ORIGINAL ARTICLE

# Clinical and ultrasonographic effectiveness of transfer energy capacitive and resistive therapy in lateral epicondylitis: a randomized controlled study

## *Eficacia clínica y ecográfica de la terapia TECAR en la epicondilitis lateral: un estudio controlado aleatorizado*

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## Abstract

**Objectives:** *To assess the clinical and ultrasonographic effectiveness of transfer energy capacitive and resistive (TECAR) therapy in managing lateral epicondylitis (LE).* **Method:** *Forty-seven patients with clinically and sonographically confirmed unilateral LE were randomized into two groups. The control group received exercise and LE banding for 3 weeks. The TECAR group received the same treatment, plus TECAR therapy 3 times weekly (nine sessions). Outcomes were evaluated using the patient-rated tennis elbow evaluation (PRTEE) as the primary measure. Secondary outcomes included Visual Analog Scale (VAS) scores, handgrip strength (HGS), common extensor tendon (CET) thickness, and total ultrasonography scale score (TUSS). Assessments were made at baseline and post-treatment.* **Results:** *Both groups demonstrated significant improvements in elbow VAS-rest, VAS-night, VAS for activities of daily living (VAS-ADL), forearm VAS-night, VAS-ADL, arm VAS-ADL, lateral epicondyle tenderness-VAS, HGS, TUSS, hypoechogenicity, and PRTEE scores after treatment compared to baseline. Treatment did not significantly improve either group's forearm VAS-rest, CET thickness, neovascularity, heterogeneity, or bone abnormality. Change in elbow VAS-ADL was found to be statistically significantly better in the TECAR group.* **Conclusions:** *TECAR therapy, when combined with conventional treatment, led to greater improvement in ADL-related pain and may be particularly beneficial for active individuals requiring faster symptom relief.*

***Keywords:*** *Lateral epicondylitis. Transfer energy capacitive and resistive. Tennis elbow. Ultrasonography.*

## Resumen

**Objetivo:** *Evaluar la eficacia clínica y ecográfica de la terapia de transferencia de energía capacitiva y resistiva (TECAR, transfer energy capacitive and resistive) en el manejo de la epicondilitis lateral (EL).* **Método:** *Cuarenta y siete pacientes con diagnóstico clínico y ecográfico de EL unilateral fueron asignados aleatoriamente a dos grupos. El grupo control recibió ejercicios y una banda para epicondilitis lateral durante 3 semanas. El grupo TECAR recibió el mismo tratamiento y además terapia TECAR tres veces por semana (nueve sesiones en total). La medida principal fue la puntuación del cuestionario PRTEE (Patient-Rated Tennis Elbow Evaluation). Las medidas secundarias incluyeron escala analógica visual (EVA), fuerza de prensión manual (FPM), grosor del tendón extensor común (TEC) y puntuación total de la escala ecográfica (TUSS, Total Ultrasonography Scale Score). Las evaluaciones se realizaron antes del inicio y después del tratamiento.* **Resultados:** *Ambos grupos mostraron mejoras significativas en la EVA de codo en reposo, por la noche y durante las actividades diarias, así como*

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*en la EVA de antebrazo y brazo, la sensibilidad del epicóndilo lateral, la FPM, la TUSS, la hipoecogenicidad y la PRTEE. No hubo mejoras significativas en la EVA de antebrazo en reposo, el grosor del TEC, la neovascularización, la heterogeneidad ni las anormalidades óseas. La mejoría de la EVA para actividades del codo fue significativamente mayor en el grupo TECAR.*
**Conclusiones:** *La terapia TECAR, combinada con el tratamiento convencional, mejora más el dolor durante las actividades diarias y puede ser especialmente útil para personas activas que requieren un alivio sintomático rápido.*

***Palabras clave:*** *Epicondilitis lateral. TECAR. Codo de tenista. Ultrasonografía.*

# Introduction

A prevalent musculotendinous degenerative condition of the extensor origin in the lateral humeral epicondyle is called lateral epicondylitis (LE)[1]. Men and women are equally affected by LE, which has been reported to have a prevalence in the general population of 1-3% in adults[2-4]. LE is most common with the highest incidence taking place between the ages of 45 and 54; those in occupations that require intensive manual labor or who use vibrating tools may be at higher risk[4,5]. Repetitive supination and pronation during heavy work or manual labor, household chores, and hobbies are considered the most important causative factors[6,7].

The LE primarily involves the tendinous attachment of the extensor carpi radialis brevis muscle. Other muscles that may also be affected include the extensor digitorum communis, extensor digiti minimi, and extensor carpi ulnaris. These muscles have a common attachment known as the common extensor origin, also referred to as the common extensor tendon (CET), which is essential for extension of the wrist and fingers and contributes to forearm supination[8,9].

Although not life-threatening or severely disabling, LE can significantly impact daily functioning[10]. Primary treatment approaches include physical therapy, activity modification, non-steroidal anti-inflammatory drugs, and injections[1].

Transfer energy capacitive and resistive (TECAR) therapy enhances blood flow, helps lessen activity-induced spasms and contractions, and promotes muscle oxygenation through hemoglobin activation. TECAR therapy improves the body's natural ability to repair tissues and minimize pain[11]. TECAR therapy is a non-ablative and non-invasive form of combined contact diathermy and electrotherapy that enhances therapeutic effects in the body using high frequency (300 KHz-1 MHz) long radiofrequency waves without external radiant energy[12,13].

TECAR is regarded as the most practical and secure diathermy technique because, in contrast to ultrasound, it has no restrictions on the treatment area and does not generate excessive heat between the electrode and the skin[14]. Both capacitive (CAP) and resistive (RES) modes of electrical charge transfer are possible with TECAR[12,13,15] CAP electrode: tissues with a higher electrolytic content – such as muscles and soft tissues – are the sites of the reactions generated by the CAP system. RES electrode: tissues with greater resistance, such as bones, tendons, and joints, are where the RES system's reactions are concentrated. TECAR effects include increased microcirculation, vasodilation (oxygenation), and increased core temperature.

Tranquilli et al. showed that TECAR therapy reduces pain in acute and chronic cases[16]. The beneficial effects of TECAR therapy are immediately noticeable: in fact, a single session is enough to see its therapeutic effectiveness[13].

There are studies on rest, education, splint use, various physical therapy modalities (short-wave diathermy, extracorporeal shock wave therapy [ESWT], therapeutic ultrasound), and injection treatments in LE[17-20]. TECAR is often used in traumatology and sports for the treatment of muscle, joint, and tendon injuries[21-23]. There is no standard protocol for the treatment of tennis elbow, and there is insufficient evidence regarding the effectiveness of recommended conservative treatments. No study on the use of TECAR treatment in LE was found in the literature.

