Title: The Efficacy of TECAR Therapy in the Management of Plantar Fasciitis: A Randomized Clinical Trial

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To appear in: ***Physical Treatments***

Received date: 2025/11/18

Revised date: 2026/01/08

Accepted date: 2026/01/25

First Online Published: 2026/02/02

Please cite this article as:

Maghroori R, Haghighat S, Izadi F. The Efficacy of TECAR Therapy in the Management of Plantar Fasciitis: A Randomized Clinical Trial. ***Physical Treatments.*** Forthcoming 2026. DOI: http://dx.doi.org/10.32598/ptj.2026.786.1

DOI: http://dx.doi.org/10.32598/ptj.2026.786.1

Abstract

Purpose: TECAR therapy is a newly emerged physiotherapy technique, demonstrating beneficial effects for different musculoskeletal pains. No earlier studies have investigated the effectiveness of this method for plantar fasciitis (PF) management.

Methods: A double-blind, randomized clinical study was performed involving 60 individuals with PF. The control group underwent a conventional treatment (a set of sport, a silicone heel pad use, and Celecoxib consumption). The intervention group underwent TECAR therapy (twice per week for 4 weeks) in addition to the conservative treatment. The Modified Roles and Maudsley (RM) score, visual analog scale (VAS), and plantar fascia thickness (PFT) were compared between the two groups at baseline, immediately post intervention, and after 2 months following the interventions.

Results: A total of 60 participants (aged 41.68±13.17 years) were enrolled equally in each group. Following treatment, both groups showed significant decrease in VAS and RM scores over time ($p<0.001$). However, TECAR therapy resulted in significantly greater pain relief at both post-treatment time points ($p<0.001$). A time-dependent decrease in PFT was evident in both study groups ($p < 0.001$). There was no significant difference in PFT between groups at baseline, but it was significantly lower in the TECAR group immediately after the intervention and at two months ($p=0.015$ and $p=0.028$, respectively). Each group showed a notable enhancement in RM scores over time, yet no statistically significant disparity was found between the groups at any measurement phase.

Discussion: TECAR therapy appears to be an effective adjuvant to conservative treatment for PF, providing greater short- and mid-term pain relief and PFT reduction.

Keywords: Plantar Fasciitis, Physical Therapy Modalities, TECAR therapy, Heel pain, Non-invasive therapy

Highlights:

- TECAR therapy, as an adjunct to conventional treatment, provided significantly greater short- and mid-term pain relief in patients with plantar fasciitis.
- Plantar fascia thickness decreased more in the TECAR group compared with the control group after treatment and at two-month follow-up.

Plain Language Summary:

Plantar fasciitis is a common source of heel pain and can significantly impair walking ability and routine daily activities. This study tested a new physiotherapy method called TECAR therapy, which uses gentle radiofrequency energy to promote healing, in addition to standard treatments such as stretching, heel pads, and pain medication. Sixty people with plantar fasciitis participated, and those who received TECAR therapy twice a week for four weeks experienced greater pain relief and a larger decrease in plantar fascia thickness compared with those who had standard care alone. These results suggest that adding TECAR therapy to conventional treatment can help patients recover faster, reduce pain more effectively, and improve daily comfort and quality of life.

1. Introduction

Plantar fasciitis (PF) commonly occurs in individuals regardless of age or physical activity status and represents a major musculoskeletal complaint [1]. This condition is characterized by discomfort in the inner heel, which worsens during weight-bearing activities [2]. The lifetime incidence is approximately 10%. In one-third of the cases, PF may manifest bilaterally [3]. This disease frequently becomes chronic, with symptoms persisting for nearly a year. It is estimated that PF accounting for nearly one million annual visits to healthcare providers across the United States [1].

The diagnosis of PF, is mostly by physical examination and clinical patient history [4]. Patients experience a severe pain during the initial steps taken upon rising from bed in the morning. Although pain tends to subside as activities commence, it may worsen at the end of the day. Tenderness may be observed at the medial calcaneal tubercle. The windlass test would be helpful in establishing the pathology with a high specificity (100%), but low sensitivity (32%) [3]. Ultrasound is also considered a sensitive instrument for PF assessment, with significant findings including increased plantar fascia thickness and hypoechoic appearance of plantar fascia. X-ray imaging is also useful in ruling out other pathologies [5].

Although the PF is self-limiting and resolves within a year, the impact of it on routine activities drives patients to pursue treatment prior to the resolution of the pain. Approximately 70% of patients reduced their pain with conservative treatment alone [6]. However, some may require a combination of conservative management and other therapies [6]. Different therapeutic options have been suggested for PF, including night splint usage [7], shock wave therapies [8], laser therapies [9], corticosteroids injections [10], and surgical interventions [11]. Nevertheless, based on the current studies, none of the aforementioned therapeutic options have demonstrated clear

superiority, and with ongoing technological advancements, the optimal approach remains a matter of debate [3].

