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The short-term effectiveness of low-level laser, phonophoresis, and iontophoresis in patients with lateral epicondylosis

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ABSTRACT

Study Design: Randomized parallel group trial.
Introduction: Various treatment options for lateral epicondylosis have been reported in the literature.
Purpose of Study: We aimed to compare the effectiveness of low-level laser therapy (LLLT), phonophoresis, and iontophoresis in terms of pain, function, and grip strength.
Methods: This study that comprised 37 patients with lateral epicondylosis was planned as a prospective randomized parallel group trial. Twelve participants were randomized to the LLLT group, 12 to the phonophoresis group, and 13 to the iontophoresis group. The Visual Analog Scale (VAS), pressure algometer, the Patient-Rated Tennis Elbow Evaluation, and grip strength dynamometer were used to measure outcomes. The measurements were performed at baseline and at the end of 15 sessions.
Results: Investigation of the pain scores revealed that all VAS scores were improved in both the laser and iontophoresis groups (VAS at rest: $P = .015$, effect size (ES) = 1.49 and $P = .016$, ES = 0.58, respectively; VAS during activity: $P = .008$, ES = 1.05 and $P = .008$, ES = 1.16, respectively; VAS at night: $P = .013$, ES = 1.01 and $P = .016$, ES = 0.72, respectively). Only advance in function and grip strength was associated with the iontophoresis group (Patient-Rated Tennis Elbow Evaluation $P = .006$, ES = 0.78; grip strength with elbow extension $P = .011$, ES = 1.03; with elbow flexion $P = .003$, ES = 0.52).
Discussion: The most effective approach could not be highlighted among the existing studies in the literature as they were applied in combination with other therapies.
Conclusion: In our study, we observed that LLLT provides a benefit only for pain, whereas iontophoresis is beneficial for both pain and function. If the effect size is evaluated, LLLT is more influential than iontophoresis for decreasing pain. However, when we compared phonophoresis and iontophoresis in terms of effectiveness, we found that iontophoresis has better effects for pain, function, and grip strength.

Introduction

Lateral epicondylosis is the most prevalent syndrome encountered at the elbow joint.[1] The incidence is estimated at approximately 1%-3%.[2] The disease symptoms have a huge impact on both daily and work activities. Patient education, behavioral modification, and active immobilization are the cornerstones of lateral epicondylosis treatment. Thermotherapy, electrical stimulation, transcutaneous electrical nerve stimulation, low-level laser therapy (LLLT), extracorporeal shock wave therapy, ultrasound (US), phonophoresis, and iontophoresis are the most prevalent electrotherapy interventions.[3] Manipulative techniques, including augmented soft tissue mobilization, friction massage, manipulation, and stretching and strengthening exercises, are widely used treatment options.[4] Acupuncture, splinting, taping, and several injections can also be used as treatment. Long-lasting and recalcitrant cases can require surgery.[5]

All treatments mostly focus on decreasing symptoms, including pain, and increasing function. The literature lacks satisfactory, prospective, randomized clinical trials to guide primarily which treatment option is the most effective for lateral epicondylosis. Most of the electrotherapy interventions are combined with

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exercise and manual therapy, making the determination of the benefits of treatment challenging because they can be caused by electrotherapy or the other treatment combined with electrotherapy. Thus, it remains unknown about the absolute isolated effect of electrotherapeutic modalities for patients with lateral epicondylosis.[4,6]

LLLT has a wide range of usage in clinics. In addition, the meta-analysis emphasized that LLLT is a beneficial application both alone and in conjunction with exercise regimen.[7] Moreover, corticosteroid drugs are another preferred treatment for lateral epicondylosis mainly in the form of injection in clinics. Despite the common use of steroids for their short-term benefits, they also carry risks regarding the vulnerability to degenerative changes. Additionally, the transmission of corticosteroid drugs can also be achieved through phonophoresis and iontophoresis, which were discovered to avoid systemic side effects of drugs during transdermal delivery. It was shown that the administration of corticosteroids via iontophoresis is an effective, noninvasive option to decrease acute pain in lateral epicondylosis.[8] Similarly, phonophoresis is another effective technique for the transmission, although only a few studies have demonstrated this technique.[9]

The current studies are insufficient to confirm which technique is predominantly used in clinical applications. As such, this study was aimed to isolate the use of electrotherapeutic modalities in the treatment of lateral epicondylosis. It was hypothesized that the determination of the effectiveness of 3 methods—LLLT, which is commonly used in clinics and mostly studied in the literature, as well as phonophoresis and iontophoresis—would result in the improvement of treatment outcomes due to their analgesic and anti-inflammatory effects in cases with lateral epicondylosis.

The primary aim of our study was to determine the effectiveness of LLLT, phonophoresis, and iontophoresis application on pain status, grip strength, and functional status, and the secondary aim was to detect which application is the most efficient.