In our study, we aimed to evaluate the effectiveness of TECAR therapy in the treatment of LE clinically and ultrasonographically.

## Method

### *Study design and setting*

This prospective, randomized, controlled study was conducted in accordance with the principles of the Declaration of Helsinki and received approval from the

local institutional review board (Protocol No. AEŞH-EK-2025-082, dated March 19, 2025).

Forty-seven patients were diagnosed with LE based on clinical and ultrasonographic findings and sought treatment at the physical medicine and rehabilitation (PMR) outpatient clinic of the local institute.

## *Participants*

Potential participants were first evaluated by one of the study's researchers to see if they satisfied the predefined inclusion criteria, and the results were then shared with the main researcher. Potential participants were shown the study, and those who satisfied the inclusion requirements and consented to take part were asked to sign a written informed consent form.

Participants' demographic data, comorbidities, duration of symptoms, dominant side, and affected side were recorded.

Physical examination demonstrated a particular area of the most tenderness, normal range of motion, reduced handgrip strength (HGS), and positive Maudsley and Cozen tests[24].

In addition, manual strength testing of the elbow and finger extensors was normal, and posterolateral elbow instability testing was negative.

In addition, elbow radiographs were evaluated for all participants to exclude degenerative changes and osteochondritis dissecans. Inclusion criteria for the study were as follows: age between 18 and 65 years, lateral elbow pain with localized tenderness, at least two positive specific LE diagnostic tests and ultrasonographic findings (change in CET thickness compared to the normal side and total ultrasound scale score [TUSS] parameters of grade 1 or higher), patients with complaints for at least 3 months, agree to participate in the study.

Among the exclusion criteria were the presence of LE in the contralateral extremity, history of physical therapy or injections for LE within the last 3 months, previous elbow surgery or elbow fracture, upper extremity neuropathy or radiculopathy, presence of concomitant neurological, rheumatic, psychiatric, or malignant conditions, inability to comply with study requirements, or contraindications in TECAR[25-27].

## *Randomization*

The study included 60 patients who met the predefined inclusion and exclusion criteria and were then randomly allocated to one of the groups: TECAR group (n = 30), control group (n = 30). Block randomization was used to ensure equal group sizes. To minimize potential bias, randomization was performed by an independent investigator who was not involved in the study.

## *Intervention procedure*

Thirteen of the 60 enrolled patients dropped out of their assigned treatment or were lost to follow-up. As a result, our analysis included 47 patients as follows:

- Group 1: TECAR group (n = 23 patients) received three TECAR sessions per week for a duration of 3 weeks, in addition to a traditional home exercise program consisting of stretching and strengthening performed 5 days/week over the same period
- Group 2: The control group (n = 24) followed a traditional home exercise program 5 days/week for 3 weeks.

At the beginning of the treatment, the traditional home exercise program was explained to the patients by a professional physiotherapist and also presented in the form of an elbow and wrist exercise brochure. Patients were instructed to do 15 min of stretching and strengthening exercises within their personal strength and pain limits. The patients' compliance was regularly checked with weekly phone calls.

Both groups were given LE bands. In addition, all patients were told about the activities to be avoided.

## *Outcome measures*

The patient-rated tennis elbow evaluation (PRTEE) was the main outcome measure. Secondary outcome measures included Visual Analog Scale (VAS) for pain, HGS by dynamometry, and ultrasonographic CET thickness in the capitellar region and TUSS.

Ultrasonography assessments were performed using a GE Logiq P9 US device with a 7-15 MHz linear transducer, operated by a PMR specialist experienced in musculoskeletal US. Measurements were made with the participant in a sitting position with the elbow flexed to 90°, the forearm pronated, and the arm supported on a pillow. All assessments

were performed bilaterally to allow comparison of ultrasound images.

The attachment of normal extensors has a typical filamentous echostructure, moderate echogenicity, and uniform thickness[10].

The PRTEE questionnaire was used to assess the pain intensity and functional status of the participants, and these were measured separately with the two subsections of the tool (pain-function)[28,29].

Ultrasonography evaluations measured CET thickness and TUSS parameters. CET was performed from the capitellar region (Fig. 1)[30-32].

Other parameters were evaluated according to the criteria in TUSS (Table 1)[17,33].

In addition, radial nerve edema was assessed with the US as present/absent.

An ultrasonography scan was performed by an independent physician who was unaware of the patient's clinic and the study group.

VAS was used to separately assess the participant's pain at rest (VAS-rest), at night (VAS-night), and during activities of daily living (VAS-ADL). 0 means: no pain, and 10 means: unbearable pain[34]. VAS pain scores were evaluated separately for the elbow, forearm, and arm. VAS was also used to assess lateral epicondyle tenderness.

A digital hand dynamometer (JAMAR) was used to evaluate HGS[35].

Measurements were made with the participant sitting, shoulder adduction, elbow 90° flexion, and forearm in a position between supination and pronation. Each measurement was recorded 3 times in kilogram-force, and the mean value was calculated. The participant was allowed to rest for 1 min between each measurement.

All measurements were recorded both at baseline (before the initiation of the interventions) and at the end of the 3-week intervention period. The evaluations were performed by the same physician who was blind to the participating groups. Patients' post-treatment satisfaction was rated according to the criteria by Verhaar et al.[36] (Table 2).

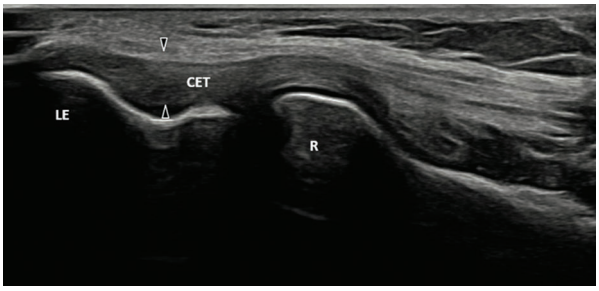


**Figure 1.** *Longitudinal US imaging obtained over the capitellar region demonstrates the upper and lower borders of the common extensor tendon and the location where it was measured (arrowheads). R: radial head; CET: common extensor tendon; LE: lateral epicondyle.*

