21 items assessing the patient's ability to carry out everyday activities like standing or walking up the stairs, and b) the Sports sub-scale which consists of 8 items assessing more difficult tasks such as running, jumping, and landing. Survey responses are rated in a 5-point Likert scale (4 to 0) ranging from "No difficulty at all" to "Unable to do". Both scores are transformed to a percentage (0–100%) to get the final score of each subscale. A higher score implies a higher level of function. In this study, we used a Persian version of FAAM which is validated in Farsi language [18].

2.11. Ultrasonographic assessments

The plantar fascia thickness at its origin to the calcaneus was obtained as the ultrasonographic outcome measure for both study groups. The thickness was measured from the hyperechogenic border of the calcaneus bone vertically to the inferior hyperechogenic rim of the plantar fascia in the longitudinal view (Fig. 1). The high-frequency linear probe of the ultrasound device was used for this purpose. Measurements were performed by the same physiatrist who performed the injections.

2.12. Statistical analysis

Statistical analysis was performed using Excel 2010 (Microsoft, Seattle, WA) and SPSS-18 (SPSS Inc. Chicago, Illinois, USA). Descriptive data were reported as mean ± standard deviation (SD) or number (%) where appropriate. A Kolmogorov-Smirnov test was used to assess the data distribution prior to statistical analyses. Our data were normally distributed, and parametric tests were

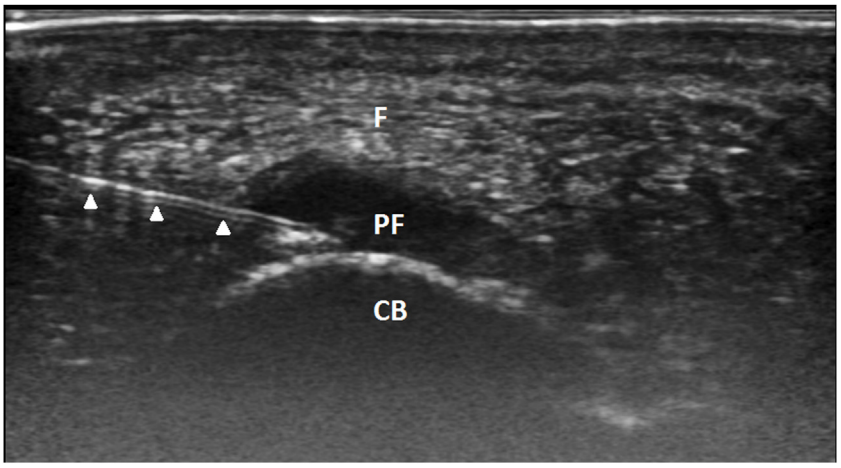

Fig. 2. Ultrasound-guided plantar fascia injection in transverse (short-axis) view. CB: calcaneus bone; F: fat pad; PF: plantar fascia; arrowheads: needle.

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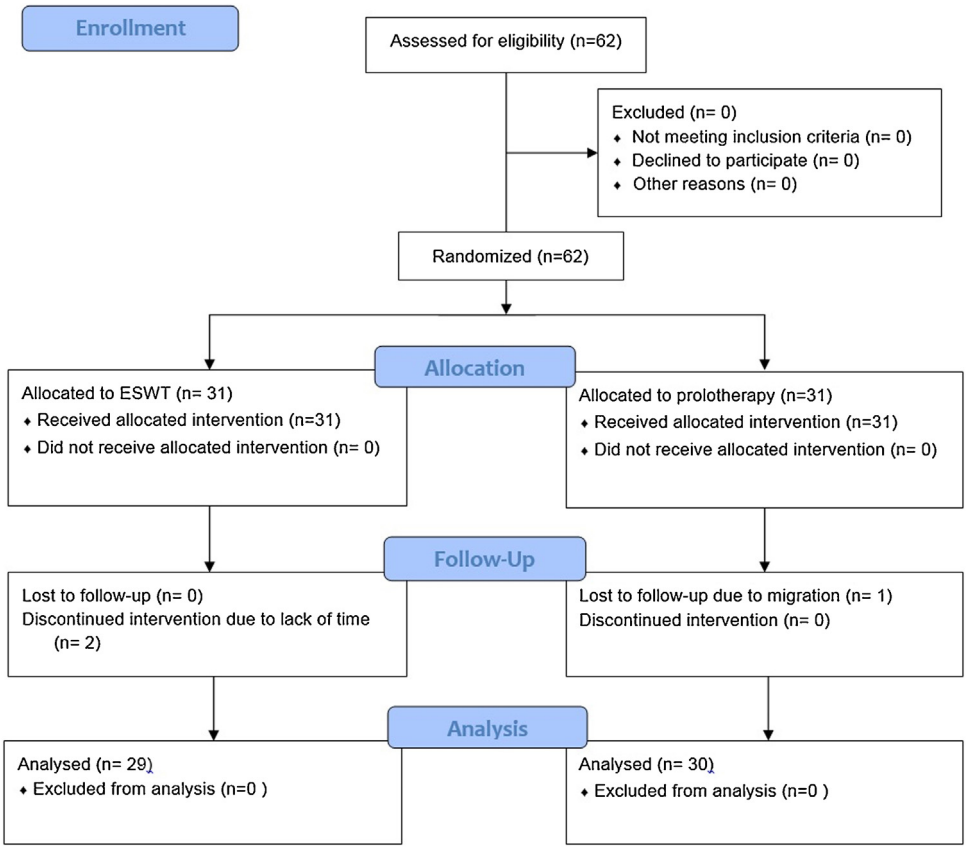

