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- The value of pulsed electro magnetic fields (PEMF) for the treatment of persistent rotator cuff tendinitis was tested in a double blind controlled study in patients whose symptoms were refractory to steroid injection and other conventional conservative measures.
- The treated group had a significant benefit compared with the control group.
- At end of the 8 week study, 65% of the patients were symptom-less and another 17% much improved
- *Clinical conclusion:* PEMF therapy may thus be useful in the treatment of above condition and possibly other chronic tendon lesions.

Journal of Rheumatology, Oct 1994 - Trock, Bollet, Markoll, Div of Rheumatology, Danbury Hospital, Danbury, Connecticut, USA

- Conducted a randomized, double blind clinical trial to determine the effectiveness of PEMF in the treatment of osteoarthritis (OA) of the knee and cervical spine
- Matched pair t-tests showed extremely significant changes from the baseline for the treated patients in both knee and cervical spine studies at the end of treatment and the one month follow-up observations
- At the end of treatment the differences in the means of the two groups (treated and placebo) reached statistical significance for pain, pain on motion and tenderness for both the knee and the cervical spine patients, where the latter achieved the greater improvement
- *Clinical conclusion:* PEMF has therapeutic benefit in painful osteoarthritis of the knee and cervical spine

Journal of Clinical Orthopedics and Related Research, Dec 1988

Borsalino et al, Dept of Orthopedics and Traumatology, Montecchio Hospital, Emilia, Italy and the Dept Clinica Medica, University of Modena, Italy

- Low frequency pulsing electro magnetic fields (PEMF) are being used in non-union healing at several centers of the world. Much debate exists as to quantification of the PEMF effects
- The results of a double blind treatment of patients with femoral intertrochanteric osteotomy for hip degenerative arthritis are reported
- Roentgenographic evaluation shows statistically significant differences between controls and stimulated patients. In this extremely homogeneous patient population, PEMF stimulation favored osteotomy healing

Journal of Bone and Joint Surgery, March 1989

"Prevention of Osteoporosis by PEMF" Rubin, McLeod, Lanyon Stonybrook, New York, USA

- Potential role of the use of PEMF in the prevention of bone loss in immobilized patients; in the aging, postmenopausal population; and in astronauts who are subject to prolonged exposure to the micro-gravitational conditions.
- Structurally deleterious loss of bone may be slowed or prevented by appropriate use of non-invasive electro magnetic stimulation.

British Journal of Dermatology, April 1992

"A portable PEMF device to enhance healing of recalcitrant venous ulcers: a double-blind, placebo-controlled clinical trial" Stiller et al, Dept of Dermatology, NY University Medical Center, New York, USA

- Assessment of the efficacy and safety of PEMF limb ulcer therapy
- 3 hour daily use, 8-week clinical trial as an adjunct to wound dressing. Wound surface area, ulcer depth and pain intensity were assessed at beginning, at weeks 4 and 8
- Significant decrease in wound area, wound depth and pain intensity favored the stimulated group
- *Clinical conclusion:* PEMF treatment is a safe and effective adjunct to non-surgical therapy for recalcitrant venous leg ulcers

Heat shock protein (from Wikipedia)

Often, cells from many organisms increase protein production when their environment changes. This group of proteins was first found in cells that were exposed to high temperatures, thus they are called 'heat shock proteins' or HSPs. They are also produced by exposure to different kind of stress conditions, such as infection, inflammation and exposure of the cell to toxins.

Heat shock proteins perform like molecular chaperones for protein molecules. They are usually cytoplasmic proteins and they perform functions in various intra-cellular processes. **They play an important role in protein-protein interactions such as folding and assisting in the establishment of proper protein configuration and prevention of unwanted protein aggregation.** HSPs are named according to their molecular weights.

The following studies indicate how pulsed electromagnetic fields stimulate heat shock factor activation in human cells, particularly HSP70.

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The Effect of Pulsed Electromagnetic Fields in the Treatment of Osteoarthritis of the Knee and Cervical Spine. Report of Randomized, Double-Blind, Placebo Controlled Trials:

Trock D. et al. Department of Medicine, Danbury Hospital, CT. J. of Rheumatology

OBJECTIVE. We conducted a randomized, double blind clinical trial to determine the effectiveness of pulsed electromagnetic fields (PEMF) in the treatment of osteoarthritis (OA) of the knee and cervical spine.

