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ORIGINAL ARTICLE

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Effectiveness of pulsed electromagnetic field therapy in lateral epicondylitis

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Abstract We aimed to investigate the efficacy of pulsed electromagnetic field (PEMF) in lateral epicondylitis comparing the modality with sham PEMF and local steroid injection. Sixty patients with lateral epicondylitis were randomly and equally distributed into three groups as follows: Group I received PEMF, Group II sham PEMF, and Group III a corticosteroid + anesthetic agent injection. Pain levels during rest, activity, nighttime, resisted wrist dorsiflexion, and forearm supination were investigated with visual analog scale (VAS). Pain threshold on elbow was determined with algometer. All patients were evaluated before treatment at the third week and the third month. VAS values during activity and pain levels during resisted wrist dorsiflexion were significantly lower in Group III than Group I at the third week. Group I patients had lower pain during rest, activity and nighttime than Group III at third month. PEMF seems to reduce lateral epicondylitis pain better than sham PEMF. Corticosteroid and anesthetic agent injections can be used in patients for rapid return to activities.

Keywords Electromagnetic fields therapy · Epicondylitis

Introduction

Lateral epicondylitis is defined as pain and tenderness related to the overuse injury of soft tissues around lateral epicondyle, which attach to this region [1, 2]. Extensor carpi radialis brevis muscle consists of a keel-shaped tendon with attachments to extensor carpi radialis longus, extensor digitorum communis, supinator muscles and attachments to the radial collateral ligament, the orbicular ligament, the capsule of the elbow joint, and the deep fascia [3]. Extensor carpi radialis brevis and extensor digitorum communis especially produce the largest increases while the superficial head of supinator produce a moderate increase in tensile force in the common extensor tendon. The excessive stress may damage the muscle attachment and cause inflammation and pain [4]. Lateral epicondylitis is a common problem effecting 1–2% of the general population [5]. Because it causes reduction in the grip strength, it restricts daily living activities. Epidemiological studies have shown that it leads to sick leave and decrease in work capacity [6]. Despite its self-limiting character, recurrence is possible in many patients. Thus, it should be treated promptly and effectively [7, 8].

Conservative treatment with its most important components, such as rest and activity modification, is reported to be the main therapeutic approach [1]. In addition, nonsteroidal anti-inflammatory drugs can be administered. Also, some physical therapy agents such as ultrasound, iontophoresis, extracorporeal shock wave therapy, laser, and acupuncture can be useful [9–13]. In cases of failure to respond to those initial treatment methods, local anesthetic and corticosteroid injections may be of use [8, 14, 15]. Deconditioning response of the forearm muscles to the pain in lateral epicondylitis can be treated by passive stretching and isometric strengthening of wrist extensor muscles followed by resistive painless exercises in rehabilitation programs for a more rapid return to a normal functional level of strength and flexibility [14, 16]. Despite the existence of many therapy choices, there is still no consensus on the effectiveness of these methods because randomized controlled studies are lacking [6, 7].

Pulsed electromagnetic field (PEMF) therapy can be used in medical practice and also musculoskeletal disorders as a therapeutic agent. There are two ways of PEMF application. The first method is the placement of opposing electrodes of the device in direct contact with the

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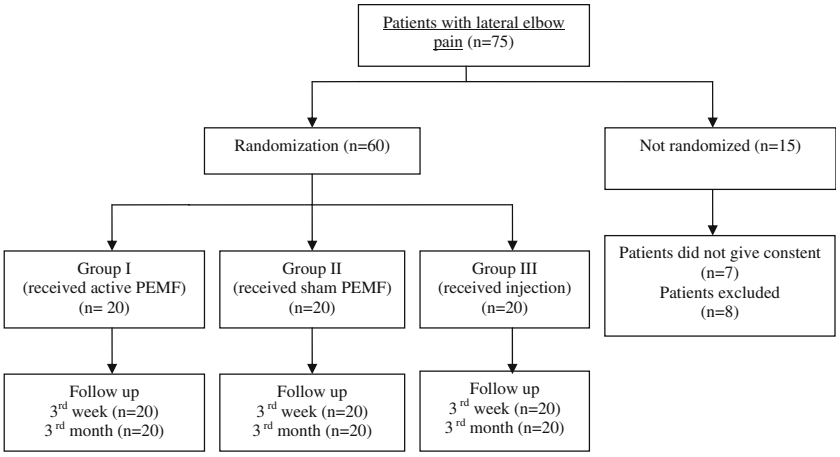
Table 1 Randomization and follow up



