Therapeutic effects of peripheral repetitive magnetic stimulation on myofascial pain syndrome

Nicola Smaniaa,b,*, Elisabetta Corato b, Antonio Fiaschi b,c, Paola Pietropoli b, Salvatore M. Agliotid, Michele Tinazzic

a Centro di Rieducazione Funzionale Policlinico G.B. Rossi, Verona, Italy
b Scuola di specializzazione in Medicina Fisica e Riabilitazione, Università di Verona, Verona, Italy
c Dipartimento di Scienze Neurologiche e della Visione, Sezione di Neurologia Riabilitativa, Università di Verona, Verona, Italy
d Dipartimento di Psicologia, Università di Roma ‘La Sapienza’ and IRCCS, Fondazione S. Lucia, Rome, Italy

Accepted 22 October 2002

Abstract

Objective: To evaluate short- and medium-term effects of peripheral repetitive magnetic stimulation (rMS) on myofascial pain.

Methods: Eighteen patients who presented with myofascial trigger points (TPs) at the level of the superior trapezius were separated into two groups according to a restricted randomization scheme. Group 1 (n = 9) underwent treatment with rMS that consisted of a total of 10 sessions, each lasting 20 min, in which 4000 magnetic stimuli were administered in 5 s trains at 20 Hz at the TP. Group 2 (n = 9) received a placebo treatment that consisted of the application of a non-functioning ultrasound therapy device to the TP. Patients were evaluated before treatment, at the end of treatment, and again 1 week and 1 month after the conclusion of the treatment. Clinical evaluation included parameters for measuring pain levels (VAS, NPDVAS and algometry), the myofascial TP characteristics and the range of cervical movement (ROM).

Results: The rMS group showed a significant improvement in VAS, NPDVAS, algometry, as well as in the characteristics of the TP after conclusion of treatment. Improvements in the ROM were also present in rotation and controlateral bending. This improvement persisted after 1 month. On the other hand, the placebo group did not show any significant improvement in the tests considered.

Conclusions: The results of this study show that peripheral rMS may have positive short- and medium-term therapeutic effects on myofascial pain.

Keywords: Myofascial pain syndrome; Repetitive magnetic stimulation; Musculoskeletal system; Pain; Rehabilitation

1. Introduction

Magnetic coil stimulation permits non-invasive evaluation of the central and peripheral nervous system because it activates neural structures without discomfort which in turn is associated with conventional electrical stimulation. For this reason, it is currently used in the clinical practice to assess the motor conduction along central and peripheral motor pathway.

The development of stimulators capable of discharging at frequencies of up to 60 Hz has greatly expanded the application for magnetic stimulation in the field of neurosciences.

Repetitive magnetic stimulation (rMS) applied over the scalp at appropriate stimulation frequency and intensity can transiently block or inhibit focal brain activity (Pascual-Leone et al., 1996).

It has been recently suggested that rMS applied to the peripheral nervous system may reduce musculoskeletal pain for several days (Pujol et al., 1998). Although the mechanism of the analgesic effect of rMS is unknown, Pujol et al. (1998) suggested that rMS could have a mechanism of action similar to that of transcutaneous electrical nerve stimulation (TENS). It has been proposed that pain relief resulting from TENS could be explained by an action both at the level of peripheral or/and central nervous system. The peripheral effect could be due to a slowing of conduction in both small and large afferent nerve fibers (Torebjork and Hallin, 1974; Walsh et al., 1995; Stanton-Hicks and Salamon, 1997). As far as the central effect is concerned,
## Table 1
Demographic and clinical features of the two groups of patients