Recently, studies have utilized a novel electrotherapy modality in the management of musculoskeletal pains known as TECAR (Transfer of Energy Capacitive and Resistive) [12–14]. TECAR therapy delivers high-frequency energy (300 kHz–1 MHz) in a non-invasive manner, stimulating the body's innate capacity for regeneration [15]. TECAR therapy operates via two modes of electric charge transfer: capacitive and resistive. The capacitive mode primarily affects soft tissues and muscles rich in electrolytes, whereas the resistive mode targets denser structures such as tendons, bones, and joints [16]. The findings of a recent meta-analysis suggested TECAR therapy as an effective method for management of sports-related pains [13].

Given the therapeutic mechanisms of TECAR therapy including enhanced blood flow and tissue oxygenation, enhanced tissue metabolism, and reduced tissue edema [17]—it is expected that this treatment would improve tissue perfusion and minimize edema in PF patients. Considering the lack of prior survey on the effectiveness of TECAR therapy in managing PF, coupled with the fact that PF has a high prevalence and clinical significance and that effective non-surgical management is required, this research was conducted to assess how TECAR treatment influences pain relief and functional improvement in individuals with PF..

2. Materials and Methods

2.1. Study Design and protocol

This was a double-blinded randomized clinical trial study (In this investigation both participants and therapists were blinded using a sham TECAR device that looked and felt identical to the active device but did not deliver therapeutic current.). The research protocol was approved by the Ethics

Committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1402.264) and subsequently recorded in the Iranian Registry of Clinical Trials (IRCT20231105059968N1, Registration date: 22 January 2024). In accordance with the Declaration of Helsinki, all participants received a detailed explanation of the study protocol and voluntarily signed written informed consent forms. Group assignment was determined using a computer-generated randomization list prepared by an independent researcher with no role in participant recruitment or evaluation. Concealment of allocation was achieved by employing consecutively numbered, sealed, and opaque envelopes. Simple randomization was applied, and no block randomization or stratification was used.

2.2. Study Participants

All patients with PF referring to the Physical Medicine and Rehabilitation Clinic, Isfahan University of Medical Sciences, Isfahan, Iran, were eligible for including in the trial. Included patients were adults (aged 18-68 years), with at least a history of heel pain for 4 weeks. The PF was diagnosed by a physiatrist through ultrasonography evaluation. The severity of heel pain was assessed using the visual analog scale (VAS). Patients with VAS score greater than 3 was included in this trial. The VAS cutoff (> 3) was selected based on prior literature [18,19] and expert consensus among the study investigators, all of whom were specialists in Physical Medicine and Rehabilitation. Pain scores ≤ 3 are generally considered mild, are less likely to cause functional impairment, and typically do not require specific interventional treatment. The exclusion criteria were history of diabetes, arthritis, Achilles tendon injury, history of trauma, injections or surgeries on the affected heel, and any contraindications for TECAR therapy (including pregnancy, utilizing pacemaker, neoplasms, open wounds and skin lesions, skin sensitivity, and lack of heat sensation). Individuals with intense level of physical activity who are unable to reduce it, were also excluded.

During the study, the patients would be excluded if their symptoms worsen and require more vigorous interventions.

2.3. Study design and intervention

During the study period, participants were enrolled consecutively from patients referred to the Physical Medicine and Rehabilitation Clinic. Individuals meeting the specified eligibility criteria and agreeing to participate were included in the study. Participants were then allocated to either the intervention or control group through computer-based randomization with concealed allocation. The required sample size was calculated using an independent two-sample mean comparison formula with a two-tailed significance level of 0.05 and 80% power. Drawing on prior evidence [20], a minimum of 26 participants in each group were found. To account for potential dropouts, 30 participants were enrolled in each group. Finally, 30 patients were eligible for inclusion in each category. In the intervention group, individuals underwent TECAR therapy (twice per week for 4 weeks), a set of sports (stretching calf muscle and plantar fascia, passive dorsiflexion of the toes, strengthening intrinsic foot muscles, and rolling the sole of the foot three times in the morning, noon and night, each set lasting 30 seconds), and also a silicone heel pad was prescribed for them. They additionally consumed Celecoxib 200mg per day for 15 days. The control group, did the same set of exercises, use silicone heel pad, and consumed the same medication.