skin surface surrounding the tissue of interest and the second method is a PEMF stimulation, which the electrodes of the applicators of the device do not require direct contact with the skin [17]. It has numerous biologic effects on tissues. PEMF is used especially in bone fractures and many musculoskeletal system diseases such as osteoarthritis and rotator cuff tendonitis. Many studies have investigated and reported the benefits of PEMF on these indications [17–22]. However, only one study, to the best of our knowledge, exists which evaluated the success of PEMF on tennis elbow [23]. In fact, experimental studies on biological effects of PEMF are encouraging to use the modality in tennis elbow. The focal degeneration in the extensor wrist tendons that attach to lateral epicondyle and microruptures in collagen fibers due to overuse and repetitive microtraumas are responsible for the occurrence of tennis elbow [24]. No thermal effect can be observed in low frequency PEMF applications. It shows its effectiveness by changing the cell membrane potentials and ion transport. This leads to an anti-inflammatory effect by inhibiting the edema and enhancing microcirculation [25, 26]. Furthermore, some in vitro cellular studies have shown that low frequency PEMF can stimulate collagen production and maintain tendon alignment by induction of both collagen-producing cells and growth factor synthesis such as transforming growth factors-β [27, 28]. So, it seems logical to think that PEMF can decrease edema and induce the healing of collagen fibers in tennis elbow.

We, in this study, aimed to investigate the efficacy of PEMF comparing the modality with sham PEMF and a local steroid injection that is another therapeutic approach.

Materials and methods

This study was approved by a local ethics committee and all patients gave informed consent.

Patient selection Seventy-five patients who applied to the outpatient clinic of Trakya University Hospital, Physical Medicine and Rehabilitation Department with lateral elbow and forearm pain that lasted for more than 6 weeks were evaluated from January 2004 to December 2004. The diagnosis was made based on the tenderness in

Table 2 The comparison of demographic characteristics and evaluated parameters in the groups before treatment

Parameters	Group I (PEMF)	Group II (Sham PEMF)	Group III (Injection)	Significance
Age	46.76±6.24	51.47±8.23	47.80±6.05	NS[a]
Pain duration (month)	4.14±3.24	2.45±0.80	3.37±1.65	NS[b]
Rest pain (VAS)	3.43±2.56	3.39±2.08	4.02±2.05	NS[a]
Activity pain (VAS)	7.26±2.08	7.31±1.47	7.70±1.52	NS[a]
Night pain (VAS)	3.14±3.79	3.47±2.97	2.65±3.74	NS[b]
Pain during resisted wrist dorsiflexion (VAS)	5.98±2.31	6.53±1.94	5.10±1.67	NS[a]
Pain during resisted forearm supination (VAS)	2.59±3.18	4.34±1.47	3.42±2.85	NS[b]
Pain during resisted forearm pronation (VAS)	1.24±2.55	2.79±2.60	2.40±2.50	NS[b]
Algometric pain threshold (kg/cm^2)	3.08±1.09	2.63±0.49	3.04±0.86	NS[a]

Data presented are mean±SD
PEMF Pulsed electromagnetic field, *VAS* visual analog scale, *NS* nonsignificant ($p>0.05$)
[a]Performed by one-way ANOVA
[b]Performed by Kruskal–Wallis ANOVA

Table 3 The changes of outcome parameters within the groups after the interventions