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Education (years)</th>
<th>Duration of illness (months)</th>
<th>Duration of pain crisis (days)</th>
<th>Number of TP (superior trapezius muscle)</th>
<th>History of cervical trauma</th>
<th>Analgesic (previous intake)</th>
<th>Physical therapy (previous treatment)</th>
<th>Referred pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>rMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>49</td>
<td>W</td>
<td>8</td>
<td>84</td>
<td>7</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>R shoulder, R forearm</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>M</td>
<td>13</td>
<td>24</td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>W</td>
<td>8</td>
<td>84</td>
<td>1</td>
<td>2</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>R L neck, R L shoulder</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>W</td>
<td>5</td>
<td>72</td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>L shoulder, L forearm</td>
</tr>
<tr>
<td>5</td>
<td>33</td>
<td>W</td>
<td>13</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>R forearm, R arm</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>M</td>
<td>13</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>L shoulder, 4th and 5th finger</td>
</tr>
<tr>
<td>7</td>
<td>27</td>
<td>M</td>
<td>13</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>R neck, R shoulder</td>
</tr>
<tr>
<td>8</td>
<td>58</td>
<td>W</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>L shoulder, R forearm</td>
</tr>
<tr>
<td>9</td>
<td>32</td>
<td>M</td>
<td>13</td>
<td>60</td>
<td>1</td>
<td>2</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>R shoulder, R forearm</td>
</tr>
</tbody>
</table>

Means 39.0 10.1 38.8 2.4 1.3
Ranges 24–58 5–13 6–84 1–7 1–2

Placebo

<table>
<thead>
<tr>
<th>Patients</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Education (years)</th>
<th>Duration of illness (months)</th>
<th>Duration of pain crisis (days)</th>
<th>Number of TP (superior trapezius muscle)</th>
<th>History of cervical trauma</th>
<th>Analgesic (previous intake)</th>
<th>Physical therapy (previous treatment)</th>
<th>Referred pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>48</td>
<td>W</td>
<td>8</td>
<td>72</td>
<td>7</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>R head, R neck, R shoulder</td>
</tr>
<tr>
<td>11</td>
<td>68</td>
<td>W</td>
<td>5</td>
<td>42</td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>R head, R forearm</td>
</tr>
<tr>
<td>12</td>
<td>56</td>
<td>W</td>
<td>5</td>
<td>72</td>
<td>2</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>L head, L shoulder, L forearm</td>
</tr>
<tr>
<td>13</td>
<td>45</td>
<td>W</td>
<td>13</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>R neck, R shoulder, R forearm</td>
</tr>
<tr>
<td>14</td>
<td>20</td>
<td>M</td>
<td>13</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>R shoulder, R forearm</td>
</tr>
<tr>
<td>15</td>
<td>50</td>
<td>W</td>
<td>13</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>R shoulder forearm</td>
</tr>
<tr>
<td>16</td>
<td>59</td>
<td>W</td>
<td>5</td>
<td>84</td>
<td>1</td>
<td>4</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>L shoulder, R arm</td>
</tr>
<tr>
<td>17</td>
<td>37</td>
<td>M</td>
<td>13</td>
<td>36</td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>L shoulder, R shoulder, L arm</td>
</tr>
<tr>
<td>18</td>
<td>25</td>
<td>F</td>
<td>18</td>
<td>48</td>
<td>7</td>
<td>2</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>L shoulder</td>
</tr>
</tbody>
</table>

Means 45.3 10.3 42.0 2.4 1.6
Ranges 20–68 5–18 6–84 1–7 1–4

* Abbreviations: R, right; L, left.
the activation of large afferent fibers induced by TENS may stimulate inhibitory neurons in the spinal dorsal horns, thus suppressing the neurons in laminae I, II, and V, which ordinarily fire in response to noxious stimuli (Melzack and Wall, 1975; Kerr, 1975) and also may activate supraspinal inhibitory systems acting on nociceptive spinal neurons (Kovac-ˇRistanovi´c et al., 1991).

It is interesting to note that a recent study has shown that a prolonged peripheral rMS could possibly induce long-term changes in neural activity of primary and secondary somatosensory cortices resulting in modulation of afferent input (Heldmann et al., 2000) (see also Strupppler et al., 1997). The advantage of rMS over conventional techniques of therapeutic electrical stimulation lies in its applicability at high level of intensity, which permits activation of anatomical structures without local discomfort for the patient (Barker et al., 1987).

The aim of this study is to evaluate the therapeutic effects of peripheral rMS in myofascial pain syndrome (MPS). MPS is one of the most common causes of musculoskeletal pain and is characterized by pain originating from one or more muscles and their fasciae, more frequently the superior trapezius muscle, and by the presence of one or more hyper-sensitive sites, referred to as the myofascial trigger points (TPs), situated within the same painful area (Travell and Simons, 1983).

