

Pulsed Electromagnetic Field (PEMF) Research

Introduction (Scroll Down for A-Z Research By Condition)

The beneficial therapeutic effects of selected low-energy, time-varying magnetic fields, called pulsed electro magnetic fields (PEMFs), have been documented with increasing frequency since 1973. Furthermore, double-blind evidence of therapeutic effects in other clinical disorders has emerged. These data, coupled with well-controlled laboratory findings on pertinent mechanisms of action, have begun to place PEMFs on a therapeutic par with surgically invasive methods but at considerably less risk and cost. Over the past decade, the number of publications on these topics has risen exponentially. They now include textbooks, specialty journals, and regular reviews by government agencies, in addition to individual articles, appearing in the wide spectrum of peer-reviewed, scientific sources. In a recent editorial in Current Contents, the editor reviews the frontiers of biomedical engineering focusing on Science Citation Index methods for identifying core research endeavors. Dr. Garfield chose PEMFs from among other biomedical engineering efforts as an example of a rapidly emerging discipline. - *Dr. Andrew Bassett, Columbia University, Critical Reviews™ in Biomedical Engineering*

Based on decades of experimental evidence an excellent argument can be made for the existence of a fundamental functional relationship between living systems and electromagnetic fields. We relate this observation to the integrated electric polarization vector, in turn a measure of the double layer charge distribution at the cell membrane. This discovery, already being applied to a number of clinical problems, lends strong support to the concept of an overarching electromagnetic framework for living systems. - *Electromagnetic Biology and Medicine*

The fundamental intrinsic electro-gravitational (neutrino-photon-phonon transduction) mechanism of human life is proposed. The finding is that the subtle forces of life and flux densities on the order of magnitude 10^{-8} gauss are the critical factors in maintaining physiological homeostasis and repair when imbalance such as cancer occurs. - *Panminerva Medica*

Various types of magnetic and electromagnetic fields are now in successful use in modern medicine. Electromagnetic therapy carries the promise to heal numerous health problems, even where conventional medicine has failed. Today, magneto-therapy provides a non invasive, safe, and easy method to directly treat

the site of injury, the source of pain and inflammation, and a variety of diseases and pathologies. Millions of people worldwide have received help in treatment of the musculoskeletal system, as well as for pain relief. Pulsed electromagnetic fields are one important modality in magneto-therapy. Recent technological innovations, implementing advancements in computer technologies, offer excellent state-of-the-art therapy. - *Electromagnetic Biology and Medicine*

Very weak magnetic fields have been shown to be associated with the human brain and heart. These fields, apparently physiologic, are about one million times weaker than the geomagnetic, the earth's steady magnetic field, which measures about 0.5 gauss. As these fields are applied to the equations for solenoidal models, currents of about a microampere are derived; in perfect accord with recent clinical data indicating the therapeutic efficacy of weak currents in repair and growth of soft tissue, bone and nerve. They may convert mal-aligned atomic lattices of oncogenes and associated particles to homologous normal structures which may promulgate an adjustment to physiological homeostasis. - *International Journal of Neuroscience*

Although interest in energy medicine has existed for centuries in some parts of the world, in recent years this is an area of heightened interest for western healthcare practitioners. This awareness has been triggered by the growing body of knowledge on how EMFs interact with cellular systems. Optimistically, EMF therapy has the potential to revolutionize medicine, which is currently dominated by pharmaceutical and surgical interventions. In this case, new therapeutic tools may be developed for future clinicians to provide noninvasive treatments with low risk of side effects and no problem with drug interactions. EMF therapy for the treatment of pain, cancer, epilepsy, and inflammatory diseases like psoriasis, tendinitis and rheumatoid arthritis is currently being explored. The long-term success of this new area of medicine is still unknown. - *Biomedical Sciences Instrumentation*

Alzheimer's disease

Impairments in visual memory and visuoconstructive functions commonly occur in patients with Alzheimer's disease (AD). Recently, I reported that external application of electromagnetic fields (EMF) of extremely low intensity (in the picotesla range) and of low frequency (in the range of 5Hz-8Hz) improved visual memory and visuoceptive functions in patients with Parkinson's disease. The report demonstrates, for the first time, that specific cognitive symptoms of AD are improved by treatment with EMF of a specific intensity and frequency. The rapid improvement in cognitive functions in response to EMF suggests that some of the mental deficits of AD are reversible being caused by a functional (i.e., synaptic transmission) rather than a structural (i.e., neuritic plaques) disruption of

neuronal communication in the central nervous system. - *International Journal of Neuroscience*

Repetitive transcranial magnetic stimulation applied to the dlPFC improves naming performance also in the advanced stages of AD. Moreover, in the severe group the effect is not specific for action naming, as in the case of the mild AD group. These findings suggest that rTMS can affect the intrinsic ability of the brain to restore or compensate for damaged function and may represent an useful new tool for cognitive rehabilitation. - *European Journal of Neurology*

Ankle sprain

Acutely sprained ankles represent a frequent and common injury among active duty troops in training, and are a significant source of morbidity with respect to days lost to training. In a randomized, prospective, double blind study of 50 grade I and II (no gross instability) sprained ankles, a statistically significant decrease in edema was noted following one treatment with pulsed electro magnetic field (PEMF) therapy. The application of this modality in acutely sprained ankles could result in significant decreases in time lost to military training. – *Military Medicine*

Back pain

Back pain and the whiplash syndrome are very common conditions involving tremendous costs and extensive medical effort. A quick and effective reduction of symptoms, especially pain, is required. Magnetic fields appear to have a considerable and statistically significant potential for reducing pain in cases of lumbar radiculopathy and the whiplash syndrome. – *Neuro Rehabilitation*

Back pain – low back

This randomized, double-blind, placebo-controlled clinical trial studied the effectiveness of pulsed electromagnetic therapy (PEMT) in patients with chronic lower back pain. PEMT produced significant pain reduction throughout the observation period compared with baseline values. The percentage change in the NRS score from baseline was significantly greater in the PEMT group than the placebo group at all three time-points measured. The mean revised Oswestry disability percentage after 4 weeks was significantly improved from the baseline value in the PEMT group, whereas there were no significant differences in the placebo group. In conclusion, PEMT reduced pain and disability and appears to be a potentially useful therapeutic tool for the conservative management of chronic lower back pain. - *Journal of International Research*

We evaluate the efficacy and safety of therapeutic electromagnetic fields (TEMF) on chronic low back pain. Secondary objectives included the investigation of the effects of TEMF on psychometric measures. Both groups improved over time. Although groups were similar during the treatment period, treated subjects (TEMF of 15 mT) improved significantly over sham treatment during the 2-week follow-up period (20.5% reduction in pain); There were no reported serious adverse events. This study demonstrates that TEMF may be an effective and safe modality for the treatment of chronic low back pain disorders. - *Pain Practice*

Bone density

To determine the effect of a 72 Hz pulsating electromagnetic field (PEMF) on bone density of the radii of osteoporosis-prone women, the nondominant forearms of 20 subjects were exposed to PEMF 10 h daily for a period of 12 weeks. The data suggest that properly applied PEMFs, if scaled for whole-body use, may have clinical application in the prevention and treatment of osteoporosis. - *The Journal of Bone and Mineral Research*

Cancer – bladder The study deals with immune status of patients operated for bladder cancer and exposed postoperatively to alternating magnetic field (MF). MF application was followed by higher T- and B-lymphocyte and CD4+, CD16+ cell levels as well as enhanced T-cell activity; no postoperative complications were registered and tumor relapse rates were relatively low. The effect was likely to be due to antistressor influence of MF. The procedure may substitute drug therapy for immunocorrection and to avoid recurrence of bladder cancer. - *Volpr Onkol*

Cancer – breast tumors The study was concerned with effect of alternating magnetic field (AMF) on immunobiological characteristics of lymphocytes from patients with locally-advanced breast tumors. Patients received infusions of treated autoblood and changes in their immunological status were followed up. Stimulation of T-, B- and NK- cells was observed. Immuno-regulating effect was apparent when autoblood was treated with 50 H/25 mT1 and 100 H/50 mT1.