Fig. 3. Flow diagram of the participants.

used for statistical analyses. Demographic features and baseline values of the two groups were compared using chi-square tests for categorical variables and independent t tests for continuous variables. Mixed analysis of variance (ANOVA) and post-hoc tests were used to evaluate the interaction effects of time and group on outcomes. Greenhouse-Geisser estimates of sphericity were used to correct degrees of freedom wherever Mauchly's test was significant. A P value ≤ 0.05 was considered significant.

3. Results

Initially, 62 patients with PF were included in this trial and randomly assigned into either the prolotherapy or ESWT groups. During the follow-up, two patients in the ESWT and one patient in the prolotherapy group were unable to complete the study due to lack of time for follow ups or moving to another city. Thus, a total of 59 patients completed the study successfully: 29 patients (20 females and 9 males) received ESWT (group A), and 30 patients (19 females and 11 males) received prolotherapy (group B). The flow diagram of the study is shown in Fig. 3. The mean age of patients was 45.12 ± 6.9 years (range, 26–62). The mean duration of symptoms was 4.6 ± 1.2 months (range 3–7 months). The baseline demographic and clinical features of the patients are summarized in Table 1. There was no significant difference in age, sex, and body mass index between the two groups. No statistically significant difference was observed in the baseline values of the study outcomes (all p values >0.05).

3.1. Outcome measures

Table 2 demonstrates the mean VAS and FAAM scores and plantar fascia thickness for the two groups at baseline, 6 and 12 weeks after treatment. The details of time by group analyses for each study variable are also summarized in this table. Table 3 demonstrates the intra-group analysis of study outcomes in the two study groups.

Table 1
The baseline demographic and clinical characteristics of the patients.

Variable	ESWT (n = 29)	Prolotherapy (n = 30)	P value
Age (years)	43.7 ± 7.6	46.5 ± 6.5	0.133
Gender (female/male)	20/9	19/11	0.647
Disease duration (months)	4.8 ± 1.2	4.5 ± 1.3	0.361
BMI (kg/m^2)	26.5 ± 3.6	25.3 ± 4.2	0.244
VAS	72.32 ± 13.1	74.6 ± 11.1	0.387
FAAM-ADL (0–100)	74.2 ± 10.2	72.4 ± 12.6	0.543
FAAM-Sport (0–100)	72.6 ± 12.3	70.1 ± 11.8	0.428
Thickness (mm)	4.5 ± 0.6	4.7 ± 0.4	0.132

Abbreviations: BMI—Body mass index; VAS—Visual analogue scale; FAAM—Foot and ankle ability measure; ADL—Activities of daily living.

3.2. VAS

The mean VAS score before the treatment period was 72.32 ± 13.16 in group A, and 74.66 ± 11.15 in group B, which was not significantly different (p = 0.38). Six weeks after the commencement of the treatments, these scores reduced to 56.55 ± 12.5 and 53.31 ± 10.11, respectively. At 12-weeks of follow-up, they were 40.82 ± 10.32 and 44.22 ± 9.5, respectively. Both groups showed significant improvements in pain intensity at 6 weeks and 12 weeks in comparison to the baseline values. In both groups, the improvement in VAS pain scores was also significant in the time interval between 6 weeks and 12 weeks (Table 3).

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Table 2
The effects of the ESWT and prolotherapy on the VAS, FAAM questionnaire, and plantar fascia thickness (N = 59 feet).