For this purpose, 9 MPS patients with TPs at the level of the superior trapezius muscle were submitted to a treatment with rMS. Nine MPS patients with the same clinical characteristics who received a placebo treatment were the control group.

2. Patients and methods

2.1. Patients

Eighteen eligible patients (6 men and 12 women; mean age 42.2 ± 14.3 years) who were having MPS of the superior trapezius muscle were recruited from the Center of Functional Re-education of the Policlinico G. B. Rossi in Verona during the period between February and July 2000. Demographic and clinical characteristics of the patients are illustrated in Table 1. Six of the 18 patients had more than one TP in the superior trapezius muscle; in this case, only the most painful TP was treated. No patient had TPs in other muscles.

The diagnosis of MPS was based on the following criteria, as suggested by Esenyel et al. (2000): (1) presence of a tender spot characterized by spontaneous pain or associated with movement of the right or left superior trapezius muscle; (2) reproduction or enhancement of the clinical symptoms by compression of the active TP; (3) presence of a palpable taut band peripherally to the TP. Non-essential criteria (Travell and Simons, 1983; Hong and Hsueh, 1996; Esenyel et al., 2000) considered in diagnosis were: presence of spontaneous referred pain in parts of the body other than the superior trapezius muscle; elicitation of referred pain by compression of the active TP; weakness of the trapezius muscle; restricted range of motion (ROM) of the cervical spine; palpable or local twitch response upon snapping palpation of the most sensitive spot in the taut band.

The following patients were excluded from the study: (1) patients with signs and symptoms of fibromyalgia; (2) patients aged below 18 or above 80 years; (3) patients with mental retardation; (4) patients with neurological deficits involving the upper limbs; (5) patients with advanced osteopathic or arthropathic disorder of the cervical spine or the shoulder of the investigated side. Furthermore, we excluded patients presenting contraindications for the administered therapies, namely patients suffering from cardiovascular disease, hypertension, coagulopathy, ulcer, recent severe hemorrhage, renal insufficiency, severe hepatic disease, neoplasia, epilepsy, cutaneous pathology or pain of central origin; patients with metallic implants (clips, cardiac valves, pacemakers) and pregnant women were also excluded (Annaratone et al., 1983; Ferrari and Pirot, 1983; DuPont et al., 1999). All patients were informed on the experimental nature of the study and gave their consent for participation. The study was approved by the Verona hospital’s ethical committee.

Patients were divided into two groups, according to a restricted randomization scheme (Bryant and Machin, 1997). The first group (rMS group) (4 men and 5 women; mean age 39 ± 12.8 years) was treated with rMS, while the second group (placebo group) (2 men and 7 women; mean age 45.3 ± 15.7 years) received a placebo treatment. All patients have been evaluated by the same examiner (C.E.), who was blinded about the treatment the patients received. The treatments were performed by another examiner (P.P.) who was blinded about the clinical state of the patients.

Multiple separated independent-sample Mann–Whitney tests showed that age, education, duration of illness, duration of pain crises, parameters for evaluating pain (VAS, NDPVAS, algometry), clinical features of the TPs, number of TPs and the cervical ROM in the rMS group were not statistically different from those found in the placebo group.

Prior to participation in the study, patients from both groups were instructed to avoid any physical therapy for 2 months and to refrain from taking any analgesic drug for 15 days. During the period of the study, all patients did not take any kind of treatment excepted for the experimental treatment.

2.2. Treatment procedure

Patients from each group received 10 treatment sessions (5 days a week for 2 consecutive weeks) lasting 20 min each. Patients were submitted to a clinical evaluation before treatment (T1), at the end (T2), and again after 1 week (T3) and 1 month (T4) from its conclusion. Evaluation included the following steps: measurement of the subjective intensity
of pain through the “visual analogue scale” (VAS) (Carlsson, 1983) and the “neck pain and disability visual analogue scale” (NPDVAS) (Wheeler et al., 1998); evaluation of the characteristics of the TP through manual palpation (Gam et al., 1998) and evaluation of the pain threshold by means of an algometric test (Esenyel et al., 2000); evaluation of the ROM of the cervical spine (Clarkson and Gilewich, 1989).