	Group 1				Group 2				Group 3			
	BT	AT	3rd month	*p*	BT	AT	3rd month	*p*	BT	AT (3rd week)	3rd month	*p*
Rest pain (VAS)	3.43±2.56	1.05±1.69[a]	0.09±0.44[b]		3.39±2.08	1.95±1.75[a]	1.79±1.93[b]		4.02±2.05	0.50±0.69[a]	1.40± 2.09[b]	0.000
Activity pain (VAS)	7.26±2.08	3.88±1.90[a]	0.62±0.80[b]	0.000	7.31±1.47	4.42±2.45[a]	3.37±2.16[b]	0.000	7.70±1.52	1.75±1.62[a]	2.75±2.90[b]	0.000
Night pain (VAS)	3.14±3.79	1.52±2.06[a]	0.00±0.00[b]	0.000	3.47±2.97	1.37±2.14[a]	0.74±1.24[b]	0.000	2.65±3.74	0.45±1.36[a]	0.65±2.01[b]	0.011
Pain during resisted wrist dorsiflexion (VAS)	5.98±2.31	2.67±1.49[a]	0.86±0.85[b]	0.000	6.53±1.94	4.16±2.47[a]	3.42±2.09[b]	0.000	5.10±1.67	1.57±1.79[a]	1.75±2.05[b]	0.000
Pain during resisted forearm supination (VAS)	2.59±3.18	1.00±1.34[a]	0.24±0.70[b]	0.000	4.34±1.47	2.39±2.31[a]	1.53±1.74[b]	0.000	3.42±2.85	0.95±1.54[a]	1.4±2.54[b]	0.001
Algometric pain threshold (kg/cm^2)	3.08±1.09	3.61±1.23[a]	4.24±1.24[b]	0.000	2.63±0.49	2.97±0.67[a]	2.98±0.71[b]	0.001	3.04±0.86	3.98±1.29[a]	3.92±1.44[b]	0.000

Data presented are mean±SD. Friedmann ANOVA and Mann–Whitney U tests were used.
BT Before treatment, *AT* after treatment, *VAS* visual analog scale
[a]After treatment, values are significantly different than before treatment values.
[b]Values at third month are significantly different than before treatment values.

the origin of the extensor carpi radialis brevis muscle and increased tenderness of dorsiflexion of the wrist against resistance and of forearm supination. Differential diagnosis from cervical problems and radial tunnel syndrome was made with radiological and electrophysiological investigations in case of an existence of clinical suspicion. The exclusion criteria were as follows: (1) accompanying painful conditions, which may confuse the clinical picture such as upper extremity fracture, inflammatory arthritic conditions, carpal tunnel syndrome, thoracic outlet syndrome, cervical radiculopathy, and tendon ruptures; (2) accompanying medial epicondylitis; (3) contraindications for PEMF such as tuberculosis, pregnancy, cardiac pacemaker, and malignancy; and (4) contraindications for corticosteroid injection. Eight patients were excluded from the study and seven patients did not want to participate so 60 patients were included in the study.

Blinding and randomization The patients were evaluated during their initial visit by investigator A who is experienced in musculoskeletal pathologies and blind to the randomization process and the therapy applications. Investigator A sent the patients to investigator B, who was blind to the clinical status of the patients, for randomization and allocation to the therapy groups. Investigator B sent the patients to investigator C for therapy applications. All the patients were sent back to investigator A 3 weeks and 3 months after their first visit for the post therapy and evaluations after 3 months. So the baseline and subsequent evaluations were performed by an investigator who was blind to the therapies applied. The patients were randomly divided into three groups according to their application turns by investigator B. Group 1 consists of the first, fourth, seventh...and 58th patient, Group 2 the second, fifth, eighth...and 59th patient, and Group 3 the third, sixth, ninth...and the 60th patient. Table 1 shows the randomization and follow-up process of the patients.

Therapy protocols in the groups Active PEMF therapy was performed in Group 1 by a magnetotherapy device (BTL-09, manufactured by BTL Benesov, Czech Republic). The injured elbow of each patient was put in the middle portion of a big circle solenoid applicator in prone position. The dose and application time were selected according to the recommendations of the manufacturer. The total dose applied was 6 mT/session. This dose was completed by applying the PEMF in a frequency of 25 Hz and a frequency of 4.6 Hz, consecutively. A therapy session lasted for 30 min and 15 sessions were performed during 3 weeks (five sessions a week for 3 weeks).

Sham PEMF was used in Group 2. Their elbows were position the same way as with the Group 1 patients in the same applicator. However, the electric current producer was connected to another solenoid applicator (small solenoid). The patient sensed the same visual and auditory stimuli like the patient taking the active therapy, but was not exposed to the real magnetic field.

