Biological Effects of Pulsed Electromagnetic Field (PEMF) Therapy

by Keith R. Holden, M.D.

Introduction

Pulsed electromagnetic field (PEMF) therapy is effective because time-varying or pulsed electromagnetic fields create microcurrents in the body's tissues. These microcurrents elicit specific biological responses depending on field parameters such as amplitude, frequency, and waveform. The body contains multiple electromagnetic fields with each tissue and organ having a unique electromagnetic signature. Computerized Axial Tomography (CAT) scans and Magnetic Resonance Imaging (MRI) scans take advantage of these unique signatures to create a map of the body's tissues using pulsed electromagnetic fields. While the diagnostic benefits of PEMFs are accepted and widely used, medical practitioners are still realizing the therapeutic benefits of PEMFs.

In 1954, Japanese scientists first reported on the piezoelectric properties of bone. This finding led to further research showing that damaged bone responded therapeutically to electric fields and pulsed electromagnetic fields. Then in 1995, scientists at the University of Kentucky found that each type of soft tissue responds favorably to specific electromagnetic frequencies.1

Since then, peer reviewed clinical research documenting the biological and therapeutic effects of PEMFs has increased dramatically. Despite this research contributing to the development of many types of effective PEMF devices, the Food and Drug Administration (FDA) has cleared relatively few of these devices for treating specific conditions. However, as clinical evidence continues to mount, and as patients drive the demand for effective but safer medical therapies, this will likely change. Since the FDA cleared the first therapeutic PEMF device over 30 years ago, there have been no postmarketing safety alerts issued for any of these devices. This reflects the overall safety of short sessions of therapeutic PEMFs.

The benefits of PEMF therapy have been documented in multiple peer-reviewed clinical studies for a wide range of medical conditions. Randomized double-blind, placebo controlled clinical trials using PEMF therapy have shown beneficial effects for chronic low back pain, fibromyalgia, cervical osteoarthritis, osteoarthritis of the knee, lateral epicondylitis, recovery from arthroscopic knee surgery, recovery from interbody lumbar fusions, persistent rotator cuff tendinitis, depression, and multiple sclerosis.2,3,4,5,6,7,8,9,10,11

PEMF therapy and current FDA status

In 1979, the FDA cleared PEMF therapy in the form of electrical bone growth stimulators for use in treating non-union fractures. Subsequently, the FDA cleared PEMF therapy for failed joint fusion following arthrodesis, failed spinal fusion, and congenital pseudoarthrosis. In 1987, the FDA formally "grandfathered" 510(k) marketing clearance to a high frequency PEMF device for adjunctive therapy in the palliative treatment of postoperative edema and pain in superficial soft tissue. A similar device was given FDA approval in 2008 to deliver what its company calls "targeted microcurrent therapy." Most recently, in October of 2008, the FDA cleared a PEMF device using repetitive transcranial magnetic stimulation (rTMS) for the treatment of Major Depressive Disorder in adult patients who failed to achieve satisfactory improvement from prior antidepressant medication. In a multicenter clinical trial, approximately half of the patients experienced significant improvement in depression

symptoms, and approximately a third of the patients experienced complete symptom relief at the end of six weeks.12

The future of PEMF therapy

The future of PEMF therapy is exciting given the findings of early research in a wide variety of health conditions. For example, preliminary data in clinical studies shows rTMS has promise in treating schizophrenia, post-traumatic stress disorder, obsessive-compulsive disorder, Alzheimer's disease, and Parkinson's disease.13,14,15,16,17

In relation to cardiovascular disease, studies show how PEMF therapy may reduce blood glucose levels, blood viscosity, total cholesterol, and triglycerides, while raising high-density lipoprotein (HDL).18,19 These studies will hopefully serve as an impetus for further investigation given that heart disease is the leading cause of death in the United States. Another study shows how PEMF therapy may accelerate the healing of damaged brain tissue following acute stroke.20

In light of the emergence of drug resistant bacteria, clinical studies show how PEMF therapy could one day become part of the standard of care in inhibiting Staphylococcus aureus infections and augmenting antibiotic therapy.21,22 Complicating the issue of antibiotic resistance are biofilms, dynamic mucous-like cities in which bacteria live and thrive. Biofilms protect bacteria and assist in bacterial cell-to-cell communication and in the exchange of genetic information. The same bacterium living outside a biofilm is less susceptible to antibiotics when living in a biofilm. Studies indicate PEMF therapy may effectively address this dangerous bacterial diversity.23,24

Studies also suggest that PEMF therapy may one day be used to treat cancer. Findings show PEMF therapy induces apoptosis of cancer cells, inhibits the growth of malignant tumors, modulates the immune system via cytokines as an anti-tumor effect, and may act synergistically with chemotherapy and photodynamic therapy to combat tumor growth.25,26,27,28

PEMF therapy and osteoporosis

The scientific evidence is accumulating regarding how PEMF therapy may one day gain FDA approval for the prevention and treatment of osteoporosis.29,30 PEMF therapy improves bone mineral density, increase growth of osteoblasts, and positively influence bone remodeling via cytokines, prostaglandins and cell growth factors.31,32,33,34

In the clinical setting, it is important to document objective measures of improvement based on the therapy chosen. Bone density test scores are used to monitor the response to therapy for osteoporosis and osteopenia over the long term. Over the short term, clinicians can use urine deoxypyridinoline (uDPD) levels to monitor response to therapy. Deoxypyridinoline cross links Type 1 collagen found in bone. In conditions where bone turnover is high, deoxypyridinoline spills into the urine in high levels. As bone turnover decreases, uDPD levels drop.

