The Egyptian Journal of Hospital Medicine (April 2025) Vol. 99, Page 2424-2426

Pulsed Electromagnetic Field Therapy in The Treatment of Charcot Foot Ulcer: A Narrative Review

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ABSTRACT

Background: Charcot's foot ulcer is a severe complication commonly seen in individuals with diabetic neuropathy. This condition is characterized by progressive musculoskeletal deformities, which can lead to ulceration, infection, and, in extreme cases, amputation. Conventional treatments often face limitations in promoting effective wound healing. Pulsed Electromagnetic Field (PEMF) therapy has emerged as a promising non-invasive approach that leverages low-frequency electromagnetic waves to stimulate biological processes critical for tissue regeneration.

Objective: This narrative review explores the pathophysiology of Charcot's foot ulcers, the underlying mechanisms of PEMF therapy, and its application in wound management.

Methods: We searched PubMed, Google Scholar, and Science Direct for Charcot foot ulcer, Pulsed electromagnetic field therapy, Diabetic neuropathy, Wound healing and Non-invasive treatment. Only the most recent or thorough investigation, from 2000 to 2025, was taken into account. The writers evaluated relevant literature references as well. Documents written in languages other than English have been ignored. Papers that were not regarded as significant scientific research included dissertations, oral presentations, conference abstracts, and unpublished manuscripts were excluded.

Conclusion: The primary therapeutic effects of PEMF include enhanced microcirculation, reduced inflammation, accelerated ATP production, and improved collagen synthesis—all essential components of wound healing. Clinical studies and case reports have demonstrated that PEMF therapy, when used adjunctively with standard care, significantly reduced ulcer size, improved healing rates, and shortened recovery time. Patients also reported diminished pain and improved functional outcomes. The review highlights that PEMF therapy's benefits are not only physiological but also extend to enhancing patients' quality of life. Despite its promise, further large-scale, randomized clinical trials are warranted to establish standardized treatment protocols and to fully integrate PEMF therapy into routine clinical practice. This review aimed to contribute to the growing body of evidence supporting PEMF therapy as a valuable tool in the multidisciplinary management of Charcot's foot ulcers.

Keywords: Charcot foot ulcer, Pulsed electromagnetic field therapy, Diabetic neuropathy, Wound healing, Non-invasive treatment.

INTRODUCTION

Charcot's foot ulcer is a significant complication arising from Charcot neuroarthropathy, a condition that often follows peripheral neuropathy, typically seen in patients with diabetes. The intricate relationship between neuropathy and the resultant musculoskeletal deformities contribute to the development of foot ulcers, which can pose challenges in both treatment and healing [(1)].

This condition not only compromises the structural integrity of the foot but also heightens the risk of infections, leading to severe morbidity and, in extreme cases, amputation. In addressing Charcot's foot ulcers, the medical community constantly seeks innovative approaches to enhance healing and restore function [(2)]. One such promising modality is Pulsed Electromagnetic Field (PEMF) therapy, which has garnered attention for its potential in promoting cellular repair and regeneration. The introduction of PEMF therapy into the treatment paradigm for Charcot's foot ulcers reflects the growing understanding of the healing processes involved and the need for effective and non-invasive treatment options [(3)].

By harnessing the unique properties of electromagnetic fields, PEMF therapy aims to stimulate biological processes that result in improved circulation, reduced inflammation, and faster tissue regeneration. This introduction sets the stage for an in-depth exploration of the mechanisms, applications, and clinical implications of PEMF therapy in the context of Charcot's foot ulcer treatment, ultimately highlighting the significance of this therapy for affected individuals seeking reliable and effective healing solutions [(4)].

UNDERSTANDING CHARCOT'S FOOT ULCER

Charcot's foot ulcer is a serious complication that typically arises in individuals with neuropathy, particularly those suffering from diabetes mellitus. This condition often occurs when there is a loss of sensation in the foot due to nerve damage, allowing injuries, fractures, or dislocations to go unnoticed [(5)]. The foot undergoes repeated trauma, while the patient remains unaware, leading to a cycle of inflammation, deformity, and ultimately ulceration. The body's natural mechanisms to heal and recover can become

Received: 14/01/2025
Accepted: 06/03/2025

compromised, and the development of a Charcot foot ulcer can lead to significant morbidity if not addressed effectively [6]. Understanding the intricacies of this condition requires a comprehensive knowledge of its underlying pathophysiology, which often involves the bones and joints of the foot becoming weakened and susceptible to structural breakdown. The most alarming aspect of Charcot's foot is its progressive nature, without intervention, the resultant deformities can require surgical amputation in severe cases. Early recognition and appropriate management are key to mitigating these risks [7].