TECAR therapy was delivered using the WINBACK 3 device (France) with a frequency of 500 Hz and an intensity range of 20–40%, adjusted according to patient tolerance at the physiotherapy section of Amin Hospital, Isfahan, Iran. Treatment was applied using a medium-sized capacitive energy transfer electrode (60 mm). The capacitive and resistive modes were applied as described above. The patient was placed in the prone position, and conductive gel was applied near the

Achilles tendon insertion. TECAR therapy was administered for 15 minutes per session (5 minutes of resistive, 10 minutes of capacitive) for 8 sessions, two sessions per week.

2.4. Data collection and measurements

At the beginning, demographic characteristics of participants including age, sex, occupation (homemaker, unemployed, employed), severity of pain, and severity of the symptoms and patient's function was recorded. Ultrasonography (Alpinion E-CUBE 9, Republic of Korea) was employed to evaluate plantar fascia thickness. Ultrasonography was performed by a single experienced physiatrist who was blinded to group allocation and clinical data. To reduce measurement variability, plantar fascia thickness was measured twice at each assessment, and the average value was used for analysis. The diagnosis of PF was made by an experienced physiatrist based on clinical presentation and ultrasonographic findings. No strict cut-off value for plantar fascia thickness was used for diagnosis; instead, ultrasonography was applied as a supportive imaging tool to confirm the clinical diagnosis and to quantify plantar fascia thickness for outcome assessment. The patients were placed in a prone position, ensuring knees were fully extended and ankles dorsiflexed to 90°, with legs allowed to hang naturally. Using a 5–13 MHz probe on the Alpinion E-CUBE 9 (Republic of Korea), plantar fascia thickness was measured twice at the standard location crossing the anterior border of the calcaneus, with the average taken to minimize potential errors from the transducer. At the end of intervention, and 2 months post intervention, the severity of the pain and symptoms, and the patient's function was assessed. VAS score was utilized for assessing the severity of pain [21]. This 10-point scale rated pain from 0 (no pain) to 10 (worst possible pain), with 1–3 indicating mild, 4–7 moderate, and 8–10 severe pain levels [22]. The reliability of Iranian version of this scale had been approved [23]. The modified Roles and Maudsley (RM) score has been used to categorize participants into four levels: excellent, good,

fair, and poor, based on their pain levels and ability to perform daily activities. This score was a functional evaluation method used to assess pain and activity limitations, often in the context of foot and ankle conditions like PF [24]. The main outcome of interest was the level of pain, determined using the VAS. Secondary outcomes included plantar fascia thickness measured by ultrasonography and functional status assessed using the modified RM score. Outcomes were evaluated at baseline, at the end of the intervention, and two months after the intervention.

2.5. Statistical analysis

Continuous data are expressed as mean ± SD, and categorical variables as n (%). Data normality was assessed through the Shapiro–Wilk test and inspection of box plots. For within-group comparisons, Repeated Measures ANOVA or Friedman tests were applied, whereas independent t-tests, ANOVA, Chi-square, or Fisher's exact tests were used for between-group analyses. All analyses were carried out using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA), with statistical significance set at $p < 0.05$.

3. Results

In each arm of the study, 30 individuals were enrolled. The mean age of all participants was 41.68 (13.17), ranging from 18 – 63 years. Most patients were male (51.7%) and the majority were employed (31.7%). The baseline characteristics of each group was shown in **Table 1**. The groups did not differ significantly with respect to age, plantar fascia thickness, gender, or employment status (p-values > 0.05 for all comparisons).

Table 1. Baseline characteristics of included participants.

	Intervention group (N = 30)	Control group (N = 30)	p-value
Age (mean ± SD)	41 ± 14.26	42.37 ± 11.74	0.691*
Gender (male%)	16 (53.3)	15 (50)	0.796**
Occupation (%)			
Homemaker	7 (23.3)	3 (10)	0.579**
Unemployed	7 (23.3)	8 (26.7)	
Employed	9 (30.0)	10 (33.3)	
Other	7 (23.3)	9 (30)	

* Independent T-test

** Chi-square test

The evaluation of the VAS scores (an indicator of severity of pain), demonstrated no significant difference within groups at the baseline (p-value = 0.693). Immediately after the intervention, the mean of VAS scores among both groups decreased significantly compared to baseline levels (p-value < 0.001). Two months after the intervention, the scores in both groups continued to diminish compared to the values immediately after intervention (p-value < 0.001). In both arms of study (immediately after intervention and 2 months later), the VAS scores showed significant lower levels among patients underwent TECAR therapy (p-value < 0.001). **Table 2** shows the mean of VAS scores in each group, before and after the intervention.