Materials and methods

A prospective randomized parallel group trial of consecutive patients with lateral epicondylosis was referred by an orthopedist from a community center at the Bezmialem University, Department of Orthopedics and Traumatology, to the electrotherapy unit of the Department of Physiotherapy of Istanbul University between January 2015 and May 2016. Fifty participants were recruited, 45 of whom fulfilled the criteria outlined in the following paragraph. They received written and verbal explanations about the study and the procedures to be applied. If they agreed to participate at the beginning of the study, they signed informed consent forms, which were approved by the ethical committee at Bakirkoy Sadi Konuk Training and Research Hospital (IRB: 2014-269).

Patients eligible for this study had an age range of 30-50 years, a history of pain around the lateral epicondyle for at least 1 month and tenderness localized to the epicondyle and anterodistal region of the epicondyle with palpation, and 2 of 4 positive results of provocative tests comprising Maudsley's, Cozen's, Thomsen and Mill's tests.[2] The exclusion criteria were neoplasia, neurologic deficits, cervical radiculopathy, peripheral nerve disease, rheumatoid arthritis, shoulder disease, radial tunnel syndrome, previous surgery of the affected upper extremities, congenital or acquired bony deformity in the ipsilateral upper extremity, the initiation of opioid analgesia or corticosteroid or analgesic injection interventions within the previous year, any physical therapy intervention on the upper extremity in the previous year, bilateral epicondylosis, and secondary orthopedic problems.

Randomization and blinding

The first physical therapist (A.R.O.) checked the patient history and applied the provocative tests against the inclusion criteria. Next, the patients were randomly assigned to 3 groups consisting of phonophoresis or iontophoresis using a computer-generated randomized table of numbers created before the beginning of the study by the first physical therapist to ensure allocation concealment. Individual sequentially numbered index cards with the random assignment were prepared. The index cards were folded and placed in sealed opaque envelopes. Next, the second physical therapist (S.B.) performing the interventions opened each envelope and allocated the participants to the LLLT, phonophoresis, or iontophoresis group according to the selected index card. The interventions were performed by the same physiotherapist at a university electrotherapy clinic. The baseline and posttreatment evaluations were carried out by another physical therapist (E.K.M.) who was blinded to which participants belonged to each group.

Intervention

All participants received treatment at the clinic (5 times a week), consisting of 15 sessions of approximately 20 minutes.

A GaAs diode laser instrument (Roland Serie Elettronica Pagani IR27/1; Italy) with a wavelength of 904 nm, frequency range of 5-7000 Hz, and maximum peak power of (27 W, 50 W, or 27 $\times$ 4 W) was applied, whereas the patient was sitting on a chair with shoulder in 90° abduction and the elbow in a slightly flexed position. The device head should be perpendicular to the region of application. The epicondylosis mode of the device was chosen for treatment. Our device only allows the determination of frequency and time. Thus, we applied LLLT according to the studies of Stergioulas[10] and Emanet et al[11] with a 50 Hz frequency. Our device automatically determined the power as 0.12 mW. The applications on the lateral epicondyle and 4 painful points around the epicondyle described by Bjordal[12] and Viola[13] as the most effective practice were performed (Appendix A).

An ultrasound device (Intelect 340 Combo; Chattanooga Group, Inc, Chattanooga, TN) was used for the application of phonophoresis. Topical prednisolone (2 mg/d) was mixed with aquasonic US gel for better transmission of the drug through the body. A 5 cm^2 US head with perpendicular contact with the skin to sustain longitudinal movements was used at a 1 W/cm^2 dosage and 1 MHz frequency for 7 minutes (Appendix A).

Direct current (Intelect; Chattanooga Group, Hixson, TN) was utilized for the execution of iontophoresis. Prednisolone-saline solution (5 mL of 0.4% prednisolone) was administered by pouring only on the sponge of the active rubber electrode for each session.[14] The active electrode (70 $\times$ 50 cm^2) was placed on the lateral epicondyle, and the passive electrode (80 $\times$ 120 cm^2) was placed on the upper arm region away from the active one at a distance consistent with the size of the passive electrode.[14,15] The prednisolone solution was useable only for 2 days without losing its efficiency.[16] The drug was transferred to the skin from the negative pole.[17] Direct current was used for efficient drug transmission.[18,19] The current must be between the range of 3-5 mA with a dosage of 40 mA/min (Appendix A).[19] Thus, the current was increased up to the point at which the patient senses it without exceeding the dosage.[19,20]

Outcome measurements

The outcome measures included pain measured by both the Visual Analog Scale (VAS) and pressure algometer, the level of function determined by Patient-Rated Tennis Elbow Evaluation