- *Volpr Onkol*

Cancer - cells

PEMF controls cell growth depending on the degree of cell differentiation. This study also shows the potentiality of PEMF as an adjunctive treatment method for malignant tumors. – *Bioelectromagnetics*

No adverse side-effects were reported in an investigation of the antitumor effect of turbulent magnetic field (TMF) carried out as a component of preoperative chemoradiotherapy for breast cancer at the Center's Clinic. The study group included 114 patients with locally advanced tumors(T3, N1-N3, M0). According to the clinical, roentgenological and histological evidence on the end-results, the procedure was highly effective. Also, it was followed by shorter and less extensive postoperative lymphorrhea. – *Volpr Onko*

Carpal Tunnel SyndromePEMF exposure in refractory carpal tunnel syndrome provides statistically significant short and long-term pain reduction and mild improvement in objective neuronal functions. Neuromodulation appears to influence nociceptive-C and large A-fiber functions, probably through ion/ligand binding. - *Pain Medicine*

Cartilage Severe joint inflammation following trauma, arthroscopic surgery or infection can damage articular cartilage, thus every effort should be made to protect cartilage from the catabolic effects of pro-inflammatory cytokines and stimulate cartilage anabolic activities. Previous pre-clinical studies have shown that pulsed electromagnetic fields (PEMFs) can protect articular cartilage from the catabolic effects of pro-inflammatory cytokines, and prevent its degeneration. The percentage of patients who used NSAIDs was 26% in the active group and 75% in the control group. At 3 years follow-up, the number of patients who completely recovered was higher in the active group compared to the control group. Treatment with I-ONE aided patient recovery after arthroscopic surgery, reduced the use of NSAIDs, and also had a positive long-term effect. - *Knee Surgery, Sports Traumatology, Arthroscopy*

Chronic pain

Specific pulsed electromagnetic fields (PEMFs) have been shown to induce analgesia (antinociception) in healthy human volunteers. These findings provide some initial support for the use of PEMF exposure in reducing pain in chronic pain populations and warrants continued investigation into the use of PEMF exposure for short-term pain relief. - *Pain Research & Management*

Dental pain

Two hours of exposure to a weak, oscillating magnetic fields induced a significant decrease in three parameters (dental sensory and cutaneous pain and tolerance thresholds), whereas the other two parameters showed a similar tendency. When the same subjects were exposed to a sham treatment, only marginal, nonsignificant variations in all parameters were observed. These results

represent the first piece of evidence that weak alterations of the magnetic field may induce hyperalgesia in humans. - *Bioelectromagnetics*

Diabetic neuropathy/angipathy

Significant improvement of symptoms, and of all registered parameters of peripheral circulation was established after the therapy. High-frequency pulsating electromagnetic field is recommended for the treatment of diabetic angiopathy. In patients with neuropathic changes it can be used as an introduction procedure. - *Srpski arhiv za celokupno lekarstvo*

This study demonstrates that pulsed electromagnetic fields are able to accelerate wound healing under diabetic and normal conditions by up-regulation of FGF-2-mediated angiogenesis. They also prevented tissue necrosis in response to a standardized ischemic insult, suggesting that noninvasive angiogenic stimulation by pulsed electromagnetic fields may be useful to prevent ulcer formation, necrosis, and amputation in diabetic patients. – *Plastic and Reconstructive Surgery*

Erectile dysfunction Combined treatment with local negative pressure and pulsating magnetic field conducted in 116 patients with erectile dysfunction aged 20-60 years produced optimal treatment results. Recovery and improvement of the erectile function were achieved in 85.7% patients given local vacuum magneto-therapy. - *Vopr Kurortol Fizioter Lech Fiz Kult*

An effect was studied of appliances for magneto-therapy on sexual function of 105 men presenting with sexual problems. A total of 96 sexological patients were examined according to a general program, to study placebo-effect. The magnetic field beneficial effect was recordable in 70-80 % of the patients, that of placebo in 33 % men. It is suggested that augmentation of sexual activity is associated with an increase in cavernous blood flow. – *Lik Sprava*

Fibromyalgia

Exposure to a specific pulsed electromagnetic field (PEMF) has been shown to produce analgesic (antinociceptive) effects in many organisms. In a randomized, double-blind, sham-controlled clinical trial, patients with either chronic generalized pain from fibromyalgia (FM) or chronic localized musculoskeletal or inflammatory pain were exposed to a PEMF (400 microT) through a portable device fitted to their head during twice-daily 40 min treatments over seven days. PEMF may be a novel, safe and effective therapeutic tool for use in at least certain subsets of patients with chronic, nonmalignant pain. - *Pain Research & Management*

Heart rate variability

Exposure to PEMF for 20 minutes resulted in more rapid recovery of heart rate variability, especially in the very low frequency range after physical strain. The study also showed the moderating influence of the subjects' constitutional VLF power on their response to PEMF treatment. These findings have since been replicated in a clinical study and should be taken into consideration when PEMF treatment is chosen. - *European Journal of Applied Physiology*

Inflammation

It is well known that electromagnetic fields (EMFs) can induce repair of non-healing bone fractures. It is generally believed that non-invasive, EMF therapy might have a broad, albeit currently unrecognized clinical potential. 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. - *Biomedical Sciences Instrumentation*

Knee pain

Low-amplitude, extremely low frequency magnetic fields are safe and effective for treating patients with chronic knee pain due to osteoarthritis. Reduction in pain after a treatment session was significantly greater in the magnetic field-on group (46%) compared to the magnetic field-off group (8%). - *Alternative Therapies in Health and Medicine*

Knee arthritis

In patients with symptomatic osteoarthritis of the knee, PMF treatment can reduce impairment in activities of daily life and improve knee function. – *Wiener Klinische Wochenschrift*

Lumbar fusion

Sixty-one randomly selected patients who underwent lumbar fusion surgeries for discogenic low back pain between 1987 and 1994 were retrospectively studied. All patients had failed to respond to preoperative conservative treatments. Forty-two patients received adjunctive therapy with pulsed electromagnetic field (PEMF) stimulation, and 19 patients received no electrical stimulation of any kind. Average follow-up time was 15.6 months postoperatively. Fusion succeeded in 97.6% of the PEMF group and in 52.6% of the unstimulated group. The use of

PEMF stimulation enhances bony bridging in lumbar spinal fusions. Successful fusion underlies a good clinical outcome in patients with discogenic low back pain. - *Advances in Therapy*

Migraine/Headaches

In the active-treatment group, all assessed criteria were significantly improved at the end of the migraine/headache study. 76% of active-treatment patients experienced clear or very clear relief of their complaints. Only 1 placebo-patient (2.5%) felt some relief; 8% noted slight and 2% reported significant worsening of symptoms. No side effects were noted. - *Advances in Therapy*

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% good, 38% excellent). Thirteen subjects from the actual exposure group elected not to receive additional exposure. Twelve of them showed decreased headache activity by the second month (29% good, 43% 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% good, 38% excellent). In conclusion, exposure to pulsing electromagnetic fields for at least 3 weeks is an effective, short-term intervention for migraine, but not tension headaches. - *Headache*

Multiple Sclerosis

There is a growing literature on the biological and clinical effects of pulsed electromagnetic fields. Some studies suggest that electromagnetic therapies may be useful in the treatment of chronic illnesses. This study is a follow-up to a placebo controlled pilot study in which multiple sclerosis (MS) patients exposed to weak, extremely low frequency pulsed electromagnetic fields showed significant improvements on a composite symptom measure. Evidence from this randomized, double-blind, placebo controlled trial is consistent with results from smaller studies suggesting that exposure to pulsing, weak electromagnetic fields can alleviate symptoms of MS. - *Alternative Therapies in Health and Medicine*

Fatigue is the most common symptom of multiple sclerosis. 75%-90% of patients with multiple sclerosis report having fatigue, and 50%-60% describe it as the worst symptom of their disease. Fatigue is significantly associated with reduced quality of life and is also a major reason for unemployment, especially for patients with otherwise minor disability. There is evidence that pulsing electromagnetic fields may improve fatigue associated with multiple sclerosis- .

Peer-Reviewed Scientific Studies on the Effects of Magnetics on Physical Ailments

The impact of treatment with magnetic fields on a variety of physical ailments are presented in the following descriptions of recent studies, published in peer-reviewed scientific journals.

Alzheimer's Disease

On review, after applying external electromagnetic fields ranging 5 to 8 Hz, large improvements were detected in Alzheimer's patients. These included improved visual memory, drawing performance, spatial orientation, mood, short-term memory and social interactions.

R. Sandyk, "Alzheimer's Disease: Improvement of Visual Memory and Visuoconstructive Performance Treatment with Picotesla Range Magnetic Fields," *International Journal of Neurosci*, 76(3-4),

June 1994, p. 185-225.

As generally supported, a person's biological daily clock may causally be related to memory deterioration in Alzheimer's patients and in the ageing. Synchronizing of the circadian rhythms using magnetic fields, (this article suggests) could lead to improved memory for those affected.

R. Sandyk, et al., "Age-related Disruption of Circadian Rhythms: Possible Relationship to Memory Impairment and Implications for Therapy with Magnetic Fields," *International Journal of Neurosci*, 59(4), August 1991, p. 259-262.

Amyotrophic Lateral Sclerosis (Lou Gehrig's Disease)

A study of three patients with Amyotrophic Lateral Sclerosis were treated with a pulsed magnetic field administered by a Magnobiopulse apparatus. Given three times a week for approximately 75 sessions to achieve maximum benefits, all three experienced beneficial effects.

A. Bellosi & R. Berget, "Pulsed Magnetic Fields: A Glimmer of Hope for Patients Suffering from Amyotrophic Lateral Sclerosis," *Second World Congress for Electricity and Magnetism in Biology and Medicine*, 8-13 June 1997, Bologna, Italy.

Ankle Sprain

Results of this double-blind, placebo-controlled study indicated that treatment with two 30-minute sessions of noninvasive pulsed radio frequency therapy is effective in significantly decreasing the time required for edema reduction in patients suffering from lateral ankle sprains.

A.A. Pilla & L. Kloth, "Effect of Pulsed Radio Frequency Therapy on Edema in Ankle Sprains: A Multisite Double-Blind Clinical Study," Second World Congress for Electricity and Magnetism in Biology and Medicine,

8-13 June 1997, Bologna, Italy, p. 300.

