Cell-Stimulation Therapy of Lateral Epicondylitis with Frequency-Modulated Low-Intensity Electric Current

R. M. Aliyev[1,2] and G. Geiger[3]

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 152, No. 11, pp. 588-591, November, 2011
Original article submitted January 26, 2010

In addition to the routine therapy, the patients with lateral epicondylitis included into experimental group were subjected to a 12-week cell-stimulation therapy with low-intensity frequency-modulated electric current. The control group received the same routine therapy and sham stimulation (the therapeutic apparatus was not energized). The efficiency of this microcurrent therapy was estimated by comparing medical indices before therapy and at the end of a 12-week therapeutic course using a 10-point pain severity numeric rating scale (NRS) and Roles–Maudsley pain score. The study revealed high therapeutic efficiency of cell-stimulation with low-intensity electric current resulting probably from up-regulation of intracellular transmitters, interleukins, and prostaglandins playing the key role in the regulation of inflammation.

Key Words: *tennis elbow*; *lateral epicondylitis; cell-stimulation therapy; rehabilitation*

Cell-stimulation therapy is a novel technique aimed to treat the chronic articular degenerative inflammatory diseases and extremity enthesopathies with the help of low-intensity frequency-modulated alternating current [2,4]. Lateral elbow epicondylitis (*Epicondylitis humeri radialis*, "tennis elbow") is an extremely widely spread disorder of the elbow joint. Most often it affects the right elbow joint in men aging 30 to 50 years. The disease can result from intensive stereotypical movements (such as extension or forearm supination) characteristic of masseurs, house painters, carpenters, and tennis players, and it finally culminates in degenerative inflammatory alterations in tendons [11,15].

Our aim was to test the new cell-stimulation methods to treat lateral elbow epicondylitis.

MATERIALS AND METHODS

During the period from November 2004 to December 2005, the patients with lateral elbow epicondylitis (n=30) were treated in Rhönblick-Clinic for Medical Rehabilitations in Orthopedics with local cell-stimulation therapy projected onto the elbow joint. The experimental group (n=30) comprised 18 men (60%) and 12 women (40%), the mean age 44 years. The control group (n=20) consisted of 13 men (65%) and 7 women (35%), mean age 44.7 years, who were also treated for lateral elbow epicondylitis. The control patients received standard therapy supplemented with placebo-therapy, which included attachment of adhesive electrodes that were not energized. The total treatment and examination period was 12 weeks in both groups. Efficiency of cell-stimulation therapy was assessed according to the questionnaires and clinical examination data. Pre-treatment and post-treatment pain was scored using a 10-point numeric rating scale (NRS) and Roles–Maudsley pain score [7,10].

The latter qualitatively scored the therapeutic results as "excellent", "good", "fair", and "poor" (Table 1). The detailed numerical assessment of pain intensity was performed with NRS subdividing the patients into the following subgroups: no pain or low pain intensity (0-3 points), moderate pain (4-7 points), and severe or intractable pain (8-10 points). The data were analyzed statistically using Sigmaplot 11.0 software. Signifi-

[1]Orthopedics and Traumatology Clinics, Bethlehem Hospital, Stolberg; [2]Rhönblick-Clinic for Medical Rehabilitations in Orthopedics, Bad Soden-Salmünster, Germany; [3]Russian Academy of Sociomedical Rehabilitation, Moscow, Russia. ***Address for correspondence:*** rauf.aliyev@gmx.de. R. M. Aliyev

0007-4888/12/1525-0653

TABLE 1. Roles–Maudsley Pain Score

Excellent (grade 1)	No pain Full movement Full activity
Good (grade 2)	Occasional discomfort (pain) Full movement Full activity
Fair (grade 3)	Some discomfort after prolonged activity Slight pain during pressure or remote pain Post-treatment subjective improvement
Poor (grade 4)	Pain limiting activities (persistent complaints)

cance was assessed by non-parametric Mann–Whitney *U* and Wilcoxon rank sum tests at the confidence level of 0.05. The data are presented as the median and quartile ranges.

The cell-stimulation therapy was performed with a low-intensity frequency-modulated alternating current (5 μA/cm^2 at 5-20 Hz) generated by a CellVAS® (S+S) Apparatus. The therapy was administered every day for 12 weeks with daily exposure time of 25 min. The microcurrent was delivered via adhesive electrodes placed laterally 10 cm apart onto the skin area above and below the elbow joint.