Local corticosteroid injection was administered to the most painful area with pressure around lateral epicondyle

Table 4 The group comparisons suggesting significant differences between the groups after therapy and at third month

	After treatment (or at 3rd week for injection group)	At 3rd month
Rest pain (VAS)[a]	Group 2 > Group 3	Group 1 < Group 2
		Group 1 < Group 3
Activity pain (VAS)[a]	Group 2 > Group 3	Group 1 < Group 2
	Group 1 > Group 3	Group 1 < Group 3
Night pain (VAS)[a]	NS	Group 1 < Group 3
Pain during resisted wrist dorsiflexion (VAS)[b]	Group 1 > Group 3	Group 1 < Group 2
	Group 2 > Group 3	Group 2 > Group 3
	Group 1 < Group 2	
Pain during resisted forearm supination (VAS)[a]	Group 1 < Group 2	Group 1 < Group 2
	Group 2 > Group 3	
Algometric pain threshold (kg/cm^2)[b]	Group 2 < Group 3	Group 1 > Group 2
		Group 2 < Group 3

VAS Visual analog scale and *NS* nonsignificant

for only once in Group 3 patients. Injected material consisted 1 cc of methylprednisolone acetate (40 mg) and 1 cc of prilocaine hydrochloride (20 mg).

All the patients in three groups were advised to rest, modify the daily living activities during 3 months, and were prescribed with volar static wrist splint. Paracetamol intake was permitted in case of pain that had the potential to restrict the daily living activities. The patients were advised not to take paracetamol 48 h before visits.

Outcome measures The pain intensity levels sensed during rest, activity of the painful elbow, and nighttime were labeled on a 10-cm visual analog scale (VAS) (from no pain = 0 to unbearable pain = 10). Furthermore, the patients graded their pain levels on the lateral side of the elbow according to the same method during resisted wrist dorsiflexion and forearm supination.

The pain threshold on elbow was determined with Fischer's algometer. The investigator applied the algometer perpendicularly on the most painful point increasing the pressure by 1 kg/cm^2 every 3 s till the patient sensed the pain. The pressure value that caused the onset of pain sensation was determined as pain threshold. The lowest pressure value among three measurements within 20-s intervals was taken as the pain threshold.

Statistical analysis Statistical evaluation was performed by SPSS program (version 11.0). Differences among groups were analyzed by Kruskal–Wallis test and between-groups comparisons were performed by Mann–Whitney U test. Friedman test was used to investigate whether there was an impact of treatment within the groups. The between-visits comparisons were performed by nonparametric *t* test for dependant variables.

Results

Sixty patients with tennis elbow (45 women and 15 men) were allocated into three groups with equal number of patients (Table 1). All the participants completed the study. The mean age of the whole study attendants was 48.60± 7.05 and the mean duration of the disorder was 3.35± 2.26 months. There was no statistically significant difference among the groups for age, gender, and duration of disorder (p>0.05). Furthermore, no significant difference was found for VAS values of pain during rest, activity, nighttime, resisted wrist dorsiflexion, and forearm supination (Table 2). Moreover, pain threshold levels on lateral epicondyle determined by algometry were not different among the groups at the baseline evaluation (Table 2).

All the pain parameters improved after therapy (3 weeks after the first visit) and at the third month in Groups 1, 2, and 3 (Table 3).

There were statistically significant differences for VAS values of pain during rest and activity, pain levels during resisted wrist dorsiflexion and forearm supination, and algometric pain threshold values on the epicondyle among the groups at the post therapy evaluation. VAS values during activity and pain levels during resisted wrist dorsiflexion were found to be significantly lower in Group 3 than Group 1. When compared with sham PEMF (Group 2), patients treated with corticosteroid injection (Group 3) had lower pain levels during rest, resisted wrist dorsiflexion, and forearm supination and higher algometric pain threshold levels on the epicondyle at the third week. Only the pain levels during resisted wrist dorsiflexion and forearm supination were found to be lower in Group 1 when compared with sham PEMF (Group 2) (Table 4).

All parameters showed differences among the groups at the third-month evaluation. Patients treated with PEMF had lower pain during rest, activity, and nighttime when compared with Group 3 patients treated with corticosteroid injection. All the pain parameters except for VAS value during nighttime were found to be significantly improved in Group 1 patients at the third month when compared with sham PEMF group. Group 3 had more favorable improvements than Group 2 in pain levels during resisted wrist dorsiflexion and algometric pain threshold values on the epicondyle (Table 4).