**Table 1. Total ultrasound scale scoring system**

| Characteristic | Grade | Grading criteria | Maximum score |
|---|---|---|---|
| Hypoechogenicity | 0 | Normal fibrillar and hypoechoic structure | 3 |
| | 1 | Hypoechoic lesions affecting < 30% of the whole tendon | |
| | 2 | Hypoechoic lesions affecting > 30% and < 50% of the whole tendon | |
| | 3 | Single large or multiple hypoechoic lesions affecting > 50% of the whole tendon | |
| Neovascularity | 0 | No detectable neovascularity | 3 |
| | 1 | Neovascularity detected in < 30% of the whole tendon | |
| | 2 | Neovascularity detected in > 30% but < 50% of the whole tendon | |
| | 3 | Neovascularity detected in > 50% of the whole tendon | |
| Heterogeneity | 0 | Absence | 1 |
| | 1 | Presence | |
| Bone abnormality | 0 | Absence | 1 |
| | 1 | Presence | |
| Total US scale score | | | 8 |

## *TECAR method*

The patients in the TECAR group received TECAR treatment at a frequency of 0.5 MHz, using the BTL-6000 TR-Therapy Pro®, UK device, 3 days a week, for 3 weeks, for a total of 9 sessions, 5 min CAP and 10 min RES.

The study group underwent a protocol consisting of nine intermittent (3 times/week) TECAR applications over 15 min on the extensor muscle and CET (5 min of CAP mode TECAR followed by 10 min of RES mode TECAR). (Fig. 2) During the treatment, patients did not experience side effects such as skin redness or burning.

**Table 2. Scoring system for the results of treatment based on the criteria by Verhaar et al.[36]**

| Grade | Criteria |
|---|---|
| Excellent | – Complete relief of pain on the lateral epicondyle<br>– Patient satisfied with the result of treatment<br>– No subjective loss of grip strength<br>– No pain provoked by resisted dorsiflexion of the wrist. |
| Good | – Occasional slight pain on the lateral epicondyle after strenuous activities<br>– Patient satisfied with the result of treatment<br>– No or slight subjective loss of grip strength<br>– No pain provoked by resisted dorsiflexion of the wrist |
| Fair | – Discomfort on the lateral epicondyle after strenuous activities, but at a more tolerable level than before treatment<br>– Patient satisfied or moderately satisfied with the result of treatment<br>– Slight or moderate subjective loss of grip strength<br>– Slight or moderate pain provoked by resisted dorsiflexion of the wrist. |
| Poor | – No decrease of pain on the lateral epicondyle<br>– Patient dissatisfied with the result of treatment<br>– Severe subjective loss of grip strength<br>– Severe pain provoked by resisted dorsiflexion of the wrist. |

### *Sample size calculation*

Sample size calculations were based on data from the previous study by Babaei-Ghazani et al.[19] The number of participants was calculated using the mean and standard deviation (SD) of grip strength of 15.2 and 2.3, respectively, with 90% power and 1% significance. Finally, we decided that at least 22 participants would be allocated to each group.

### *Data availability*

The authors confirm that the data supporting the findings of this study are available within the article. The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

### *Statistical analysis*

The Statistical Package for the Social Sciences (SPSS) statistical software (SPSS for Windows, SPSS, IBM Corp., Armonk, NY, USA) was used to analyze the data. The Shapiro-Wilk test was used to examine the conformity of continuous variables to normal distribution. Descriptive statistics were shown as mean (SD) or median (minimum-maximum) for continuous variables, frequency (n) and percentage (%) for nominal and categorical variables. The t-test was used for normally distributed continuous variables, and the Mann-Whitney U test was used for variables that were not normally distributed. Comparisons for nominal and categorical variables were investigated with the $\chi^2$ test. Repeated measurements within groups were evaluated with the Wilcoxon test or t-test. A value of $< 0.05$ was considered statistically significant.

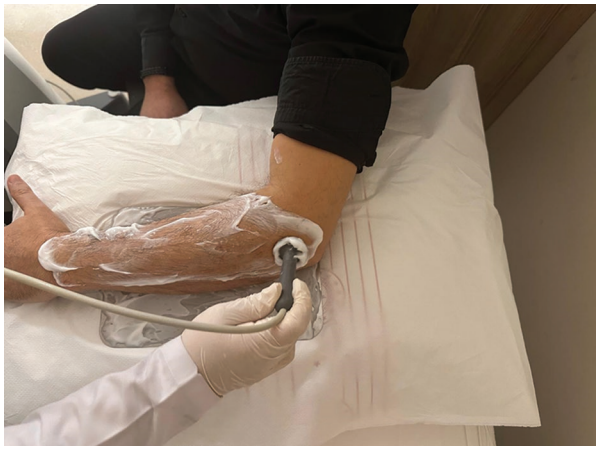

**Figure 2.** *Transfer energy capacitive and resistive therapy application in the treatment of lateral epicondylitis.*

## Results

The flow diagram of patient enrollment, allocation, follow-up, and analysis is shown in figure 3. The first participant enrolled in the study had their measurements in April 2025, and the last participant had their measurements on May 31, 2025. Of the 72 patients diagnosed with LE, 12 did not meet the inclusion criteria. The remaining 60 participants were randomized into two groups, with 30 participants in each group. Thirteen did not participate in the control assessments. Therefore, their measurements were not included in the statistical analysis.

Demographic and clinical data of the groups are summarized in table 3.

There was no difference between the groups in terms of age, gender, body mass index, education status, occupation, comorbidity, affected side, dominant side, duration of symptoms, presence of radial nerve edema, and Verhaar treatment outcome.

Table 4 presents the pre- and post-treatment results of clinical and sonographic parameters within and