2.3. Testing procedure

2.3.1. VAS

Subjective pain was evaluated with the VAS. It essentially consists of an 11-point linear scale drawn on a sheet of paper. Patients were asked to rate the intensity of their pain on a continuum from ‘absence of pain’ at one end of the line to ‘intolerable pain’ at the other (Carlsson, 1983).

2.3.2. NPDVAS

Disability related to pain in everyday activities and to functional limitation of the cervical spine was evaluated with the NPDVAS (Wheeler et al., 1998). Patients were asked 20 questions about subjective pain intensity and problems in performing everyday activities. Answers to each question are scored on an analogical continuum where 0 represents absence of disability and 5, intolerable disability. Total score ranges from 0 to 100 and consists of the sum of scores for the single answers.

2.3.3. Algometry

Pain threshold at the TP was measured with a pressure algometer (Effegi, Alfonsine, Italy), according to the technique recommended by Fischer (1988). The principal myofascial TP of the upper trapezius muscle was identified and marked, so that successive measurements would be performed over the same area. After having explained the pain threshold measuring technique, the patient was asked to maintain a relaxed position, since muscular tension prevents transmission of pressure to the TP and results in falsely high threshold indications. The algometer was applied to the TP with the metal rod perpendicular to the surface of the skin. Compression pressure was gradually increased at the rate of approximately 1 kg/s. The patient was asked to signal when he began to feel pain or any discomfort, at which point compression was stopped. Four consecutive measurements were performed during an interval of 2 min. The average of these evaluations was used for data analysis of pressure threshold measurements (Hong and Hsueh, 1996; Esenyel et al., 2000).

2.3.4. Evaluation of the trigger points

Each patient was asked to point with his finger to the most painful zone in the affected trapezius. Subsequently, the characteristics of the TP were evaluated by the examiner through palpation of the zone pointed out by the patient. Zero points were assigned when the examiner noticed an increased consistency of the TP in absence of pain; 1 point when the consistency was increased but the patient reported pain only after an explicit question from the doctor; 2 points when the consistency was increased and the patient spontaneously reported pain; 3 points when the consistency was increased and the patient manifested withdrawal from palpation (Dyrehag et al., 1998; Gam et al., 1998).

2.3.5. Range of movement (ROM)

Range of movement of the cervical spine was evaluated by means of a tape measure, according to the technique proposed by Clarkson and Gilewich (1989). Bending and extension were evaluated by measuring the distance between the point of the chin and the suprasternal sulcus in the positions of maximum bending and extension of cervical spine. Lateral bending was evaluated measuring the distance between mastoid process and homolateral acromion in the positions of maximum bending at both sides of the cervical spine. Rotation was evaluated by having the patient rotate the head up to the limit of movement and measuring the distance between the point of the chin and the acromion at both sides of the cervical spine. These measurements were expressed as a ratio according to the following formula, to avoid influences by the different bodily dimensions of the subjects (Chibnall et al., 1994): values in anatomical position = values of maximum articular excursion/ values in anatomical position.

2.4. Treatment procedures

2.4.1. Repetitive magnetic stimulation (rMS)

Treatment was administered using a Magstim Super Rapid Stimulator (Magstim Company Ltd, Whitland, Wales, UK). Two different coils were alternated in each session, as heating prevents prolonged coil use: a focal 16 cm figure-8-shaped coil and a 16 cm circular coil. Both have different stimulation qualities (Cohen and Cuffin, 1991) but they may complement each other to cover a painful area. The figure-8-shaped coil induces more intense and focal stimulation, while the stimulation induced by the circular coil is less intense and more diffuse (Roth et al., 1991). In this way, the figure-8-shaped coil is more suitable for stimulating the TP, while the circular coil is able to also stimulate the taut band (Rothwell et al., 1991; Ruohonen et al., 1996). Stimulation sessions always began with the figure-8-shaped coil, which was used until coil temperature reached 40°C and was then replaced by the circular coil. Magnetic stimulation was focused on the TP. The specific coil location was adjusted to the area of tenderness identified by palpation. The parameters of rMS in this study have been chosen according to those employed in the study of Pujo et al. (1998). These parameters showed the best therapeutic effect in a preliminary pilot study in which we submitted 4 patients with MPS to different frequencies (10, 15, 20, 25, 30 Hz) and stimulation time (1, 3, 5 s) of magnetic impulses.

