REVIEW ARTICLE

Electromagnetic field as a pain relieving modality: A review of the current literature

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Abstract

The therapeutic effects of electromagnetic fields (EMFs) on a variety of diseases ranging cancer to chronic pain have been reported by many medical literatures. Different modalities of EMFs have shown significant potential as pain relieving agents. This study aims to review the therapeutic efficacy of EMFs as analgesic modalities and recent advances in clinical applications. In addition, the mechanisms of actions of pain relieving effects of EMFs are discussed. The databases of PubMed (1990-2016), EMBASE (1990-2016), Web of Sciences (1990-2016), and Google Scholar (1980-2016) were searched using the set terms of "EMFs," "pain," and "effectiveness." The obtained records were reviewed, and relevant studies were selected for comprehensive review of the current literature. Current evidence indicates relatively high pain relieving effectiveness of different modalities of EMFs for both in acute and chronic pains. Pulsed EMFs have shown promising therapeutic effects in reducing post-operative pains as well as idiopathic pains have shown significantly reduced post-operative pain and also narcotic use in the immediate post-operative period. To reach an efficient protocol for each type of pain, conducting large sample size multi-center clinical trials is needed.

Key words: Effectiveness, electromagnetic fields, pain, post-operative

INTRODUCTION

The idea of using electric and magnetic fields for disease treatment and health promotion dated back to early human civilization when Scribonius Largus recommended the use of torpedo fish for the treatment of headaches and gouty arthritis.[1] However, the first medical application of electromagnetic fields (EMFs) as a field of study has started in late 18th century when European and American scientists began to investigate the medical application of electromagnetism. The underpinning concept of using electric and magnetic fields in diseases originate in the nature of living cells that is based on electrical and magnetic phenomena. EMFs can easily interact with endogenous electric and magnetic fields which in turn result in permanent cellular and molecular, physiological, and behavioral changes in living creatures. One main hypothesis for application of EMFs for the treatment of disorders is that in any disease; the electrical or magnetic features of the involved cells, tissues, organs, or systems are disrupted and applying exogenous EMFs can balance them to the healthy state. These changes can be directed to treat different disorders. In this regard, different EMF based methods have been developed for the treatment of different disorders.

Therapeutic devices based on EMFs have been confirmed by the US Food and Drug Administration and widely used in various diseases such as wound healing, knee arthritis, union of fractures, ligament and muscle injuries, chronic and acute pain, treatment, and prevention of osteoporosis.[2-12] Different types of electric, magnetic, and EMFs including static magnetic and electric fields, and pulsed EMFs (PEMFs) have been used for the relief of acute and chronic pain for centuries, but their mechanisms of actions are not fully understood.

The ability of EMFs to relieve pain is dependent on the origin of pain and its type such as acute or chronic.

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Mechanisms of pain are complex and may be originated from the peripheral or central nervous system. Base on the location and features of pain, therapies should be designed in the individual patient. For solve the problem and provide most effective pain management strategies especially for chronic pain require the review and design of various and multiple studies. Scientific evidence of static or EMFs effects on reduce pain and other biologic problems had not been known until recently.[13] The main objective of treatment is rapid pain relief. The control of pain leads to reduction of treatment period and costs. In addition, it causes rapid return of patients to work and normal lifestyles.[14] PEMFs was shown a significant effect on reduce pain and disability in patients with chronic pain.[5,6] In response to EMF exposure, a reduction of experimental synovitis was observed.[15,16] The efficacy and optimal modes of EMF are intensely controversial, and researchers are trying to find an optimal therapeutic strategy with the most effectiveness and affordable.

EMF THERAPY USE TO CHRONIC PAIN

The transcutaneous electric nerve stimulation had become a beneficial physical therapy tool for acute and chronic pain in the early 1970s.[17,18] In addition, pulsed electromagnetic therapy (PEMT) has been evaluated for the treatment of chronic pain, and the clinical benefits were comparable to those of placebo.[5,6,19] One of the most common reasons of referring patients for medical treatment is chronic back pain. Based on these requirements development of effective symptomatic treatment for reduced pain and disability is vital.