METHODS. A controlled trial of 18 half-hour active or placebo treatments was conducted in 86 patients with OA of the knee and 81 patients with OA of the cervical spine, in which pain was evaluated using a 10 cm visual analogue scale, activities of daily living using a series of questions (answered by the patient as never, sometimes, most of the time, or always), pain on passive motion (recorded as none, slight, moderate, or severe), and joint tenderness (recorded using a modified Ritchie scale). Global evaluations of improvement were made by the patient and examining physician. Evaluations were made at baseline, midway, end of treatment, and one month after completion of treatment.

RESULTS. Matched pair t tests showed extremely significant changes from baseline for the treated patients in both knee and cervical spine studies at the end of treatment and the one month follow-up observations, whereas the changes in the placebo patients showed lesser degrees of significance at the end of treatment, and had lost significance for most variables at the one month follow-up. Means of the treated group of patients with OA of the knee showed greater improvement from baseline values than the placebo group by the end of treatment and at the one month follow-up observation. Using the 2-tailed t test, at the end of treatment the differences in the means of the 2 groups reached statistical significance for pain, pain on motion, and both the patient overall assessment and the physician global assessment. The means of the treated patients with OA of the cervical spine showed greater improvement from baseline than the placebo group for most variables at the end of treatment and one month follow-up observations; these differences reached statistical significance at one or more observation points for pain, pain on motion, and tenderness.

CONCLUSION. PEMF has therapeutic benefit in painful OA of the knee or cervical spine.

Low-amplitude, extremely low frequency magnetic fields for the treatment of osteoarthritic knees: a double-blind clinical study. Jacobson J. et al. Inst. for Biophysical Research, Jupiter, FL, USA

CONTEXT: Non-invasive magneto-therapeutic approaches to bone healing have been successful in past clinical studies.

OBJECTIVE: To determine the effectiveness of low-amplitude, extremely low frequency magnetic fields on patients with knee pain due to osteoarthritis. **DESIGN:** Placebo-controlled, randomized, double-blind clinical study. **SETTING:** 4 outpatient clinics. **PARTICIPANTS:** 176 patients were randomly assigned to 1 of 2 groups, the placebo group (magnet off) or the active group (magnet on). **INTERVENTION:** 6-minute exposure to each magnetic field signal using 8 exposure sessions for each treatment session, the number of treatment sessions totalling 8 during a 2-week

period, yielded patients being exposed to uniform magnetic fields for 48 minutes per treatment session 8 times in 2 weeks. The magnetic fields used in this study were generated by a resonator, which consists of two 18-inch diameter (46-cm diameter) coils connected in series, in turn connected to a function generator via an attenuator to obtain the specific amplitude and frequency. The range of magnetic field amplitudes used was from 2.74×10^{-7} to 3.4×10^{-8} G, with corresponding frequencies of 7.7 to 0.976 Hz. **OUTCOME MEASURES:** Each subject rated his or her pain level from 1 (minimal) to 10 (maximal) before and after each treatment and 2 weeks after treatment. Subjects also recorded their pain intensity in a diary while outside the treatment environment for 2 weeks after the last treatment session (session 8) twice daily: upon awakening (within 15 minutes) and upon retiring (just before going to bed at night). **RESULTS:** Reduction in pain after a treatment session was significantly ($P < .001$) greater in the magnet-on group (46%) compared to the magnet-off group (8%).

CONCLUSION: Low-amplitude, extremely low frequency magnetic fields are safe and effective for treating patients with chronic knee pain due to osteoarthritis.