Four-thousand pulsed magnetic stimuli were adminis-
tered throughout each 20 min session in 5 s trains at 20 Hz (100 stimuli/train) separated by 25 s pauses. Stimulation intensity was adjusted in each patient based on the patient’s subjectively reported pain threshold. It became clear early in the study that patients experiencing localized pain perceive a characteristic feeling when rMS is applied to the painful region: the sensation usually reminds the patient of his/her pain and is sharp in character, well localized and particularly dependent on coil position and stimulation intensity. To define the optimal stimulation intensity, we started stimulating at 15% of maximal output power and increased the intensity by 2% steps until the patient perceived significant local sensation without excessive discomfort. Mean stimulation intensity delivered in this study was 25 ± 5.1% when the figure-8-shaped coil was used and 20.5 ± 4.4% for the circular coil.

### 2.4.2. Placebo

The sham treatment was administered using a device for ultrasound therapy positioned over the TP (Supersonic 1010, Sanitas Electric, Pero, Italy). The device was applied while turned off over the zone of the TP. All patients in the placebo group were in a waiting list for rehabilitation treatment. Two months after the conclusion of the placebo treatment, all controls were submitted to a cycle of conventional treatment. An interview showed that none of the patients was aware of receiving placebo or active treatment.

### 2.5. Complementary experiment

A further control of the placebo effect of rMS was included in order to take into account the difference of somatosensory receptors activation between rMS and ultrasound therapy. Indeed, at variance with ultrasound therapy, rMS could induce a nociceptor activation. With this aim, a supplementary sample of 5 patients with MPS of the superior trapezius muscle have been submitted to the same stimulation protocol of the rMS group except for the site of stimulation that was shifted over the non-affected infraspinatus muscle.

### 2.6. Statistical analysis

Statistical analyses were performed using non-parametric tests that take into account the possibility of a non-homogeneous variance and the effects of non-normal distributions. The paired Wilcoxon test was used for comparing data recorded in T1–T2, T1–T3, T1–T4, T2–T3, T2–T4 and T3–T4. The level of significance for multiple comparisons was adjusted according to the Bonferroni procedure. Furthermore, the Mann–Whitney test was used for comparing the effect of treatment in the two groups of patients. For this purpose, we computed the differences between performances in T1–T2, T1–T3, T1–T4 in all the outcome measures.

### 3. Results

As shown in Table 2 and in Figs. 1–4 the rMS group showed a significant improvement in all parameters for evaluating pain (VAS, NPDVAS, algometry) and in the characteristics of the TPs in the T1–T2 comparison. This improvement remained stable in both post-treatment follow-ups (T3 and T4).

No significant variation was recorded in the T2–T3, T2–T4 and T3–T4 comparisons except for algometry, for which an increase in pain threshold was found in the T2–T4 (Z = −2.66; P = 0.016) and T3–T4 (Z = −2.52; P = 0.024) comparisons. On the other hand, the placebo group did not display any significant effect of treatment on pain in any of the outcome measures.

The comparisons between the effect of the two treatments (rMS vs. placebo) confirmed a greater effectiveness of rMS. Detailed statistical data are presented in Table 3.

In the evaluation of cervical ROM, a significant improvement was found in the T1–T2 comparison for the contralateral bending and the ipsilateral rotation tests. (Contralateral bending: Z = −2.28; P = 0.046; Ipsilateral...
rotation: $Z = -2.38; P = 0.034$). A borderline significance was found in the controlateral rotation test ($Z = -2.21; P = 0.054$).

The improvement in the 3 ROM tests was also present in the follow-ups at T3 and T4 (Fig. 5) although it did not completely reach the level of statistical significance. No significant improvement of performance was found in the other ROM tests. As to the placebo group no significant effect of treatment was found in any of the ROM tests.

As to the 5 patients who took part in the complementary experiment (see stimulation of the infraspinatus muscle), after 10 sessions of rMS, there was no sign of improvement in any of the pain tests (T1 vs. T2: algometry: mean: 2.94–3, SD: 0.77–0.62; VAS: mean: 5.2–5.6, SD: 0.83–1.51; NDPVAS: mean: 47.8–49, SD: 12.69–10.05). These parameters were substantially unmodified also at the 1-week follow-up (T3: algometry: mean: 2.94, SD: 0.72; VAS: mean: 5.8, SD: 0.83; NDPVAS: mean: 49.4, SD: 10.89). In the same way, a tendency towards modification was seen neither in the TP characteristics nor in the cervical ROM.

