TECHNOLOGY UPDATE:

Pulsed radio-frequency electromagnetic field (PEMF) therapy as an adjunct wound healing therapy

Author:
Ian Rawe

Pulsed radio-frequency electromagnetic field (PEMF) is a non-ionising energy at the shortwave radio-frequency band of the electromagnetic spectrum that has achieved success in the healing of chronic wounds. This article examines how, why and when this treatment is appropriate.

INTRODUCTION

The use of pulsed radio-frequency electromagnetic field (PEMF), also termed pulsed radiofrequency energy (PRFE) therapy has shown notable success in healing of chronic wounds. PEMF is a non-ionising energy at the shortwave radiofrequency band of the electromagnetic spectrum, commonly at a frequency of 27.12MHz. Since the introduction of PEMF in the 1950s, clinical studies on healing of chronic wounds[1][2] and surgical recovery[3][4], as well orthopaedic studies [5][6] have documented PEMF as a successful clinical therapy.

A series of case reports [7][8] and a retrospective study on a wound registry[9] have reintroduced PEMF therapy as an adjunct wound healing therapy, as newer, more portable devices have been introduced. Meta-analysis of the published clinical studies determined that PEMF therapy was statistically significant for wound healing outcomes, as well as pain and oedema[10].

KNOWN DOWNSTREAM BIOLOGICAL EFFECTS

While the exact mechanism by which PEMF interacts with cells to initiate the therapeutic effect is not fully understood, cell studies have given a valuable insight into the downstream biological effects of PEMF therapy. Human fibroblasts exposed to PEMF signal show p42/44 mitogen-activated protein (MAP) kinase activation[11], and increased cell proliferation. The MAP kinase family of proteins are important in that they are often central to initiating cell responses to many biological stimuli, which can lead to cell differentiation or proliferation.

Co-cultures of human epidermal keratinocytes and human dermal fibroblasts, which were studied by gene array, demonstrated an up-regulation of gene families associated with all phases of the wound healing cycle[12][13]. These included many genes involved in the inflammatory stage of wound repair and expression of genes involved in angiogenesis and tissue remodeling.

In mouse models of diabetes, wound healing rates were increased when exposed to PEMF, compared with animals that did not receive the energy therapy[14]. A notably increased proliferation of dermal fibroblasts was determined, measured by the cell proliferation marker Ki67 — a protein that accumulates in the cell nucleus of cells progressing through the cell cycle.

PEMF DELIVERY

PEMF therapy is none invasive and is delivered through the wound dressing, and to date has shown no unwanted side effects. With positive reports in the literature documenting PEMF as an effective therapy, its wider adoption as an adjunct therapy seems warranted. However, limitations existed, which have restricted its adoption as a widely employed wound healing therapy. Standard treatment regimens require 2 x 30-minute treatments per day and are delivered by clinic-based, mains-powered devices.

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Figure 1 shows a patient with a venous stasis leg ulcer and *Figure 2* the wound dressing incorporating a PEMF device. *Figure 3* shows the wound after three weeks of PEMF therapy. *Figure 4* shows a patient with a substitute skin graft and *Figure 5* the wound dressing is shown along with the PEMF device. *Figure 6* shows the wound after 19 days therapy.

Considering that even in the healing phase wounds can persist for weeks, this makes a clinic-based therapy impractical for most patients. The potential answer to this limitation is more portable PEMF technology — either devices that can be used at home or devices that can be worn, becoming an integral part of the wound dressing (as shown in *Figure 2* and *Figure 5*). Stiller et al 1992[15], published a randomised controlled trial, in which a portable, wearable device was used to deliver PEMF therapy. The device allowed for a home-based treatment — in this case, it was used predominantly for venous leg ulcers. The PEMF delivery device that was used weighed 508g with a treatment protocol lasting three hours per day.

Significant decreases in wound area, wound depth, healthy granulation tissue and decreased pain intensity favouring the active group were seen. This study suggests that wearable, portable forms of PEMF could

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Figure 1. Venous stasis leg ulcer.

Figure 2. Wound dressing with PEMF device in situ.

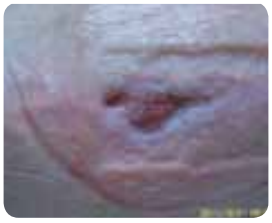

Figure 3. Wound after three weeks of PEMF therapy.

Figure 4. Substitute skin graft.

Figure 5. Wound dressing with PEMF device.

Figure 6. Wound after 19 days of PEMF therapy.

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Page points

1. *Nicole and Bentall [16] were the first to publish a study using a wearable battery-powered extended use time PEMF device in which oedema and bruising were reportedly decreased following blepharoplasty.*
2. *Design improvements to wearable portable devices suggest that they could become a standard in wound care, given more successful clinical study.*
3. *A significant reduction in postoperative pain in randomised, double-blind placebo controlled studies has been reported with treatment using PEMF.*

be an effective adjunct wounding healing therapy. Nicole and Bentall[16] were the first to publish a study using a wearable battery-powered extended use time PEMF device in which oedema and bruising were reportedly decreased following blepharoplasty.

Bentall [17], also published a paper demonstrating how wearable, extended use time PEMF reduced the healing time of experimental human skin wounds. Healing was measured at 52 days in the untreated group, compared with 39 days in the PEMF-treated group. Histological analysis also showed advanced wound architecture, including near normal epidermal thickness in the treated wounds compared with a thin epidermis in the untreated wounds.

More recent studies, using up-to-date technology have demonstrated the effectiveness of small wearable extended use time PEMF devices. A significant reduction in postoperative pain in randomised, double-blind placebo controlled studies has been reported[18][19][20]. Plantar fasciitis, a recalcitrant heel pain has also been successfully treated with portable, wearable extended use PEMF therapy[21].

Given that postoperative pain is significantly controlled by wearable PEMF, it seems probable that chronic wounds can also be treated with these devices. One recently published report demonstrated the successful treatment and healing of four patients with non-healing wounds using portable wearable PEMF devices[22].

Design improvements to wearable portable devices suggest that they could become a standard in wound care, given more successful clinical study. The modern devices are very small and lightweight (approximately 8g) and can easily be applied to most wound dressing protocols.

CONCLUSION

While extensive randomised control trials are needed to fully evaluate PEMF therapy for wound care, the positive clinical reports, ease of use and lack of any side effects suggest that this therapy could have an important role, both in improving wound healing outcomes and also in reducing wound pain.

AUTHOR DETAILS

Ian Rawe, *PHD, BioElectronics Corporation, Frederick, MD, USA.*