Variable	Time of intervention	Intervention	Mean	SD		P-Value		P-Value
VAS	Baseline	ESWT	72.32	13.16	Group and Time Interaction	0.231	Baseline vs.12 weeks	
		Prolotherapy	74.66	11.15				0.102
	After 6 weeks	ESWT	56.55	12.52				
		Prolotherapy	53.31	10.11				
	After 12 weeks	ESWT	40.82	10.32				
	12 weeks	Prolotherapy	44.22	9.5				
FAAM-ADL	Baseline	ESWT	74.2	10.2	Group and Time Interaction	0.287	Baseline vs.12 weeks	0.183
		Prolotherapy	72.4	12.8				
	After 6 weeks	ESWT	88.3	7.2				
		Prolotherapy	87.5	8.7				
	After	ESWT	91.3	6.8				
	12 weeks	Prolotherapy	90	8.9				
FAAM-sport	Baseline	ESWT	72.6	12.3	Group and Time Interaction	0.038	Baseline vs.12 weeks	
		Prolotherapy	70.1	11.8				0.018
	After 6 weeks	ESWT	88.7	11.1				
		Prolotherapy	83.3	10.8				
	After	ESWT	92.3	10.2				
	12 weeks	Prolotherapy	85.8	9.3				
Fascia thickness	Baseline	ESWT	4.5	0.6	Group and Time Interaction	0.532	Baseline vs.12 weeks	0.072
		Prolotherapy	4.7	0.4				
	After 6 weeks	ESWT	4	0.3				
		Prolotherapy	4.1	0.3				
	After 12 weeks	ESWT	3.8	0.3				
		Prolotherapy	3.7	0.4				

Abbreviations: VAS—Visual analogue scale; ESWT—Extracorporeal shock wave therapy; FAAM—Foot and ankle ability measure; ADL—Activities of daily living.

Table 3
Intra-group analysis of the VAS, FAAM and plantar fascia thickness in two groups of ESWT and prolotherapy patients (N = 59 feet).

Variables	Intervention	Time of investigation	VAS	FAAM-ADL	FAAM-sport	Fascia thickness
Intragroup changes	ESWT	Baseline vs. 6 weeks	0.0001	<0.0001	<0.0001	0.0001
		Baseline vs. 12 weeks	<0.0001	<0.0001	<0.0001	<0.0001
		6 weeks vs. 12 weeks	<0.0001	0.103	0.195	0.034
	Prolotherapy	Baseline vs. 6 weeks	<0.0001	<0.0001	<0.0001	<0.0001
		Baseline vs. 12 weeks	<0.0001	<0.0001	<0.0001	<0.0001
		6 weeks vs. 12 weeks	0.002	0.28	0.316	0.0001

Abbreviations: VAS—Visual analogue scale; FAAM—Foot and ankle ability measure; ADL—Activities of daily living; ESWT—Extracorporeal shock wave therapy.

The interaction effects of group and time on this outcome measure were not significant (P = 0.231). This implies that the behaviors of both groups were similar regarding the changes in this outcome.

3.3. FAAM

As demonstrated in Tables 2 and 3, both interventions were associated with a significant increase in the FAAM-ADL and FAAM-sport scores at 6 and 12 weeks follow-up. The increase in the FAAM score implies improvement in functional abilities. There was no significant difference in the FAAM scores between 6 weeks and 12 weeks in either of the groups.

The interaction effects of group and time on the FAAM-ADL subscale were not significant (P = 0.287). However, analysis of the FAAM-Sport subscale showed significant interaction effects between time and group in comparison of pre-treatment and three-month post-treatment (P = 0.038) in favor of ESWT (Table 2).

3.4. Plantar fascia thickness

The mean plantar fascia thickness in patients before the treatment was 4.5 ± 0.6 mm in group A and 4.7 ± 0.4 mm in group B, which was not significantly different (p = 0.13). The mean thickness reduced to 4.0 ± 0.3 mm vs. 4.1 ± 0.3 mm six week after treatment, respectively. At 12 week follow-up, the corresponding figures were 3.8 ± 0.3 mm in group A and 3.7 ± 0.4 mm in group B (Table 2). Both groups showed significant reduction in plantar fascia thickness between 6 and 12 weeks after the initiation of treatment. The reduction in thickness was also statistically significant between the intervals 6 weeks and 12 weeks after the treatment (Table 3).

Statistical difference was not detected (P = 0.532) concerning interaction effect of time and group on plantar fascia thickness between the two groups (Table 2).

3.5. Adverse events

All patients tolerated the interventions well and no serious adverse events (hematomas, infections, or soft tissue atrophy) were observed in any of the cases.