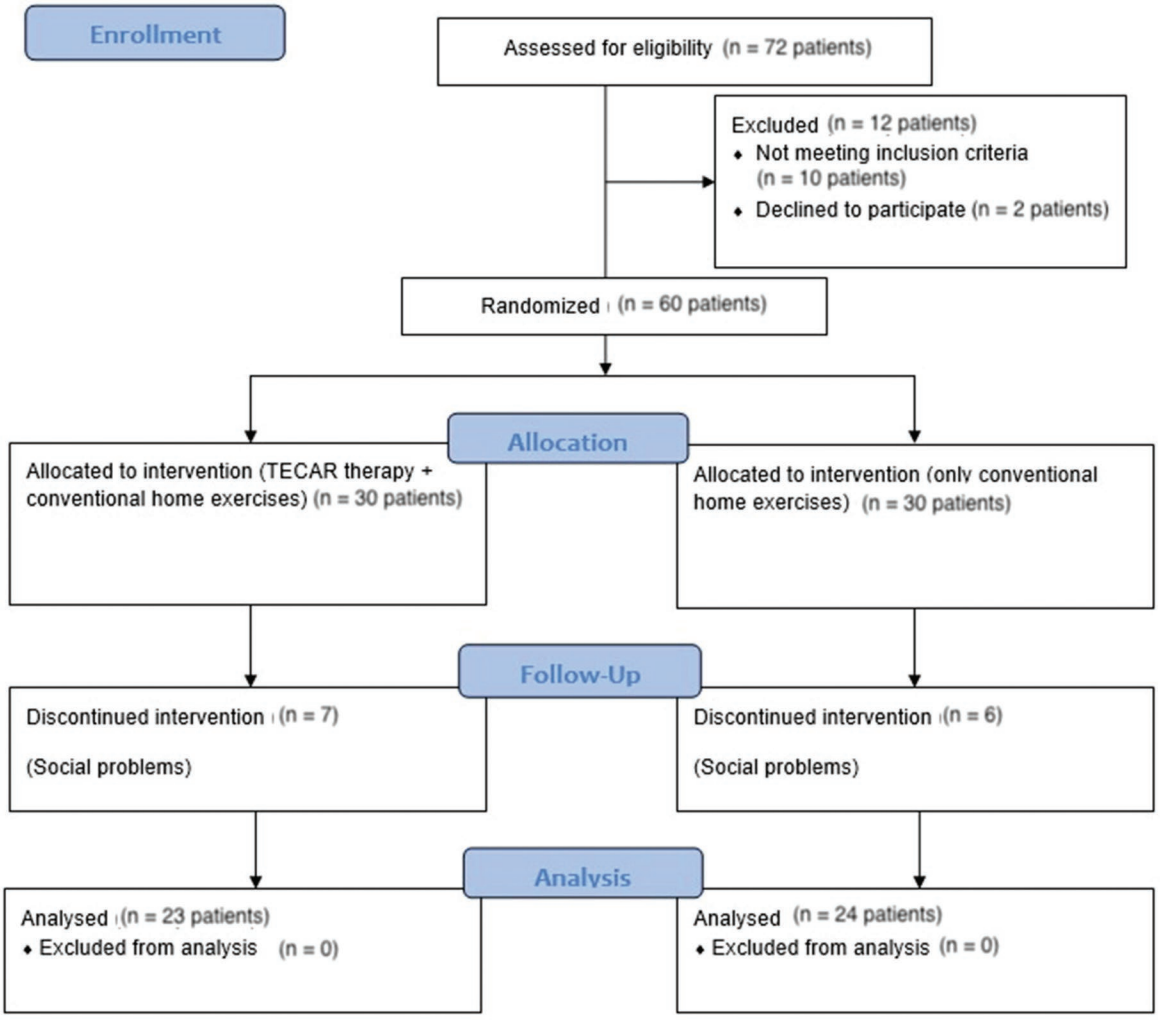


**Figure 3.** *Flow diagram of patient enrollment, allocation, follow-up, and analysis.*

between groups. According to the baseline values, both groups were homogeneous, but elbow VAS-ADL was worse in the TECAR group. Both groups showed statistically significant improvements after treatment compared to pre-treatment in elbow VAS-rest, elbow VAS-night, elbow VAS-ADL, forearm VAS-night, forearm VAS-ADL, arm VAS-ADL, lateral epicondyle tenderness-VAS, HGS, TUSS, hypoechogenicity, PRTEE-pain-function, and total. The control group showed significant improvement after treatment in arm VAS-night.

No significant improvement was achieved in forearm VAS-rest, CET thickness, neovascularity, heterogeneity, and bone abnormality with treatment in both groups.

Table 5 shows the comparison of changes (Δ) in clinical and sonographic parameters between the two groups before (T0) and after (T1).

The change in elbow VAS-ADL was found to be statistically significantly better in the TECAR group than in the control group.

No side effects or complications were observed during and after treatment.

## Discussion

In this study, in which the effectiveness of TECAR therapy in LE was investigated clinically and sonographically, we demonstrated the clinical benefit of exercise therapy with or without TECAR. We found that TECAR showed a significant difference in terms of improvement in the elbow VAS ADL when compared to the control group, despite the higher initial values.

There was no difference between the groups in the parameters that did and did not change with treatment

**Table 3. Demographic and clinical characteristics of patients**

| Characteristics | TECAR group (n = 23) | Control group (n = 24) | p |
|---|---|---|---|
| Age years, mean (SD) | 43.95 (8.7) | 44.1 (10.2) | 0.940 |
| Gender, n (%) | | | |
| Female | 11 (47.8) | 15 (62.5) | 0.385 |
| Male | 12 (52.2) | 9 (37.5) | |
| BMI | 28.03 (5.57) | 27.66 (5.37) | 0.817 |
| Education level, n (%) | | | |
| Illiterate | 0 (0) | 2 (8.3) | 0.062 |
| Literate | 1 (4.3) | 1 (4.2) | |
| Primary school | 7 (30.4) | 8 (33.3) | |
| Secondary school | 0 (0) | 2 (8.3) | |
| High school | 8 (34.8) | 2 (8.3) | |
| Associate degree | 0 (0) | 4 (16.7) | |
| Bachelor's degree | 7 (30.4) | 5 (20.8) | |
| Occupation | | | |
| Housewife | 9 (39.1) | 10 (41.7) | 0.863 |
| Worker | 8 (34.8) | 6 (25) | |
| Civil servant | 5 (21.7) | 6 (25) | |
| Retired | 1 (4.3) | 2 (8.3) | |
| Comorbidity, n (%) | | | |
| HT | 1 (4.3) | 3 (12.5) | 0.317 |
| DM | 1 (4.3) | 3 (12.5) | 0.317 |
| CAD | 1 (4.3) | 0 (0) | 0.302 |
| HL | 1 (4.3) | 3 (12.5) | 0.317 |
| Hypothyroidism | 2 (8.7) | 2 (8.3) | 0.965 |
| Asthma | 1 (4.3) | 1 (4.2) | 0.975 |
| Dominant side, n (%) | | | |
| Right | 22 (95.7) | 24 (100) | 0.302 |
| Left | 1 (4.3) | 0 (0) | |
| Affected side, n (%) | | | |
| Right | 14 (60.9) | 13 (54.2) | 0.642 |
| Left | 9 (39.1) | 11 (45.8) | |
| Symptom duration *months, median (min-max) | 3 (3-12) | 3 (3-12) | 0.701 |
| Radial nerve edema | 4 (17.4) | 3 (12.5) | 0.638 |
| Veerhar treatment response, n (%) | | | 0.113 |
| Excellent | 6 (26.1) | 4 (16.7) | |
| Good | 10 (43.5) | 7 (29.2) | |
| Fair | 7 (30.4) | 8 (33.3) | |
| Poor | 0 (0) | 5 (20.8) | |