Arthritis

Three hours of exposure to a 50-Hz magnetic field in this study revealed that experimentally induced inflammation and suppressed arthritis in rats was significantly inhibited as a result.

Y. Mizushima, et al., "Effects of Magnetic Field on Inflammation," *Experientia*, 31(12), December 15, 1975, p.1411-1412.

Another double-blind, placebo-controlled research study on the effects of pulsed electrical fields administered over a 4 week period revealed significant improvement in patients receiving the therapy relative to the controls.

J.C. Reynolds, "The Use of Implantable Direct Current Stimulation in Bone Grafted Foot and Ankle Arthrodeses: A Retrospective Review," Second World Congress for Electricity and Magnetism in Biology and Medicine, 8-13 June 1997, Bologna, Italy.

In this general review article on the treatment of patients with psoriatic arthritis with magnetic fields, the authors state that an alternating low-frequency magnetic field (30-40 mT) from such generators as "Polius-1" and "Polius-101" improves the clinical state of afflicted joints. Such treatments are normally carried out for 30 minutes per day over a period of 15 to 20 days.

V.D. GrigorTMeva, et al., "Therapeutic Use of Physical Factors in Complex Therapy of Patients with Psoriatic Arthritis," *Vopr Kurortol Fizioter Lech Fiz Kult*, (6), 1995, p. 48-51

This research studied the effects of magnetolaser therapy alone or combined with conventional drugs in rheumatoid arthritis patients. This treatment utilized a AMLT-01 device for magnetolaser therapy and consisted of 14 days with 6 minute exposures daily. An obvious improvement was seen after 3 days of treatment, with greater

improvement by patients suffering from mild to moderate levels of the disease. End results computed into a 90 percent patient improvement rate.

9B.Y. Drozdovski, et al., "Use of Magnetolaser Therapy with an AMLT-01 Apparatus in Complex Therapy for Rheumatoid Arthritis," *Fiz Med*, 4(1-2), 1994, p. 101-102

This study on 7 to 14 year old juveniles suffering from rheumatoid arthritis examined effects of low-frequency magnetic fields from a Polius-1 device. Ten

daily treatment exposures of 10 to 12 minutes each were conducted on three experimental groups. The three groups showed 58, 76, 37 percent beneficial effects from the treatment.

E.A. Shlyapok, et al., "Use of Alternating Low-Frequency Magnetic Fields in Combination with Radon Baths for Treatment of Juvenile Rheumatoid Arthritis," *Vopr Kurortol Fizioter Lech Fiz Kult*, 4,

1992, p. 13-17.

Low frequency and constant magnetic fields in patients suffering from rheumatoid arthritis and osteoarthritis was the focus of this study. Patients with stages 1 & 2 rheumatoid arthritis as well as patients with osteoarthritis deformans, showed the beneficial effects from treatments. These low frequency, constant magnetic fields were found especially beneficial to the knees, ankles and wrists.

V.D. GrigorTMeva, et al., "Therapeutic Application of Low-Frequency and Constant Magnetic Fields in Patients with Osteoarthritis Deformans and Rheumatoid Arthritis," *Vopr Kurortol Fizioter Lech Fiz Kult*, 4, 1980, p. 29-35.

Blepharitis (infection of the eyelid)

Study results indicated that using a magnetic ointment containing reduced iron powder, with an alternating magnetic field had beneficial effects with patients suffering from chronic blepharitis.

V.A. Machekhin, et al., "A New Method for Treating Chronic Blepharitis Using Magnetic Compounds and an Alternating Magnetic Field," *Vestn Oftalmol*, 109(4), July-September 1993, p. 16-18.

Bone Fractures

A group of 83 adults with ununited fractures were examined for the effects of bone grafting and pulsed electromagnetic fields for this study. Results showed a successful healing rate of 87 percent in the original 38 patients treated with bone grafts and PEMF for ununited fractures with wide gaps, malalignment, and synovial pseudarthrosis. Of the 45 patients that were not successfully treated with PEMF and had bone grafting,

when re-treated with pulsing electromagnetic fields, achieved a 93 percent success rate.

C.A. Bassett, et al., "Treatment of Therapeutically Resistant Non-unions with Bone Grafts and Pulsing Electromagnetic Fields," *Journal of Bone Joint Surg*, 64(8),

October 1982, p. 1214-1220.

Examining the effects of pulsing electromagnetic fields on 125 patients suffering from ununited fractures of the tibial diaphysis, showed a healing success rate of 87%.

C.A. Bassett, et al., "Treatment of Ununited Tibial Diaphyseal Fractures with Pulsing Electromagnetic Fields," *Journal of Bone Joint Surg*, 63(4),

April 1981, p. 511-523.

Results of this study showed treatment with pulsed electromagnetic fields resulted in an overall success rate of at least 75 percent in patients suffering from tibial lesions.

M.W. Meskens, et al., "Treatment of Delayed Union and Nonunion of the Tibia Pulsed Electromagnetic Fields. A Retrospective Follow-up," *Bull Hosp Jt Dis Orthop Inst*, 48(2),
Fall 1988, p. 170-175.

This review article makes the following observations with respect to the use of pulsed electromagnetic fields in treating ununited fractures, failed arthrodeses, and congenital pseudarthroses. The treatment has been shown to be more than 90 percent effective in adult patients. In cases where union does not occur with PEMFs alone after approximately four months, PEMF treatment coupled with fresh bone grafts ensures a maximum failure rate of only 1 to 1.5 percent. For those with delayed union three to four months following fracture, PEMFs appear to be more successful than in patients treated with other conservative methods. For more serious conditions, including infected nonunions, multiple surgical failures, long-standing atrophic lesions, failed knee arthrodeses after removal of infected prostheses, and congenital pseudarthroses, PEMF treatment has exhibited success in most patients.¹⁷

C.A. Bassett, "The Development and Application of Pulsed Electromagnetic Fields (PEMFs) for Ununited Fractures and Arthrodeses," *Clin Plast Surg*, 12(2), April 1985, p. 259-277.

Results of this study found that 35 of 44 nonunited scaphoid fractures 6 months or older healed in a mean time of 4.3 months during pulsed electromagnetic field treatment using external coils and a thumb spica cast.

G.K. Frykman, et al., "Treatment of Nonunited Scaphoid Fractures Pulsed Electromagnetic Field and Cast," *Journal of Hand Surg*, 11(3),

May 1986, p. 344-349.

This double-blind, placebo-controlled study examined the effects of pulsed electromagnetic fields in femoral neck fracture patients undergoing conventional therapy. PEMF treatment was started within two weeks of fracture, and patients

were instructed to make use of the electromagnetic device for 8 hours per day over a 90-day period. Results showed beneficial effects relative to controls after 18 months of follow-up.

E. Betti, et al., "Effect of Electromagnetic Field Stimulation on Fractures of the Femoral Neck. A Prospective Randomized Double-Blind Study," *Second World Congress for Electricity and Magnetism in Biology and Medicine*, 8-13 June 1997, Bologna, Italy.

Results of this double-blind study showed significant healing effects of low-frequency pulsing electromagnetic fields in patients treated with femoral intertrochanteric osteotomy for hip degenerative arthritis.

G. Borsalino, et al., "Electrical Stimulation of Human Femoral Intertrochanteric Osteotomies. Double-Blind Study," *Clin Orthop*, (237), December 1988, . 256-263.

In this study, 147 patients with fractures of the tibia, femur, and humerus who had failed to benefit from surgery-received treatment with external skeletal fixation in situ and pulsed electromagnetic fields. Results indicated an overall success rate of 73 percent. Femur union was seen in 81 percent and tibia union in 75 percent.

M. Marcer, et al., "Results of Pulsed Electromagnetic Fields (PEMFs) in Ununited Fractures after External Skeletal Fixation," *Clin Orthop*, (190), November 1984, . 260-265

This study examined the effects of extremely low frequency electromagnetic fields (1-1000 Hz, 4 gauss) on new bone fractures of female patients. Results led the authors to suggest that EMF treatment accelerates the early stages of fracture healing.

O. Wahlstrom, "Stimulation of Fracture Healing with Electromagnetic Fields of Extremely Low Frequency (EMF of ELF)," *Clin Orthop*, (186), June 1984, . 293-301.

This study examined the preventive effects of low-frequency pulsing electromagnetic fields against delayed union in rat fibular osteotomies and diaphyseal tibia fractures in humans. Results indicated such treatment modulated and accelerated fracture union in both groups.

A.W. Dunn & G.A. Rush, 3d, "Electrical Stimulation in Treatment of Delayed Union and Nonunion of Fractures and Osteotomies," Southern Medical Journal, 77(12), December 1984, . 1530-1534.

This article discusses the cases of two children with bone malunion following lengthening of congenitally shortened lower legs. Pulsed sinusoidal magnetic field treatment was beneficial for both patients.

F. Rajewski & W. Marciniak, "Use of Magnetotherapy for Treatment of Bone Malunion in Limb Lengthening. Preliminary Report," Chir Narzadow Ruchu Ortop Pol, 57(1-3),

1992,. 247-249.

Results of this study showed that 13 of 15 cases of long bone nonunion treated with pulsed electromagnetic fields in combination with Denham external fixator united within several months.

R.B. Simonis, et al., "The Treatment of Non-union Pulsed Electromagnetic Fields Combined with a Denham External Fixator," Injury, 15(4),

January 1984, . 255-260.