Pulsed electromagnetic field treatment for knee osteoarthritis: a randomised, double-blind, placebo-controlled study. *Pipitone N. et.al. Rheumatology Department, King's College Hospital (Dulwich), London, UK*

We assessed the efficacy and tolerability of low-frequency pulsed electromagnetic fields (PEMF) therapy in patients with clinically symptomatic knee osteoarthritis (OA) in a randomised, placebo-controlled, double-blind study of six weeks' duration. While the treated group demonstrated improvement over different indices to the contrary, the control group demonstrated none. There were no clinically relevant adverse effects attributable to active treatment. These results suggest that the devices are beneficial in reducing pain and disability in patients with knee OA resistant to conventional treatment in the absence of significant side effects.

Electrochemical therapy of pelvic pain: effects of pulsed electromagnetic fields (PEMF) on tissue trauma. *Jorgensen W. et.al. International Pain Research Institute, Los Angeles, California.*

Unusually effective and long-lasting relief of pelvic pain of gynaecological origin has been obtained consistently by short exposures of affected areas to the application of a magnetic induction device. Treatments are short, fasting-acting, economical and in many instances have obviated surgery. This report describes typical cases such as dysmenorrhoea, endometriosis, ruptured ovarian cyst, acute lower urinary tract infection, post-operative haematoma, and persistent dyspareunia in which pulsed magnetic field treatment has not, in most cases, been supplemented by analgesic medication. Of 17 female patients presenting with a total of 20 episodes of pelvic pain, 16 patients representing 18 episodes (90%) experienced marked, even dramatic relief, while two patients representing two episodes reported less than complete pain.

Evaluation of electromagnetic fields in the treatment of pain in patients with lumbar radiculopathy or whiplash syndrome. *Thuile Ch. et.al. International Society of Energy Medicine, Vienna, Austria.*

Back pain and whiplash syndrome are very common diseases involving tremendous costs and extensive medical effort. A quick and effective reduction of symptoms, especially pain, is required. In two prospective randomized studies, patients with either lumbar radiculopathy in the segments L5/S1 or whiplash syndrome were investigated. Electromagnetic devices are pulsed field (PEMF) and constant wave (CW) types. These studies indicate both are effective, PEMF usually more quickly than CW. Pulsed magnetic fields appear to have a considerable and statistically significant potential for reducing pain in cases of lumbar radiculopathy and whiplash syndrome.

Treatment of migraine with pulsing electromagnetic fields: a double-blind, placebo-controlled study. *Sherman R. et.al. Orthopaedic Surgery Service, Madigan Army Medical Center, Tacoma, WA, USA.*

The effect of exposure to pulsing electromagnetic fields on migraine activity was evaluated by having 42 subjects (34 women and 8 men), who met the International Headache Society's criteria for migraine; participate in a double-blind, placebo-controlled study. During the first month of follow-up, 73% of those receiving actual exposure, reported decreased headaches (45% substantial decrease, 14% excellent decrease) compared to half of those receiving the placebo (15% worse, 20% good, 0% excellent). Ten of the 22 subjects who had actual exposure received 2 additional weeks of actual exposure, after their initial 1-month follow-up. All showed decreased headache activity (50% substantial, 38% excellent). Eight of the subjects in the placebo group elected to receive 2 weeks of actual exposure after the initial 1-month follow-up with 75% showing decreased headache activity (38% substantial, 38% excellent). In conclusion, exposure to pulsing electromagnetic fields for at least 3 weeks is an effective, short-term intervention for migraine.

Impulse magnetic-field therapy for erectile dysfunction: a double-blind, placebo-controlled study.

Pelka R. Et.al. Universitat der Bundeswehr Munchen, Neubiberg/Munich, Germany.

This double-blind, placebo-controlled study assessed the efficacy of 3 weeks of pulsing magnetic-field therapy for erectile dysfunction (ED). In the active-treatment group, all efficacy endpoints were significantly improved at study end ($P < \text{or} = .01$), with 80% reporting increases in intensity and duration of erection, frequency of genital warmth, and general well-being. Only 30% of the placebo group noted some improvement in their sexual activity; 70% had no change. No side effects were reported.

The Treatment Of Rheumatoid Arthritis Of The Hand With Pulsed Electrical Fields (Meeting Abstract). Zizic, T. M.; Hoffman, K. C.; He, Y. D.; Caldwell, J. R.; Deal, C.; Holt, P. A.; Hungerford, D. S.; Jacobs, M. A.; Klaussen, L. W.; Krackow, K.; O'Dell, J. R.; Smith, C. Johns Hopkins Univ. Sch. of Medicine, Baltimore, MD 21239 (T.M.Z., P.A.H., D.S.H., M.A.J., K.K.)

