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Investigating the Effectiveness of TECAR Therapy Versus Conventional Physiotherapy in Alleviating Symptoms of Shoulder Impingement Syndrome: A Randomized Clinical Trial

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Abstract

Background: Shoulder impingement syndrome is a common clinical condition characterized by pain and reduced shoulder range of motion. As the efficacy of Transfer of Energy Capacitive and Resistive (TECAR) therapy, a form of noninvasive electrothermal therapy, in managing this condition is not yet well-established, this study aims to investigate and compare the effectiveness of TECAR therapy and conventional physiotherapy in improving pain, shoulder disability, and the painless active abduction range of motion in patients with shoulder impingement syndrome.

Methods: Fifty patients were randomized into two groups. The first group received conventional physiotherapy, which included continuous ultrasound, transcutaneous electrical nerve stimulation, infrared therapy, and hot packs (10 sessions administered on alternate days). The second group underwent TECAR therapy in both resistive and capacitive modes (two sessions per week). Both groups took daily meloxicam and performed exercises for 3 weeks. Outcome measures included the painless active abduction range of motion, assessed using a goniometer, and the Shoulder Pain and Disability Index. Assessments were conducted at baseline, immediately after the intervention, and at the 3-month follow-up.

Results: The between-group comparisons showed no significant differences between the two treatment methods in any outcome measure, either immediately after treatment or at the 3-month follow-up ($P > 0.05$), indicating comparable effectiveness of the interventions over time. Between-group effect size estimates were small both immediately post-treatment (range: d = 0.24–0.25) and at the 3-month follow-up for pain (d = 0.33), disability (d = 0.33), and range of motion (d = 0.40), further supporting the absence of clinically meaningful differences between groups. Within-group analyses demonstrated that both groups showed significant improvements in all outcome measures from baseline to post-treatment and follow-up ($P < 0.001$).

Conclusion: In conclusion, both TECAR therapy and traditional physiotherapy are effective therapeutic approaches for shoulder impingement syndrome and can be considered equally viable treatment options, with no clear superiority between them. The choice of treatment should therefore depend on the preference of the therapist and the patient.

Keywords: Shoulder impingement syndrome, Physiotherapy, TECAR therapy, Pain

Conflicts of Interest: *None declared*
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Introduction

Shoulder impingement syndrome (SIS) is the most common disorder of the shoulder, accounting for approx-

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↑What is "already known" in this topic:
TECAR therapy has demonstrated potential in managing musculoskeletal disorders; however, its comparative efficacy relative to conventional physiotherapy, particularly for shoulder impingement syndrome (SIS), remains unclear.

→What this article adds:
This randomized trial demonstrates that TECAR therapy and traditional physiotherapy are equally effective in reducing pain, improving shoulder function, and enhancing pain-free active abduction range of motion in SIS patients, providing evidence for clinical equipoise in treatment selection.

imately 40% of all shoulder conditions (1). It represents the leading complaint among patients visiting orthopedic clinics, with a reported prevalence ranging from 44% to 65% (2). As a result, it is a frequent diagnosis in individuals presenting with shoulder pain and functional impairment (3).

The hallmark clinical features of shoulder impingement syndrome include pain and restricted range of motion, particularly during external rotation and abduction. This condition is primarily caused by osteophyte formation or the compression of the rotator cuff muscles and the subdeltoid bursa. During arm abduction, the humeral head moves closer to the acromion, narrowing the subacromial space and causing impingement. This process can be attributed to either structural abnormalities, such as acromial osteophytes, or functional deficits, such as muscle imbalances between the deltoid and rotator cuff, which cause excessive superior translation of the humeral head (4).

Neer classified shoulder impingement into three progressive stages. Stage one is typically caused by repetitive overhead activity, resulting in reversible hemorrhage, edema, or both. Stage two is characterized by progressive fibrosis and tendinosis of the rotator cuff. In stage three, chronic fibrosis leads to tendon degeneration and tearing. (5) As the condition progresses, appropriate management strategies become crucial to alleviate symptoms and prevent further structural damage.

Management of shoulder impingement is generally conservative, including rest, anti-inflammatory medications, subacromial injections, suprascapular nerve blocks, and physical and manual therapies (6). Notably, among the available treatment modalities, TECAR (Transfer of Energy Capacitive and Resistive) therapy has gained significant attention for its potential therapeutic benefits.