*Mann-Whitney test, other Student t-test.
TECAR: transfer energy capacitive and resistive; BMI: body mass index; HT: hypertension; DM: diabetes mellitus; CAD: coronary artery disease; HL: hyperlipidemia.

in the sonographic findings. In our study, significant improvement was achieved in both groups in PRTEE, which was our primary outcome. During ADL, elbow, forearm, and arm VAS values decreased significantly in both groups. Although arm VAS improved in both groups during rest, it was not significant because the initial pain level was not high. Significant improvement was achieved in both groups in all regions of the elbow, forearm, and arm during ADL, where patients had more complaints.

In the study by Murat et al., significant improvement was shown in both PRTEE and elbow VAS levels compared to the baseline in both the control and treatment groups[37].

Apart from a poster presentation, no published study on TECAR therapy in LE was found in the literature. Kaux et al., in their study with 3- and 6-month evaluations of 17 patients with chronic lateral elbow tendinopathy, could not show the superiority of TECAR therapy over exercise in terms of pain and functionality[38]. We think that the small number of patients and the lack of acute period results are limitations of this study.

The addition of TECAR treatment results in a rapid improvement in the acute inflammatory process and return of muscle strength compared to other combination treatments[39]. We believe that the result we obtained in the early post-treatment period in elbow pain is due to the effect of TECAR.

Konarski and Pobozy almost never observed increased vascularity with US, except in patients with spondyloarthritis[10]. We also found neovascularity in very few patients.

Clark and Ahmad stated that tendon thickness measured by ultrasonography may not correlate with the patient's clinical condition[40]. In our results, there was no change in CET thickness, but clinical improvement was detected. This result was the same in both groups. The initial elbow VAS-ADL values of the TECAR group were significantly higher than the control group. On the other hand, there was no significant difference between the two groups in terms of initial CET thickness.

Songur et al. showed improvement in CET thickness, TUSS, and hypoechogenicity levels in the capitellar region in groups using lateral epicondylitis bands and wrist extensor splint[17]. We did not find a significant improvement in CET thickness in the capitellar region in either group. We found significant improvement in TUSS and hypoechogenicity scores in both groups.

Murat et al. randomized 42 patients into two groups and applied ESWT and sham ESWT. They evaluated the patients after treatment and 1 month after the end of treatment. They found a significant decrease in CET thickness in the ESWT group at both times[37]. We could not show such a tendon thickness reduction with TECAR. If there were an ESWT group in our study, then we could have reached clearer results for

**Table 4. Comparison of clinical and sonographic parameters within and between groups before (T0) and after treatment (T1)**

| Parameters | Groups | T0 | T1 | p |
|---|---|---|---|---|
| Elbow VAS-rest | TECAR | 3.26 (3.44) | 1.826 (2.309) | 0.005 |
| | Control | 2.75 (2.862) | 1.291 (1.921) | 0.003 |
| | p | 0.582 | 0.392 | |
| Elbow VAS-night | TECAR | 4.69 (3.94) | 1.521 (2.212) | 0.000 |
| | Control | 3.916 (3.174) | 1.75 (2.471) | 0.001 |
| | p | 0.459 | 0.741 | |
| Elbow VAS-ADL | TECAR | 8.69 (1.29) | 3.521 (2.643) | 0.000 |
| | Control | 7.5 (1.769) | 4.0417 (2.773) | 0.000 |
| | p | 0.012 | 0.514 | |
| Forearm VAS-rest | TECAR | 1.739 (3.092) | 0.739 (1.572) | 0.067 |
| | Control | 1.33 (2.639) | 0.583 (1.471) | 0.05 |
| | p | 0.630 | 0.727 | |
| Forearm VAS-night | TECAR | 2 (3.477) | 0.826 (1.922) | 0.033 |
| | Control | 2.08 (3.28) | 0.875 (2.006) | 0.01 |
| | p | 0.933 | 0.932 | |
| Forearm VAS-ADL | TECAR | 3.913 (3.93) | 1.56 (2.71) | 0.002 |
| | Control | 3.75 (3.95) | 2.08 (2.701) | 0.002 |
| | p | 0.888 | 0.515 | |
| Arm VAS-rest | TECAR | 0.956 (2.549) | 0.087 (0.417) | 0.086 |
| | Control | 1.083 (2.301) | 0.541 (1.614) | 0.073 |
| | p | 0.859 | 0.197 | |
| Arm VAS-night | TECAR | 1.478 (3.409) | 0.304 (1.019) | 0.053 |
| | Control | 1.833 (3.198) | 0.708 (1.944) | 0.022 |
| | p | 0.714 | 0.380 | |
| Arm VAS-ADL | TECAR | 2.956 (3.948) | 0.521 (1.162) | 0.002 |
| | Control | 3 (3.718) | 1.416 (2.375) | 0.009 |
| | p | 0.969 | 0.110 | |
| Lateral epicondyle tenderness VAS | TECAR | 8.608 (1.588) | 3.304 (2.754) | 0.000 |
| | Control | 8.041 (2.095) | 3.66 (3.059) | 0.000 |
| | p | 0.303 | 0.672 | |
| HGS | TECAR | 21.521 (9.217) | 27.817 (12.191) | 0.000 |
| | Control | 21.69 (10.038) | 26.18 (10.45) | 0.000 |
| | p | 0.952 | 0.624 | |
| CET thickness | TECAR | 0.262 (0.067) | 0.251 (0.078) | 0.624 |
| | Control | 0.241 (0.078) | 0.231 (0.07) | 0.419 |
| | p | 0.335 | 0.349 | |