In my preliminary analyses, I find that PEMF therapy lowers uDPD in patients with osteoporosis. In one patient, uDPD decreased by 53% in two months with weekly sessions, and the reduction was sustained with once-monthly sessions. If this finding is reproducible in a double-blind, placebo-controlled clinical trial, this would affirm the ability for PEMF therapy to positively impact bone remodeling in osteoporosis.Fig. 1

Conclusion

As Abraham Liboff, Ph.D. has so aptly stated "… it is possible to view the living system as an electromagnetic entity, with the response of the system to a given electric or magnetic signal as an outcome expected on the basis of physical law." PEMF therapy has scientifically documented beneficial effects on multiple biological tissues ranging from bone to brain. The reason for these beneficial effects is because PEMF therapy triggers a cascade of biological processes that supports ailing tissues. Before any chemical or physiologic response is elicited in a biological system, there is always an exchange of energy. The use of specific pulsed electromagnetic frequencies prompts this therapeutic exchange of energy in a safe and cost-effective manner.

BIO

Keith R. Holden, M.D. graduated from Louisiana State University School of Medicine in New Orleans in 1992 as a member of the Alpha Omega Alpha Honor Medical Society. He is board certified in Internal Medicine, and practices Functional Medicine in Ponte Vedra Beach, FL. Dr. Holden has been studying and using pulsed electromagnetic field therapy and microcurrent therapy in his practice since 2008. Dr. Holden is a member of The Institute for Functional Medicine.

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1 Siskin B F, Walker J. Therapeutic aspects of electromagnetic fields for soft-tissue healing. In Blank M ed. Electromagnetic fields: Biological interactions and Mechanisms. Advances in Chemistry Series. Vol 250. Washington, DC: American Chemical Society; 1995:277-285.

2, Lee PB, Kim YC, Lim YJ, et al. Efficacy of pulsed electromagnetic therapy for chronic lower back pain: a randomized, double-blind, placebo-controlled study. J Int Med Res. March-April 2006;34(2):160-7.

3, Thomas AW, Graham K, Prato FS, et al. A randomized, double-blind, placebo-controlled trial using low-frequency magnetic fields in the treatment of musculoskeletal chronic pain. Pain Res Manag. Winter 2007;12(4):249-58.

4, Sutbeyaz ST, Sezer N, Koseoglu BF. The effect of pulsed electromagnetic fields in the treatment of cervical osteoarthritis: a randomized, double-blind, sham-controlled trial. Rheumatol Int. February 2006;26(4): 320-4.

5, Nicolakis P, Kollmitzer J, Crevenna R, Bittner C, Erdogmus CB, Nicolakis J. Pulsed magnetic field therapy for osteoarthritis of the knee – a double-blind, sham-controlled trial. Wien Klin Wochenschr. August 2002; 114(15-16):678-84.

6, Uzunca K, Birtane M, Tastekin N. Effectiveness of pulsed electromagnetic field therapy in lateral epicondylitis. Clin Rheumatol. January 2007;26(1):69-74.

7, Benazzo F, Zanon G, Pederzini L, et al. Effects of biophysical stimulation in patients undergoing arthroscopic reconstruction of anterior cruciate ligament: prospective, randomized and double blind study. Knee Surg Sports Traumatol Arthrosc. June 2008;16(6):595-601.

8, Mooney V. A randomized double-blind prospective study of the efficacy of pulsed electromagnetic fields for interbody lumbar fusions. Spine. July 1990;15(7):708-12.

9, Binder A, Parr G, Hazleman B, Fitton-Jackson S. Pulsed electromagnetic field therapy of