TECAR therapy is a noninvasive thermotherapy that was initially introduced in the 1920s and later refined for musculoskeletal applications. It is now widely used in the management of both acute and chronic musculoskeletal disorders (7). Operating at a frequency of 0.5 megahertz, TECAR therapy falls within a range between shortwave diathermy (27.1 megahertz) and frequencies that induce muscle contraction. By generating endogenous heat in superficial and deep tissues, TECAR therapy enhances circulation, metabolism, and vasodilation, thereby reducing inflammation and muscle spasms (8). This therapy utilizes two distinct modes—capacitive and resistive—each delivered through specific electrodes. The capacitive mode primarily targets tissues rich in electrolytes, such as muscles and soft tissues, while the resistive mode is more effective for tendons, bones, and joints (9).

While considered safe, TECAR therapy does have specific contraindications. These include use in patients with cardiac pacemakers or other implanted electronic devices, during the first six months of pregnancy, and over areas of known or suspected malignancy, uncontrolled ischemic heart disease, local pulmonary embolism, active bleeding, and open wounds (10). While TECAR therapy has been explored in previous studies, its comparative effectiveness against traditional physiotherapy in shoulder impingement syndrome remains unclear. To address this evidence gap, this randomized controlled trial is the first to directly compare TECAR therapy with traditional physiotherapy in this population, assessing their effects on pain relief, functional improvement, and range of motion in shoulder abduction. This study evaluates the modalities separately and integrates both treatments within a pragmatic framework, including medication and exercise, to determine their relative effectiveness. The findings are intended to provide clinicians with evidence-based guidance to inform treatment selection for shoulder impingement syndrome.

Methods

Study Design and Patient Selection:

This single-blind, randomized controlled trial was conducted at the Physical Medicine and Rehabilitation Clinics of Isfahan University of Medical Sciences. Participants were patients diagnosed with shoulder impingement syndrome by a board-certified physiatrist between 2023 and 2024.

The inclusion criteria were: (1) a clinical diagnosis of SIS, (2) age between 20 and 70 years, (3) pain duration exceeding one month, and (4) a pain intensity score greater than 3 at rest on the Visual Analog Scale (VAS). Exclusion criteria comprised: (1) prior history of shoulder surgery, (2) recent rehabilitation treatments for shoulder pain within the past three months, (3) concurrent neurological or infectious diseases, (4) diagnosed cognitive disorder, malignancy, and heart or kidney disease, (5) the presence of a pacemaker, (6) pregnancy, (7) low patient compliance.

Prior to treatment initiation, baseline demographic characteristics, specifically age and gender, were recorded for all participants. Outcome measures were assessed at baseline, immediately after the treatment, and at a three-month follow-up.

The primary outcome was pain intensity. Secondary outcomes were upper extremity functional status and shoulder range of motion (ROM). Pain intensity was evaluated using the Visual Analog Scale (VAS), functional status was assessed with the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, and ROM was quantified by measuring the maximum pain-free active shoulder abduction using a goniometer.

Safety outcomes involved the monitoring and documentation of any adverse effects related to the interventions, such as increased pain, skin burns, irritation, or discomfort occurring during or after TECAR therapy or physiotherapy sessions. Data from both post-treatment assessment time points were collected, analyzed, and compared.

Prior to the intervention, the study's purpose, procedures, and the voluntary nature of participation were explained to all potential participants. Written informed consent was obtained from each individual before any treatment commenced.

Interventions

All patients were prescribed a daily 15 mg dose of meloxicam to be taken after a meal for three weeks. They were also instructed to perform therapeutic exercises three times daily, with each session consisting of three sets of

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30-second repetitions. The regimen began with an initial phase focused on stretching the posterior capsule and trapezius muscles, along with range-of-motion exercises such as Codman's pendulum exercise and wall walking. As pain decreased, a progression phase was introduced, incorporating strengthening exercises for the rotator cuff and shoulder girdle muscles. Patient compliance with the exercise protocol was monitored via phone calls.

The first group received a standardized physiotherapy, protocol consisting of 10 sessions held every other day. Each 60-minute session included 5 minutes of continuous ultrasound, 20 minutes of transcutaneous electrical nerve stimulation (TENS), 15 minutes of infrared therapy, and the application of a hot pack. This was followed by the prescribed therapeutic exercise regimen and medication.

