Clin Rheumatol (2007) 26:1234–1239
DOI 10.1007/s10067-006-0464-2

ORIGINAL ARTICLE

Therapeutic effect of pulsed electromagnetic field in conservative treatment of subacromial impingement syndrome

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Received: 21 July 2006 / Revised: 5 October 2006 / Accepted: 5 October 2006 / Published online: 4 November 2006

Abstract Subacromial impingement syndrome (SIS) is a frequent cause of shoulder pain. Our purpose in this double-blinded, randomized, and controlled study was to demonstrate whether the pulsed electromagnetic field (PEMF) provides additional benefit when used with other conservative treatment modalities in acute phase rehabilitation program of SIS. Forty-six patients with unilateral shoulder pain who had been diagnosed as having SIS were included in this trial. The cases were randomly separated into two groups. All cases received a treatment program for 3 weeks consisting of Codman's pendulum exercises and subsequent cold pack gel application on shoulders with pain 5 times a day, restriction of daily activities that require the hands to be used over the head, and meloxicam tablet 15 mg daily. One group was given PEMF; the other group was given sham PEMF daily, 25 min per session, 5 days per week for 3 weeks. Shoulder pain during rest and activity and which causes disturbance of sleep was evaluated using a visual analogue scale, and total Constant score investigated shoulder function. Daily living activities were evaluated by shoulder disability questionnaire. Results were assessed before and after treatment. When compared with the baseline values, significant improvements in all these variables were observed at the end of the treatment in both groups ($p<0.05$). No significant difference between treatments was observed for any of these variables ($p>0.05$). There is no convincing evidence that electromagnetic therapy is of additional benefit in acute phase rehabilitation program of SIS.

Keywords Conservative treatment · Pulsed electromagnetic fields · Subacromial impingement syndrome

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Introduction

Shoulder pain is a common complaint with much diverse etiology [1, 2]. The prevalence of shoulder pain accompanied by disability is approximately 20% in the general population. Subacromial impingement of rotator cuff tendons, the long head of the biceps tendon and subacromial bursa between the humeral head, and the structures that make up the coracoacromial arch are among the most frequent problems leading to shoulder pain and consequent functional limitation [3–6]. The literature indicated that most patients who have impingement syndrome eventually recover with non-operative intervention [3, 7–9].

The goals of non-operative intervention are to reduce the pain, to help in recovery and maintain a passive range of motion, to strengthen the rotator cuff in a non-impingement range of motion, and to prevent the occurrence of progressive pathological changes [10]. Many treatment modalities based on empirical evidence including nonste-

roidal anti-inflammatory drugs (NSAID), physical therapy, activity modification, and corticosteroid injections have been advocated to be of benefit in SIS [9, 11–14]. However, there is little evidence to support the efficacy of therapeutic applications for shoulder pain [15].

Pulsed electromagnetic field (PEMF) has been suggested as a treatment method for musculoskeletal system disorders [16], but literature is contradictory about the treatment of shoulder pain [17, 18]. Electromagnetic fields have shown to cause biological changes. PEMF treatment induces changes to the cell environment and restores the integrity and function [19–23]. In addition to that, it increases membrane potentials of erythrocytes, increases oxygen content of tissue, vasodilatating blood vessels, and relieves pain without increasing local temperature [24].

Previous clinical studies have shown that magnetic field therapy may increase and accelerate callus formation in delayed union fractures [25, 26], wound healing [27] and nerve regeneration [28, 29] and reduce osteoarthritis changes [30, 31]. In addition, the effects of PEMF on ligament healing were investigated. PEMF-stimulated tissue showed an earlier increase in capillaries and fibroblasts and more matured, prominent longitudinal orientation of collagen fibers. PEMF enhanced the earlier stage of ligament healings [32–35]. PEMF was also found to be effective in reducing pain and edema after soft tissue injury [36–39].