*(Continues)*

**Table 4. Comparison of clinical and sonographic parameters within and between groups before (T0) and after treatment (T1) *(continued)***

| Parameters | Groups | T0 | T1 | p |
|---|---|---|---|---|
| TUSS | TECAR | 1.739 (0.751) | 1.087 (0.949) | 0.01 |
| | Control | 1.875 (1.075) | 1.25 (1.188) | 0.001 |
| | p | 0.620 | 0.607 | |
| Hypo echogenicity* | TECAR | 2 (0-2) | 1 (0-1) | 0.002 |
| | Control | 2 (0-2) | 2 (0-2) | 0.001 |
| | p | 0.705 | 1.0 | |
| Neovascularity* | TECAR | 1 (0-1) | 1 (0-1) | 0.317 |
| | Control | 1 (0-1) | 1 (0-1) | 1.0 |
| | p | 0.662 | 0.730 | |
| Heterogeneity* | TECAR | 1 (0-1) | 1 (0-1) | 0.665 |
| | Control | 1 (0-1) | 1 (0-1) | 0.083 |
| | p | 0.646 | 0.917 | |
| Bone abnormality* | TECAR | 1 (0-1) | 1 (0-1) | 0.317 |
| | Control | 1 (0-1) | 1 (0-1) | 1.0 |
| | p | 0.767 | 0.482 | |
| PRTEE-pain | TECAR | 31.826 (6.859) | 16.95 (9.735) | 0.000 |
| | Control | 30.375 (8.484) | 16.83 (10.61) | 0.000 |
| | p | 0.523 | 0.967 | |
| PRTEE-function | TECAR | 31.695 (8.1446) | 14.065 (9.9147) | 0.000 |
| | Control | 31.479 (10.48) | 14.104 (11.83) | 0.000 |
| | p | 0.938 | 0.99 | |
| PRTEE-total | TECAR | 63.956 (14.052) | 31.41 (17.55) | 0.000 |
| | Control | 61.854 (17.271) | 30.937 (21.538) | 0.000 |
| | p | 0.65 | 0.934 | |

*Mann-Whitney test; other: Student t-test.
VAS: visual analog scale; ADL: activities of daily living; HGS: hand grip strength; CET: common extensor tendon; TUSS: total US scale score; PRTEE: patient-rated tennis elbow evaluation.

TECAR. TUSS was not evaluated in the Murat et al. study. Unfortunately, ESWT did not have hypoechogenicity, neovascularity, heterogeneity, or bone abnormality results. In addition, the occupations of the patients were not mentioned in this study. All of our patients, except for our three patients, were actively working patients. Perhaps for this reason, tendon thickness did not change much in our study.

Tezen et al. found TECAR treatment to be beneficial in reducing pain and improving symptoms and functions in CTS patients, but observed that its effects were not as long-lasting as US[41]. We evaluated the patients at the end of the 3rd week, which is the end of the interventions. If we had followed them for a long time, there might have been no difference between the two groups in terms of VAS ADL change. Bilir et al. found significant improvement in CET thickness in both groups in their LE study comparing high-intensity laser therapy and ESWT[42]. However, the lack of a control group is a limitation of this study.

In chronic LE, Turgay et al. found that ESWT was more effective than low-level laser therapy (LLLT) in reducing pain and improving function[43]. However, this

**Table 5. Effects of treatment models on clinical and sonographic parameters according to pre-treatment (T0) and post-treatment (T1) change values**

| Parameters | TECAR group | Control group | p |
|---|---|---|---|
| Elbow rest VAS Δ (T0-T1) | 1.434 (2.191) | 1.458 (2.186) | 0.971 |
| Elbow night VAS Δ (T0-T1) | 3.173 (3.284) | 2.166 (2.632) | 0.251 |
| Elbow VAS-ADL Δ (T0-T1) | 5.173 (2.656) | 3.458 (2.781) | 0.036 |
| forearm rest VAS Δ (T0-T1) | 1 (2.486) | 0.75 (1.775) | 0.692 |
| Forearm night VAS Δ (T0-T1) | 1.173 (2.479) | 1.208 (2.105) | 0.959 |
| Forearm VAS-ADL Δ (T0-T1) | 7.13 (3.401) | 5.416 (2.976) | 0.072 |
| arm rest VAS Δ (T0-T1) | 0.869 (2.321) | 0.541 (1.413) | 0.56 |
| Arm night VAS Δ (T0-T1) | 1.173 (2.757) | 1.125 (2.251) | 0.947 |
| Arm VAS-ADL Δ (T0-T1) | 2.434 (3.300) | 1.583 (2.717) | 0.339 |
| Lateral epicondyle tenderness VAS Δ (T0-T1) | 5 (0-10) | 4 (0-10) | 0.252 |
| HGS Δ (T0-T1) | −6.295 (4.897) | −4.491 (6.669) | 0.298 |
| CET thickness Δ (T0-T1) | 0.01 (0.100) | 0.01 (0.059) | 0.986 |
| TUSS Δ (T0-T1) | 0.652 (1.112) | 0.625 (0.824) | 0.924 |
| Hypoechogenicity Δ (T0-T1)* | 0 (0-2) | 0 (0-2) | 0.884 |
| NeovascularityΔ (T0-T1)* | 0 ([−1]-1) | 0 (0-0) | 0.291 |
| Heterogeneity Δ (T0-T1)* | 0 ([−1]-1) | 0 (0-1) | 0.525 |
| Bone abnormality Δ (T0-T1)* | 0 (0-1) | 0 (0-0) | 0.307 |
| PRTEE-pain Δ (T0-T1) | 14.86 (9.55) | 13.54 (8.59) | 0.619 |
| PRTEE-function Δ (T0-T1) | 17.63 (9.293) | 17.37 (10.87) | 0.932 |
| PRTEE-total Δ (T0-T1) | 32.54 (17.94) | 30.91 (18.07) | 0.758 |

*Wilcoxon test; others: t-test.
TECAR: transfer energy capacitive and resistive; VAS: visual analog scale; ADL: activities of daily living; HGS: hand grip strength; CET: common extensor tendon; TUSS: total US scale score; PRTEE: patient-rated tennis elbow evaluation.

study did not compare the changes in parameters between the two groups before and after treatment.

Baktır et al. observed that LLLT was only beneficial for pain in the lateral epicondyle, whereas iontophoresis was beneficial for both pain and function. When the effect size was evaluated, they found that LLLT was more effective than iontophoresis in reducing pain. However, when phonophoresis and iontophoresis were compared in terms of effectiveness, they found that iontophoresis had better effects in terms of pain, function, and grip strength[44]. In a study comparing kinesiotaping, US, and ESWT, CET thicknesses showed a significant decrease only in the ESWT group after 8 weeks[45]. ESWT, which has been proven to be effective in many studies in LE, had no effect on CET thickness in the 2nd week, but an effect was seen in the 8th week. If we had done long-term follow-up, we might have seen a decrease in tendon thickness. Again, in the same study, grip strength improved only in the kinesio taping group within 6 weeks after the completion of treatment[45]. However, we found a significant improvement in hand grip strength in both groups in a short time.