CONCLUSION: The improvements in the clinical assessment of the treated hand that included the physician's global evaluation, pain and function suggest that pulsed electrical stimulation as used in this study is effective for treating rheumatoid arthritis of the hand.

OBJECTIVE: To evaluate the safety and effectiveness of stimulation from pulsed electrical fields for the treatment of rheumatoid arthritis (RA) of the hand. **METHODS:** Patients with rheumatoid arthritis of the hand were enrolled in a multi-center, prospective, parallel, double-blinded, randomized, placebo device controlled clinical study. Entry into the study required that the patient be over the age 20 yr, meet the inclusion and exclusion criteria of the American College of Rheumatology (ACR) for rheumatoid arthritis and have active symptomatic synovitis of the treated hand. Background arthritis medications were to be maintained constant throughout the study. Patients were randomized to receive either an active device or an identical appearing placebo device that was to be used for 8 +/- 2 hr per day for a 4 wk treatment period. The weekly efficacy assessments included the physician's global evaluation of the treated hand, the patient's assessment of pain and function, joint tenderness and swelling, range of motion, grip strength, morning stiffness and activities of daily living. **DEVICE:** The study device provided a 100 Hz spike-shaped signal with an amplitude in the range of 0-12 V that was applied to the surface of the patient's skin by a cathodic glove electrode and a second electrode on the upper arm.

RESULTS: Eight-nine patients from 6 study centers were randomized to receive either an active device (N=45) or a placebo device (N=44). Eleven patients did not complete the study for reasons that included treatment for unrelated medical conditions, medication change, rash and failure to show-up for study visits. No significant difference was observed in the rate of dropout between active and placebo device groups. There were no significant baseline differences at entry for demographic and rheumatoid arthritis outcome variables between the active and placebo device groups. The active device group demonstrated significant improvement compared to the placebo device group using repeated measures for the primary clinical outcome assessments that included the physicians global evaluation of the treated hand, the patient's evaluation of pain in the treated hand and the patient's evaluation of function in the treated hand.

Experiments showing that electromagnetic fields can be used to treat inflammatory diseases. Keyword:

EMF's can regulate lymphocyte proliferation in vitro and in vivo, bone psoriasis and Biomed Sci Instrum 2000, 36:7-13

Ort: Terre Haute Center for Medical Education, Indiana University School of Medicine 47803, USA *Animal; Antibodies, Monoclonal (ME/PD); Antigens, CD3 (IM); Cell Division; Cells, Cultured; Electromagnetic Fields (*); Human; Jurkat Cells; Lymphocytes (ME/*PH); Rats; Rats, Sprague-Dawley; Receptors, Antigen, T-Cell (ME);*

Abstract: While it is well known that electromagnetic fields (EMF's) can induce repair of non-healing bone fractures, EMF therapy remains confined to orthopedic clinics mainly because the biological and physical mechanisms underlying the therapy are unknown. However, it is generally believed that non-invasive, EMF therapy might have a broad, albeit currently unrecognized clinical potential. In support of this view, we report that 0.1 mT, 60 Hz EMF's induce a 20% mean-increase in anti-CD3 binding to T cell receptors (TcRs) of Jurkat cells, a T lymphocyte cell line. Additionally, we show that 60 Hz sinusoidal EMF's and a commercial bone healing EMF modulate signal transduction pathways that regulate lymphocyte proliferation and that are normally triggered by activating the Jurkat TcR. Similar EMF effects are shown in human peripheral blood lymphocytes (hPBLs), exposed to EMF's in culture and in rat PBLs, when donor animals are exposed to a bone healing field (21 days, 4 hr/day). Although we do not yet satisfactorily understand the differences we obtain in cell and animal based experiments, our findings clearly demonstrate that EMF's can regulate lymphocyte proliferation in vitro and in vivo. **Since T cells are key modulators of inflammation, the development of EMF based therapeutic devices to regulate their activity can be expected to provide important tools to treat numerous human inflammatory diseases such as psoriasis and arthritis.**