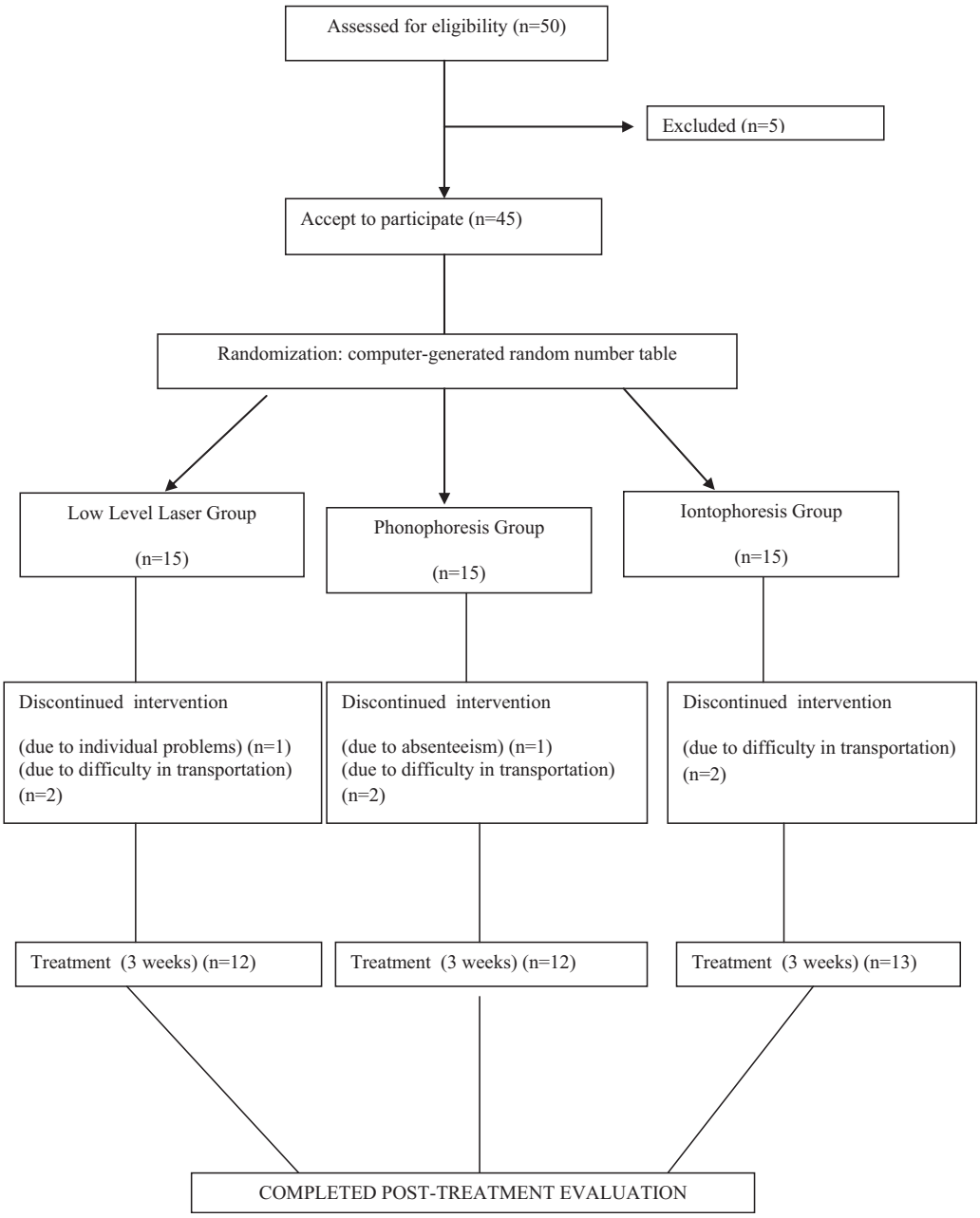

Fig. 1. Design of the study (STROBE flow diagram).

(PRTEE), and grip strength measurement. The measures were obtained at baseline and at the end of treatment (15 sessions).

Pain-related measures

Visual Analog Scale

Pain intensity was assessed using the VAS, in which the patient is asked to indicate his/her perceived pain during rest, activity, and at night (0- to 10-cm VAS, with 0 as no pain and 10 as the worst imaginable pain).[21] The minimal clinically important difference shown in VAS was 9 mm (95% confidence interval: 6-13 mm).[22]

The pressure pain threshold

The pressure pain threshold (PPT) was measured using a Baseline 1200-304 system (Push-Pull Force Gauge; Fabrication Enterprises, Inc), which is a handheld pressure algometer with a linear response to force application between 0 and 10 kg (22 lbs × 1/4 lb and 10 kgs × 100 gm). The PPT was assessed in all participants at 2 sites, the lateral epicondyle[23] and 1 cm lateral to the epicondyle. The patient was sitting with the shoulder at 30° abduction, the elbow at 90° flexion, and the forearm, wrist, and hand supported on the table. Three measurements of the PPT were taken in this position for each case.[24,25]

When evaluating the PPT of the subjects, the following standardized instructions were used. At the onset, 1 trial PPT measurement on the hand was performed with the algometer to ensure that the measurement procedure was understood, and each subject was coached in differentiating his or her reports of tactile and painful stimuli. The PPT was taken as the amount of pressure required to elicit a sensation of pain distinct from pressure or

discomfort.[24] The algometer probe was lowered at a constant rate of approximately 1 lb/s until the PPT was reached, as indicated by the subject's verbal report. We asked the subjects to say "stop" as soon as a discernible sensation of pain was felt; at this point, the algometer pressure was immediately released, and the probe was retracted by the rater.

