# Pulsed Electro-Magnetic Field Therapy and Benefits

## Brief History overview

The principals of Pulsed Electro-Magnetic Field (PEMF) therapy were first described by Nikola Tesla in 1898.

Various types of PEMF devices have been accepted by the regulating bodies in many countries and are sold all over the world.

The US FDA accepted the use of PEMF devices in the healing of:

- Non-union bone fractures in 1979
- Urinary incontinence in 1998
- Muscle stimulation in 1998
- Depression and anxiety in 2006
- Israel has accepted the use of PEMF devices for migraine headaches
- Canada has accepted PEMF devices for powered muscle stimulators.
- The European Union accepted the use of PEMF therapy in many areas including healing and recovery from trauma, degeneration, and the treatment of the pain associated with these conditions.

## Benefits of High Power Pulsed Electro-Magnetic Fields

Worldwide more than 2,000 double-blind, university level medical studies have demonstrated that PEMF therapy is a safe and effective treatment for a variety of medical conditions, as well as to promote and maintain general cellular health and function. Clinical evidence shows that PEMF therapy reduces pain associated with trauma from accidents, sports injuries, surgeries and burns as well as from disease and degeneration. PEMF therapy improves these conditions in many different ways that include mechanical, electrical, chemical, and magnetic processes within the cells of the body. In 1995, Siskin and Walker provided a summary of clinical results on soft tissue damage. PEMF therapy is a non-contact, non-invasive, non-pharmacological and effective treatment for many conditions. No adverse effects were noted and the following positive effects were reported:

- Decreased pain
- Reduced inflammation
- Increased range of motion
- Faster functional recovery
- Reduced muscle loss after surgery
- Increased tensile strength in ligaments
- Faster healing of skin wounds
- Enhanced capillary formation
- Acceleration of nerve regeneration
- And decreased tissue necrosis.

## PEMF Therapy Reduces Pain

After a study on the treatment of migraine with PEMF, Sherman R. et.al (Tacoma, WA) reported decreased headaches in 73% of those receiving actual exposure.

In a study on tissue trauma, Jorgensen W. et.al. (CA, USA) state: *"Unusually effective and long-lasting relief of pelvic pain of gynecological origin has been obtained"* by where 90% of the patients experienced marked, even dramatic relief, while 10% reported less than complete pain.

In yet another study, Hedén P, Pilla AA (Stockholm, Sweden) concluded: *"Pulsed electro-magnetic field therapy, adjunctive to standard of care, can provide pain control with a noninvasive modality and reduce morbidity due to pain medication after breast augmentation surgery".*

Trakya University Medical Faculty of the Physical Medicine and Rehabilitation Department, Edirne, Turkey reports on lateral epicondylitis: *"Pain levels were significantly lower in the group treated with the local steroid at the third week but the group treated with PEMF had lower pain during rest, activity and nighttime than the group receiving steroids at the third month".*

Lau (School of Medicine, Loma University, USA) reports on the application of PEMF therapy to the problems of diabetic retinopathy: *"All patients had a reduction of pain, with 66% reporting that they were totally pain-free".*

Riva Sanseverino, E. et.al. (Universita di Bologna, Italy) studied the therapeutic effects of PEMF on joint diseases, in chronic as well as acute conditions. A general average value of 78.8% of good results and 21.2% of poor results was obtained. A higher, 82% of good results were observed when single joint diseases were considered and 66% of good results with respect to multiple joint diseases (polyarthrosis).

## PEMF Therapy Blocks Pain

A pain signal is transmitted by an electric signal in the nerve cells interrupted by pre-synaptic terminals. A change in the transmembrane potential (TMP) from a normal -70mV to the +30mV threshold is needed to cause the release of a chemical neurotransmitter from a synaptic vesicle contained within the membrane at those terminals. Research by Warnke, 1983; Warnke, et al 1997) suggests that PEMF therapy lowers the TMP to a hyperpolarized level of –90mV thus preventing the pain signal from triggering the neurotransmitter exocytosis as the TMP can only raised to +10mV.