persistent rotator cuff tendinitis. A double-blind controlled assessment. Lancet. March 1984;1(8379):695-8.
10, Blumberger DM, Mulsant BH, Fitzgerald PB, et al. A randomized double-blind sham-controlled comparison of unilateral and bilateral repetitive transcranial magnetic stimulation for treatment-resistant major depression. World J Biol Psychiatry. July 2011.
11 Lappin MS, Lawrie FW, Richards TL, Kramer ED. Effects of pulsed electromagnetic therapy on multiple sclerosis fatigue and quality of life: a double-blind, placebo controlled trial. Altern Ther Health Med. July-August 2003;9(4):38-48.
12 Demitrack MA, Thase ME. Clinical significance of transcranial magnetic stimulation (TMS) in the treatment of pharmacoresistant depression: synthesis of recent data. Psychopharmacol Bull. 2009;42(2):5-38.
13, Poulet E, Haesebaert F, Saoud M, Suaud-Chagny MF, Brunelin J. Treatment of schizophrenic patients and rTMS. Psychiatr Danub. November 2010;22 Suppl 1:S143-6.
14, Watts BV, Landon B, Groft A, Young-Xu Y. A sham controlled study of repetitive transcranial magnetic stimulation for posttraumatic stress disorder. Brain Stimul. January 2012;5(1):38-43.
15, Blom RM, Figee M, Vulink N, Denys D. Update on repetitive transcranial magnetic stimulation in obsessive-compulsive disorder: different targets. Curr Psychiatry Rep. August 2011;13(4):289-94.
16, Bentwich J, Dobronevsky E, Aichenbaum S. Beneficial effect of repetitive transcranial magnetic stimulation combined with cognitive training for the treatment of Alzheimer's disease: a proof of concept study. J Neural Transm. March 2001;118(3):463-71.
17 Pal E, Nagy F, Aschermann Z, Balazs, E, Kovacs N. The impact of left prefrontal repetitive transcranial magnetic stimulation on depression in Parkinson's disease: a randomized, double-blind, placebo-controlled study. Move Disord. October 2010;25(14):2311-7.
18, Mert T, Gunay I, Ocal I. Neurobiological effects of pulsed magnetic field on diabetes-induced neuropathy. Bioelectromagnetics. January 2010;31(1):39-47.
19 Luo E, Shen G, Xie K, et al. Alimentary hyperlipidemia of rabbits is affected by exposure to low-intensity pulsed magnetic fields. Bioelectromagnetics. December 2007;28(8):608-14.
20 Grant G, Cadossi R, Steinberg G. Protection against focal cerebral ischemia following exposure to pulsed electromagnetic field. Bioelectromagnetics. 1994;15(3):205-16.
21, Obermeier A, Matl FD, Friess W, Stemberger A Growth inhibition of Staphylococcus aureus induced by low-frequency electric and electromagnetic fields. Bioelectromagnetics. May 2009;30(4):270-9.
22 Matl FD, Obermeier A, Zlotnyk J, Friess W, Stemberger A, Burgkart R. Augmentation of antibiotic activity of low-frequency electric and electromagnetic fields examining Staphylococcus aureus in broth media. Bioelectromagnetics. July 2011;32(5):367-77.
23, Di Campli E, Di Bartolomeo S, Grande R, Di Giulio M, Cellini L. Effects of extremely low-frequency electromagnetic fields on Helicobacter pylori biofilm. Curr Microbiol. June 2010;60(6):412-8.
24 Pickering SA, Bayston R, Scammell BE. Electromagnetic augmentation of antibiotic efficacy in infection of orthopedic implants. J Bone Joint Surg Br. May 2003;85(4):588-93.
25, Zeng F, Zheng C, Zhang X, et al. Experimental studies on ultralow frequency pulsed gradient

magnetic field inducing apoptosis of cancer cell and inhibiting growth of cancer cell. Sci China C Life Sci. February 2002 45(1):33-9.
26, Yamaguchi S, Ogiue-Ikeda M, Sekino M, Ueno S. Effects of pulsed magnetic stimulation on tumor development and immune function in mice. Bioelectromagnetics. January 2006;27(1):64-72.
27, Rihova B, Etrych T, Sirova M, Tomala J, Ulbrich K, Kovar M. Synergistic effect of EMF-BEMER-type pulsed weak electromagnetic field and HPMA-bound doxorubicin on mouse EL4 T-cell lymphoma. J Drug Target. December 2011;19(10):890-9.
28 Radeva M, Berg H. Differences in lethality between cancer cells and human lymphocytes caused by LF-electromagnetic fields. Bioelectromagnetics. October 2004;25(7):503-7.
29, Rubin CT, McLeod KJ, Lanyon LE. Prevention of osteoporosis by pulsed electromagnetic fields. J Bone Joint Surg Am. March 1989;71(3):411-7.
30 Tabrah F, Hoffmeier M, Gilbert F Jr, Batkin S, Bassett CA. Bone density changes in osteoporosis-prone women exposed to pulsed electromagnetic fields (PEMFs). J Bone Miner Res. May 1990;5(5):437-42.
31, Shen WW, Zhao JH. Pulsed electromagnetic fields stimulation affects BMD and local production of rats with disuse osteoporosis. Bioelectromagnetics. February 2010;31(2):113-19.
32, Jing D, Cai J, Shen G, et al. The preventive effects of pulsed electromagnetic fields on diabetic bone loss in streptozocin-treated rats. Osteoporos Int. June 2011;22(6):1885-95.
33, Li JK, Lin JC, Liu HC, Chang WH. Cytokine release from osteoblasts in response to different intensities of pulsed electromagnetic field stimulation. Electromagn Biol Med. 2007;26(3):153-65.
34 Schnoke M, Midura RJ. Pulsed electromagnetic fields rapidly modulate intracellular signaling events in osteoblastic cells: comparison to parathyroid hormone and insulin. J Orthop Res. July 2007;25(7):933-40.