4. Discussion

ESWT has long been established as an effective treatment for PF. In recent years, prolotherapy is increasingly being used in the field of musculoskeletal medicine [10]; however, few studies have investigated its effectiveness on PF. In this study, 59 patients with plantar fasciitis were randomly assigned into two groups to receive either ESWT or dextrose prolotherapy injections. The study intended to compare four different outcome measures up to 3 months after treatments. Both groups showed significant

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reduction in VAS pain score and plantar fascia thickness, and improvements in FAAM scores. The inter-group comparison revealed that except for the FAAM-sport subscale which favored ESWT, the interaction effects of group and time were not significant on the other outcome measures (i.e. VAS score, FAAM-ADL and plantar fascia thickness).The findings of this study carry important clinical implications for physicians practicing musculoskeletal medicine, as ESWT is less technically demanding and easier to perform in daily clinical practice.

Regenerative injection therapies, including 5% dextrose prolotherapy, is an emerging field in the treatment of PF. To our knowledge, only three previous trials have assessed the efficacy of dextrose prolotherapy in patients with PF [13–15]. The first report of application of dextrose 5% prolotherapy for PF was published in 2009 by Ryan et al. [13]. The authors performed a prospective study on 20 patients (17 women, 3 men) with chronic PF who were unresponsive to conservative treatments. The patients received ultrasound-guided injection of 25% dextrose for an average of three sessions. Pain intensity was assessed by a 100-point VAS at baseline and at an average of 11.8 months. Compared to the baseline values, a significant reduction in the VAS scores was obtained, and 16 patients (80%) reported "good" or "excellent" treatment effects. However, this study was limited in its lack of a control group and lack of a functional outcome measure, which makes it difficult to determine whether the improvements were clinically relevant. In another investigation, Ersen et al. [14] included 50 patients in a study evaluating clinical effectiveness of prolotherapy for PF. Among the subjects, 26 patients were allocated to receive three ultrasound-guided 15% dextrose injections with a three-week interval, and 24 control patients were allocated to receive instructions for plantar fascia and Achilles tendon stretching exercises. The outcome measures were VAS score, Foot and Ankle Outcome Score, and Foot Function Index. The measures were evaluated at baseline and at 21, 42, 90, and 360 days. Their results indicated that the improvements in the VAS score and functional measures were higher in the prolotherapy group in the short-term follow-ups. However, both groups had similar scores after 360 days.

Finally, Kim and Lee [15] performed a randomized clinical trial comparing the efficacy of 2 cc dextrose 15% versus 2 cc of autologous platelet-rich plasma (PRP) in patients with recalcitrant plantar fasciitis. The outcome measures were VAS pain score and Foot Function Index (FFI). The injections in both groups were performed two times with a two-week interval, and under ultrasound guidance. Both groups of patients showed a significant pain reduction at 2 months post-injection. However, the between-group difference in improvement on the FFI did not reach statistical significance.

To our knowledge, there are no similar studies in the literature comparing dextrose prolotherapy with ESWT in patients with PF. Therefore we are unable to compare our results with those of other authors. In our study, we used ultrasonography to investigate the structural changes of the plantar fascia after dextrose prolotherapy injection. Our observations revealed a marked reduction in the plantar fascia thickness three months after the first injection. Unfortunately, there is no literature on the ultrasonographic changes of the plantar fascia thickness after prolotherapy injection. However, we found our results consistent with a similar study on patients with chronic Achilles tendinopathy, which demonstrated a significant reduction in the Achilles thickness after injection of 25% dextrose solution [19]. In the index study, dextrose was injected into hypoechoic regions of the Achilles tendon under ultrasound guidance. At 12 weeks, the mean tendon thickness decreased from 11.7 to 11.1 mm, which was statistically significant. In addition, the hypoechoic and anechoic tendon regions, as well as neovascularity were all improved in some, but not each, subjects. The ultrasonographic changes in the plantar fascia after dextrose therapy may be related to the resolution of the active inflammation and edema in the plantar fascia. These structural changes are reflected by decrease in fascial thickness, hypoechogenicity and neovascularity in the ultrasound examination [20,21]. Similar changes in ultrasonographic structural appearance has also been reported after local corticosteroid injection into the plantar fascia [22].

Magnetic resonance imaging (MRI) is considered as the most sensitive imaging modality in the diagnosis of plantar fasciitis [20]. The typical MRI findings are thickening of the plantar fascia, increased signal intensity on T2-weighted sequences predominantly in the proximal plantar fascia, edema in the adjacent soft tissues, and bone marrow edema within the medial calcaneal tuberosity [20]. Several studies have investigated the effects of ESWT on MRI parameters in patients with plantar fasciitis. These studies have consistently identified significant reductions in the thickness of the plantar fascia, high-signal intensity areas, soft-tissue edema and bone marrow edema after ESWT [23–25]. To date, however, no investigation has been conducted on MRI changes after prolotherapy in these patients.