## PEMF Therapy Decreases Inflammation

Several factors contribute to inflammation including injury, tissue damage, a poor localized circulation with swelling and the formation of edema. As PEMF therapy increases circulation and cellular activity

## PEMF Increases Blood Circulation

A study done at the New York University Medical Center (Institute of Reconstructive Plastic Surgery, NY, NY, USA) demonstrates that electro-magnetic fields increases angiogenesis, the growth of new blood vessels, in vitro and in vivo through the endothelial release of FGF-2, fibroblast growth factor-2. The delivery of PEMF therapy in low doses identical to that currently in clinical use significantly increased endothelial cell proliferation and tubulization, which are both important processes for vessel formation. The

ability of PEMF to increase cell proliferation seems unique to endothelial cells releasing a protein in a paracrine fashion (or signaling to adjacent cells and other types of cells) to induce changes in neighboring cells and tissues. The coordinated release of FGF-2 suggests that PEMF therapy may facilitate healing by augmenting the interaction between osteogenesis and blood vessel growth. The fibroblast and endothelial cells are made to go embryonic due to drastic changes in ionic concentrations in the cells' cytoplasm and therefore the cells' nuclei. These ionic concentrations react with the cell DNA opening up some gene sets and closing down others. PEMF therapy has proven efficacious in increasing the flow of ions and nutrients as well as blood flow. Through the same processes, vital organs such as the liver, kidneys and colon are able to rid themselves of impurities thus detoxifying the body and allowing better organ functionality.

## PEMF Increases Cellular Membrane Permeability

As early as 1940 it was suggested that magnetic fields might influence membrane permeability as it affects the TMP and the flow of ions in and out of the cells. Healthy cells in tissue have a voltage difference between the inner and outer membrane referred to as the resting TMP ranging from -70 to -80 mV. This causes a steady flow of ions through the membrane's voltage-dependant ion channels. In damaged cells, the TMP is raised to -50mV causing an increased cations inflow through the Na+ and CA2+ channels. As their concentration rises, interstitial fluid is attracted to the inner cellular space causing swelling and edema. The application of PEMF therapy to damaged cells accelerates the re-establishment of normal potentials reducing swelling and increasing the rate of healing. As the electro-magnetic field pulses temporarily hyperpolarize and depolarize the membrane, the ion channels open and close allowing a more efficient ion exchange, as with the Na/ K pump, and increasing cellular oxygenation and nutrition. (Sansaverino).

## PEMF Increases Cell Metabolism

It has since been established that magnetic fields can influence ATP (Adenosine Tri-phosphate) production; increase the supply of oxygen and nutrients via the vascular system; improve the removal of waste via the lymphatic system; and help to re-balance the distribution of ions across the cell membrane.

## PEMF Increases Energy Storage and Cellular Activity

As the pulsed fields expand and collapse through a tissue, the protein molecules, such as the cytochromes in the cells' mitochondria, gain electrons and, in doing so, store energy by converting ADP to ATP molecules more rapidly. The ATP molecules store and transport the energy that is then used in all the metabolic functions of living cells.

## PEMF Increases Cellular Membrane Flexibility and Elasticity

A study entitled "Modulation of collagen production in cultured fibroblasts by a low-frequency pulsed magnetic field" by Murray J. et.al. (Biochim Biophys Acta) shows that PEMF therapy successfully increases membrane flexibility by increasing the synthesis of collagen, a crucial protein that supports membrane elasticity, within the fibroblasts. In doing so PEMF therapy increases tissue and muscle flexibility and, therefore, increases range of motion, usually within minutes.

## PEMF Stimulates Cellular Communication and Replication

DNA synthesis is linked to pulsed, low intensity magnetic fields (Liboff et al, 1984; Rosch et al, 2004). As conductors of electricity, proteins are subject to electrophoresis. The Ribonucleic Acid ("RNA") messengers that are synthesized from a Deoxyribonucleic Acid ("DNA") template during transcription mediate the

transfer of genetic information from the cell nucleus to ribosomes in the cytoplasm and serve as a template for protein synthesis. Dandliker et al. (1997) show that DNA conducts electrons along the stacked bases within the DNA double helix, electro-magnetic fields may initiate transcription of the precursor mRNA by accelerating electrons moving within the DNA helix (McLean et al, 2003). Therefore, the flow of information to and from genes may be linked to changing magnetic fields (Einstein, 1977; Goodman et al, 1983).

## PEMF Increases Cellular Genesis (Cellular Growth and Repair)

In December 2004, the Swiss Medical Tribune stated that PEMF therapy provided: "improvement of blood circulation, relief from pain, improvement of bone healing and the stimulation of nerve cells".

- PEMF and the spine

Long-term studies such as those by Marks RA. (*Richardson Orthopaedic Surgery, TX, USA*) and Richard A. Silver, M.D. (*Tucson Orthopaedic & Fracture Surgery Associates, Ltd., Tucson, AZ, USA*) demonstrate that adjunctive treatment with PEMF is effective in promoting spinal fusion following PLIF procedures across all patient subgroups.