Although we did not find a significant difference between the two groups in terms of Verhaar treatment response, there were no "bad" results in the TECAR group, whereas 20.8% of the patients in the control group had bad results. Again, the excellent and good results rates were higher in the TECAR group. This supports the effect of TECAR in the treatment of LE.

This is the first study to evaluate the effect of TECAR treatment in LE clinically and ultrasonographically, and draws attention to an alternative physical therapy modality in the treatment of LE.

The lack of long-term follow-up may be a limitation. We thought that there was no need for a sham group since there were not only subjective evaluations of the patients but also ultrasonographic evaluations. We think that our study will prioritize future comparative studies with longer follow-up and different physical therapy agents.

## Conclusions

To our knowledge, this is the first study to evaluate the clinical and ultrasonographic efficacy of TECAR therapy in LE. We obtained better results in the TECAR group than the control group in terms of VAS ADL in the early post-treatment period. It may be preferred in addition to exercise therapy in patients with high elbow pain. TECAR therapy can be used as an alternative treatment option in LE. However, further research is needed to standardize treatment protocols for this patient group, to determine the long-term effects of TECAR therapy, and to determine the safety and efficacy of this treatment method.

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## Conflicts of interest

The authors declare no conflicts of interest.

## Ethical considerations

**Protection of human subjects and animals.** The authors declare that the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the World Medical Association and the Declaration of Helsinki. The procedures were authorized by the Institutional Ethics Committee.

**Confidentiality, informed consent, and ethical approval.** The authors have followed their institution's confidentiality protocols, obtained informed consent from all patients, and secured approval from the Ethics Committee. SAGER guidelines have been followed as applicable to the nature of the study. The study protocol received institutional review board approval (AESH-EK-2025-082, dated March 19, 2025) in the format required by the clinical research ethics committee of the local institute, University of Health Sciences, Ankara Etlik City Hospital, Ankara, Turkey.

**Declaration on the use of artificial intelligence.** The authors declare that no generative artificial intelligence was used in the writing or creation of the content of this manuscript.

## References


1. Tosti R, Jennings J, Sewards JM. Lateral epicondylitis of the elbow. Am J Med. 2013;126:357.e1-6.
2. De Smedt T, De Jong A, Van Leemput W, Lieven D, Van Glabbeek F. Lateral epicondylitis in tennis: update on aetiology, biomechanics and treatment. Br J Sports Med. 2007;41:816-9.
3. Calfee RP, Patel A, DaSilva MF, Akelman E. Management of lateral epicondylitis: current concepts. J Am Acad Orthop Surg. 2008;16:19-29.
4. Shiri R, Viikari-Juntura E. Lateral and medial epicondylitis: role of occupational factors. Best Pract Res Clin Rheumatol. 2011;25:43-57.
5. Shiri R, Viikari-Juntura E, Varonen H, Heliövaara M. Prevalence and determinants of lateral and medial epicondylitis: a population study. Am J Epidemiol. 2006;164:1065-74.
6. Binder AI, Hazleman BL. Lateral humeral epicondylitis--a study of natural history and the effect of conservative therapy. Br J Rheumatol. 1983;22:73-6.
7. Chard MD, Hazleman BL. Tennis elbow--a reappraisal. Br J Rheumatol. 1989;28:186-90.
8. Duncan J, Duncan R, Bansal S, Davenport D, Hacker A. Lateral epicondylitis: the condition and current management strategies. Br J Hosp Med (Lond). 2019;80:647-51.
9. Krogh TP, Fredberg U, Ammitzbøl C, Ellingsen T. Ultrasonographic characteristics of the common extensor tendon of the elbow in asymptomatic individuals: thickness, color Doppler activity, and bony spurs. Orthop J Sports Med. 2017;5:2325967117704186.
10. Konarski W, Poboży T. The use of ultrasonography in the diagnosis and treatment of the lateral epicondylitis. Pictorial essay. Med Ultrason. 2022;24:479-84.
11. Yokota Y, Sonoda T, Tashiro Y, Suzuki Y, Kajiwara Y, Zeidan H, et al. Effect of capacitive and resistive electric transfer on changes in muscle flexibility and lumbopelvic alignment after fatiguing exercise. J Phys Ther Sci. 2018;30:719-25.
12. Ganzit G. Tecar® Therapy in the Treatment of Acute and Chronic Pathologies in Sports. ResearchGate. Available from: https://www.researchgate.net/publication/267853490_tecarr_therapy_in_the_treatment_of_acute_and_chronic_pathologies_in_sports [Last accessed on 2022 Dec 20].
13. Hawamdeh M. The effectiveness of capacitive resistive diathermy (Tecartherapy®) in acute and chronic musculoskeletal lesions and pathologies. Eur J Sci Res. 2014;118:336-40.
14. Yokota Y, Tashiro Y, Suzuki Y, Tasaka S, Matsushita T, Matsubara K, et al. Effect of capacitive and resistive electric transfer on tissue temperature, muscle flexibility, and blood circulation. J Nov Physiother. 2016;7:325.
15. Parolo E, Combi F. Hyperthermia through resistive and capacitive energy transfer in the treatment of acute and chronic musculoskeletal lesions. Medicine (Baltimore). 2009;88:e1-6.
16. Tranquilli G, Bazzucchi I, Felici F, Sacchetti M, Di Cesare A, Gatti R. Multicentre Study on Tecar Therapy in Sports Pathologies. Rome: FMSI Institute of Sports Medicine; 2009.
17. Songur K, Demir ZD, Baysan C, Dilek B. Clinical and ultrasonographic effectiveness of two different splints used for the treatment of lateral epicondylitis: a prospective randomized controlled study. Arch Phys Med Rehabil. 2024;105:655-63.
18. Ustabaşıoğlu F, Günay B, Samancı C, Emre Ustabaşıoğlu F. Assessment of common extensor tendon vascularization using superb microvascular imaging: a potential tool in the evaluation of extracorporeal shock wave therapy and therapeutic ultrasound effectiveness in lateral epicondylitis. Acta Radiol. 2023;64:2828-35.
19. Babaei-Ghazani A, Shahrami B, Fallah E, Ahadi T, Forough B, Ebadi S. Continuous shortwave diathermy with exercise reduces pain and improves function in lateral epicondylitis more than sham diathermy: a randomized controlled trial. J Bodyw Mov Ther. 2020;24:69-76.
20. Uygur E, Aktas B, Yilmazoglu EG. The use of dry needling vs. Corticosteroid injection to treat lateral epicondylitis: a prospective, randomized, controlled study. J Shoulder Elbow Surg. 2021;30:134-9.
21. Duñabeitia I, Arrieta H, Torres-Unda J, Gil J, Santos-Concejero J, Gil SM, et al. effects of a capacitive-resistive electric transfer therapy on physiological and biomechanical parameters in recreational runners: a randomized controlled crossover trial. Phys Ther Sport. 2018;32:227-34.
22. Rodríguez-Sanz J, López-De-Celis C, Hidalgo-García C, Canet-Vintró M, Fanlo-Mazas P, Alburquerque-Sendín F. Temperature and current flow effects of different electrode placement in shoulder capacitive-resistive electric transfer applications: a cadaveric study. BMC Musculoskelet Disord. 2021;22:139.
23. De Sousa-De Sousa L, Tebar Sanchez C, Maté-Muñoz JL, Hernández-Lougedo J, Barba M, Lozano-Estevan MD, et al. Application of capacitive-resistive electric transfer in physiotherapeutic clinical practice and sports. Int J Environ Res Public Health. 2021;18:12446.
24. Karanasios S, Korakakis V, Moutzouri M, Drakonaki E, Koci K, Pantazopoulou V, et al. Diagnostic accuracy of examination tests for lateral elbow tendinopathy (LET) - a systematic review. J Hand Ther. 2022;35:541-51.
25. Henderson CA, Gomez CG, Novak SM, Mi-Mi L, Gregorio CC. Overview of the muscle cytoskeleton. Compr Physiol. 2017;7:891-944.
26. Szabo DA, Neagu N, Teodorescu S, Predescu C, Sopa IS, Panait L. TECAR therapy associated with high-intensity laser therapy (hilt) and manual therapy in the treatment of muscle disorders: a literature review on the theorised effects supporting their use. J Clin Med. 2022;11:6149.
27. Shamrock AG, Varacallo M. Achilles tendon rupture. In: StatPearls. Treasure Island, FL: StatPearls Publishing; 2021.
28. Overend TJ, Wuori-Fearn JL, Kramer JF, MacDermid JC. Reliability of a patient-rated forearm evaluation questionnaire for patients with lateral epicondylitis. J Hand Ther. 1999;12:31-7.
29. Altan L, Ercan I, Konur S. Reliability and validity of Turkish version of the patient rated tennis elbow evaluation. Rheumatol Int. 2010;30:1049-54.
30. Du Toit C, Stieler M, Saunders R, Bisset L, Vicenzino B. Diagnostic accuracy of power Doppler ultrasound in patients with chronic tennis elbow. Br J Sports Med. 2008;42:872-6.
31. Lee MH, Cha JG, Jin W, Kim BS, Park JS, Lee HK, et al. Utility of sonographic measurement of the common tensor tendon in patients with lateral epicondylitis. Am J Roentgenol. 2011;196:1363-7.
32. Toprak U, Baskan B, Üstüner E, Öten E, Altin L, Karademir MA, et al. Common extensor tendon thickness measurements at the radiocapitellar region in diagnosis of lateral elbow tendinopathy. Diagn Interv Radiol. 2012;18:566-70.
33. Palaniswamy V, Ng S, Manickaraj N, Ryan M, Yelland M, Rabago D, et al. Relationship between ultrasound detected tendon abnormalities, and sensory and clinical characteristics in people with chronic lateral epicondylalgia. PLoS One. 2018;13:e0205171.
34. Boonstra AM, Schiphorst Preuper HR, Balk GA, Stewart RE. Cut-off points for mild, moderate, and severe pain on the visual analogue scale for pain in patients with chronic musculoskeletal pain. Pain. 2014;155:2545-50.
35. Wuori JL, Overend TJ, Kramer JF, MacDermid J. Strength and pain measures associated with lateral epicondylitis bracing. Arch Phys Med Rehabil. 1998;79:832-7.
36. Verhaar JA, Walenkamp G, Kester A, Van Mameren H, Van derLinden T. Lateral extensor release for tennis elbow: a prospective long-term follow-up study. JBone Joint Surg Am. 1993;75:1034-43.
37. Murat S, Dogruoz Karatekin B, Zengin M. Clinical and sonographic evaluation of the effectiveness of extracorporeal shock wave therapy in patients with lateral epicondylitis. Medeni Med J. 2024;39:109-16.