Table 2. Comparison of pain based on the Visual Analog Scale (VAS) and plantar fascia thickness between the TECAR therapy and control groups.

	Groups	Before	Immediately after intervention	After two months	p-value trend***	p-value before-after	p-value before-after two months	p-value immediately after-after two months
VAS score	Intervention	6.50±1.97	3.93±2.21	2.60±2.29	<0.001	<0.001	<0.001	<0.001
	Control	6.70±1.93	5.17±2.18	4.13±2.34	<0.001	<0.001	<0.001	<0.001
	p-value	0.693* Cohen's d=0.103	<0.001** η^2=0.231	<0.001** η^2=0.224				
Plantar fascia	Intervention	4.73±0.38	4.64±0.39	4.14±0.51	<0.001	0.142	<0.001	<0.001
	Control	4.88±0.15	4.88±0.14	4.46±0.27	<0.001	0.999	<0.001	<0.001
	p-value	0.057* Cohen's d=0.508	0.015** η^2=0.100	0.028** η^2=0.082				

* Independent T-test.

** ANOVA test.

*** One-way Repeated Measures ANOVA.

There was no significant different in the plantar fascia thickness between 2 groups, at baseline (p-value = 0.057). Immediately after the intervention, and after 2 months, the plantar fascia thickness was significantly lower in TECAR therapy group compared to the control group (p-value = 0.015, p-value = 0.028, respectively). There was no significant change in the fascia thickness immediately after the intervention in both groups (p-value = 0.142 for intervention group, and p-value = 0.999 for control group). However, measurements in both arms of study, 2 months after

the intervention revealed a significant decrease in the fascia thickness compared to the baseline levels, and levels immediately after the intervention (all p-values < 0.001). **Table 2** shows the mean of plantar fascia thickness in each group, before and after the intervention.

Regrading the RM scores, there was no significant difference between the two groups before the intervention (p-value = 0.796), immediately after the intervention (p-value = 0.342), and 2 months later (p-value = 0.874). The Friedman test revealed a significant improvement in RM scores distribution over time in both the Tecar therapy group (p-value < 0.001) and the control group (p-value < 0.001). The pairwise Wilcoxon test showed a significant improvement in pain intensity both immediately after treatment compared to before (p-value < 0.001) and two months after treatment compared to baseline (p-value < 0.001). Additionally, a significant improvement in the distribution of RM categories was observed, 2 months after the intervention compared to immediately after (p-value < 0.001). **Table 3** presents the distribution of RM scores in each group, before and after the intervention.

Table 3. Comparison of routine activity-related pain (RM) between the TECAR therapy and control groups.

		Intervention N (%)	Control N (%)	p-value
Before	Poor	16 (53.3)	15 (50)	0.796*
	Acceptable	14 (46.7)	15 (50)	
Immediately after intervention	Poor	5 (16.7)	3 (10)	0.342**
	Acceptable	12 (40)	16 (53.3)	
	Good	13 (43.3)	9 (30)	
	Perfect	0 (0)	2 (6.7)	
Two months after intervention	Acceptable	9 (30)	8 (26.7)	0.874*
	Good	13 (43.3)	15 (50)	
	Perfect	8 (26.7)	7 (23.3)	
p-value***		<0.001	<0.001	

* Chi-squared test.

** Fishers exact test.

*** Friedman test.

4. Discussion

In this double-blinded randomized clinical trial we aimed to assess the efficacy of TECAR therapy in management of PF. Our findings showed that, both TECAR therapy and standard conservative management considerably diminishes the pain intensity among PF patients over the time. Although the groups did not differ significantly at baseline, the TECAR therapy group demonstrated better pain relief than the control group, as evidenced by significantly lower VAS scores both immediately following the intervention and two months later. Accordingly, TECAR therapy may provide better short- and mid-term analgesic effects than those obtained with traditional

management alone. Additionally, within-group analyses showed that both groups' functional status significantly improved over time, despite the fact that there were no discernible differences in RM scores between groups at any point in time. Plantar fascia thickness did not differ significantly between groups at baseline; however, it was significantly lower in the TECAR therapy group both in immediate post-treatment measurements and at the two-month follow-up. Both groups showing a significant reduction in thickness only at the two-month mark compared to baseline and immediate post-treatment measurements. This highlights, that the effect of treatments on plantar fascia thickness may appear delayed.