Our purpose in this double-blinded, randomized, and controlled study was to demonstrate whether the PEMF provides additional benefit when used with other conservative treatment modalities in acute phase rehabilitation program of SIS.

Patients and methods

Patient selection

Forty-six patients with unilateral shoulder pain who are diagnosed as having SIS by investigator B, who is experienced in shoulder pathologies, were included in this trial. Details were recorded about the patient's ages, sexes, occupations, body mass index (BMI), hand dominancy, duration of pain, measurement of pain, and additional problems. Diagnosis was based on history, clinical examination, conventional radiography, subacromial injection test, and magnetic resonance imaging. A careful examination of the neck and shoulder was performed to rule out abnormalities of the cervical spine and other shoulder pathology. Detailed routine laboratory tests were performed. The patients with positive impingement tests (Neer, Hawkins–Kennedy, and painful arc tests) and positive subacromial injection test were diagnosed as having SIS [3, 11, 40].

The patients who had: (1) other concomitant shoulder pathologies such as adhesive capsulitis, calcific tendonitis, partial and full-thickness tears of the rotator cuff, osteoarthritis of the acromioclavicular joint, dislocations, acute traumatic conditions, etc., (2) cervical pain or other painful conditions such as fibromyalgia conflicting the clinical picture, (3) inflammatory or systemic diseases, (4) history of gastritis or peptic ulcer that may cause complications with NSAID use, (5) prior applications of any treatment modality such as physiotherapy, corticosteroid injections, and NSAID during the preceding 3 months, (6) malignancy, (7) female patients who might be pregnant, and (8) pulmonary disorders and cardiac pace maker were excluded from the study.

A local ethics committee approved the procedures followed in this study. The patients were informed about the study procedure and signed the informed consent prepared for this study.

Study groups

A double-blind, randomized controlled study was used. Patients and physicians remained blind to the group allocation throughout the study. Patients were randomly divided into two equal groups of 23 patients in a simple systematic manner (x+1) according to the therapeutic PEMF or sham PEMF application. A separate individual was provided the randomization list and informed therapist. All cases received a treatment program for 3 weeks consisting of Codman's pendulum exercises (5 times a day/5 min each time) and subsequent cold (cold pack gel, 5 times a day, 20 min per session) application on the shoulders with pain, restriction of daily activities that require the hands to be used over the head, and meloxicam tablet 15 mg daily. One group was given PEMF; the other group was given sham PEMF. A magnetic field treatment unit was used with a concealed switch for either the presence or absence of waves when activated by the patient's attendant. All of the subjects could see the timer and the control panel working during the treatment.

Magnetoterapia model MG/3P (manufactured by Elettromed, Roma, Italy) was used to deliver the PEMF. The PEMF was delivered at a frequency of 50 Hz with a field intensity of 30 G for 25 min per session, 3 weeks (five sessions a week for 3 weeks). A U-shaped applicator, 30× 15 cm in size, was used to deliver the shoulder.

Outcome evaluation

The evaluation of the patients was performed before and after therapy by investigator C. Shoulder pain during rest and activity periods, also, pain causing sleep disturbance, was evaluated using a visual analog scale (VAS) [41]. The

patients were instructed to choose the grade of their pain intensity on a 10-point scale in which '0' means no pain, '5' means moderate pain, and '10' means intolerable pain. Functional status of the shoulder joint was evaluated by total Constant scale [42]. This scale evaluates overall shoulder function in 100 points. Shoulder pain, as a subsection of this analysis, was evaluated in 15 points, daily living activities in 20 points, active range of motion in 40 points, and strength in 25 points. Daily living activities were evaluated by shoulder disability questionnaire (SDQ). The SDQ is a pain-related disability questionnaire, which contains 16 items describing common situations that may induce symptoms in patients with shoulder disorders. All items refer to the preceding 24 h. Response options are either 'yes', 'no', or 'not applicable'. The 'not applicable' category should be used when the situation at issue has not occurred during the preceding 24 h. A final score is calculated by dividing the number of positively scored items by the total number of applicable items and subsequently multiplying the score by 100, resulting in a final score ranging between 0 (no disability) and 100 (all applicable items positive) [43]. Results were assessed before treatment and at the end of the treatment. In addition, the patients were assessed by physical examination.