The standard therapeutic procedures in both groups consisted of curative gymnastics to strengthen the antebrachial muscles, thermal sessions, acupuncture, and local infiltration of anesthetics and glucocorticoids. In cases with acute and subacute pain syndrome, we used, first, the peripheral analgetics (nonsteroidal anti-inflammatory drugs) and second, the central analgetics. In addition to physical therapy, the patients were treated with massage combined with cryotherapy as well as with deep transversal petrissage of the extensor tendons in the lateral condyle according to Cyriax (deep transverse friction). The target of conservative treatment was moderation of inflammatory irritation (treatment is generally impeded due to the absence of sufficient vascularization of apophyseal periosteum).

RESULTS

In experimental group, subjective pain assessment by a 10-point NRS pain score revealed pronounced decrease of the mean index from the baseline value of 8.1 obtained at the onset of treatment to the post-treatment value of 2.4 ($p<0.001$, Fig. 1). Assessment of the treatment efficiency according to objective Roles–Maudsley pain score was "excellent" or "good" in 80% cases. Specifically, the experimental patients ($n=30$) demonstrated excellent ($n=11$, 36.7%), good ($n=13$, 43.3%), fair ($n=2$, 6.7%), and poor ($n=4$, 13.3%) post-treatment score. Thus, the cell-stimulation therapy was successful in 26 (87%) patients, although it failed in 4 (13%) patients (Fig. 2).

In the control group, subjective NRS pain score decreased significantly from the mean baseline value of 8.0 obtained at the onset of treatment to the post-treatment value of 5.6 ($p<0.001$, Fig. 1). The objective Roles–Maudsley score documented excellent ($n=5$, 25%), good ($n=7$, 35%), fair ($n=2$, 10%), and poor ($n=6$, 30%) results of the routine therapy (Fig. 2). Thus, both NRS and Roles–Maudsley scales revealed significantly better results of the treatment of lateral epicondylitis in the experimental group.

Treatment of lateral epicondylitis with cell-stimulation therapy employing low-intensity frequency modulated alternating current resulted in significantly positive effects. This result corroborates the data of Dertinger and Sontag [5], who demonstrated that despite inability to produce an energetic effect in damaged tissues, a weak frequency-modulated alternating current must possess a certain entropic property capable to induce the cell-regulatory effects. According to the above paper [5], the entropic properties manifested within some frequency and modulator ranges (so called "biological frequency window"). In this ranges, the weak (low-intensity) electric current can produce significant therapeutic effects affecting the biological-information properties [5]. It is hypothesized that information carried out in the low-frequency electromagnetic signals can affect such important cellular function as differentiation and

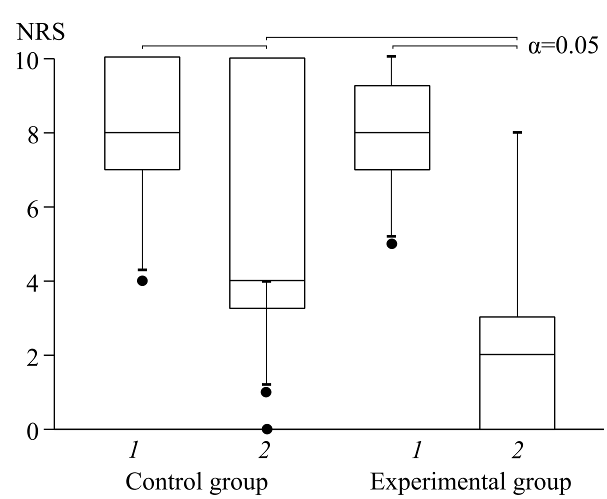

Fig. 1. Boxplots of NRS scores versus treatment group at admission (1) and discharge (2). The whiskers indicate the 10th and 90th percentile. The boxes show upper quartile, median and lower quartile from top to bottom respectively. The outliers are shown by dots. The bars on top linking two boxes indicate a significant difference between both samples at significance level α=0.05.

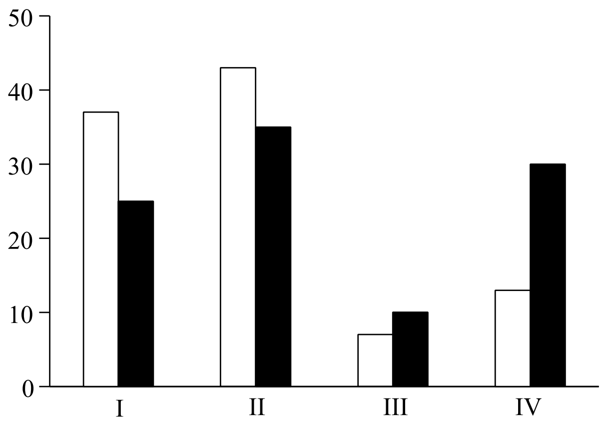

Fig. 2. Therapeutic effect assessed with Roles–Maudsley pain score. Open and closed bars correspond to experimental and control groups, respectively. The grades are: I (excellent), II (good), III (fair), and IV (poor).

immune modulation as well as the key processes of cell metabolism [6,8].