The second group received TECAR therapy in addition to a standard exercise regimen and medication. Treatment consisted of six TECAR sessions administered twice weekly (e.g., Sundays and Wednesdays) using the WIN-BACK 3 device. During each session, patients were seated comfortably with their upper limbs relaxed at their side. A conductive cream was applied to the shoulder, and a medium-sized (60 mm) electrode was used. The frequency was set to 500 KHz, with the intensity adjusted within a 20%–50% range according to the patient's reported sensation of a deep, comfortable warmth. A neutral plate was positioned in the axillary region of the affected shoulder. Each treatment included 10 minutes in capacitive mode followed by 10 minutes in resistive mode.

Assessments

Pain severity was assessed using the VAS. This scale is a unidimensional measure ranging from 0 to 10, where 0 represents "no pain" and 10 corresponds to "the worst pain imaginable." Patients were instructed to mark a point on the line that best reflected their current pain intensity. The VAS is extensively validated and demonstrates high reliability in pain-related research (11, 12).

Upper extremity functional status was evaluated using the DASH questionnaire. The DASH consists of 30 items, each scored on a 5-point Likert scale (1 = no difficulty, 5 = unable to perform). The first 21 items assess the ability to perform daily activities, while the subsequent five items evaluate pain severity during activity and rest, as well as the presence of joint weakness and stiffness. The final four items examine the impact of upper limb dysfunction on social and occupational activities. Raw scores are transformed into a standardized score ranging from 0 to 100, where 0 indicates no disability, and 100 represents maximal disability. This scoring system allows for a comprehensive assessment of upper limb function and its impact on quality of life (13). The validity and reliability of the Persian version of the DASH questionnaire have been established (14).

To assess shoulder ROM, participants were seated in a standardized upright position on a chair with their feet flat on the floor. Pain-free active shoulder abduction was measured using a digital goniometer, with the scapula stabilized to minimize compensatory movements. A trained physiotherapist ensured that participants did not engage in trunk lateral flexion or excessive scapular elevation during the measurement. ROM was assessed at a pain-free threshold to prevent discomfort-related limitations.

Sample Size

To determine the minimum required sample size with a 95% confidence level and 90% statistical power, the calculation was based on a 16-point difference in DASH scores between the TECAR therapy and physiotherapy groups, which was considered the minimum clinically important difference. The mean and standard deviation values were derived from the study by Paolucci et al. (15). Based on these values, the required sample size per group was calculated to be 21 participants. Accounting for an anticipated 20% dropout rate, the final estimated sample size was adjusted to 25 participants per group.

Randomization and Blinding Process

Participants were randomly allocated to one of two intervention groups using a computer-generated sequence created with Microsoft Excel. The sequence generated 50 random assignments, and participants were enrolled sequentially based on this list. To ensure allocation concealment, the randomization list was prepared in advance by an independent researcher who was not involved in recruitment or outcome assessment. Group assignments were placed in sealed, opaque, consecutively numbered envelopes, which were opened only after a participant was deemed eligible and had provided informed consent.

This study employed a single-blind design. Only the data analyst responsible for the final statistical evaluation was blinded to treatment group allocation. Blinding was maintained by using coded study IDs; only the treatment team had access to the group assignment key. The primary and secondary outcome data were collected and subsequently provided to the blinded analyst.

Statistical Analysis

Statistical analysis was performed using SPSS software (Version 23). Descriptive statistics are presented as mean and standard deviation (SD). The normality of quantitative data distribution was assessed using the Shapiro-Wilk test, and the homogeneity of variances was evaluated with Levene's test. Categorical variables were analyzed using the chi-square test. For between-group comparisons of quantitative variables, independent samples t-tests or the non-parametric Mann-Whitney U test were applied as appropriate. Changes in outcome measures over time (baseline, post-treatment, follow-up) were analyzed using a generalized linear model (GLM), with gender included as a covariate to control for its potential effect. A *P*-value of less than 0.05 was considered statistically significant for all tests.

Results

In this study, 72 patients with shoulder impingement syndrome were initially screened for eligibility. Eight patients did not meet the inclusion criteria, 12 met at least