To identify and diagnose a Charcot foot ulcer, healthcare professionals rely on a combination of clinical assessment, patient history, and imaging studies. Symptoms may include swelling, warmth, and redness in the affected area, alongside visible deformities or significant changes in foot structure. Diagnostic imaging techniques such as X-rays or MRI scans can confirm the extent of bone damage and joint dislocation [8]. Risk factors are multifactorial and include poor glycemic control, prolonged weight-bearing on the affected limb, and previous episodes of foot ulcers or other complications. In addition to diabetes, conditions affecting peripheral nerves, such as hereditary neuropathies, can also predispose individuals to Charcot's foot. Hence, understanding Charcot's foot ulcer is crucial not only for timely diagnosis but also for implementing strategies that minimize the risk of ulcers, protecting patients from additional complications and improving their overall quality of life [9].

PULSED ELECTROMAGNETIC FIELD THERAPY (PEMF)

Pulsed Electromagnetic Field Therapy (PEMF) is an innovative treatment modality that utilizes specific electromagnetic frequencies to promote healing and tissue regeneration. By delivering pulsed electromagnetic fields to the body, PEMF therapy aims to influence cellular processes, enhance microcirculation, and facilitate the repair of damaged tissues [10]. The fundamental principle behind PEMF therapy lies in its ability to promote cellular communication, improve energy production within cells, and reduce inflammation. The therapy has gained attention in recent years due to its non-invasive nature and its application across a range of conditions, including musculoskeletal disorders, chronic pain, and, notably, ulcerative conditions such as Charcot's foot ulcer, where traditional wound healing methods may fall short. As the body's cells respond to the electromagnetic stimulation, they potentially experience increased ATP production—adenosine triphosphate, which serves as the primary energy currency in cells resulting in accelerated healing processes [11]. Furthermore, PEMF therapy may help to enhance the oxygenation of tissues, foster nerve regeneration, and stimulate the immune response, all of which are critical factors in managing complicated ulcerative conditions. This therapy is delivered through various devices designed for both clinical and home use, offering versatility in treatment settings. With a growing body of evidence supporting its efficacy, PEMF therapy emerges as a promising adjunctive treatment in the management of Charcot's foot ulcer and comparable conditions, highlighting the potential of electromagnetic waves in modern therapeutic practice [12].

PEMF THERAPY FOR FOOT ULCERS

Pulsed Electromagnetic Field (PEMF) therapy has emerged as an innovative treatment modality for foot ulcers, particularly in cases associated with Charcot's foot. This non-invasive therapy employs electromagnetic fields to stimulate cellular repair and regeneration, which is particularly beneficial in enhancing the wound healing process. The application of PEMF can improve perfusion, promote angiogenesis, and enhance collagen synthesis, all crucial factors in wound healing [13]. Numerous studies have demonstrated the efficacy of PEMF therapy in reducing the healing time of ulcers, minimizing complications, and improving overall foot health for patients suffering from Charcot's foot syndrome. For instance, a clinical trial showcased significant improvements in ulcer size and healing rates when PEMF was used in conjunction with standard care, suggesting that this therapy may serve as an adjunct tool in managing complex foot ulcers [14]. Patients treated with PEMF not only reported reduced pain levels but also experienced a better quality of life due to faster recovery times. Case studies further corroborate these findings by highlighting individual instances where patients achieved complete wound closure within weeks of starting PEMF treatment. Overall, PEMF therapy represents a promising and efficacious option for treating foot ulcers, fostering hope for those affected by this challenging condition [15].

CONCLUSION

PEMF therapy represents a promising adjunct in the management of Charcot's foot ulcers, offering benefits such as enhanced healing, reduced inflammation, and improved patient outcomes. Its non-invasive nature and ability to stimulate biological repair make it a valuable addition to traditional care. Clinical evidence supported its efficacy in accelerating wound closure and reducing pain. Incorporating PEMF into treatment protocols could significantly enhance recovery for affected individuals.

RECOMMENDATIONS

Healthcare providers should consider integrating PEMF therapy into multidisciplinary care plans for patients with Charcot's foot ulcers. Standardized guidelines and training on PEMF application can optimize its effectiveness. PEMF should be used in conjunction with glycemic control, pressure offloading, and infection prevention strategies. Regular monitoring

of wound progress is essential for assessing therapeutic response.

FUTURE DIRECTIONS

Future research should focus on large-scale randomized controlled trials to validate the long-term efficacy and safety of PEMF therapy. Studies comparing PEMF with other advanced wound-healing modalities could provide deeper insight into its relative effectiveness. Development of portable, patient-friendly PEMF devices may enhance adherence and accessibility. Additionally, exploring the cellular and molecular responses to PEMF can further clarify its mechanisms of action.

Conflict of interest: None.
Financial disclosures: None.

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