Results of this study found electromagnetic field stimulation to be an effective treatment for nonunion among a group of 37 French

L. Sedel, et al., "Acceleration of Repair of Non-unions electromagnetic Fields," Rev Chir Orthop Reparatrice Appar Mot,

67(1), 1981, . 11-23.

Results of this study found treatment induced pulsing to be beneficial in patients suffering from nonunions unresponsive to surgery.>

J.C. Mulier & F. Spaas, "Out-patient Treatment of Surgically Resistant Non-unions Induced Pulsing Current – Clinical Results," Arch Orthop Trauma Surg, 97(4), 1980,.293-297.

In this interview with Dr. C. Andrew L. Bassett, a physician researching the use of pulsed electromagnetic fields for the past 30 years at Columbia University's Orthopedic Research Lab, Dr. Bassett notes that approximately 10,000 of the 12,000-plus orthopedic surgeons in the U.S. have used pulsed electromagnetic fields on at least one patient. Many such surgeons have incorporated the therapy on a more regular basis. He estimates that a total of at least 65,000 patients nationwide have received the treatment, with a probable success rate of between 80 and 90 percent. Use of the

treatment has been primarily in patients suffering from nonunited fractures, fusion failures, and pseudoarthrosis.

C.A. Bassett, "Conversations with C. Andrew L. Bassett, M.D. Pulsed Electromagnetic Fields. A Noninvasive Therapeutic Modality for Fracture

Nonunion (Interview)," Orthop. Review, 15(12)1986 781-795.

Results of this study showed pulsed electromagnetic fields to have beneficial healing effects in patients suffering from difficult to treat and surgically resistant bone nonunions.

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This review article notes that the use of pulsed electromagnetic fields began in 1974, and that 250,000 nonunion patients have received the treatment since. The author argues that success rates are comparable to those of bone grafting, and that PEMF treatment is more cost-effective and free of side effects. The FDA approved PEMF use in 1982, although it remains widely unused due to physician misunderstanding and lack of knowledge concerning the treatment.

A. Bassett, "Therapeutic Uses of Electric and Magnetic Fields in Orthopedics," in D.O. Carpenter & S. Ayrapetyan, (eds.), Biological Effects of Electric and Magnetic Fields. Volume II: beneficial and Harmful Effects, San Diego: Academic Press, 1994, . 13-48.

This 7-year study examined data on more than 11,000 cases of nonunions treated with pulsed electromagnetic fields for up to 10 to 12 hours per day. Results indicated an overall success rate of 75 percent.

A.A. Goldberg, "Computer Analysis of Data on More than 11,000 Cases of Ununited Fracture Submitted for Treatment with Pulsing Electromagnetic Fields," Bioelectrical Repair and Growth Society, Second Annual Meeting, 20-22 September 1982, Oxford, UK, . 61.

This study examined the effects of low-frequency electromagnetic fields (1-1000 Hz) on middle-aged female patients suffering from fresh radius fractures. Results showed significant increases in scintimetric activity surrounding the fracture area after two weeks of EMF treatment relative to controls.

O. Wahlstrom, "Electromagnetic Fields Used in the Treatment of Fresh Fractures of the Radius," Bioelectrical Repair and Growth Society, Second Annual Meeting, 20-22 September 1982, Oxford, UK, . 26.

This study examined the effects of constant magnetic fields in patients suffering from fractures. Results showed that magnetic exposure reduced pain and the onset of edema shortly after trauma. Where edema was already present, the treatment exhibited marked anti-inflammatory effects. The strongest beneficial effects occurred in patients suffering from fractures of the ankle joints.

G.B. Gromak & G.A. Lacis, "Evaluations of the Efficacy of Using a Constant Magnetic Field in Treatment of Patients with Traumas," in I. Detlav, (ed.), *Electromagnetic Therapy of Injuries and Diseases of the Support-Motor Apparatus*. International Collection of Papers, Riga, Latvia: Riga Medical Institute,

1987, . 88-95.<

Results of this study found that 10 hours per day of electromagnetic stimulation (1.0-1.5 mV) produced complete union in 23 of 26 patients receiving the treatment for nonjoined fractures.

A.F. Lynch & P. MacAuley, "Treatment of Bone Non-Union Electromagnetic Therapy," *Ir Journal of Med Sci*, 154(4), 1985, . 153-155.

This review article looks at the history of pulsed electromagnetic fields as a means of bone repair. The author argues that success rates have been either superior or equivalent to those of surgery, with PEMF free of side effects and risk.

C.A.L. Bassett, "Historical Overview of PEM-Assisted Bone and Tissue Healing, " *Bioelectromagnetics Society, 10th Annual Meeting*,

19-24 June 1988, Stamford, CT, . 19.

Bronchitis;

Results of this double-blind, placebo-controlled study indicated that both low-frequency electromagnetic field treatment and treatment with pulsed electromagnetic fields proved effective in patients suffering from chronic bronchitis when coupled with standard drug therapies. Magnetic field treatment consisted of a total of 15 15-20-minute daily exposures.

V.M. Iurlov, et al., "The Efficacy of the Use of Low-Frequency Electromagnetic Fields in Chronic Bronchitis," *Voen Med Zh*, 3, 1989, . 35-36.

Cancer

Results of this study found that prolonged exposure to a 7-tesla uniform static magnetic field for a period of 64 hours inhibited growth of three human tumor cell lines in vitro.

R.R. Raylman, et al., "Exposure to Strong Static Magnetic Field Slows the Growth of Human Cancer Cells in Vitro," *Bioelectromagnetics*, 17(5), 1996, . 358-363.

This study examined the effects of a rotational magnetic field on a group of 51 breast cancer patients. Results showed a significant positive response in 27 of them.

N.G. Bakhmutskii, et al., "The Assessment of the Efficacy of the Effect of a Rotational Magnetic Field on the Course of the Tumor Process in Patients with Generalized Breast Cancer," *Sov Med*, (7), 1991, . 25-27.

Results of this study indicated that exposure to a rotational magnetic field inhibited Walker's carcinoma tumor growth as much as 90 percent in some cases.

N.G. Bakhmutskii, et al., "The Growth Dynamics of Walker Carcinosarcoma During Exposure to a Magnetic Eddy Field," *Vopr Onkol*, 37(6), 1991, . 705-708.

Results of this study indicated that pulsed magnetic field stimulation increased the incorporation of antitumor agents into cells, and thus increased antitumor activity shifting the cell cycle to a proliferative from a nonproliferative phase.

Y. Omote, "An Experimental Attempt to Potentiate Therapeutic Effects of Combined Use of Pulsing Magnetic Fields and Antitumor Agents," *Nippon Geka Gakkai Zasshi*, 89(8), August 1988, .. 1155-1166.

Results of this study found that 20-30 sessions of magnetotherapy administered preoperatively exhibited antitumor effects in patients suffering from lung cancer.

L.S. Ogorodnikova, et al., "Morphological Criteria of Lung Cancer Regression Under the Effect of Magnetotherapy," *Vopr Onkol*, 26(1), 1980, . 28-34.

This study examined the effects of microwave resonance therapy (MRT) in patients suffering from various forms of cancer. Results showed that MRT treatment prior to surgery reduced the spread of cancer-associated conditions and reduced the risk associated with surgery in 87 percent of patients. MRT applied postoperatively had beneficial effects in 68 percent.

D.V. Miasoedov, et al., "Experience with the Use of Microwave Resonance Therapy as a Modifying Factor in Oncological Therapy," *Abstracts of the First All-Union Symposium with International Participation*, May 10-13, 1989, Kiev, Ukraine, .. 313-315.

Results of this study proved that the combination of weak pulsed electromagnetic fields with antioxidant supplementation is beneficial in the treatment of patients

suffering from tongue cancer, improving speech, pain control, and tolerance to chemotherapy.

U. Randoll & R.M. Pangan, "The Role of Complex Biophysical-Chemical Therapies for Cancer,"

Bioelectrochem Bioenerg, 27(3), 1992, . 341-346.

Results of this controlled study indicated that treatment with a constant magnetic field significantly improved long-term (3-year) survival time in patients undergoing radiation therapy for cancer of the throat. Constant magnetic field therapy consisted of the application of 300 mT for 30 minutes to tumor and metastasizing regions immediately prior to each irradiation.

V.G. Andreev, et al., "Radiomodifying Effect of a Constant Magnetic Field in Radiation Therapy of Patients with Cancer of the Throat," Fizicheskaja Meditsina, 4(1-2), 1994,. 92.

Results of this Russian study indicated that the use of whole body eddy magnetic fields, coupled with more conventional cancer therapies (including magnetotherapy) is effective in the treatment of patients suffering from a variety of different malignancies.

V. Smirnova, "Anti-Tumorigenic Action of an Eddy Magnetic Field," Vrach, 2, 1994, . 25-26

This article reports on the case of a 48-year-old-woman with breast cancer who was treated successfully with magnetotherapy. Infiltration showed a marked decrease following 30 whole body exposures to an eddy magnetic field for 60 minutes. One metastatic node disappeared while the size of others was reduced following 60 such exposures. A total regression of tumor and metastases was seen following the completion of a course of 110 exposures.