Function-based measurements

Patient-Rated Tennis Elbow Evaluation

PRTEE is a simple, reliable, and valid form for the evaluation of pain and function that is specifically oriented for patients diagnosed with lateral epicondylosis. The tool was developed by MacDermid and published with reliability statistics in 1999,[26] updated wording in 2005,[27] and was independently evaluated by Rompe et al in 2007.[28] The Turkish version demonstrated high reliability and validity as reported by Altan et al in 2010.[29] The tool comprises 2 subscales for pain and function. The first one contains 5 questions to investigate the pain status and the second one comprises 10 questions to investigate the level of function both daily (4 items) and usual activities (6 items) in the previous week with using a 0-10 numeric pain rating: 0 indicates no pain or difficulty to perform different activities of daily living, and 10 indicates terrible pain that limits the performance of any activity.[28] In our study, we calculated total PRTEE scores as well as subscales of PRTEE score that include PRTEE-P (pain) and PRTEE-F (function) scores. PRTEE has excellent reliability (intraclass correlation coefficients: PRTEE-pain subscale: 0.94; PRTEE-specific activities subscale: 0.93; PRTEE usual activities, 0.85) and responsiveness. The standardized response mean was 2.1 in PRTEE.[26]

Grip strength measurement

A handheld dynamometer (Baseline Hydraulic Hand Dynamometer; Fabrication Enterprises Inc, Irvington, NY) is a practical tool to gauge the grip strength of the hand.[30] The handle of the meter is adjusted at the second position, as advised by Mathiowetz et al[31] in 1984 and 1985. The dynamometer has a diameter of 1.5 inches. The American Society of Hand Therapists proposed 2 standardized arm positions for grip strength evaluation as determined with the shoulder in adduction, both elbows at an angle of 90° flexion and 0° flexion and the wrist in neutral.[31,32] Initially, a trial measurement was performed for each elbow position with the nonaffected side to ensure that the measurement procedure was understood. The participants were instructed to squeeze as hard as possible on the device. Next, with the subjects in the upright position, 3 tests for grip strength were performed using the affected hand.[32] The mean values of the 3 grip strength measurements (kilogram-force) were calculated and used in analyses.[33]

Statistical analyses

The data were evaluated using the Statistical Package for the Social Sciences 20.0 program for Windows and by analyzing descriptive statistics (frequency, mean, and standard deviation). Demographic comparisons of the groups were conducted using the chi-squared analysis for categorical variables and the Kruskal-Wallis test for continuous variables. Intragroup comparisons of score changes measuring the decrease in pain levels and improvements in the level of function and muscle strength were carried out using Wilcoxon signed rank test. The Kruskal-Wallis test was used to determine whether there was equal variance between groups in the within-group score change (baseline to after the treatment). The within-group score change was calculated as the means with their 95% confidence intervals. The effect size was calculated as the mean score difference divided by the standard deviation from the initial measurement according to Kazis et al[34] An effect size of 0.2 was considered small, that of 0.5 was considered moderate, and that of 0.8 was considered large. *P* values lower than 0.05 were considered as statistically significant for all analyses.

Results

Fifty patients were screened for possible inclusion. Of these, 5 did not meet the inclusion criteria, resulting in a total of 45 patients who were included in the study; 15 were randomized to the LLLT group, 15 to the phonophoresis group, and 15 to the iontophoresis group. Three participants in the LLLT and phonophoresis groups and 2 of the iontophoresis participants discontinued treatment. Therefore, 37 patients were analyzed at the end of the treatment (please refer to the STROBE flow diagram; Fig. 1). The demographic data of the participants are presented in Table 1. The mean age and body mass index were similar in all groups.

In the intragroup evaluation of pain, both the LLLT and iontophoresis groups showed statistically significant improvement in all VAS parameters (VAS-rest: $P = .015$ and $P = .016$, respectively; VAS-activity: $P = .008$ and $P = .008$, respectively; VAS-night: $P = .013$ and $P = .016$, respectively; Table 2). On the other hand, when the pain was evaluated both on the lateral epicondyle and 1 cm lateral to the epicondyle using an algometer, the improvement in the mean scores between the beginning and end of the study was not statistically significant in all groups ($P > .05$; Table 3). When we compared the intergroup evaluation of pain, the mean change scores after treatment among the groups was not statistically significant regarding VAS and algometric results ($P > .05$; Tables 2 and 3). Effect sizes were large for LLLT, and moderate to large of the iontophoresis group had significantly improved outcomes in all the VAS parameters. However, in the phonophoresis group, the effect size was detected as low to moderate (Table 2).