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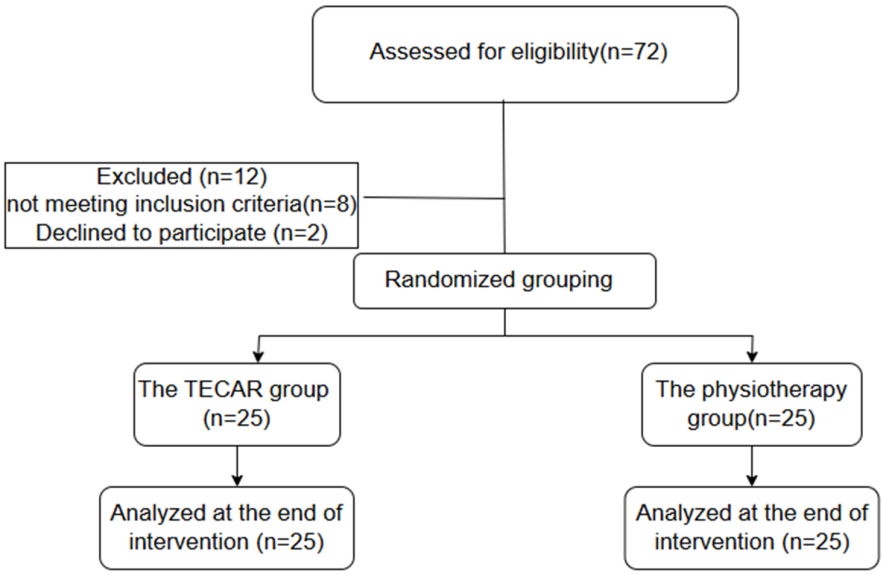

Figure 1. Flowchart illustrating the process of subject recruitment and retention

Table 1. Comparison of demographic characteristics of patients between two treatment groups

Variables	All patients	TECAR Therapy	Physiotherapy	*P*-value	Mean diff (95% CI)
Age*	54.46 ± 12.03	55.32 ± 12.54	53.6 ± 11.69	0.600	1.72 (-5.17, 8.6)
Gender&					
Female	36 (72)	14 (56)	22 (88)	0.025	
Male	14 (28)	11 (44)	3 (12)		

*mean ± SD & N (%)

Table 2. Variables change over time

Factor	Time	TECAR Therapy	Physiotherapy	Comparison between two groups		
		Mean ± SD of Pain score		*P*-value	Mean diff (95% CI)	Cohen's d
Pain score	Before intervention	8.76 ± 1.26	8.4 ± 2.25	0.943	0.36 (-0.68, 1.4)	
	After intervention	4.0 ± 2.02	4.52 ± 2.14	0.219	-0.52 (-1.7, 0.7)	0.25
	3 months after intervention	3.21 ± 1.74	4.0 ± 2.97	0.256	-0.79 (-2.23, 0.64)	0.33
	P-value*	P<0.001	P<0.001	0.336$		
Disability score	Before intervention	47.53 ± 22.2	51.86 ± 13.4	0.408	-4.33 (-14.7, 6.1)	
	After intervention	29.63 ± 13.61	32.5 ± 10.42	0.424	-2.86 (-9.9, 4.2)	0.24
	3 months after intervention	26.52 ± 13.18	21.7 ± 15.67	0.270	4.81 (-3.87, 13.5)	0.33
	P-value*	P<0.001	P<0.001	0.932$		
Range of motion score	Before intervention	105.84 ± 37.85	85.32 ± 38.41	0.087	20.52 (-1.2, 42)	
	After intervention	149.8 ± 36.58	139.42 ± 50.55	0.514	10.38 (-15, 35.7)	0.24
	3 months after intervention	170.0 ± 22.15	157.14 ± 39.89	0.248	12.86 (-6.5, 32.3)	0.40
	P-value*	<0.001	<0.001	0.192$		

* Score changes over time

one exclusion criterion, and two declined participations. The remaining 50 patients underwent baseline assessment and were randomly assigned to either the TECAR therapy group or the physiotherapy group (n = 25 per group).

No dropouts occurred during the study (Figure 1). No systemic complications or severe local adverse events were observed in either group.

The cohort comprised 36 women (72%) and 14 men (28%). A significantly higher proportion of men was assigned to the TECAR therapy group compared to the physiotherapy group (P = 0.025). The overall mean ± SD age was 54.46 ± 12.03 years (range: 21–70 years), with no significant difference between groups (P = 0.600). Patient demographic characteristics are summarized in Table 1.

Pain, disability, and pain-free active abduction range of motion (ROM) were assessed at multiple time points in both groups; the results are presented in Table 2.

A significant reduction in pain scores was observed over time in both groups ($P < 0.001$), with a more pronounced reduction noted in the TECAR group. However, the overall change in pain scores across the assessment periods did not differ significantly between the groups (P = 0.336). Similarly, no significant between-group differences in pain scores were found at any individual time point. (Figure 2).