N.G. Bakhmutskii, et al., "A Case of Successful Treatment of a Patient with Breast Cancer Using a Rotating Electromagnetic Field," Soviet Medicine, 8, 1991, . 86-87.

This study examined the effects of whole body magnetic fields (16.5-35 G, 50-165 Hz) on patients suffering from different forms of cancer. Treatment consisted of 15 cycles, each 1-20 minutes in duration, and was coupled with more traditional cancer therapies. Results showed that the magnetotherapy had overall beneficial effects, particularly with respect to improved immune status and postoperative recovery.

V.A. Lubennikov, et al., "First Experience in Using a Whole-Body Magnetic Field Exposure in Treating Cancer Patients,"

Vopr Onkol, 41(2), 1995, . 140-141.

Heart Disease

Results of this study found that the addition of magnetotherapy to the treatment of patients suffering from ischemic heart disease and osteochondrosis led to clinical improvements.

I. Rodin, et al., "Use of Low-Intensity Eddy Magnetic Field in the Treatment of Patients with Skin Lymphomas," *Voen Med Zh*, 317(12), 1996, . 32-34.

Results of this study involving 23 parasystolic children found that low-frequency magnetic field exposure improved humoral and cellular processes involved in the regulation of cardiac rhythm.

M.A. Dudchenko, et al., "The Effect of Combined Treatment with the Use of Magnetotherapy on the Systemic Hemodynamics of Patients with Ischemic Heart Disease and Spinal Osteochondrosis,"

Lik Sprava, (5), May 1992, . 40-43.

The authors of this study report on their development of a polymagnetic system called *Avrora-MK-01* used to administer impulse magnetic fields to diseases of the leg vessels. Results indicated positive effects on peripheral capillaries in 75-82 percent of patients receiving the treatment at a pre-gangrene stage.

E.M. VasilTMeva, et al., "The Effect of a Low-frequency Magnetic Field on Erythrocyte Membrane Function and on the Prostanoid Level in the Blood Plasma of Children with Parasystolic Arrhythmia," *Vopr Kurortol Fizioter Lech Fiz Kult*, (2),

March-April 1994, . 18-20.

Results of this study showed exposure to low-frequency alternating magnetic fields had beneficial effects in children with primary arterial hypertension, as seen in the attenuation of sympathetic and vagotonic symptoms.

Y.B. Kirillov, et al., "Magnetotherapy in Obliterating Vascular Diseases of the Lower Extremities," *Vopr Kurortol Fizioter Lech Fiz Kult*, (3), May-June 1992, . 14-17.

This study demonstrated that traveling pulsed magnetic field and magnetic laser treatment produced beneficial effects in patients suffering from the initial stages of essential hypertension.

V.S. Zadionchenko, et al., "Prognostic Criteria of the Efficacy of Magnetic and Magnetic-laser Therapy in Patients with the Initial Stages of Hypertension," *Vopr*

Kurortol Fizioter Lech Fiz Kult, (1),
January-February 1997, . 8-11.

In this article, the authors propose a new approach to treating atherosclerosis through the alteration of biophysical properties both intracellularly and extracellularly. Citing their own preliminary data, they suggest atherosclerotic lesions might be selectively resolved without harming normal blood vessels allowing the lesions to take up the magnetically excitable submicron particles and then applying an external alternating electromagnetic field.

R.T. Gordon & D. Gordon, "Selective Resolution of Plaques and Treatment of Atherosclerosis Biophysical Alteration of Cellular and Intracellular Properties," *Medical Hypotheses*, 7(2), February 1981, . 217-229.

This study examined the effects of constant MKM2-1 magnets on essential hypertension patients. Results indicated the treatment decreased arterial pressure in stage II patients, with magnetotherapy being shown to produce beneficial effects on the central hemodynamics and microcirculation.

S.G. Ivanov, et al., "The Magnetotherapy of Hypertension Patients," *Ter Arkh*, 62(9), 1990, . 71-74.

Results from several recent studies conducted the author are reviewed. Conclusions are that pulsed electromagnetic fields exhibit protective effects against necrosis from acute ischemia in rats, cerebral infarcts in rabbits, and myocardium infarcts in rats.

R. Cadossi, "Protective Effect of Electromagnetic Field Exposure on Acute Soft Tissue Ischaemic Injury," *Second World Congress for Electricity and Magnetism in Biology and Medicine*, 8-13 June 1997, Bologna, Italy.

This study examined the effects of extremely high frequency electromagnetic radiation (EHF EMR) in 93 patients suffering ischemic heart disease. EHF treatment consisted of 10 to 15 exposures of the lower end of the sternum from a YavTM-1-7,1 device. Treatment was performed five times weekly for a total of 30 minutes per day, with drug therapy being maintained during this period. Positive results tended to occur after 5 to 6 treatment sessions, with a good or satisfactory response being reported in 82 of 93 patients, and lasting as long as 11 months after hospital release.

I.E. Ganelina, et al., "Electromagnetic Radiation of Extremely High Frequencies in Complex Therapy for Severe Stenocardia," *Millimetrovie Volni v Biologii I Meditsine*, (4), 1994, . 17-21.

This review article concerning the clinical application of electromagnetic fields notes that microwave therapy has been shown to improve local circulation and vascular tone, increase the volume of functional capillaries, lower hypertension, stimulate protein and

carbohydrate metabolism, stimulate the pituitary-adrenal system, produce anti-inflammatory effects, and improve digestive organ function. Studies have shown decimeter wave therapy capable of stimulating the secretory function of the stomach, as well as blood circulation, respiratory function, and the immune system. Side effects have been reported in both human and animal studies.

V.V. Orzeshkovskii, et al., "Clinical Application of Electromagnetic Fields," in I.G. Akoevs & V.V. Tiazhelov, (eds.), Topics of Experimental and Applied Bioelectromagnetics. A Collection of Research Papers, Pushechino, USSR, USSR Academy of Sciences, Biological Sciences Research Center,

1983, . 139-147.

In this study, 30 myocardial infarction patients received millimeter-wave (MW) therapy in the form of 10 exposures of 30 minutes per day, with a 2-day interruption after the fifth exposure. Patients continued conventional drug treatment during the MW therapy period. Better results were seen in those patients exposed to the MW therapy relative to an equal number of patients receiving conventional treatment only.

N.N. Naumcheva, "Effect of Millimeter Waves on Ischemic Heart Disease Patients," Millimetrovie Volni v Biologii i Meditsine, (3), 1994, . 62-67.

This study examined the effects of millimeter wave therapy in approximately 450 patients suffering from a variety of diseases, including those of the musculoskeletal, digestive, pulmonary, and nervous systems. Treatment consisted of 25-30 minutes per day using the "Porog-1" apparatus and generally lasted for a period of up to 10 days. Results showed positive effects in over 87 percent of the patients.

A.P. Dovganiuk & A.A. Minenkov, "The Use of Physical Factors in Treating Chronic Arterial Insufficiency of the Lower Limbs," Vopr Kurortol Fizioter Lech Fiz Kult, (5),

1996, . 7-9.

Results of this study found that the use of magnetophore therapy (constant magnets applied to adrenal regions 10 hours per day for 15 days) significantly improved symptoms associated with hypertension in about 35 percent of patients

studied, with mild improvement seen in 30 percent, and no improvement in 35 percent. Patients receiving decimeter-band waves (460 MHz, field intensity of 35-45 W, for 10-15 minutes per day for a total of 15 days) experienced similar results.

V.V. Orzheshovski, et al., "Efficacy of Decimeter-Band Waves and Magnetophore Therapy in Patients with Hypertension," Vrach Delo, (1), 1982, . 65-67.

Results of this placebo-controlled study demonstrated a 76-percent effectiveness rate for running impulse magnetic field therapy in a group of arterial hypertensive patients.

Treatment consisted of two 25-minute exposures per day over a period of 10-20 total exposures, at frequencies of 10 or 100 Hz and magnetic field intensity of 3 or 10 mT.

L.L.Orlov, et al., "Indications for Using a New Magnetotherapeutic Method in Arterial Hypertension," Soviet Medicine, (8), 1991, . 23-24.

This study examined the efficacy of the reinfusion of autologous blood following magnetic field exposure in hypertensive patients. Positive effects were found in 92 percent of patients receiving the treatment.

I.G. Alizade, et al., "Magnetic Treatment of Autologous Blood in the Combined Therapy of Hypertensive Patients," Vopr Kurortol Fizioter Lech Fiz Kult, (1), 1994, . 32-33

This double-blind, placebo-controlled study examined the effects of magnetotherapy in patients suffering from first-or second-stage hypertension. A magnetic field of 50 Hz, 15-25 mT was applied to acupuncture points He-Gu and ShenTM-Men for 15-20 seconds per day for a total of 9-10 days. Results: The treatment improved headaches in 88 percent of patients, dizziness in 89 percent, and irritability in 88 percent. In general, 95 percent of hypertensive patients experienced beneficial effects from the treatment, and the morbidity rate decreased twofold following one course extended over a period of 5-6 months.

E.V. Rolovlev, "Treatment of Essential Hypertension Patients an Alternating Magnetic Field Puncture," All-Union Symposium: Laser and Magnetic Therapy in Experimental and Clinical Studies,

June 16-18, 1993, Obninsk, Kaluga Region, Russia, . 221-223.