38. Kaux JF, Forthomme B, Croisier JL, Demoulin C, Vanderthommen M, Crielaard JM. Effectiveness of Tecar Therapy Combined with Eccentric Exercises in Lateral Elbow Tendinopathy. In: World Congress on Osteoporosis, Osteoarthritis and Musculoskeletal Diseases. Paris, France; 2022.
39. Vahdatpour B, Haghighat S, Sadri L, Taghian M, Sadri S. Effects of transfer energy capacitive and resistive on musculoskeletal pain: a systematic review and meta-analysis. Galen Med J. 2022;11:e2407.
40. Clarke AW, Ahmad M, Curtis M, Connell DA. Lateral elbow tendinopathy: correlation of ultrasound findings with pain and functional disability. Am J Sports Med. 2010;38:1209-14.
41. Tezen Ö, Ata AM, Uzun Ö, Çakır F, Yaşar E. Comparison of the effectiveness of ultrasound and transfer energy capacitive and resistive (TECAR) therapy in patients with carpal tunnel syndrome. Lasers Med Sci. 2025;40:147.
42. Bilir EE, Atalay SG, Tezen Ö, Karaköseoğlu I. Comparison of high intensity laser therapy and extracorporeal shock wave in treatment of lateral epicondylitis: a randomized controlled study. Lasers Med Sci. 2024;39:270.
43. Turgay T, Günel Karadeniz P, Sever GB. Comparison of low level laser therapy and extracorporeal shock wave in treatment of chronic lateral epicondylitis. Acta Orthop Traumatol Turc. 2020;54:591-5.
44. Baktir S, Razak Ozdincler A, Kaya Mutlu E, Bilsel K. The short-term effectiveness of low-level laser, phonophoresis, and iontophoresis in patients with lateral epicondylosis. J Hand Ther. 2019;32:417-25.
45. Ozmen T, Koparal SS, Karatas O, Eser F, Ozkurt B, Gafuroğlu TU. Comparison of the clinical and sonographic effects of ultrasound therapy, extracorporeal shock wave therapy, and Kinesio taping in lateral epicondylitis. Turk J Med Sci. 2021;51:76-83.