Effect Of Pulsed Electromagnetic Fields On Hematological And Biochemical Blood Indices And Milk Production In Sheep - Milewski S., Szczepański W., Depta A., Rychlik A. 2001. *Electronic journal of polish agricultural universities, veterinary medicine, volume 4, issue 2.* <http://www.ejpau.media.pl/series/volume4/issue2/veterinary/art-01.html>

Abstract: The studies were conducted on lactating ewes. Stimulation with a pulsed electromagnetic field generated by BEMER 3000 VET was carried out for 4 weeks. The basic haematological and biochemical blood indices were determined, including the activity of ALT and ALP, the levels of glucose, total protein, cholesterol, triglycerides, total calcium, inorganic phosphorus, electrolytes (Na⁺, K⁺, Cl⁻) and the parameters of the acid-base equilibrium. Milk production and composition, and the growth rate of lambs were determined as well. The sheep subjected to the above stimulation showed slight changes indicating increased intensity of lipid metabolism and activity of the respiratory center, and stability of the electrolyte equilibrium and water balance. The ewes examined showed also a growing tendency as concerns the milk yield, which was confirmed by a considerably higher growth rate of lambs, observed from the 2nd to 70th day.

CONCLUSIONS

1. The haematological and biochemical research results show that the pulsed electromagnetic fields had no negative effect on lactating ewes.
2. The sheep subjected to the above stimulation showed slight changes indicating increased intensity of lipid metabolism and activity of the respiratory center, and stability of the electrolyte equilibrium and water balance.
3. The ewes examined showed a growing tendency as concerns the milk yield, as well as content of dry matter, protein and fat in their milk.

Enzymatic activity assessment in bony lesion exposed to PEMFT

Abstracts from the Second World Congress for Electricity and Magnetism in Biology and Dept. of Morphological Science and Forensic Medicine, Section of Human Anatomy, Res. Unit of ICEmB, I-41100 Modena, Italy (V.C., D.Z., F.C.) Copyright (c) 1994-1998, Information Ventures, Inc.

Content: The finding in the PEMF-treated holes of a greater expression of both TRAP (marker of the osteoclasts) and TALP, (marker of osteoblasts) with respect to the controls demonstrates that PEMFs alter cellular enzymatic activity during the early stages of bone repair. In other words PEMFs seem to accelerate the processes of bone remodeling during the early stages of the repair of transcortical holes.

Abstract: Our previous investigations on the rate of repair of transcortical holes in the diaphyseal region of metacarpal bone (McIII) of adult horses show that low-frequency pulsed electromagnetic fields (PEMFs) modulate TNFalpha- and TGF-beta1 gene expression during the early stages of bone repair, increase osteoblast activity during osteogenetic phase of the repair process, improve the closure of the above-mentioned experimental bony lesion in the shaft bones of horse and affect the physical resistance of the new bone in its contents. Recent in vitro studies suggest that extremely low-frequency electric fields seem to modulate bone cell enzymatic activity. On the basis of these results, we carried out a new series of experiments to detect whether PEMFs are involved in modulating the enzymatic activity of alkaline phosphatase (TALP) and tartrate resistant acid phosphatase (TRAP) during the early phase of reparative process of transcortical holes drilled in long bones of horse. Two transcortical holes (4.5 mm diameter) were drilled at the same diaphyseal level in the lateral margin of the right and left metacarpal bone (McIII) of 6 adult male horses. The left McIII were exposed to PEMFs (75 Hz; 2.8 mT, 1.3 msec impulse width) 24 hr/day; the right untreated McIII were used as controls. Horses were sacrificed 8 and 15 days after the operation. The bone segments containing the holes were fixed, dehydrated in ethanol solutions and, undecalcified, embedded in methylmethacrylate. The mid-longitudinal sections of the holes were either stained with toluidine blue or processed for the evaluation of the total alkaline phosphatase (TALP) and the tartrate resistant acid phosphatase (TRAP). The values of the parameters obtained on the PEMFs and control side were compared by a paired t-test. A 2-tailed p value was calculated. Fig. 1 - micrographs showing PEMF-treated hole (A); control hole (B); bar = 1 mm; positivity = dark colour. Fig. 2 - Histogram showing Mean and SD values of the TALP positive tissue in PEMF-treated (A) and in the control holes (B). Fig. 3 - Micrographs showing PEMF-treated hole (A); control hole (B); fibroblasts are well represented in A; bar=100 um. In PEMF-treated holes we found: (a) TALP is strongly positive with respect to the control ones (p<0.0002) (Figs. 1, 2); (b) fibroblastic cell component is well represented in repair tissue with respect to the control ones (Fig. 3); (c) the newly formed bony trabeculae are more abundant than in the controls; (d) the presence of osteoclasts is much more evident than in the controls (Fig. 4 - Micrograph showing TRAP positivity is more evident in PEMF treated holes (A) than in controls (B); bar=50 um). **The finding in the PEMF-treated holes of a greater expression of both TRAP (marker of the osteoclasts) and TALP, (marker of osteoblasts) with respect to the controls demonstrates that PEMFs alter cellular enzymatic activity during the early stages of bone repair. In other words PEMFs seem to accelerate the processes of bone remodeling during the early stages of the repair of transcortical holes.**

