THE EVOLUTION OF PEMF THERAPY IN SCIENCE AND MEDICINE

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History of Electro-Magnetic Therapy

Humans have evolved and continue to evolve with the environment. Environmental factors such as weather, temperature, seasonal changes, and diurnal variations are important elements in our world and all intimately involved with electromagnetic energy. This Earth we live on generates a geomagnetic field that is crucial to survival of all biological systems on this planet. The inseparable relationship between energy and matter have always been of interest to scientists and has emerged as an invisible web that connects all of this world and the universe we live in.

Early Shamans, doctors, and scientists innately knew of this connection with nature and sought to use this force to influence our health. Magnetically charged lodestones were used to manipulate the flow of blood and ionic or charged particles within the body. In addition, acupuncture needles were used at specific points to stimulate the human biofield (referred to as qi) and influence blood flow.

Natural electricity and magnetism have also been used throughout recorded history for therapeutic purposes. Accounts from ancient Roman physicians (ca 47 AD) discuss the use of electric eels (torpedo fish) to treat a range of medical problems from gout to headaches and even musculoskeletal injuries. Applying a combination of electricity and magnetism is the cutting edge of emerging technologies such as Pulsed Electromagnetic Field (PEMF) Therapy that we have at our disposal to maintain and sustain health and treat disease.

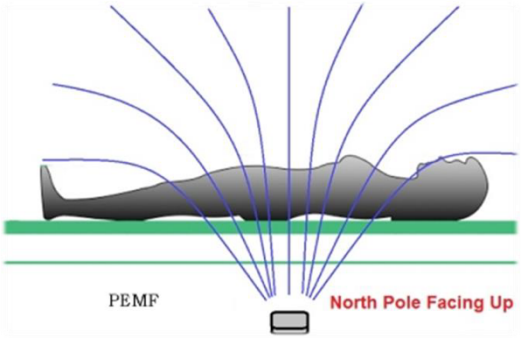

Figure 1. Pulsed Electromagnetic Field as a systemic therapy.

In the 1800's most of the discoveries relating electricity to magnetism were made by the early pioneers of our modern technical world (e.g., *Gauss, Weber, Faraday and Maxwell*). By the end of the 19th century, the electron was discovered and electro-magnetism was brought into the realm of science on the atomic level. By the 20th century, Albert Einstein showed that electricity and magnetism are not discrete phenomena, but different aspects of the same phenomenon. Not until after World War WII did scientists in Japan begin generating various electromagnetic wave shapes by changing electrical currents and

observing their physiological effects. This modality quickly moved to Europe and then forward to the United States.

In the 1970s Bassett et al. (1974) introduced at Columbia University Medical Center a new approach for the treatment of non-healing bone fractures and pseudarthroses that employed very specific bi-phasic, low frequency, electromagnetic signals. Public awareness also increased in the mid-1970s amidst reports of successful enhancement of the speed and endurance of race horses treated with electromagnetic fields.

The U.S. Food and Drug Administration cleared the application of electromagnetic fields for non-union and delayed union fractures based on the published work of Bassett et al. (1977; 1982). In 1987 the FDA cleared the use of pulsed electromagnetic fields for the treatment of pain and edema in superficial soft tissues. More recently the FDA cleared in 2008 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. The latest clearance by the FDA was in 2013 for the treatment of Migraine Headaches when applied during the prodrome or migraine aura.

While all these approvals were with high power PEMF devices, it is now commonly accepted that even weak or low power pulsed electromagnetic fields with the appropriate waveform are capable of initiating various beneficial biological processes leading to numerous applications in healthcare and medicine.

PEMF Therapeutic Effects & Clinical Applications

Table 1 describes many of the therapeutic effects and clinical applications of PEMF Therapy. A therapeutic modality like PEMFT can do so much because it is not a drug with one or two isolated mechanisms of action. PEMFT provides an activation energy that triggers innate, self-regulating mechanisms within the body. The most common manner in which PEMF works is through an inductive effect. PEMF influences charged particles within the body. The other more complex effect is that which occurs through resonance-activating molecules, cells, and tissues.

Table 1. Effects of PEMF through research and clinical practice (left column) and diseases that can benefit from PEMFT (right column).