This placebo-controlled study examined the effects of constant and of running magnetic fields in patients suffering from stage II hypertension. Results found that constant magnetic fields exhibited benefits in 68 percent of patients treated, and running magnetic fields were helpful in 78 percent. Only 30 percent of controls showed improvement. Constant magnetic field treatment consisted of

constant magnets applied to the inner side of the wrist on each hand for 35-40 minutes daily over a period of 7-10 days. Running magnetic field treatment involved the use of a "Alimp-1" apparatus for 20 minutes per day for a total of 12-15 days.

S.G. Ivanov, et al., "Use of Magnetic Fields in the Treatment of Hypertensive Disease," Vopr Kurortol Fizioter Lech Fiz Kult, (3),

1993, . 67-69.

This double-blind, placebo-controlled study found that magnetotherapy was effective in the treatment of symptoms associated with stage II hypertension, such as headache,

dizziness, and cardiodynia. The therapy consisted of permanent circular magnets (16 mT) applied to the inner forearm for 30-45 minutes per day over a period of 10 sessions.

S.G. Ivanov, "The Comparative Efficacy of Nondrug and Drug Methods of Treating Hypertension," *Ter Arkh*, 65(1),

1993, . 44-49.

This controlled study examined the effects of magnetotherapy in patients suffering from neurocirculatory hypotension (low blood pressure) or hypertension (high blood pressure). Treatment consisted of a running pulsed magnetic field generated an "ALIMP" device (0.5 mT, 300 Hz) administered for 20 minutes per day over a course of 10 days. Patients suffering from hypotension did not benefit significantly from the magnetotherapy. Hypertension patients, however, showed a marked improvement with respect to symptoms including headache, chest pain, extremity numbness, abnormal systolic and diastolic blood pressure, and work capacity.

L.L. Orlov, et al., "Effect of a Running Pulse Magnetic Field on Some Humoral Indices and Physical Capacity in Patients with Neurocirculatory Hypo- and Hypertension," *Biofizika*, 41(4),

1996, . 944-948.

This double-blind, placebo-controlled study found that low-frequency, low-intensity electrostatic fields (40-62 Hz) administered for 12-14 minutes per day helped normalize blood pressure in patients suffering from hypertension.

T.A. Kniazeva, "The Efficacy of Low-Intensity Exposures in Hypertension," *Vopr Kurortol Fizioter Lech Fiz Kult*, 1, 1994, . 8-9.

This study examined the effects of low-frequency alternating magnetic fields in patients suffering from arteriosclerosis or osteoarthritis deformans. Treatment

involved 10-15 minute daily leg exposures over a total of 15 days. Results showed the treatment to be effective in 80 percent of arteriosclerosis patients and 70 percent of those with osteoarthritis deformans.

A.G. Kakulia, "The Use of Sonic Band Magnetic Fields in Various Diseases," *Vopr Kurortol Fizioter Lech Fiz Kult*, 3, 1982, . 18-21.

This study examined the effects of low-frequency magnetic fields (25 mT) in patients suffering atherosclerotic encephalopathy. Treatment involved 10-15 minute daily

exposures over a total of 10-15 applications. Results showed clinical improvements with respect to chest pain, vertigo, headache, and other symptoms.

S.S. Gabrielian, et al., "Use of Low-Frequency Magnetic Fields in the Treatment of Patients with Atherosclerotic Encephalopathy," *Vopr Kurortol Fizioter Lech Fiz Kult*, 3, 1987, . 36-39.

Chronic Venous Insufficiency

This study examined the effects of alternating magnetic fields (15-20 minutes per day over a period of 20 days) in patients suffering from chronic venous insufficiency, varicose veins, and trophic shin ulcers. Results showed good effects in 236 of the 271 patients receiving the treatment. Thirty-four patients reported satisfactory effects. Only one patient experienced no effects.

E.I. Pasyukov, et al., "Therapeutic Use of Alternating Magnetic Field in the Treatment of Patients with Chronic Diseases of the Veins of the Lower Limbs," *Vopr Kurortol Fizioter Lech Fiz Kult*, 5, 1976, . 16-19.

This review article notes that magnetotherapy in a variety of forms has been successfully used in the treatment of chronic venous insufficiency and is a commonly used physical therapy for the condition.

A.P. Dovganiuk, "Balneologic and Physical Therapy of Chronic Venous Insufficiency of Extremities," *Vopr Kurortol Fizioter Lech Fiz Kult*, 2, 1995, . 48-49.

This study examined the effects of running impulse magnetic fields in patients suffering from vessel obliteration diseases of the legs. Treatment consisted of 15-20 whole body exposures (0.5-5 mT, 1-2 Hz) lasting 15-20 minutes each. Results showed treatment led to a significant reduction in the number of patients experiencing leg pain while at rest. Among patients previously unable to walk a

500-m distance, 52 percent were able to complete the distance following treatment. Circulation improved in 75-82 percent of patients.

Y.B. Kirillov, et al., "Magnetotherapy for Obliterative Disease of the Vessels of the Legs," *Vopr Kurortol Fizioter Lech Fiz Kult*, 3, 1992, .. 14-17.

Dental Problems

This placebo-controlled study examined the effects of micromagnets in the treatment of periodontal disease. Micromagnets were attached to the skin over areas of inflammation for a period ranging from 1 to 8 days, with the number of magnets used at once varying from 1 to 6. The course of treatment lasted as long as 4 weeks. Results indicated that

patients receiving the micromagnet therapy experienced earlier and more trouble-free recoveries following oral surgery, as well as less pain relative to controls.

V.E. Kriokshina, et al., "Use of Micromagnets in Stomatology," *Magnitologiya*, (1), 1991, . 17-20.

This controlled study examined the effects of adjunctive Diapulse electromagnetic therapy on oral surgery recovery. Patients received the therapy once per day beginning between 3 to 5 days prior to oral surgery. Therapy was maintained until the point of hospital release. Results found the therapy produced significant healing relative to controls, which received conventional treatment only.

L.C. Rhodes, "The Adjunctive Utilization of Diapulse Therapy Pulsed High Peak Power Electromagnetic Energy) in Accelerating Tissue Healing in Oral Surgery," *Q National Dental Association*, 40(1),

1981, . 4-11

This study found that patients suffering from various oral diseases experienced more rapid healing when treated with both conventional therapies and 30 minutes per day of pulsed electromagnetic fields (5 mT, 30 Hz), as opposed to conventional therapies alone.

V. Hillier-Kolarov & N. Pekaric-Nadj, "PEMF Therapy as an Additional Therapy for Oral diseases," *European Bioelectromagnetics Association*, 1st Congress, 23-25 January 1992, Brussels, Belgium.

Depression

This review article examined the literature concerning the use of transcranial magnetic stimulation in the treatment of depression. Results showed the high-frequency, repetitive transcranial magnetic stimulation treatment to be an effective, side-effect free therapy for depression that may hold promise for

treating related psychiatric disorders as well.

M.T. Kirkcaldie, et al., *Transcranial Magnetic Stimulation as Therapy for Depression and Other Disorders*, *Aust N Z J Psychiatry*, 31(2), April 1997, . 264-272.

Noting that there is good reason to believe the pineal gland is a magnetosensitive system and that application of magnetic fields in experimental animals has a similar effect to that of acute exposure to light with respect to melatonin secretion, the authors propose that magnetic treatment could be a beneficial new therapy for winter depression in humans.

R. Sandyk, et al., "Magnetic Fields and Seasonality of Affective Illness: Implications for Therapy," *International Journal of Neurosci*, 58(3-4), June 1991, . 261-267.

This review article notes that transcranial magnetic stimulation has been shown to elicit antidepressant effects, electrically stimulating deep regions of the brain.

C. Haag, et al., "Transcranial Magnetic Stimulation. A Diagnostic Means from Neurology as Therapy in Psychiatry?" *Nervenarzt*, 68(3), March 1997, . 274-278.

In this theoretical paper, the author argues that deep, low-rate transcranial magnetic stimulation can produce therapeutic effects equivalent to those of electroconvulsive therapy but without the dangerous side effects.

T. Zyss, "Will Electroconvulsive Therapy Induce Seizures: Magnetic Brain Stimulation as Hypothesis of a New Psychiatric Therapy," *Psychiatr Pol*, 26(6), November-December 1992, . 531-541.

This study examined the effects of millimeter wave (MW) therapy as a supplemental treatment in patients suffering from various types of depression. MW therapy involved the use of a "YavTM-1" apparatus (5.6 mm wavelength, 53 GHz), and consisted of up to 60 minutes of exposure per day, 2 to 3 times per week, for a total of as many as 15 exposures. Results showed that combined MW/conventional treatment produced a complete recovery in over 50 percent of cases studied, a significant improvement in 41 percent, and some improvement in 8 percent. Recovery rates among controls (conventional treatment only) were 4, 48, and 41 percent, respectively.

G.V. Morozov, et al., "Treatment of Neurotic Depression with a Help of Extremely High Frequency Electromagnetic Radiation," *Zh Nevropatol Psikhiatr Im S S Korsakova*, 96(6),

1996, . 28-31.

Results of this study led researchers to conclude that patients suffering from major depression experienced a significant reduction of depressive symptoms following treatment with transcranial magnetic stimulation coupled with standard medication relative to patients taking the medicine. This was true after just three TMS treatments.