Gene expression during the early phases of bone repair in transcortical holes in the horse: effects of Electromagnetic field exposure - Abstracts from the Second World Congress for Electricity and Magnetism in Biology and Ort: Dept. of Medical Oncological and Radiological Sciences, Univ. of Modena, 41100 Modena, Italy (P.Z., R.C.)

The expression of the other mRNAs investigated was not affected. IL-6 increased expression in the metaphysis compared to the diaphysis suggests that the healing process is more advanced at the metaphyseal level. The difference in IL-6 expression was more evident in PEMF exposed metacarpal bones than in control ones.

We have previously demonstrated that pulsing electromagnetic fields (PEMFs), by increasing the osteogenic response, favor bone repair in transcortical holes drilled in the metacarpal bone in adult horses. The effect was constant and reproducible in the diaphyseal region. Here we have investigated the effect of PEMF exposure during the earliest phases of bone repair, we evaluated the expression of TGF-beta1, TNF-alpha and IL-6 mRNAs. Five horses were operated. Holes (4.5 mm inner diameter) were drilled into the 4th metacarpal bone. The left metacarpal bone was exposed to PEMF continuously 24 hr/day. The characteristics of the electromagnetic field were: 75 Hz, 1.3 msec impulse width, 2.8 mT (Biostim Igea). Right metacarpals were used as controls and exposed to non-energized coils. Eight days after surgery animals were sacrificed. The soft tissue present in the holes was collected and frozen in liquid nitrogen. The weight of the tissue recovered was recorded. RNA was extracted using a modification of guanidium isothiocyanate-phenol-chloroform procedure. Gene expression was evaluated by reverse transcriptase polymerase chain reaction amplification (RT-PCR), followed by Southern blot analysis. Paired Student's t-test was used for statistical analysis. We found that the weight of soft tissue present in metaphyseal holes was always larger than that of diaphyseal ones ($p < 0.05$). For what refers to diaphyseal holes, in average we recovered 0.088 +/- 0.03 mg of soft tissue from PEMF exposed and 0.069 +/- 0.02 mg from controls ($p < 0.05$). From metaphyseal holes we recovered 0.139 +/- 0.06 mg from PEMF exposed holes and 0.104 +/- 0.03 mg from controls ($p < 0.05$). When the level of mRNA was investigated we observed a trend toward a decrease of TNF-alpha expression in holes exposed to PEMF. No significant difference was observed in mRNA levels of TGF-beta1 and IL-6 between exposed and control holes. We found that IL-6 mRNA expression was higher in metaphyseal holes than in diaphyseal one in PEMF exposed holes. **Our results show that the amount of soft tissue present in the holes of metacarpals exposed to PEMF is always higher than in control ones. TNF-alpha expression showed a tendency to decrease holes exposed to PEMFs compared to unexposed controls.**

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