Discussion

The statement of Cyriax, which he made in 1936 about the prognosis of tennis elbow that "lateral epicondylitis usually resolves spontaneously in 8 to 12 months" still preserves its value [6]. In most of the placebo-controlled studies, pain levels of the patients who had received placebo also improved and the patients who had received active therapy [29–31]. We similarly found improvements in pain levels in our patients who were treated with sham PEMF at post therapy and evaluations after 3 months. This positive effect in this group may possibly be related with placebo effect but may be due to splint applications, rest, and daily living activity modifications as well.

The usual spontaneous pain resolution period is too long for a patient and a physician to wait. Most of the patients usually expect to reach painless status and functional independence as quickly as possible. The earlier relief of pain seems to be usually provided successfully with corticosteroid injections according to the previous data on the point. In a previous study, local corticosteroid injections were found to be more beneficial for pain and functional incapacities of tennis elbow patients when compared with placebo and naproxen at the fourth week of evaluation. However, there was no difference between placebo and corticosteroid injection and similar relapse rates were observed in three groups at the 12th month [15]. In another study, Smidt et al. [8] compared the efficacy of a combination of physical therapy interventions including pulsed ultrasound, deep friction massage, and exercise with local corticosteroid injections and reported that the injection therapy was more successful to relive pain and restore grip strength upon evaluation 6 weeks after therapy. But recurrence rate in the injection group was high and long-term differences between injections and physiotherapy were significant in favor of physiotherapy. Perhaps greater initial reduction in pain in the injection group may have led them to greater early increases in activity and subsequent reaggravation of the condition. The findings of our study supported the early benefits of corticosteroid injections mentioned in these studies as pain parameters in our patients treated with injection resolved significantly when compared with sham and active PEMF group after 3 weeks. In our study, we also observed that patients treated with PEMF had lower pain levels during rest, activity, and nighttime when compared with patients treated with corticosteroid injections after 3 months, although pain during resisted wrist dorsiflexion and forearm supination maneuvers and algometric values were not different.

The only randomized controlled trial on the effect of PEMF in tennis elbow was conducted by Devereaux et al. [23] in 1985. No difference of pain reduction effect could be found after 6 weeks after active PEMF therapy when compared with sham PEMF. Although the improvements in the hand grip strength and thermographic parameters were greater in the PEMF group and continued until the eight week, the difference between the groups did not reach statistical significance. The study of Devereaux et al. was stopped in the eight week and the long-term benefits of PEMF therapy could not be evaluated [23]. The applied frequency and dosage were different from the parameters that we used in our study. The difference between the application methods, dosage, and the evaluation time may be the main reasons of the opposite findings that we found in our study.

A few weeks of time for human tissues may not be sufficient for the completion of biological effects and the total recovery that were observed in in vitro cellular and animal studies. Despite the lack of strict clinical evidence on the point, the various efficacy levels of different frequencies and dosages may lead to different findings on healing tissues. For instance, in an experimental study, 17-Hz-pulsed magnetic field was reported to suppress extravascular edema in all stages of an Achilles tendonitis, while a 46-Hz PEMF only suppressed accompanying edema to the inflammation in the late phases of the study [29]. If we could have performed histopathological investigations to explain the clinical improvements, we would have put forward stronger evidence. However, this was impossible because of ethical concerns and impossibility of getting consent from the patients. Short-term follow-up in this study can be criticized but the self-limiting character of lateral epicondylitis in about 8–12 months could have confused long-term results.

Another limitation of our study was that we did not evaluate the daily living activities and functional status of the tennis elbow patients. However, resisted wrist dorsiflexion and forearm supination are two of the key motions during daily living activities and pain investigation during these motions, we think, can give some idea about the functional status.

In conclusion, PEMF seems to reduce pain better than sham PEMF and may be a helpful modality in the treatment of lateral epicondylitis. Although the treatment time is quite long and necessitate compliance, it can be used in patients avoiding invasive approaches. Corticosteroid and anesthetic agent injections can be used in patients for rapid return to activities.

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