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Wireless Electrical Stimulation: An Innovative Powerful Tool for the Treatment of a Complicated Chronic Ulcer

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Abstract

High-voltage electrical stimulation has been long proposed as a method of accelerating the wound healing process. Its beneficial effect has been successfully evaluated in the treatment of a number of chronic ulcers and burns. We present here the implementation of a new wireless electrical stimulation technique for the treatment of a complicated chronic ulcer of the lower limb. The device is transferring charges to the wound, without any contact with it, creating a microcurrent that is able to generate the current of injury. The results suggest that this easy-to-use method is an effective therapeutic option for chronic ulcers.

Keywords

chronic wound, electrical stimulation, venous insufficiency, wound healing

Introduction

Electrical stimulation (ES) has long been introduced and is currently recommended as an adjunct treatment for chronic ulcers, for reinitiating or accelerating the healing process of wounds.[1] It is suggested as transcribing the electrical current that occurs when the skin is broken.[2] High-voltage ES has shown significant results in healing chronic ulcers by increasing blood flow and oxygen concentration around the wound,[3] directing cell migration,[4,5] stimulating growth of granulation tissue,[2] producing bactericidal effects,[6] and increasing synthesis of collagen and other components of the extracellular matrix.[7] The usual principle for ES implementation is to transfer the current through surface electrode pads that are in wet, electrolytic contact with both the external skin surface and the wound bed.[8] Despite the good effects on the healing rate of chronic wounds, this method is not often used because of the disadvantages entailed when electrodes are used to transfer the current.

Bearing in mind the difficulties involved in healing chronic ulcers with traditional ES, our aim is to describe the effects of a new method, called *Wireless Microcurrent Stimulation* (WMCS), on the treatment of a chronic ulcer of the lower limb.[9,10] Chronic ulcers of the lower limbs are defined as wounds situated below the knee that fail to heal within 6 weeks and are considered a serious public health issue, since they are persistent and often recurrent.[11]

The Case

We report here the case of a 47-year-old male patient, nonsmoker, with a severe chronic leg ulcer on the right lower limb, size 70 mm × 30 mm and 5 mm deep before the initiation of the WMCS treatment (Figure 1A, left). The patient was involved in a serious car accident more than 20 years ago; his mobility was subsequently impaired and was moving with the aid of a walking stick. The ulcer appeared 2 years ago following a superficial wound, on a

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Figure 1. Photographs illustrating the ulcer prior to (A) and following treatment (B, C, D, and E). A, day 0; B, day 8; C, day 11; D and E, day 35

ground of chronic venous insufficiency. Conventional wound dressing was initially adopted for the healing process, but the size of the ulcer gradually increased. Fourteen months ago, surgical debridement had happened and the chronic wound was reconstructed with a split-thickness skin autograft. The graft was initially successfully attached and vascularized; however, within few weeks it was rejected presumably due to poor vein circulation. At that time point no further improvement was anticipated and no alternative treatment was adopted.

WMCS Treatment

The individual agreed to participate in the study and signed an informed consent form. The patient subsequently received daily WMCS applications; the WMCS W200 device (Wetlinghealth, Fredensborg, Denmark) was used. The new WMCS method uses the current-carrying capacity of charged air gas, based on the ability of nitrogen and oxygen to accept or donate electrons. Briefly, the device (Figure 1A, right) is transferring air-borne N_2^+ and O_2^-, which are "sprayed" to the skin by the accelerator equipment. Based on the voltage of the equipment, positive N_2^+ molecules will move to the equipment (when the equipment's voltage is negative) and become neutralized, whereas the negative O_2^- will be moved away from the equipment through the field created between the equipment and the target/skin. The O_2^- when arriving on the surface of the skin is releasing the charge of e- with a voltage of about 1.6×10^{-19} coulomb. The device is able to produce a specific number of charged particles that are covering the area to be treated and by this way a microcurrent of 1.5 to 4.0 μA intensity is generated.

The instrument was adjusted to a distance of about 10 to 15 cm vertical to the wound by the attending physician and a specialized nurse (Figure 1A, right). Before WMCS therapy, the patient was connected to the cathode via a wrist strap, according to the manufacturer's instructions. Standardized photography was used to record the wounds prior to treatment and after sessions. Personal data were collected and a physical examination was performed. Pain perception was assessed using a subjective 0 to 5 score.