Basically, two types of ESWT are widely used for treating plantar fasciitis: radial EWT, and focused ESWT. The efficacy of radial ESWT for treating chronic recalcitrant plantar fasciitis has been investigated by several well-designed clinical trials in the literature. A large multicenter trial by Gerdesmeyer et al. [5] on 245 patients with chronic plantar fasciitis showed significant improvements in pain scale (VAS), functional measurements, and quality of life after three treatment sessions of radial ESWT. This trial was performed as an FDA approval study, and the patients were followed for 12 months. Nearly all outcome measures at 12 months after intervention were superior in the radial ESWT group. A more recent study on 50 patients with chronic plantar fascist [7] with two years of follow up showed significant long-term improvements in pain score and functional outcomes. This study was a continuation of an earlier trial with six months follow up [26] which also had shown an excellent efficacy of radial ESWT in chronic plantar fasciitis. Chang et al. [9] conducted a systematic review and network meta-analysis and compared the effectiveness of radial versus focused ESWT for treating plantar fasciitis. The result of network meta-analysis revealed that radial ESWT was more advantageous over focused ESWT in terms of treatment success and pain relief. The authors suggested radial ESWT as an appropriate alternative for the traditional focused ESWT because of its lower costs and possible equal or better effectiveness. In a more recent meta-analysis by Sun et al. [6] radial ESWT was found to be more effective than placebo and focused ESWT; however, because of significant heterogeneity between studies on radial ESWT, a robust conclusion could not be drawn with the currently available data. Radial ESWT has a number of advantages over the traditional focused ESWT that makes its application easier in daily clinical practice. The costs of a radial ESWT device (as well as treatment expenses for the patients) are lower. Besides, application of radial ESWT requires a lower level of expertise than focused ESWT (focused ESWT requires precise focusing, or, at times, a good knowledge of ultrasonography). Taking all together, radial ESWT seems to be a good alternative choice for focused ESWT because of its lower costs and its possible equal or better effectiveness in clinical practice [9].

In recent years, several randomized controlled trials have been conducted exploring the relative efficacy of new and emerging therapies such as botulinum toxin type A [27], autologous blood-derived products [28], and ultrasound therapy [29] in comparison with ESWT as an established therapeutic modality for PF. None of these novel treatments demonstrated superiority to ESWT in terms of pain relief or functional improvement. Recently, Li and

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colleagues [30] conducted a meta-analysis which reviewed 19 randomized clinical trials investigating the efficacy of ESWT, ultrasound-guided pulsed radiofrequency treatment, low-level laser therapy, and noninvasive interactive neurostimulation for the treatment of plantar fasciitis. In their study, ESWT demonstrated relatively more effective and stable pain relief when compared to other modalities. Therefore, the authors recommended treating plantar fasciitis with ESWT. In another meta-analysis, Sun et al. [8] included 13 randomized clinical trials and concluded that, when compared to other therapies, ESWT results in more therapeutic benefits in patients with PF. Our study adds to the current literature by demonstrating no significant differences in pain or functional outcomes in prolotherapy versus ESWT in the short- (1 months) or long-term (3 months) in patients with PF. While considerable expertise is required to perform an ultrasound-guided injection of the plantar fascia, ESWT is less technically demanding and is easier to perform in daily clinical practice. The costs of musculoskeletal ultrasound-guided injections and ESWT vary in different countries and between public and private sectors. The insurance coverage of these interventions also seem to differ dramatically between the countries. To date, no cost-effectiveness analysis has been performed to determine the economic value of ESWT compared with that of ultrasound-guided injections in chronic plantar fasciitis. Therefore, due to the lack of literature, whether ESWT is more cost-benefit than ultrasound-guided injection remains to be studied.

This study has a number of limitations. The majority of the participants were female. Hence, our results may not be generalized to the male population. Another limitation was the fact that we were not able to completely blind the patients because of the nature of the interventions. Finally, we did not include a control group (receiving no intervention but only conservative measures) in this study, and therefore, we cannot evaluate the extent of natural recovery in the improvement of clinical findings. This study was the first on this topic, and further studies, with larger sample size and longer follow-up, are warranted to compare these methods

5. Conclusions

To our knowledge, this is the first study that compared the clinical effectiveness of dextrose prolotherapy and ESWT in patients with chronic PF. Our findings demonstrated that dextrose prolotherapy has comparable efficacy to ESWT in improving pain, functional outcomes and ultrasonographic features in these patients. No serious adverse effects were observed in either group.

Declarations of interest

None.

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