4. Discussion

The results of this study show the possible short- and medium-term therapeutic effects of rMS in the treatment of myofascial pain. The patients who underwent treatment with rMS showed significant benefits as measured through subjective and objective indices and through myofascial TP characteristics. There was also evidence of improvement of the cervical ROM, particularly in rotation and controlateral bending. Overall, the positive effects of treatment lasted from 1 week to 1 month after its conclusion. On the other hand, the group receiving placebo treatment did not show any significant improvement. These results could not be ascribed to a difference in strength of placebo effect between rMS and non-functioning ultrasound therapy because none of the patients taking part in the complementary experiment showed any clinical improvement from magnetic stimulation of the infraspinatus muscle.

The use of magnetic fields in the treatment of musculoskeletal pain is not new. Magnetic therapy has been successfully used for the past 30 years in the treatment of pain in many osteoarticular diseases (Annaratone et al., 1983; Trock et al., 1994). In particular, pulsed electromagnetic fields have been proven effective in the treatment of osteoarthritis of the knee and the cervical column and for tendinitis of the rotator cuff (Binder et al., 1984; Trock et al., 1994). It is important to underline that the technique of magnetic stimulation used in the present study presents noticeable differences in comparison with traditional magnetic therapy, in that rMS can be used at intensities of stimulation much greater than those reached using traditional magnetic therapy. In our study, rMS reached an intensity of 4000 G without causing any notable discomfort to the patient, whereas traditional treatment typically tops off at 100 G (Binder et al., 1984; Trock et al., 1994). The advantage of using a high-intensity magnetic stimulation is that it affects deep anatomical structures and thus may interfere with the abnormal neural transmission occurring in chronic muscular pain. In addition, while classic magnetic therapy is generally applied to a large body area (the torso or the limbs), rMS may be used for the treatment of more focal pain, as myofascial TPs. Very recently, Pujol et al. (1998) proposed the use of peripheral rMS to reduce musculoskeletal pain. The authors evaluated patients suffering from pain with different etiologies located at different sites (e.g. epicondylitis, carpal tunnel syndrome, ulnar nerve compression syndrome, traumatic semilunar bone injury, posterior tibial tendinitis). The
patients underwent one session of rMS applied to the painful site for 40 min. At the end of the treatment session and 1 week later, the patients treated with rMS showed a statistically significant reduction in pain as compared to a control group who received a placebo treatment (Pujol et al., 1998).

The results of our study extend these findings by demonstrating that rMS is effective in a group of patients with MPS. A novel result of our study is that beneficial effects in the rMS group were maintained not just for 1 week but also for 1 month after the treatment. It is difficult to establish if the long-term effect obtained in our study could be due to the higher number of sessions of rMS stimulation in comparison with Pujol et al.’s treatment protocol (10 sessions vs. 1 in Pujol et al.’s study) because their clinical assessment was limited to 1 week after the treatment. However, it is necessary to underline that, generally, physiotherapeutic treatment yields more sustainable effects after a reasonable number of sessions (Ceccherelli et al., 1989; Leandri et al., 1990; Byrn et al., 1991; Marchand et al., 1993; Trock et al., 1994; Wreje and Brorsson, 1995; Gam et al., 1998; Grant et al., 1999; Esenyel et al., 2000).

Another notable difference between our study and Pujol et al.’s concerns the protocol of clinical evaluation. In Pujol et al.’s study only the numerical rating scale was used to provide a subjective clinical evaluation of pain. In our study, we used multiple parameters of evaluation, including subjective and objective evaluation of pain, evaluation of the characteristics of the TP and assessment of the cervical ROM. All these parameters showed a significant improvement after treatment, suggesting that many aspects of myofascial pain may be modified by rMS therapy.