The intragroup assessment of function demonstrated that the mean of the total PRTEE scores and PRTEE-P subscale scores were improved in all groups (LLLT, phonophoresis, iontophoresis groups: total PRTEE: $P = .04$, $P = .05$, and $P = .006$, respectively; PRTEE-P: $P = .006$, $P = .037$, and $P = .001$, respectively; Table 4). However, only a statistically meaningful improvement was determined in the iontophoresis group regarding PRTEE-F subscale scores (Table 4) and grip strength in both the extension and flexion positions of the elbow ($P = .023$, $P = .011$, and $P = .003$, respectively; Table 5). No statistically significant difference was found in the functional status

Table 1
Demographic and clinical features of the groups

Demographic	Laser group, $n = 12$	Phonophoresis group, $n = 12$	Iontophoresis group, $n = 13$	*P*
Age (y) (mean ± SD)	45.33 ± 6.22	43.75 ± 7.94	49.31 ± 9.23	.36[a]
BMI (kg/m^2)	28.65 ± 4.50	27.43 ± 3.06	29.52 ± 6.97	.83[a]
Sex				
Female	10 (83.3%)	9 (75%)	10 (76.9%)	.00[b]
Male	2 (16.7%)	3 (25%)	3 (23.1%)	
Dominant side				
Right	11 (91.7%)	12 (100%)	13 (100%)	.34[b]
Left	1 (8.3%)	0	0	
Affected side				
Right	3 (25%)	7 (58.3%)	10 (76.9%)	.03[b]
Left	9 (75%)	5 (41.7%)	3 (23.1%)	
Disease duration (wk) (mean ± SD)	44.00 ± 60.25	49.00 ± 61.59	48.00 ± 81.51	.72[a]

BMI = body mass index; SD = standard deviation.
[a] Kruskal-Wallis test.
[b] Chi-squared test.

Table 2
Comparison of pain status (VAS)

Assessment of pain VAS	Group	Baseline, mean ± SD	After treatment, mean ± SD	P[a]	Effect size	Within-group score change, mean (95% CI)	F	P[b]
VAS-rest	Laser group	6.08 ± 2.06	3.00 ± 2.82	**0.015**	1.49	−3.08 (−4.75 to −1.33)	2.816	.07
	Phonophoresis group	3.17 ± 2.25	3.08 ± 2.61	0.96	0.04	−0.08 (−2.80 to 1.75)		
	Iontophoresis group	5.31 ± 3.14	3.46 ± 2.40	**0.016**	0.58	−1.84 (−3.00 to −0.61)		
VAS-activity	Laser group	7.92 ± 2.61	5.17 ± 2.91	**0.008**	1.05	−2.75 (4.00 to −1.50)	0.423	0.65
	Phonophoresis group	6.33 ± 2.49	4.58 ± 2.15	0.16	0.70	−1.75 (−3.58 to −0.81)		
	Iontophoresis group	7.38 ± 1.85	5.23 ± 2.38	**0.008**	1.16	−2.15 (−3.15 to −1.00)		
VAS-night	Laser group	7.08 ± 3.37	3.67 ± 2.99	**0.013**	1.01	−3.41 (5.41 to −1.50)	1.307	0.52
	Phonophoresis group	4.33 ± 3.55	2.50 ± 3.70	0.13	0.51	−1.83 (−3.91 to 0.16)		
	Iontophoresis group	5.00 ± 3.71	2.31 ± 3.11	**0.016**	0.72	−2.69 (−4.61 to −0.92)		

Bold values are statistically significant.
CI = confidence interval; SD = standard deviation; VAS = Visual Analog Scale.
[a] Wilcoxon signed rank test.
[b] Kruskal-Wallis test.

regarding PRTEE and grip strength measurements among the groups ($P > .05$; Tables 4 and 5). Effect sizes were large for significantly improved outcomes of total PRTEE and PRTEE-P subscale measurements (Table 4). However, PRTEE-F and grip strength of the elbow had an effect size as low to moderate (Tables 4 and 5).

Discussion

In this study, it was found that the LLLT and iontophoresis applications are both effective in the treatment of pain in lateral epicondylosis.[35,36] However, improvement in parameters related to function and grip strength was only detected in the iontophoresis group. The recovery of pain was reflected only in the PRTEE pain scores in the phonophoresis group. However, no pain recovery was reflected in the pain pressure threshold measurement outcomes for any type application. Consistent with VAS and PRTEE scores, our results indicate that either LLLT or iontophoresis alone provides benefits over phonophoresis when the effectiveness of the 3 applications is evaluated. Additionally, the effect sizes of our applications range from moderate to large.

Lateral epicondylosis is the most restricting syndrome of the elbow joint that is developed after powerful and rapid concentric or eccentric contraction of wrist extensor muscles.[36] The main complaint of this disease is pain concomitantly accompanied by a decrease in grip strength, difficulty in squeezing, use of the vibratory objects, carrying objects with an extended elbow, and pulling activities with elbow flexion affecting the functionality of individuals.[36] In the literature, LLLT, phonophoresis, and iontophoresis are all mentioned as effective methods to reduce pain in different pathologies.[3,4] The common feature of all these studies was that they all were applied in combination with several therapies in the literature, possibly masking the isolated effect of electrotherapeutic modalities. Thus, our study was designed to determine the isolated effect of each these electrotherapy modalities in lateral epicondylosis.