The device was initially applied for 45 minutes each day for the first 10 days and was well tolerated; the patient complained of mild pain (score = 1-2) that from time to time he vaguely described as numb, itchy, sore, or tender. During that period, careful removal of necrotic tissue was performed 3 times in total by the attending physician. The aim was the complete removal of necrosis and excess callus formed around the ulcer before the initiation of each session (Figure 1B, right), a practice clearly encouraged in WMCS instructions. While dressing the wound, no iodine solutions were used; gauzes were simply soaked with normal saline. The leg was not compressed during the period of treatment.

By the end of the initial 10 sessions, the fibrin and other covering disappeared (Figure 1C); the treatment itself was better tolerated as the patient suffered no pain at all (score = 0).

On day 10 of treatment, the therapy plan was accelerated, and 45-minute sessions were performed twice daily (morning and afternoon). This alteration in the protocol was well tolerated and welcomed by the patient. After 15 sessions, healthy new epithelial tissue was visible in the wound bed and at the wound edge. A clear reduction in the ulcer's dimensions and total area was achieved, allowing for fewer dressing changes. Fucidin Intertulle gauzes were applied on the wound herein.

The wound showed total response and reepithelialized completely by day 30, but the patient completed the 35-day treatment plan (Figure 1D and E). The new epithelium was initially friable; a reconstruction of the wound was observed following the initial reepithelialization. The patient was subsequently discharged on day 35; instructions were given for weekly follow-up visits in the outpatient clinics of the eepartment. The patient suffered no somatic or physical disorders during or after any session.

Clinical and Laboratory Assays

Sonographic examination of the lower extremity vascular system was performed prior to initiation of treatment. Arterial waveforms and patency were within normal limits. However, insufficiency of superficial, perforator, and deep veins of both extremities was documented with valvular incompetence that was more pronounced in the affected (right) limb, possibly in the course of a metathrombotic vascular event.

Hematological and biochemistry remained largely unchanged. A marginal increase in C-reactive protein, which did not exceed 1.5 mg/L, was documented during the first days of treatment. All other exams showed insignificant fluctuations. For histopathology assessment, tissue specimens were obtained from the healthy skin area as well as the skin area around the ulcer. In the former, immunohistochemistry illustrated even distribution of collagen fibers within dermis without expansion to subcutis, whereas in the latter immunohistochemistry showed abundance of thick collagen fibers extending to subcutis with rare giant cell granuloma formation, moderate fibroblastic proliferation, and focal increase of mast cells (up to 12/high-power field) within the collagen fibers of subcutis. Moderate vascular proliferation of capillaries of mid dermis with hemosiderin-laden macrophages around the capillary lumens was observed.

Discussion

Chronic ulcers have several implications for the individual, as they affect quality of life,[12] cause pain and loss of functional mobility, limit daily activities, and diminish productivity at work. Altering the patient's somatic ego, they are a source of psychological morbidity. For the community the burden is multifactorial, financial, social, and infrastructural.

Several authors[13,14] have demonstrated the effect of ES in healing chronic ulcers of the lower limbs of different etiologies, reporting a reduction of almost 50% in the surface area of the lesion. The present study outlines, for the first time, the use of a novel innovative device in the treatment of ulcers. WMCS provided an impressively, rapid, uncomplicated healing in a treatment-resistant chronic incurable ulcer.

Costs remained low as there were no consumables (bar the expense of Fucidin Intertulles), and treatment per se did not require expensive additional medication. Furthermore, procedures were simple and noncontaminating, minimizing the related dangers for infections; the absence of surface electrode pads in contact with the wound served in preventing hospital-acquired infections.

Lesser as well as excess mobility are both proven cofactors for chronic ulcer's recurrence with multifunctional underlying mechanisms.[15] In this context, an important aspect in a patient's management with WMCS is whether the treatment should be appointed in an outpatient ambulatory basis or in an inpatient environment. The former might predispose to excess physical activity (travel to and from treatment setting) while the latter with sparse mobility. Related to the question on the optimal facility to provide WMCS treatment was the finding that the W200 device could not be fixed easily on certain models of the newer fully automatic medical beds. The adjustment of the equipment on the bed is time consuming and could potentially damage the apparatus, so in practical terms, a better option might be a prefixed (perhaps screwed) apparatus on the bed.

The choice of the most appropriate treatment setting is also related to the existing infrastructure (specialized day clinics carefully dispersed among prefectures might prove more cost-effective in terms of minimizing medical fees and optimizing equipment use) and patient compliance (more anxious patients will probably prefer day clinics, whereas obedient patients with comorbidities might opt for inpatient stay). Regular assessment by a dedicated specialized nurse and by an experienced psychologist remains paramount.

Declaration of Conflicting Interests

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