Disability scores showed a significant decrease over time in both groups ($P < 0.001$, Figure 3). The difference in the magnitude of improvement between the two groups was not statistically significant ($P = 0.0932$), indicating

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that the two treatment methods had comparable effects on reducing disability.

Similarly, pain-free active abduction ROM improved significantly over time in both groups ($P < 0.001$, Figure 4). Again, there was no statistically significant difference between the two treatment methods in their effect on ROM improvement ($P = 0.192$).

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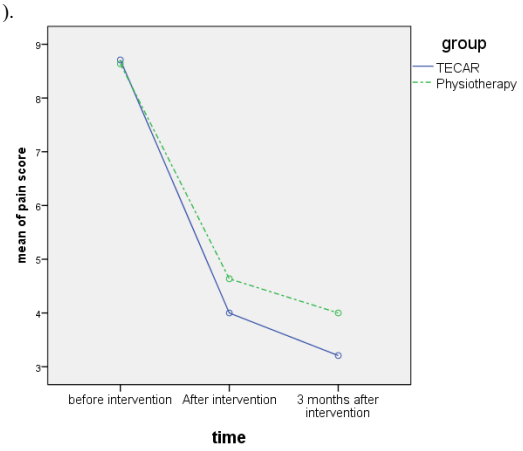

Figure 2. Pain score changes over time between two groups

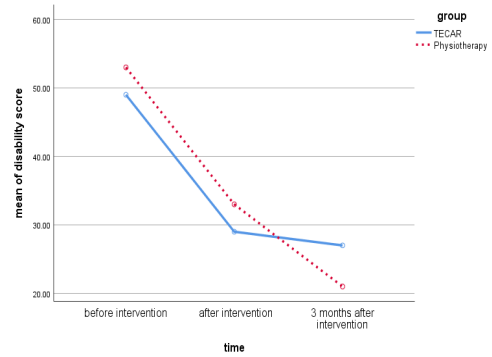

Figure 3. Disability score changes over time between the two groups

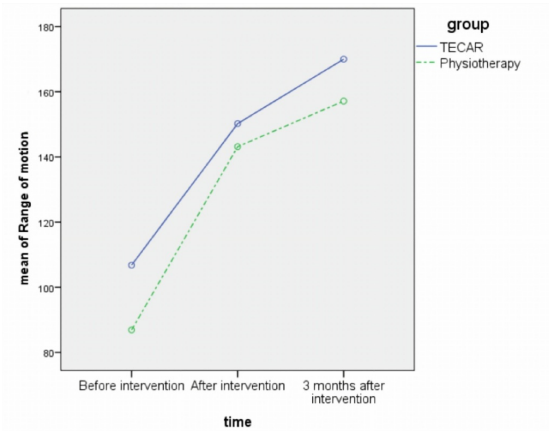

Figure 4. The range of motion changes over time between the two groups

Discussion

TECAR therapy has gained attention as a modern treatment modality; however, its comparative efficacy remains under investigation. In this study, both TECAR therapy and traditional physiotherapy led to significant improvements in pain, function, and pain-free active abduction range of motion in patients with shoulder impingement syndrome, with no significant differences observed between the two groups.

Importantly, although both TECAR therapy and traditional physiotherapy achieved comparable clinical improvements, their physiological mechanisms differ. TECAR therapy primarily exerts its effects through radiofrequency-induced diathermy, producing deep thermal energy that enhances tissue oxygenation, blood flow, and metabolic activity (16). In contrast, traditional physiotherapy modalities such as ultrasound and TENS work through different mechanisms: ultrasound facilitates localized tissue healing via mechanical vibration and microstreaming, while TENS modulates pain perception via neuromodulation based on the gate control theory (17, 18).

TECAR therapy operates in capacitive and resistive modes, with studies suggesting that combining both modes yields superior outcomes by facilitating heat transmission to both superficial and deep tissues (19). This deep penetration is a distinguishing feature, as it enhances hemoglobin saturation (20). Its effectiveness appears to stem from a combination of thermal effects and the therapist's manual expertise, which together may contribute to patient satisfaction (21).

The study by Ida et al. demonstrated that TECAR therapy has positive effects on both healthy and symptomatic tissues. It primarily increases tissue temperature, with deeper tissues experiencing more warming than surface layers (22). However, this temperature increase has no adverse effect on even highly heat-sensitive structures, such as the lens, as shown in a study using it as a noninvasive therapy for meibomian gland dysfunction (23). In symptomatic tissues, it alleviates pain and enhances function in muscles, tendons, and joints, while in healthy tissues, it promotes circulation and improves tissue mobility (22). Furthermore, TECAR therapy has been found to reduce hypertonicity, as shown in a clinical trial where a single session improved muscle tone in post-stroke patients (24).