In a previous meta-analysis, the effectiveness of LLLT was proven over placebo.[12] In another meta-analysis, it is emphasized that the effectiveness of LLLT was over placebo if the treatment lasted for 3 months, but its effect is not sound in long term.[37] Okuni et al[38] used LLLT in the treatment of elbow pain on the tender point. At the end of 4 weeks (8 sessions), the VAS scores were meaningfully decreased similar to our LLLT application results. Lam et al[35] used GaAs LLLT in the treatment of epicondylosis. The application lasted 3 weeks (9 sessions) on painful points. However, the prescription of the home exercises for both the LLLT and sham LLLT groups was different in that study in terms of recovery than in ours. At the end of treatment, their results showed a significant improvement in VAS, PPT, and grip strength, whereas we determined only recovery in the VAS and PRTEE pain scores. Stergioulas[10] investigated LLLT and plyometric exercises in 2 groups. One of the groups had LLLT and plyometric exercise, whereas the other underwent placebo LLLT and plyometric exercise for 8 weeks. The groups participated in 2 weekly treatment sessions from the first to fourth week and 1 weekly session between the fourth and eighth weeks. They concluded that LLLT is effective to decrease rest pain and increase grip strength in 12 sessions, whereas we demonstrated an effect only in decreasing pain even in 15 sessions. The most spectacular difference in our study was the effect of LLLT without exercise and other methods that possibly suppress the isolated effect of LLLT.

Iontophoresis and phonophoresis are other methods for pain reduction in patients with lateral epicondylosis by transmitting drugs through the tissue as mentioned in the literature.[8] However, few studies have demonstrated the effect of the phonophoresis technique, which uses the US device for drug transmission. Holdsworth et al[39] investigated the effectiveness of US with and without a coupling medium and orthoses in 4 groups. The first group was treated by US, the second group was treated by phonophoresis with hydrocortisone, the third group was treated by US and an elbow brace, and the fourth group was treated by

Table 3
Comparison of pain status (pain pressure threshold)

Assessment of pain Pain pressure threshold	Group	Baseline, mean ± SD	After treatment, mean ± SD	P[a]	Effect size	Within-group score change, mean (95% CI)	F	P[b]
Lateral epicondyle	Laser group	3.22 ± 1.20	3.91 ± 1.02	0.48	0.57	−0.45 (−1.19 to −0.26)	0.114	.89
	Phonophoresis group	3.91 ± 1.02	4.13 ± 1.21	0.48	0.21	−0.22 (−0.72 to 0.24)		
	Iontophoresis group	3.41 ± 1.00	3.76 ± 1.04	0.34	0.35	−0.34 (−0.94 to 0.29)		
1 cm lateral to lateral epicondyle	Laser group	4.72 ± 1.28	5.15 ± 1.96	0.25	0.33	−0.43 (−1.15 to 0.34)	0.142	0.86
	Phonophoresis group	5.97 ± 1.21	6.62 ± 1.42	0.18	0.53	−0.64 (−1.31 to −0.01)		
	Iontophoresis group	4.60 ± 1.10	4.95 ± 1.36	0.80	0.31	−0.35 (−1.26 to 0.48)		

CI = confidence interval; SD = standard deviation.
[a] Wilcoxon signed rank test.
[b] Kruskal-Wallis test.

Table 4
Comparison of functional status (PRTEE)

Assessment of functional status PRTEE	Group	Baseline, mean ± SD	After treatment, mean ± SD	P[a]	Effect size	Within-group score change, mean (95% CI)	F	P[b]
PRTEE	Laser group	66.33 ± 20.43	47.45 ± 25.18	**0.04**	0.92	18.87 (10.0-27.53)	0.023	0.97
	Phonophoresis group	53.58 ± 22.59	33.41 ± 19.92	0.05	0.89	20.16 (8.04-31.74)		
	Iontophoresis group	60.73 ± 23.64	42.07 ± 23.61	**0.006**	0.78	18.65 (9.53-27.34)		
PRTEE-pain	Laser group	70.0 ± 17.31	45.83 ± 23.33	**0.006**	1.44	24.1 (14.00-34.50)	0.537	0.58
	Phonophoresis group	54.67 ± 17.42	38.25 ± 18.48	**0.037**	0.94	16.41 (4.08-29.74)		
	Iontophoresis group	67.85 ± 18.02	45.85 ± 23.43	**0.001**	1.22	22.00 (15.85-27.84)		
PRTEE-function (specific + usual)	Laser group	59.09 ± 24.96	47.89 ± 30.76	0.15	0.44	11.20 (−3.33 to 22.98)	0.293	0.74
	Phonophoresis group	41.10 ± 21.11	27.95 ± 22.13	0.09	0.62	13.15 (1.91-25.07)		
	Iontophoresis group	57.88 ± 29.19	39.57 ± 25.00	**0.023**	0.60	18.30 (4.50-30.91)		