In 1977, Prof. Adey and his team from University of California at Los Angeles reported that the low-intensity electromagnetic fields affected calcium transport in rabbit brain. A low-intensity AC electromagnetic field with the frequency of 16 Hz doubled the calcium inflow into the cerebral cells. The frequency range where this effect was observed was termed "Adey window" or "biological window". It was hypothesized that electromagnetic field at this frequency range (3-25 Hz) can trigger some informational signals affecting the cell metabolism. The existence of especially efficient "biological windows" is hypothesized to be within so called Schumann resonance frequency range near 10 Hz [6,12]. To explain a high sensitivity of cells to weak low-frequency electromagnetic fields, the stochastic resonance theory was advanced [8].

Thus, we assume the conception of entropy nature of the observed therapeutic effect [1-4], which postulates that this beneficial effect originates not from the energy action of electromagnetic field, but results from activation of some pathologically disturbed subsystem with electromagnetic signal via triggering the entire cascade of complex mediator chains. Taking into consideration the isolating effect of plasmalemma, the direct effect of this electromagnetic signal on the intracellular structure seems to be little probable. In contrast, it is more likely that alternating electromagnetic field affects the external membrane structures (receptors) leading to transduction of the signal via second messenger cAMP.

The communication between the first messengers (hormones, neurotransmitters, and other biologically active agents) and cAMP is provided by adenylate cyclase complex. The first messenger binds to a receptor and thereby activates adenylate cyclase, which produces cAMP from ATP.

The transmitters that activate the signaling cascades (protein kinases) and the released second messengers (cAMP and cGMP) are involved in various processes of intracellular signaling and potentiate the effects of a large moiety of hormones and neurotransmitters. Moreover, cGMP plays an important role in the regulation of Ca^{2+} signalization and homeostasis in various cells.

The weak low-frequency electromagnetic field up-regulates the intracellular level of IL and prostaglandins, which play the key roles in modulation of the inflammatory process [5,9,13,14]. Probably, this mechanism underlies the highly benevolent effect of cell-stimulation therapy with the weak low-frequency electromagnetic field.

REFERENCES

1. R. M. Aliyev, *Phys. Med. Rehab. Kuror.*, **20**, 201-206 (2010).
2. R. Aliyev and D. Mandler, *Prävent. Rehabil.*, No. 1, 27-33 (2009).
3. R. Aliyev and D. Mandler, *Orthopäd. Prax.*, **44**, No. 10, 518-524 (2008).
4. R. M. Aliyev, Q. Muslimov, and G. Geiger, *Georg. Med. News*, No. 187, 35-42 (2010).
5. H. Dertinger and W. Sontag, *Biologic Effects of Light*, Eds. M. F. Holick and Jung (Eds.), Boston (1999), pp. 281-286.
6. G. Knedlitschek, M. Noszvai-Nagy, H. Meyer-Waarden, *et al.*, *Radiat. Environ. Biophys.*, **33**, No. 2, 141-147 (1994).
7. K. L. Krämer and F. P. Maichl, *Scores, Bewertungsschemata und Klassifikationen in Orthopädie und Traumatologie* [in German], Stuttgart (1993).
8. I. L. Kruglikov and H. Dertinger, *Bioelectromagnetics*, **15**, No. 6, 539-547 (1994).
9. G. Pidoux and K. Tasken, *J. Mol. Endocrinol.*, **44**, No. 5, 271-284 (2010).
10. N. C. Roles and R. H. Maudsley, *J. Bone Joint Surg.*, **54**, No. 3, 499-508 (1972).
11. I. Schleicher, G. Szalay, and J. Kordelle, *Sportverletz. Sportschaden*, **24**, No. 4, 218-224 (2010).
12. W. Sontag and H. Dertinger, *Bioelectromagnetics*, **19**, No. 8, 452-458 (1998).
13. K. Tasken and E. M. Aandahl, *Physiol. Rev.*, **84**, No. 1, 137-167 (2004).
14. E. J. Welch, B. W. Jones, and J. D. Scott, *Mol. Interv.*, **10**, No. 2, 86-97 (2010).
15. C. J. Wirth, I. Zichner, and A. K. Martini, *Orthopädie und Orthopädische Chirurgie* [in German], Ellenbogen (2003).