- PEMF on bone and cartilage

In a study entitled: *"Modification of biological behavior of cells by Pulsing Electro-magnetic fiel*ds", Ben Philipson, Curatronic Ltd. (*University of Hawaii School of Medicine, HI, USA)* demonstrates that PEMF application increases bone density, promotes bone union by electric current induction, which changes the permeability of cell membrane allowing more ions across, affects the activity of intracellular cyclic adenosine monophosphate (cAMP) and cyclic guanosine monophosphate (cGMP), and accelerates osteoblast differentiation. PEMF stimulation also increases the partial oxygen pressure and calcium transport. Repair and growth of cartilage is thus stimulated, preventing grinding of the bones.

- PEMF and tendonitis

The department of rheumatology at Addenbrookes Hospital showed a 65% total success and 18% improvement rate with the use of PMFT for the treatment of persistent rotator cuff tendonitis.

- PEMF and intestines

An experimental study by Nayci A. et.al. Cakmak M, Aksoyek S, Renda N, Yucesan S. (Department of Pediatric Surgery, Mersin University Medical Faculty, Turkey) demonstrated that electro-magnetic field stimulation provided a significant gain in anastomotic healing in both small and large intestine, and a significant increase in both biochemical and mechanical parameters.

- PEMF and the brain

Grant G. et.al. of the Department of Neurosurgery, Stanford University, CA, USA observed that exposure to PEMF attenuated cortical ischemia edema on MRI and reduced ischemic neuronal damage as he stated*:" PEMF stimulation may accelerate the healing of tissue damage following ischemia. Preliminary data suggest that exposure to a PEMF of short duration may have implications for the treatment of acute stroke".*

- PEMF and multiple sclerosis ("MS")

Scientific studies have demonstrated the effects of PEMF on nerve regeneration, brain electrical activity (electro-encephalography), neurochemistry, and immune system components, all important effects for disease pathology and clinical symptoms in MS. Evidence from many studies showed a significant increase in alpha EEG magnitude, a significant improvement in the PS combined rating for bladder control, cognitive function, fatigue level, mobility, spasticity, and vision. Sandyk R. summarizes recent clinical work on the therapeutic effects of PEMF in MS: *"A host of biological phenomena associated with*

*the disease involving interactions among genetic, environmental, immunologic, and hormonal factors, cannot be explained on the basis of demyelination alone and therefore require refocusing attention on alternative explanations, one of which implicates the pineal gland as pivotal. The pineal gland functions as a magnetoreceptor organ. This biological property of the gland provided the impetus for the development of a novel and highly effective therapeutic modality, which involves transcranial applications of PEMF flux density".*

As evidenced by the many studies cited herein, it is clear that PEMF treatment stimulates many aspects of cellular activity. In doing so, PEMF therapy promotes neural regeneration and brain function, and improves neuro-muscular function and general health.

Beyond the complex mechanisms by which it operates remain the health benefits associated with PEMF therapy. PEMF therapy increases blood circulation in and around damaged tissue, and effectively helps damaged cells heal. Generally, PEMF therapy produces one main effect; it stimulates the cell metabolism by increasing the flow of electrons and ions across the cell membrane. This effect involves a chain of processes in the human body, which leads to improvement of health without side effects including:

- Decreased swelling, inflammation and pain
- Increased blood flow by angiogenesis with the formation of new capillaries
- Improved circulation with mechanical contraction and relaxation of blood vessels, and de-clumping of blood cells
- Improved interstitial fluid circulation
- Stimulation of the Na/K pump by increased opening of the ions channels in the cell membrane
- Improved elimination of carbon dioxide and waste products away from the cells
- Increased supply of oxygen, ions and nutrients to cells
- Increased partial oxygen pressure
- Increased ATP production by excitation and increased transport of electrons in the mitochondria
- Stimulation of RNA, DNA and protein bio-synthesis by electron and energy transfer
- Stimulation of inter cellular communication
- Regulation of the anti-oxidation by increased circulation of available electrons
- Increased collagen production with associated enhanced cellular and tissue elasticity
- Increased calcium transport and absorption for stronger bones, joints and muscles
- Increased cellular genesis promoting bone, cartilage, tendon and soft tissue growth
- Stimulation of cellular repair mechanisms
- Enhanced macro circulation: by mechanically de-clumping blood cells, by alternately dilating and constricting vessels, and by angiogenesis, the growth of new blood vessels
- Accelerated detoxification of cells and organs
- Decreased swelling, inflammation and pain
- Activation of cellular and molecular processes enhancing the internal self-regulating mechanisms of the body.
- PEMF therapy helps the body's natural processes and promotes healing.