Bold values are statistically significant.
CI = confidence interval; PRTEE = Patient-Rated Tennis Elbow Evaluation; SD = standard deviation.
[a] Wilcoxon signed rank test.
[b] Kruskal-Wallis test.

phonophoresis with hydrocortisone and an epicondylosis clasp. The pain was only decreased in group 4, remained the same in groups 1 and 3, and increased in group 2. Thus, using hydrocortisone phonophoresis with an epicondylosis clasp is an effective method to reduce pain and improve grip strength. However, hydrocortisone phonophoresis alone was not found to be effective for pain and grip strength, as similarly found in our study. In their treatment protocol, Nagrale et al[40] made a comparison between the effectiveness of Cyriax physiotherapy and phonophoresis. Cyriax physiotherapy includes Mill's manipulation and transverse friction massage (10 minutes) vs traditional physiotherapy covering phonophoresis with diclofenac as a coupling medium and supervised exercise. The treatment lasted for 4 weeks (12 sessions). However, they concluded that Cyriax physiotherapy is preferable to traditional physiotherapy to overcome pain and enhance grip strength and functionality. Baskurt et al[9] compared iontophoresis and phonophoresis using naproxen. They also added stretching and strengthening exercises in their treatment program. At the end of their study, both treatments were found to be equally effective in diminishing pain and improving grip strength. The addition of exercise to treatment programs is well known to lead to better results in terms of pain and function.[41,42] The equal results of their studies might also be derived from the addition of exercise, and this type of regulation in studies precludes the differentiation of the isolated impact of each method. By contrast, in our study, the isolated application of phonophoresis did not supply any benefit for pain and grip strength.

Nirschl et al[14] compared the effect of iontophoretic administration of sodium and dexamethasone sodium phosphate with placebo iontophoresis. Fifteen sessions were performed similar to our study, but the sessions were 1-3 days apart from each other. At the end of the study, effectiveness was found on pain, consistently with our outcomes. Fathy[43] compared 20 minutes of iontophoresis application with 10 minutes of Cyriax-type exercises. In their study, stretching exercises were added to both groups named the iontophoresis and Cyriax exercise groups. Consequently, no difference was detected between these methods. The cause may be that, as mentioned in the previous studies, exercise likely had a huge effect, closely affecting the course of events when it is combined with other types of therapies.[42] Baskurt et al[9] could not find any superiority on pain and grip strength in their study using naproxen (analgesic) phonophoresis and iontophoresis. Our results differently showed that the administration of corticosteroid drug through iontophoresis was more influential than phonophoresis for both pain and function. In phonophoresis, the use of drug in the form of cream instead of liquid might result in conductivity deficiency. Finally, Stefanou et al[8] applied corticosteroid iontophoresis using a dexamethasone patch and compared it with dexamethasone injection to determine how the difference in the transmission of dexamethasone affects the pain, function, grip strength and return-to-work status. Their outcomes reflected that both applications were equally effective. Similar to the results of our study, iontophoresis application showed efficient results in terms of the development of pain and grip strength. Our results indicate the development of function only in the iontophoresis group. Functional improvement includes grip strength, which has also been evaluated by many studies, and the PRTEE score, which is a lateral epicondylosis specific evaluation. Injection is prevalently used for the treatment of epicondylosis in clinics, although its only benefits have been proven in the short term.[43,44] In addition, a neurogenic inflammatory mechanism is commonly discussed in chronic tendinopathies rather than acute inflammatory signs.[45,46] Injection causes direct contact with the devastating substance in the tissue. Angiofibroblastic hyperplasia results in a defective healing potential.[47-49] Stefanou et al[8] emphasized that corticosteroid iontophoresis is as effective as corticosteroid injection. Consistent with their

Table 5
Comparison of functional status (grip strength)

Assessment of functional status Grip strength	Group	Baseline, mean ± SD	After treatment, mean ± SD	P[a]	Effect size	Within-group score change, mean (95% CI)	F	P[b]
Elbow in extension	Laser group	13.16 ± 6.92	15.49 ± 9.46	0.11	0.33	2.32 (0.07-2.01)	2.971	0.06
	Phonophoresis group	16.39 ± 8.59	17.02 ± 9.05	0.50	0.07	0.70 (−2.13 to 3.32)		
	Iontophoresis group	13.16 ± 5.49	18.85 ± 6.18	**0.011**	1.03	5.68 (2.70-8.57)		
Elbow in 90° flexion	Laser group	15.12 ± 7.22	15.98 ± 7.96	0.48	0.11	0.86 (1.69-2.99)	1.489	0.24
	Phonophoresis group	17.66 ± 7.29	18.08 ± 7.31	0.72	0.05	0.76 (−2.14 to 4.25)		
	Iontophoresis group	15.84 ± 6.37	19.21 ± 5.76	**0.003**	0.52	3.36 (1.73-4.96)		

Bold values are statistically significant.
CI = confidence interval; SD = standard deviation.
[a] Wilcoxon signed rank test.
[b] Kruskal-Wallis test.

outcomes, our study also showed supportive findings using the iontophoresis. When the harm of the injection is considered, the iontophoresis will be a wiser option to support the healing potential of tissue during the period of recovery.