Conca, et al., "Transcranial Magnetic Stimulation: A Novel Antidepressive Strategy?" *Neuropsychobiology*, 34(4), 1996, . 204-207.

Dermatitis

This study examined the effects of conventional treatments combined with millimeter wave (MW) therapy (54- to 70-GHz frequency, 8-15 daily exposures of 15-30 minutes each) on patients suffering from atopic dermatitis. Results indicated that the MW

therapy was well-tolerated all patients, with the rash generally regressing after 7-8 exposures. Marked recovery was seen among 78 percent of patients receiving the combination treatments. Two-year follow-up showed a 23-percent relapse rate among combination patients, compared to 54 percent among controls.

V.P. Adaskevich, "Effectiveness of the Use of Millimeter-Range Electromagnetic Radiation in Complex Treatment of Atopic Dermatitis Patients," *Millimetrovie Volni v Biologii i Meditsine*, (3), 1994, . 78-81

Diabetes

In this study, 320 diabetics received impulsed magnetic field treatment while 100 diabetics (controls) received conservative therapy alone. Results showed beneficial effects with respect to vascular complications in 74 percent of the patients receiving magnetotherapy combined with conservative methods, compared to a 28-percent effectiveness rate among controls.

I.B. Kirillov, et al., "Magnetotherapy in the Comprehensive Treatment of Vascular Complications of Diabetes Mellitus," *Klin Med*, 74(5), 1996, . 39-41.

This study involving 72 diabetics with purulent wounds found that magnetic fields aided healing significantly.

R.A. Kuliev & R.F. Babaev, "A Magnetic Field in the Combined Treatment of Suppurative Wounds in Diabetes Mellitus," *Vestn Khir Im I I Grek*, 148(1), January 1992, . 33-36.

Diseases of the Larynx

Results of this study found that alternative magnetic field of sound frequency proved to be an effective treatment in patients suffering from acute inflammatory

diseases of the larynx.

D.I. Tarasov, et al., "Effectiveness of Local Magnetic Field of the Acoustic Frequency in the Treatment of Patients with Acute Inflammatory Diseases of the Larynx," *Vestn Otorinolaringol*, (6),

November-December 1995, . 11-15.

Duchenne-Erb Disease

This study examined the effects of electromagnetic fields in the treatment of 5-year-old children suffering from Duchenne-Erb disease. Children were exposed to either UHF or DMW therapy for 8-12 minutes per day on alternating days over a period of approximately 10 days. Following the electromagnetic fields course, children received

mud applications on the collar area and injured extremity. Results showed that treatment decreased contractures in shoulder and elbow joints, increased mobility and muscle strength, and improved general function of the arm.

A.D. Burigina, et al., "Electromagnetic Waves in Complex Therapy of Children with Birth Trauma: Effects of Ultra-High-Frequency Electric Fields on Central Hemodynamics and the Shoulder Plexus," *Vopr Kurortol Fizioter Lech Fiz Kult*, (4), 1992, 35-38.

Endometriosis

This study found that a combined treatment consisting of magnetic-infrared-laser therapy (10-15 min/day every other day over a period of 10-14 exposures, then repeated in 2-3 months) and conventional drug therapy proved highly effective in women suffering from endometriosis.

M. Damirov, et al., "Magnetic-Infrared-Laser Therapeutic Apparatus (MILTA) in Treatment of Patients with Endometriosis," *Vrach*, 12, 1994, . 17-19.

Endometritis

Results of this study found that the administration of constant magnetic field in combination with other treatment modalities led to significant beneficial effects in patients suffering from acute endometritis following abortion.

V.M. Strugatskii, et al., "A Permanent Magnetic Field in the Combined Treatment of Acute Endometritis After an Artificial Abortion," *Vopr Kurortol Fizioter Lech Fiz Kult*, (6), November-December 1996, . 21-24.

Epilepsy

This article reports on the cases of three patients with partial seizures who received treatment with external artificial magnetic fields of low intensity. Such treatment led to a significant attenuation of seizure frequency over a 10-14-month period.

P.A. Anninos, et al., "Magnetic Stimulation in the Treatment of Partial Seizures," *International Journal of Neurosci*, 60(3-4),

October 1991, . 141-171.

Experimental results indicated that the administration of modulated electromagnetic fields of 2-30 Hz suppressed epilepsy in rats.

G.D. Antimonii & R.A. Salamov, "Action of a Modulated Electromagnetic Field on Experimentally Induced Epileptiform Brain Activity in Rats," *Biull Eksp Biol Med*, 89(2),

February 1980, .

This review article cites one study in particular in which results showed that pretreatment with 30 minutes of exposure to a 75-mT pole strength, DC-powered magnetic field significantly prevented experimentally induced seizures in mice.

M.J. McLean, et al., "Therapeutic Efficacy of a Static Magnetic Device in Three Animal Seizure Models: Summary of Experience," Second World Congress for Electricity and Magnetism in Biology and Medicine, 8-13 June 1997, Bologna, Italy.

This double-blind, placebo-controlled study examined the effects of 2-hour exposure to weak magnetic fields (0.2-0.7 G, irregularly oscillating 0.026-0.067 Hz) produced by 3 pairs of orthogonal Helmholtz coils on pain perception in healthy subjects. Results showed that magnetic treatment significantly reduced the perception of pain.

F. Sartucci, et al., "Human Exposure to Oscillating Magnetic Fields Produces Changes in Pain Perception and Pain-Related Somatosensory Evoked Potentials," Second World Congress for Electricity and Magnetism in Biology and Medicine, 8-13 June 1997, Bologna, Italy.

This article reports on the case of a severe epileptic who experienced a significant lessening of behavior disturbances and seizure frequency following treatment with low-frequency, external artificial magnetic fields.

R. Sandyk & P.A. Anninos, "Magnetic Fields Alter the Circadian Periodicity of Seizures," International Journal of Neurosci, 63(3-4), April 1992, . 265-274.

Low-frequency, external artificial magnetic field treatment was shown to significantly reduce seizures in four adult epileptic cases.

R. Sandyk & P.A. Anninos, "Attenuation of Epilepsy with Application of External Magnetic Fields: A Case Report," International Journal of Neurosci, 66(1-2), September 1992, . 75-85.

Gastroduodenitis

Results of this study indicated that treatment with decimeter-band electromagnetic fields improved motor function of the stomach and reduced dyspepsia and pain in children suffering from chronic gastroduodenitis. Treatment made use of the "Romashka" apparatus (a cylinder applicator, 100 mm in diameter, power of 6-8 W) applied to the gastroduodenal region, and consisted of 6-12 minute exposures every other day for a total of 8-12 exposures.

L.M. Petrukhina, et al., "Effect of a Decimeter Wave Electromagnetic Fields on the Motor Function of the Stomach in Children with Strong Gastroduodenitis," Vopr Kurortol Fizioter Lech Fiz Kult, (1), 1987, . 54-56.

This controlled study examined the effects of sinusoidally modulated currents (100 Hz) coupled with conventional therapy in children suffering from chronic gastroduodenitis. Children received 8-10 exposures lasting between 6 and 10 minutes. Results showed that the treatment reduced inflammation in 72 percent of patients relative to just a 45-percent rate among controls. About 77 percent of treatment patients experienced elimination of gastro-esophageal and duodeno-gastral refluxes, compared to 29 percent of controls.

O.V. Bukanovich, et al., "Sinusoidally-Modulated Currents in the Therapy of Chronic Gastroduodenitis in Children," *Vopr Kurortol Fizioter Lech Fiz Kult*, 2, 1996, . 22-26.

General

Results of this study indicated that the optimal frequency of pulsed magnetic fields ranges between 10.0 and 25.0 Hz in the treatment of chronic inflammatory conditions of the locomotor apparatus, ischemia of the blood vessels of the lower extremities, dyspeptic syndrome, lactation mastitis, and other diseases. Treatment proved best when the therapeutic cycle was repeated after a 2-3 month period.

L. Navratil, et al., "Possible Therapeutic Applications of Pulsed Magnetic Fields," *Cas Lek Cesk*, 132(19), October 11, 1993, . 590-594.

This article reviews the use of magnetotherapy in Czechoslovakia. Noting that this modality has been used for more than a decade, the author states that magnetotherapy has been shown to be effective in treating rheumatic diseases, sinusitis, enuresis, and ischemic disorders of the lower extremities. Positive findings have also been shown with respect to multiple sclerosis and degenerative diseases of the retina.

J. Jerabek, "Pulsed Magnetotherapy in Czechoslovakia—A Review," *Rev Environ Health*, 10(2), April-June 1994, . 127-134.

This review article notes that pulse-type electromagnetic fields (PEMF) are the most frequently used type of electromagnetic therapy. Another form is pulsed radio frequency; PRF therapy generally includes daily sessions of 30-minute exposure and is primarily used in cases of pain and edema, with results being apparent quickly when the therapy is effective. PEMF treatment is most successful when used in bone healing, with results occurring over a longer period of time.

A.A. Pilla, "State of the Art in Electromagnetic Therapeutics: Soft Tissue Applications," *Second World Congress for Electricity and Magnetism in Biology and Medicine*, 8-13 June 1997, Bologna, Italy.