In musculoskeletal contexts, TECAR therapy has shown promising results, particularly for muscular injuries (8). When combined with other modalities, such as high-intensity laser therapy or manual therapy, its therapeutic benefits may be enhanced (25). TECAR therapy has also been investigated for chronic low back pain, with evidence suggesting that its combination with manual therapy yields superior results compared to manual therapy alone, likely due to the simultaneous mechanical and thermal effects (26). These findings underscore TECAR"s potential relevance in musculoskeletal rehabilitation.

[DOI: 10.47176/mjiri.39.162]

Beyond musculoskeletal applications, TECAR therapy has been studied for various conditions. Cau et al. reported that TECAR therapy was more effective than manual drainage for managing lymphedema (27), likely due to its ability to enhance fluid reabsorption through increased tissue temperature. Moreover, it has shown potential in alleviating pain and sensory disturbances in diabetic peripheral neuropathy (28).

One study evaluated the effectiveness of the HIPER-500® device, which utilizes Capacitive-Resistive Electrical Transfer, in reducing shoulder pain and improving function. This study demonstrated improvements in pain and function in patients with shoulder conditions.

The outcomes were compared with a group treated with therapeutic ultrasound, and no significant differences were found between the two groups immediately after or one month after treatment. However, patients who received HIPER-500® therapy reported higher satisfaction, attributed to a faster perceived sensation of warmth (29).

While these results are consistent with ours regarding the effectiveness of TECAR therapy, our research focused specifically on patients with a confirmed diagnosis of shoulder impingement syndrome, rather than general shoulder pain.

Paolucci et al. evaluated the effects of nine sessions of TECAR therapy compared to a SHAM treatment (device turned off) in patients with painful shoulder impingement. Their results demonstrated a statistically significant reduction in VAS scores in the TECAR group immediately post-treatment and at a two-month follow-up, while no improvement was observed in the SHAM group, supporting the specific efficacy of TECAR therapy (15).

While these findings align with our observation that TECAR is an effective treatment, our study extends the evidence by directly comparing TECAR therapy with an established active treatment (traditional physiotherapy) rather than a placebo. Furthermore, both treatment groups in our protocol incorporated standard medication and exercise, reflecting a pragmatic and comprehensive clinical management approach.

This design allows for a more applicable assessment of TECAR therapy's comparative effectiveness in routine practice, aiding clinicians in evidence-based decision-making.

Limitations

Despite the distinct approaches used in the two treatment groups, our results showed no statistically significant difference in efficacy. Several factors may explain this finding. First, the relatively small sample size may have limited the statistical power to detect a clinically meaningful difference between the groups. Furthermore, the study design evaluated the addition of either physiotherapy or TECAR therapy to a standardized conventional treatment protocol (meloxicam and exercise). As the primary objective was to compare these two modalities as adjuncts to standard care, a control group receiving only the conventional treatment was not included. This design limits the ability to isolate the specific contribution of each modality. Future studies should include a broader range of comparisons, particularly evaluating TECAR therapy against conventional therapies as standalone interventions, to better clarify its distinct role in managing shoulder impingement syndrome.

Conclusion

Based on our results, TECAR therapy is a noninvasive treatment that provides pain relief and improves range of motion and function in patients with shoulder impingement syndrome. However, as no significant differences were observed between TECAR therapy and traditional physiotherapy for any outcome measure, our findings suggest that both interventions are equally effective treatment options when used as part of a comprehensive management plan.

Authors' Contributions

Shila Haghighat: Conceptualization, Methodology, Formal Analysis, Supervision, Visualization, Writing–review and editing; Saeid Khosravi: Review and editing, Supervision; and Maryam Behroozinia: Methodology, Project administration, Data curation, Software, Validation, Writing–original draft.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Ethics Committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1402.118). The trial was performed under an approved clinical trial protocol (Registration No. IRCT20190618043931N4; first registered on 2023-12-22) and is reported in compliance with the CONSORT guidelines.

Before starting the intervention, we explained the study's purpose to the participants and informed them of their right to accept or decline the treatment. The treatment began after obtaining written informed consent.

Acknowledgment

Nil.

Conflict of Interests

The authors declare that they have no competing interests.

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