Analysis

The findings were analyzed using statistical package for social sciences for windows, version 11.5. The Mann–Whitney *U*, paired and unpaired *t* test, chi-square test, and Fisher's exact test were used for statistical analysis.

Table 1 Pain values measured by VAS in the groups

	Group 1 (PEMF; n=20)		Group 2 (sham PEMF; n=20)		Significance between groups
	BT	AT	BT	AT	
Rest pain (VAS)	3.3± 3.01	0.9± 1.55[a]	2.5± 1.76	0.85± 1.56[a]	NS
Activity pain (VAS)	7.5± 2.03	2.7± 2.51[a]	6.7± 1.83	2.75± 2.22[a]	NS
Pain disturbing sleep (VAS)	5.7± 3.68	0.8± 1.59[a]	5.5± 2.96	2.25± 3.27[a]	NS

Data presented are mean±SD. Differences of all baseline values between the groups are not significant (p>0.05).
PEMF Pulsed electromagnetic field, *BT* before treatment, *AT* after treatment, *NS* not significant (p>0.05)
[a] Significant change between after treatment and before treatment values (p<0.05)

Table 2 Total constant scores and the scores of its subsectional parameters in the groups

	Group 1 (PEMF; n=20)		Group 2 (sham PEMF; n=20)		Significance between groups
	BT	AT	BT	AT	
Pain score	2.25± 3.43	9.5± 3.59[a]	3.00± 2.51	9.0± 3.83[a]	NS
Daily living activities score	10.8± 3.51	15.1± 4.27[a]	10.4± 4.23	14.9± 3.27[a]	NS
Active range of motion score	32.5± 9.21	35.9± 6.91[a]	32.9± 5.52	36.7± 3.13[a]	NS
Strength score	10.35± 6.97	12.25± 7.33[a]	9.45± 5.99	11.5± 7.17[a]	NS
Total Constant score	55.9± 16.53	72.65± 17.99[a]	56.25± 13.87	72.0± 12.78[a]	NS

Data presented are mean±SD. Differences of all baseline values between the groups are not significant (p>0.05).
PEMF Pulsed electromagnetic field, *BT* before treatment, *AT* after treatment, *NS* not significant (p>0.05)
[a] Significant change between after treatment and before treatment values (p<0.05)

Results

No significant difference was found between the groups in terms of age, gender, BMI, dominant hand, and symptom duration before the therapy. The mean ages±SD in the two groups were 48.7±9.0 and 53.9±11.2, respectively, beginning from the first group (p>0.05). Every group consisted of 15 female and 5 male patients (p>0.05). BMI was 26.5±3.5 and 27.6±4.3 (p>0.05). The mean symptom duration was 4.82±3.75 months in first group and 4.80±3.47 in the second group (p>0.05).

Forty patients completed the study. Three patients from each group could not continue treatment program. Therefore, six patients dropped out of the study.

Baseline values of pain measured by VAS, total and subsectional functional parameters of the Constant scale,

Table 3 SDQ scores in the groups

	Group 1 (PEMF; n=20)		Group 2 (sham PEMF; n=20)		Significance between groups
	BT	AT	BT	AT	
SDQ score	76.37± 20.74	45.80± 30.86[a]	73.18± 21.19	46.29± 25.17[a]	NS

Data presented are mean±SD. Differences of all baseline values between the groups are not significant (p>0.05)
PEMF Pulsed electromagnetic field, *BT* before treatment, *AT* after treatment, *NS* not significant (p>0.05)
[a] Significant change between after treatment and before treatment values (p<0.05)

and SDQ scores were all comparable among each group ($p>0.05$). When compared with the baseline values, significant improvements in all these variables were observed at the end of the treatment (3 weeks later) in both groups ($p<0.05$; Tables 1, 2, 3). No significant difference between treatments was observed for any of these variables ($p>0.05$).