This study examined the effects of electromagnetic fields administered over a period of 10 days on 354 patients suffering from various orthopedic conditions. Results showed

the effects to be positive, with the greatest benefit experienced among patients with acute lesions.

G. Annaratone, et al., "Magnetotherapy in Clinical and Ambulatory Practice," *Minerva Med*, 74(14-15), April 7, 1983, . 823-833.

Noting that beneficial effects of low-energy, time-varying magnetic fields have been shown since the early 1970s, this review article cites studies pointing to its success in the treatment of a wide range of conditions. The best results for this modality obtained in the area of bone healing.

C.A. Bassett, "Fundamental and Practical Aspects of Therapeutic Uses of Pulsed Electromagnetic Fields (PEMFs)," *Crit Rev Biomed Eng*, 17(5), 1989, . 451-529.

This review article claims that over a quarter of a million patients worldwide with chronically ununited fractures have experienced beneficial results from treatment with pulsed electromagnetic fields. In addition, the author cites studies pointing to the treatment's efficacy with respect to other conditions such as nerve regeneration; wound healing, graft behavior, diabetes, heart attack, and stroke.

C.A. Bassett, "Beneficial Effects of Electromagnetic Fields," *Journal of Cell Biochem*, 51(4), April 1993, p. 387-393.

This review article notes that low-intensity millimeter waves have been used for treating a wide variety of medical conditions in the former Soviet Union since 1977, with more than a million patients treated and more than a thousand treatment centers in existence. This therapy has been approved for widespread use by the Russian Ministry of Health, and over 300 scientific publications have described its effects. A typical course of treatment involves 10-15 daily exposures ranging from 15 to 60 minutes each.

A.G. Pakhomov, "Millimeter Wave Medicine in Russia: A Review of Literature," *Infrared Lasers and Millimeter Waves Workshop: The Links Between Microwaves and Laser Optics*, January 21-22, 1997, Brooks Air Force Base, Texas.

This study concluded that the use of millimeter wave (MW) therapy was effective in the treatment of both children and adults suffering from a variety of orthopedic diseases, including osteochondrosis, arthrosis, infantile cerebral paralysis, Perthes' disease, and inborn femur dislocation. MW therapy made use of the G4-142 apparatus (55-65 GHz). Exposure was for 15-30 minutes in children or 30-60 minutes in adults over a period of 10-12 total exposures.

S.D. Schvchenko, et al., "Experience with Treating Some Orthopedic Diseases with Millimeter Range Radiation of Nonthermal Intensity," *Millimeter Waves in Medicine*

and Biology. Digest of Papers of the 11th Russian Symposium with International Participation,

April 21-24, 1997, Zvenigorod, Moscow Region, Russia, p. 33-35. 139. A.M.

This research examined the effects of low-frequency pulsed electromagnetic fields on patients suffering from a wide range of disorders, including musculoskeletal disorders, neurological disorders, circulatory diseases, traumatic disorders, gastroenterological problems, and stress-related morbidity. Treatment made use of the Rhumart apparatus, which produced waveforms with peak amplitudes up to 30 G. Results, based on the patients' own subjective ratings, indicated the treatment to be beneficial across most conditions, with the strongest effects seen in those suffering from musculoskeletal and traumatic disorders.

Begue-Simon & R.A. Drolet, "Clinical Assessment of the Rhumart System based on the Use of Pulsed Electromagnetic Fields with Low Frequency," *International Journal of Rehabil Research*, 16(4),

1993, p. 323-327.

This review article summarizes findings presented at the Third Workshop on the

use of low-intensity millimeter waves in medicine, held in Zvenigorod, Moscow Region, Russia. Such findings pointed to the efficacy of MW therapy with respect to alcoholism and its associated symptoms, gastric and duodenal ulcers, psoriasis, chronic furunculosis, and cardiovascular diseases.

Y.L. Arzumanov, "An Overview of the Third Workshop ~Use of Millimeter Waves in Medicine," *Millimetrovie Volni v Biologii i Meditsine*, (3), 1994, p. 104-107.

This study examined the effects of magnetotherapy on patients suffering from a variety of eye and brain vascular disorders. Treatment made use of the "Polius-1" apparatus (50 Hz), with most patients receiving a course of 15-20 daily exposures. Results showed overall general improvements in 95 percent of patients with eye diseases.

N. Gilinskaya & L.V. Zobina, "Magnetic Field Application for the Treatment of Vascular Diseases of the Brain and Eyes," in Y.A. Kholodov & N.N. Lebedeva (eds.), *Problems of Electromagnetic Neurobiology*, Moscow, Nauka,

1988, p. 94-98.

This review article notes that low-frequency electromagnetic therapy has been used for a variety of purposes. Those specifically identified by the author include cell growth promotion, pain reduction, improved blood circulation, bone repair, increased wound healing, sedative effects, enhanced sleep, and arthritic relief.

R.A. Drolet, "Rhumart Therapy: A Non-invasive Cell Regeneration Ion and Anti-Inflammatory Therapy Using LF-EM Fields," Bioelectromagnetics Society, 4th Annual Meeting,

28 June-2 July 1982, Los Angeles, CA, p. 45.

This review article notes that treatment with an "Infita" apparatus, used to deliver low-frequency magnetic fields, has been shown to improve general hemodynamics and microcirculation in addition to exhibiting anti-inflammatory, sedative, and analgesic effects in Olympic-level Russian athletes.

A. Zaslavskii, et al., "A Low-frequency Impulse Apparatus for Physical Therapy "Infita"™," Med Tehk, 5, 1994, p. 39-41.

This review article cites studies pointing to the efficacy of low-frequency magnetic fields in the treatment of a wide variety of conditions, including burns, arthritis, fractures, arterial aneurysms, PMS, phantom pain, tuberculosis, ischemic heart disease, hypertension, bronchial asthma, and ulcerated varicose

veins, among others.

V.M. Bogoliubov & L.A. Skurikhina, "Therapeutic Application of Constant and Low-Frequency Magnetic Fields," Vopr Kurortol Fizioter Lech Fiz Kult, (2), 1979, p. 65-72.

This study examined the effects of extremely-low-frequency magnetic fields (TAMMAT device) in the treatment of a group of 650 patients suffering from a host of various diseases. Treatment consisted 15-25 minute daily exposures 5 days per week over a total of 20-25 days. Most patients experienced improvements after 2-3 exposures. Marked improvements were seen with respect to analgesic, anti-inflammatory, anti-tumor, and immune-enhancing effects.

V.I. Kovalchuk, et al., "Use of Extremely-Low-Frequency Magnetic Fields in Clinical Practice," Fizicheskaia Meditsina, 4(1-2), 1994, p. 87

This article reports on the efficacy of a Russian electromagnetic stimulation apparatus termed "Cascade." The authors state that data from 508 patients suffering from various ailments who were treated with the device indicate it to be anywhere from 75 to 100 percent effective. Examples of conditions in which the device was used include stubborn fractures, post-traumatic contractures, crush syndrome, and Perthes'™ disease.

S.A. Schastnyi, et al., "Contact-Free, Biologically Adequate Electromagnetic Stimulation of Repair Regeneration of Osseous, Cartilaginous, and Muscular Tissues in Children," *Vestn Ross Akad Med Nauk*, (3), 1994, p. 38-42.

This review article on the use of pulsed magnetotherapy in Czechoslovakia points to its efficacy across a variety of conditions, including joint problems, enuresis, multiple sclerosis, diabetes, and carpal tunnel syndrome.

J. Jerabek, "Pulsed Magnetotherapy in Czechoslovakia: A Review," *First World Congress for Electricity and Magnetism in Biology and Medicine*,

14-19 June 1992, Lake Buena Vista, FL, p. 81.

Glaucoma

In this study, patients with primary open-angle glaucoma with compensated intraocular pressure were administered magnetotherapy using an ATOS device with 33-mT magnetic field induction. The procedure was administered to a patient in a sitting posture with a magnetic inductor held before the eye. Sessions lasted 10 minutes and each course included 10 sessions. Following 4-5 months of therapy, results showed improved vision acuity 0.16 diopters, on an average of

29 out of 30 eyes with vision acuity below 1.0.

Bisvas, et al., "Possibilities of Magnetotherapy in Stabilization of Visual Function in Patients with Glaucoma," *Vestn Oftalmol*, 112(1), January-March 1996, p. 6-8.

Hair Loss

This double-blind, placebo-controlled study examined the effects of pulsed electromagnetic fields on hair loss in men suffering from male pattern baldness. PEMF exposures were administered to the head for 12 minutes and were given weekly or twice weekly over a period of 36 weeks. Results found the PEMF treatment both prevented hair loss and promoted regrowth without side effects.

W.S. Maddin, et al., "The Biological Effects of a Pulsed Electrostatic with Specific Reference to Hair: Electrotrichogenesis," *International Journal of Dermatology*, 29(6), 1990, p. 446-450.

Headache

Results of this double-blind, placebo-controlled study demonstrated that the administration of a pulsed magnetic field for less than one hour to headache patients produced significant beneficial effects, as shown subjective patient reports, as well as EEG activity.

O. Grunner, et al., "Cerebral Use of a Pulsating Magnetic Field in Neuropsychiatry Patients with Long-term Headache," EEG EMG Z Elektroenzephalogr Verwandte Geb, 16(4),

December 1985, p. 227-230

This article reports on the case of a