PF, also known as jogger's heel, policeman's heel, or tennis heel, is frequently classified as an overuse injury, mainly resulting from repetitive strain that leads to micro-tears in the plantar fascia [25]. Nearly half of individuals suffering from this condition will additionally experience heel spurs; however, these spurs are not the underlying cause. PF is frequently linked to runners and older individuals; however, additional risk factors encompass obesity, heel pad atrophy, the aging process, jobs that necessitate extended periods of standing, and weight-bearing activities [26]. Either chronic inflammation, which involves sustained immune cell activity, or chronic degeneration, which is characterized by fibroblastic proliferation without immune involvement, can be the course of PF. Histological investigations that demonstrate tissue alterations like collagen degradation and angiofibroblastic hyperplasia in the absence of inflammatory cells frequently lend credence to the degenerative pathway [27].

There is currently no single universally accepted treatment for PF, as its management typically involves a combination of conservative and adjunctive therapies tailored to individual patient needs [28]. Conservative measures such as stretching exercises, orthotics, NSAIDs, and physical therapy remain the first-line approach, particularly in the early stages of the condition. Adjunctive

treatments, including corticosteroid injections, extracorporeal shockwave therapy, PRP, and newer modalities like TECAR therapy, have shown varying degrees of success, particularly in patients with persistent symptoms [3,29]. Surgical intervention is generally reserved for chronic, refractory cases that do not respond to non-surgical treatment [30].

TECAR therapy is newly emerged physical therapy technique that utilizes radiofrequency energy (300 KHz to 1 MHz) to generate heat within biological tissues, enhancing the body's natural healing processes. It works through two main mechanisms: capacitive energy transfer (CET), which targets superficial tissues with high water content using an insulated electrode, and resistive energy transfer (RET), which targets deeper, denser tissues using a non-insulated electrode. CET promotes local heating to muscles and soft tissues, improving blood flow, metabolic activity, and tissue flexibility, and reduces muscle tension. RET delivers energy to tissues like bone and tendons, promoting collagen synthesis, tissue healing, and reduces inflammation [12]. Results of a meta-analysis on patients with diverse musculoskeletal pain such as low back pain, shoulder pain, knee pain, and leg pain, demonstrated beneficial effects of TECAR therapy in management of musculoskeletal pains, particularly in long-term follow-ups [31]. Going along with the finding of this study. Results of our trial indicated that TECAR therapy significantly affect the healing process of PF. However, its beneficial effects were not considerably more than traditional treatments.

Although the diagnosis of PF is primarily based on physical examination and patient history, the assessment of plantar fascia thickness using ultrasonography has been identified as a potential diagnostic tool [32]. It has been noted that, the plantar fascia thickness among PF patients is more than normal individuals. The values above 4 mm is considered to be diagnostic for PF [33]. Our findings indicated that therapeutic interventions decreased the thickness of plantar fascia in PF

patients, but did not return it to normal range. This thickness may return to normal levels during longer-term follow-ups.

This study possesses several strengths. Notably, to our knowledge, it is the first to examine the effectiveness of TECAR therapy in patients with PF. Second, due to the double-blinded manner of this study, the selection and performance bias has been minimized. Third, utilizing standardized outcome measures, including the VAS and RM scores, and objective assessment of plantar fascia thickness adds robustness to the data collection and interpretation. However, the limitations should be mentioned. Due to the modest sample size, the study's findings may have limited generalizability and reduced statistical power, especially for functional outcome measures Participants were recruited consecutively from a single center, which may limit the generalizability of the findings. However, random sequence generation, allocation concealment, and blinding were applied to minimize selection and performance bias. Although ultrasonography was performed by a single blinded evaluator with repeated measurements to reduce variability, formal inter- or intra-rater reliability analysis was not conducted. Additionally, the short duration of follow-up may not capture the long-term therapeutic effects, particularly in terms of returning plantar fascia thickness to normal levels. Moreover, the absence of a third group receiving sham TECAR therapy in addition to medication and exercise prevented a more precise isolation of the specific effects attributable to TECAR therapy.

5. Conclusion

This trial indicated that TECAR therapy, in combination with traditional conservative treatment, offers better short- and mid-term pain relief and a more significant reduction in plantar fascia thickness compared to conservative treatment alone in PF patients. Both groups exhibited improved functional outcomes, with no significant difference between them. TECAR therapy is a

promising adjuvant treatment, but larger studies with longer follow-up are needed to establish its long-term effectiveness.

Declarations

Ethics approval: This randomized controlled trial received approval from the Ethics Committee of Isfahan University of Medical Sciences (ID: IR.MUI.MED.REC.1402.264).

Consent to participate: Written informed consent was obtained from the participants.

Competing Interests: None to declare.

Funding: The work received financial support from Isfahan University of Medical Sciences.

Data Availability: Data from this study are accessible from the corresponding author and may be provided to interested parties upon request.

Acknowledgments: None.

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