Lee *et al*. in a randomized, double-blind and placebo-controlled study evaluated the efficacy of PEMT for chronic low back pain. Results have shown that PEMT reduced pain and disability. They suggested that PEMT has a potentially useful therapeutic tool for the conservative management of chronic lower back pain.[19] Many devices of PEMFs were developed and reported successful outcomes in the treatment of sports injuries sustained. Various frequencies have shown different results for the treatment of pain. Comparison between the results of treatment with the higher and lower frequency of PEMF has shown that PEMF signal with the lower frequency has better results in a reduction of inflammation and for the treatment of pain in sports injuries such as a better return of the tendon to histologic normality.[8] Zizic *et al*. in a randomized study evaluated the therapeutic effects of pulsed electrical stimulation in the treatment of chronic knee osteoarthritis (OA). The results reported the improvements in clinical measures for pain and function in the patients with the active devices. They suggested that pulsed electrical stimulation is effective for treating OA of the knee.[20] In another study, Zizic *et al*. evaluated the therapeutic and cost effectiveness of pulsed electrical stimulation therapy for treatment of knee OA in total knee replacement candidates. Their findings have suggested that pulsed electrical stimulation therapy is a cost-effective and promising therapy for relieving pain and can be a viable alternative for unnecessary total knee replacement surgery.[21] Perrot *et al*. in a randomized, double-blind controlled study determined the effectiveness of PEMF in painful knee OA. The results of the study confirmed the analgesic and functional efficacy of PEMF in painful knee OA.[22] In addition, PEMFs have more benefit compared to physical therapy for neck pain. Results of several studies have demonstrated that PEMT can be used at home easily as a successful treatment and without side effects for patients with neck and shoulders pain.[23-26] Larger studies are needed for confirm of these findings.

EMF THERAPY IN ACUTE PAIN

Understanding the mechanisms of post-operative pain is an important contributing factor in surgical procedures. Several studies have demonstrated that PEMFs significantly reduced post-operative pain.[27-30] Results of a double-blind randomized pilot study showed that PEMF accelerates postsurgical pain relief in breast augmentation patients and also cause to decrease in the use of pain medication.[27] Jorgensen *et al*. evaluated the effect of PEMF applied during electrochemical therapy on tissue trauma and pelvic pain in 17 female patients with acute and/or chronic pelvic pain. They observed no significant hyperthermic effect on biological tissues and a significant decrease in resolving pelvic pain.[14] The post-operative use of PEMF after breast augmentation for management of pain is new techniques and has been improved throughout the past decade.[31-34] Similarly, findings of a study reported the positive results on pain reduction and swelling after distal radius fractures with using PEMF.[35] Weintraub (2009) in a pilot study demonstrated that PEMF therapy can provide short-term analgesic effects in more than 50% of individuals.[36] Results of another pilot study confirmed the efficacy of magnetic foot pads on decreasing pain in painful diabetic peripheral neuropathy.[31] Further studies with randomized placebo-controlled design and longer treatment periods are required to confirm the results and determine optimal treatment approaches.

MECHANISMS OF ACTION

The effects of EMFs on living tissue in pain perception reduction are operated in direct and indirect and indirect mechanisms. The direct mechanisms include effect on membrane potentials, neuron firing, endorphin levels and nerve regeneration and indirect effect include physiologic function such as inflammation, muscle, edema, cellular metabolism, and cell energy levels.[3,9,10,13] Exposure to PEMF for 15-360 min has reportedly increased amino acid uptake by 45%. PEMFs trigger or alter the releasing of

trans-membrane energy transport enzymes. The previous studies have shown that on PEMF exposure for 2 h on healthy humans were showed reduce pain perception and decreased pain-related brain signals. Clinical evaluation confirmed PEMF effectiveness on pain reduction through biochemical changes in the blood of treated patients.[13,37] Results of several studies have suggested that EMF stimulation can influence small C-fibers and sensory neurons through altering membrane potential.[38,39] Several studies have investigated the efficacy of PEMFs on pain reduction in post breast augmentation surgery and found that these fields can modulate Ca^{2+} binding to calmodulin and alter nitric oxide as signaling molecule in the anti-inflammatory cascade.[27,40-42] Magnetic fields through inducing analgesia influence the releasing of endogenous opioids as well as consumption of exogenous opioids.[43-45] PEMF showed effectiveness in stimulate neuronal repair and reduce diabetic neuropathic pain.[46] Although a number of features of these effects have been established and used for pain relief, the physiological mechanisms involved in these treatments requires definition.[47,48]

CONCLUSION

One of the most important of socioeconomic problem and an extremely urgent health issue is controlling and reducing pain.[13] Outpatient EMF therapy, based on a few small clinical studies, has been used as a useful adjunctive treatment for bone and joint disorders.[3,10,28,49,50] This technique is simple to use and affordable for healthcare and patients. Based on the results, EMFs have shown analgesic properties, and this characteristic may reduce sedations with associated side effects for postsurgical pain relief.[27,28] EMF therapy is a non-invasive method and is not associated with any side-effects. Further studies are required to confirm these findings and to specify biophysical and physiological mechanism of EMF actions in living organisms for determine the optimal treatment protocol.

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