With reference to cervical ROM, it is important to note that the parameter which indicated a significant improvement in the rMS group was exclusively the rotation and bending contralateral to the myofascial TP, while other ROMs were not modified. This is not surprising since it is known that the superior trapezius muscle is much more implicated in contralateral bending and rotation than in other movements. This result is in accordance with other studies on the treatment of MPS, in which it was shown that the most evident functional limitations concerned these movements (Travell and Simons, 1983; Hong and Hsueh, 1996; Hsueh et al., 1997; Esenyel et al., 2000).

Another interesting point of our study is that the effects of rMS showed a tendency towards progressive improvement over time. This improvement was particularly evident in algometer results (see T2–T4 and T3–T4 comparisons), a test widely considered as a reliable measure of myofascial pain (Fischer, 1988; Graff-Radford et al., 1989; Hong and Hsueh, 1996; Hsueh et al., 1997; Wheeler et al., 1998; Esenyel et al., 2000).

As previously reported, the reduction of pain of MPS resulting from magnetic stimulation could be explained both by an interference with peripheral nervous system and by triggering of central mechanisms of pain modulation. It is worth noting here that the improvement in pain measurement parameters observed in the rMS group paralleled a progressive trend towards normalization of tissue anomalies featuring myofascial pain syndrome (see: muscle contracture, taut band, trigger points). Considering the fact that interactions of magnetic stimulation with biological tissues are largely unknown (Vallbona et al., 1997), we could hypothesize that the reduction of pain itself could

---

Table 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>T1–T2 Difference</th>
<th>T1–T3 Difference</th>
<th>T1–T4 Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS</td>
<td>(0.072)</td>
<td>0.009</td>
<td>0.009</td>
</tr>
<tr>
<td>NDPVAS</td>
<td>0.010</td>
<td>0.009</td>
<td>0.002</td>
</tr>
<tr>
<td>Algomtery</td>
<td>0.003</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Evaluation of the TP</td>
<td>0.005</td>
<td>0.014</td>
<td>0.002</td>
</tr>
<tr>
<td>ROM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bending</td>
<td>(0.052)</td>
<td>0.018</td>
<td>(0.066)</td>
</tr>
<tr>
<td>Extension</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Ipsilateral bending</td>
<td>0.020</td>
<td>0.088</td>
<td>(0.087)</td>
</tr>
<tr>
<td>Contralateral bending</td>
<td>0.006</td>
<td>0.003</td>
<td>0.026</td>
</tr>
<tr>
<td>Ipsilateral rotation</td>
<td>0.035</td>
<td>0.018</td>
<td>0.012</td>
</tr>
<tr>
<td>Contralateral rotation</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
</tr>
</tbody>
</table>

* The effects of treatment were defined as the difference between two evaluation sessions (i.e. T1 – T2) at the Mann–Whitney non-parametric test. () : trend to significance. /: not significant.

---

Fig. 5. Changes in the evaluation of the ROM in contralateral bending, in ipsilateral rotation and in contralateral rotation in the rMS group and in the placebo group. Legend: mean and standard deviation.
possibly lead to a break of a pathological vicious circle accounting for the chronicization of myofascial pain syndrome (Porta et al., 1998). In this vicious circle, pain could sustain tissue anomalies typical of MPS and tissue anomalies themselves lead to a reinforcement of pain (Travell and Simons, 1983). On this basis, a possible amelioration of MPS symptoms could usually be obtained both by acting at the level of pain (see effect of standard analgesic treatment) or at the level of tissue modification (see effect of muscle stretching, etc). Therefore, reduction of pain after rMS could also indirectly trigger a progressive normalization of tissue abnormalities. This process of tissue normalization could lead to a longer period of time for its establishment than that required for pain relief, and could possibly continue even after the end of rMS treatment. This could account for the medium-term progressive improvement seen in the rMS group.

These results should encourage further research aimed at establishing the long-term clinical usefulness of this new procedure in the treatment of MPS. In particular, it would be interesting in the future to compare the effect of rMS with that of other conventional physical therapies in this pathology.

Acknowledgements

We thank Dr Thomas Pawelzik for his assistance in editing the manuscript.

References


Torebjörk HE, Hallin RG. Responses in human A and C fibers to repeated

Travell JG, Simons DG. Myofascial pain and dysfunction. The trigger points manual – the upper parts of the body, Baltimore, MD: Williams & Wilkins, 1983 p. 5–164.