Our study has some limitations that should be highlighted. First, we had a relatively small sample size. Second, our study failed to reflect satisfactory long-term follow-up results. Third, our groups were not homogenously distributed in terms of sex due to the use of a computer-generated randomized table.

The methodological strength of our study includes its prospective design and it being the first study comparing iontophoresis and phonophoresis by transmitting the same drug.

Conclusion

In our study, we have confirmed the finding reported by others that LLLT is effective in providing pain relief. Although LLLT provides larger effects on pain, iontophoresis is beneficial for both pain and function. Iontophoresis was superior to phonophoresis regarding all outcomes: pain, function, and grip strength. Accordingly, we recommend the use of iontophoresis as a first choice and LLLT as an alternative method based on availability of equipment and when pain is the primary issue. Due to our small sample and the controversies in the literature, there is a need for future prospective studies with larger sample sizes and longer follow-up.

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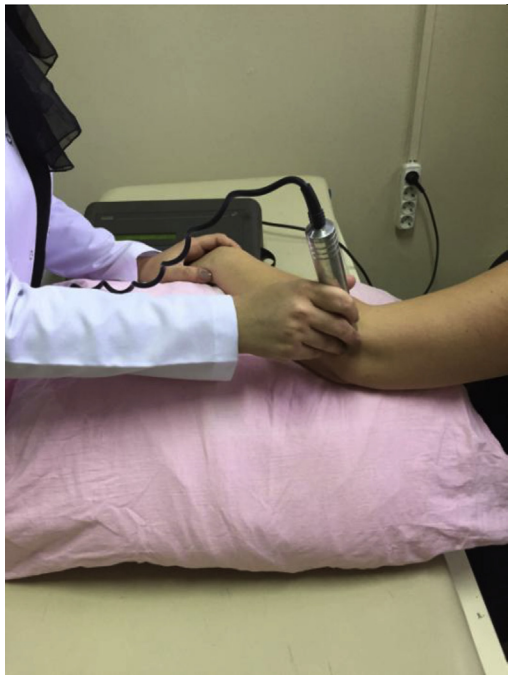
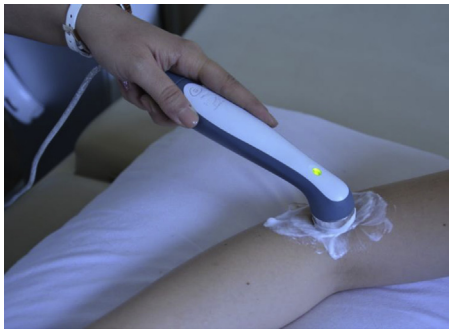
Appendix A

The type of application	The method of application	The picture of application
Low-level laser therapy (LLLT)	The device only permits for determining frequency and time. Power output: Automatically determined as 0.12 Mw. Frequency: 50 Hz. Treatment duration: 5 min Method of application: Resting the probe for 1 min on lateral epicondyle and most painful 4 points around it. Total number of sessions: 15 sessions.	
Phonophoresis	Topical prednisolone (2 mg/d) was mixed with aquasonic US gel for better transmission of drug through the body. Size of head: 5 cm^2 applicator head of US. Dosage: 1 W/cm^2. Frequency: 1 MHz Treatment duration: 7 min Method of application: US head was performed with perpendicular contact with skin on the lateral epicondyle by sustaining longitudinal movements. Total number of sessions: 15 sessions.	
Iontophoresis	The Active electrode: 70 × 50 cm^2 was placed on lateral epicondyle. The passive electrode: 80 × 120 cm^2 was placed on the upper arm region. Intensity of the current: Between the range of 3-5 mA at the point of sensation of patient was set. Dosage: 40 mA/min. Treatment duration: Calculated accordingly with intensity of current. Method of application: Prednisolone-saline solution (5 mL of 0.4% prednisolone) was administered by applying only on the sponge of active rubber electrode for each session. Total number of sessions: 15 sessions.	

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Quiz: # 632

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1. The LLLT
   a. was most effective in reducing pain
   b. was effective in improving all outcomes
   c. was ineffective in improving any outcomes
   d. was only effective in improving grip strength
2. Pain improved
   a. in all groups
   b. only in the phonophoresis group
   c. in none of the groups
   d. most in the iontophoresis group
3. Outcomes were measured using
   a. grip dynamometry
   b. a VAS
   c. the PRTEE
   d. all of the above
4. Effectiveness was assessed at _____ post intervention
   a. 5 weeks
   b. 5 months
   c. 15 weeks
   d. 15 months
5. The authors recommend iontophoresis as the treatment of choice for lateral epicondylosis
   a. false
   b. true

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