Discussion

SIS is a common shoulder problem with symptoms of pain and loss of motion [4]. The classically accepted underlying pathologies causing these symptoms are edema, hemorrhage, fibrosis, tendinitis, and partial or complete ruptures of the rotator cuff tendons at different stages of the syndrome [3]. Non-operative treatment modalities aim to treat these conditions by decreasing the inflammation and stimulating the healing in the tendons [44]. Some experimental and clinical studies have shown that PEMF may produce anti-inflammatory effect [34, 36, 45, 46]. Based on the hypothesis that PEMF could reduce inflammation and reduce pain, these findings prompted us to use magnetic field therapy in the treatment of SIS.

The goals of phase 1 of SIS rehabilitation program [47, 48] are to relieve pain and inflammation, prevent muscle atrophy, reestablish non-painful ROM (range of motion), and normalize arthrokinematics of the shoulder complex. This phase includes a period of active rest, eliminating any activity that may cause an increase in symptoms. ROM exercises may include Codman's pendulum exercises and symptom-limited, active, assisted ROM exercises. Modalities are used as an adjunctive treatment and include cryotheraphy, transcutaneous electrical nerve stimulation, high-voltage galvanic stimulation, ultrasound, phonophoresis, or iontophoresis [49].

In our shoulder policlinics, with these major principals including NSAID, relative rest, ice, and Codman's pendulum exercises to SIS phase 1 treatment, we also planned to add magnetic field treatment because it does not have any heating effect. To observe the effect of the magnetic field treatment in this phase, we used PEMF in one of the groups and sham PEMF in the other. However, this belief was reinforced by the fact that these outcomes showed an improvement with therapy in both groups. Having found no difference in these outcomes in both groups, we concluded that PEMF has no additional effect on patients receiving this form of therapy.

As we evaluated the previous studies about the pain-relieving effects of PEMF, we faced with conflicting results [39, 50–52]. The same results were also obtained in shoulder pain about the use of magnetic field therapy [17, 18, 52]. At the study of Binder et al.'s [18] patient group—which is similar to our group—who had received magnetic field therapy, better results about the pain scores were observed in PEMF group than the control group. On the other hand, in the study of Leclaire et al. [17], it was shown that shoulder periarthritis—which is a different pathology—(nowadays, we prefer to use adhesive capsulitis terminology) did not benefit from magnetic field therapy.

The limitation of our study was that we did not evaluate the long-term effects of the PEMF. Short-term follow-up in our study can be criticized, but in the study of Binder et al. [18], it was observed that the treatment period was very long (weeks 16+). However, in the first phase (weeks 0–4) of the treatment of persistent rotator cuff tendonitis, which have been resistant to conventional conservative measures, the group treated with PEMF had a significant advantage over the placebo group. In another study, although the treatment period was 12 weeks, there was no difference between PEMF and sham PEMF at the end of treatment [17].

On the review of Quittan et al.'s musculoskeletal system disorders, which evaluated the effects of magnetic field therapy, it was reported that application times varied from 15 min to 24 h per day between 3 weeks and 18 months and electromagnetic fields of 2 to 100 G (0.2 to 10 mT) with a frequency between 12 and 100 Hz, and optimal dosimeter for therapy with electromagnetic fields has not yet been established [31]. We also agree that the differences between the previous studies and our study depend on these factors.

As a conclusion of this study, with this period of time (25 min per session, 3 weeks) and dosimeter (30 G, 50 Hz), there is no convincing evidence that PEMF therapy is of additional benefit in SIS acute phase rehabilitation program.

Acknowledgment This study was supported by the Department of Physical Medicine and Rehabilitation, Cerrahpasa Medical Faculty, Istanbul University.

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