Modulates inflammation	Cardiovascular related diseases
Reduces pain and edema	Diabetic related diseases
Improves blood flow	Eye diseases
Promotes tissue repair	Concussion/Traumatic Brain Injury (TBI)
Promotes tissue regeneration	Osteoporosis/Osteopenia
Improves wound care outcomes	Muscle atrophy
Improves neurological function	Arthritis
Improves cardiac function	Stroke rehabilitation
Reduces fatigue	Urinary Incontinence
Improves performance	Sleep disorders
Accelerates recovery	Seizures and Epilepsy
Enhances well-being	Neuro-degenerative diseases
Supports detoxification	Peripheral Neuropathy

For example, PEMF reduces or modulates inflammation and promotes repair by triggering a signaling compound in the body called nitric oxide (NO). There is a pro-inflammatory form of nitric oxide (iNOS) and two anti-inflammatory forms (eNOS and nNOS). Excess levels of the pro-inflammatory form cause chronic pain and many autoimmune and inflammatory diseases. The anti-inflammatory forms promote blood flow, oxygenation, growth and repair, and relaxation of blood and lymph vessels. Studies show PEMF promotes the anti-inflammatory forms of nitric oxide, which supports recovery, regeneration, and the modulation of inflammation. PEMF enhances the repair of bones and tissue by increasing the flow of blood

and lymph. The lymphatic system removes waste products and blood delivers oxygen and nutrients to the body's tissues and organs. PEMF enhances these systems, stimulating the growth of new blood vessels (angiogenesis) and bone, and speeds repair and recovery from injuries and wounds.

The resting potential of damaged and diseased cells is up to 80 percent lower than normal. This lowers metabolism and energy and makes the body more vulnerable to damage from disease-causing free radicals. PEMF raises the body's supply of circulating electrons, thus serving as a potent antioxidant to boost cellular energy. PEMF's antioxidant benefits, along with its proven ability to repair and regenerate tissue, make it a powerful anti-aging or healthy aging tool. Studies show that PEMF's effect on the nervous system dramatically improves neuropathies, insomnia, reduces the damage from strokes, and improves symptoms associated with multiple sclerosis.

Parameters of PEMF

The following parameters are integral to Pulsed Electromagnetic Field Therapy: waveform, frequency, intensity/flux density, timeline, delivery system.

PEMF Research

a. Preclinical studies

NASA research interests include physiological and molecular genetic effects of time-varying electromagnetic fields on human neuronal cells (Goodwin, 2003). Walther (2007) reported the results of his study that indicate that the exposure to weak, low-frequency pulsed electromagnetic fields is able to alter the gene expression of a limited number gene products in human mesenchymal stem cells and human chondrocytes. Regulated genes identified in Walther's study via gene chip analyses mainly affect cell metabolism and the cellular matrix.

Kafka et al. (2005) reports that the effects appear to be cell specific. There was no increased expression of genes known to be linked to cancer development nor inductions observed of mRNA levels related to other diseases in their study on MSCs and chondrocytes or in previous study on human osteoblasts. This study confirmed the data retrieved from several other trials where, so far, there is no evidence that low-energy pulsed electromagnetic fields may induce the development of malignant tumors (Feychting and Forssén, 2006; Johansen and Olsen, 1998; Loberg et al., 2000; Tynes and Haldorsen, 2003).

b. Bone Loss and Muscle Atrophy

Although studies on PEMF have been ongoing for more than 20 years, little is known about the molecular and cellular mechanisms involved in their beneficial therapeutic effects. In particular, the field energetics must be precisely defined and optimized for specific applications, such as frequencies, pulse shape, waveforms, amplitude, and spatial orientation (Byerly et al., 2005)

c. Chronic Degenerative Muscle and Musculoskeletal Disorders

The therapy administered in combination with traditional physiotherapy procedures reduces chronic lower back pain in the short term and may be effective in the long-term treatment of patients with osteoarthritis of knee (Gyulai et al., 2015).

d. Multiple Sclerosis Fatigue

In one pilot study (Piatkowski et al., 2009) it was demonstrated that a specific PEMF Therapy had a beneficial effect on MS-related fatigue. There was a statistically significant advantage for the treated patients after 12 weeks of daily use. In another open-label trial (Piatkowski et al., 2011) the positive effects of long-term PEMF use are both a safe and effective adjunctive treatment for MS-related fatigue.

e. Wound Healing

In wound healing studies the following therapeutic endpoints following PEMF Therapy could be

evaluated: inflammation of the perilesional skin; pain or neuropathy; diameter and depth of lesion; infection; PO_2 - PCO_2 percutaneous; metalloproteases; temperature and humidity; capillary changes; healing times; and, number of visits to the physician.

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