

WIRELESS MICRO CURRENT STIMULATION TECHNOLOGY IMPROVES FIREWORK BURN HEALING

Clinical applications of WMCS technology

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Abstract— Fireworks are used worldwide during national and cultural celebrations, but they often cause moderate to severe injuries. A young male was injured by fireworks during festivities, as a unit hit him at the right arm causing severe and extended (second degree) burn. The patient volunteered for treatment with the Wetling-W200 Wireless Micro Current Stimulation (WMCS) device, an innovative, noninvasive technology to transfer current wirelessly to wound site. After 10 sessions of 60 minutes, with the spraying intensity set at 1.5 microamperes, the patient had completely recovered in just 10 days post initial treatment; pain had been greatly reduced after the first two sessions and continued to decline after every session. The treatment sessions had been unobtrusive and painless and there was no infection or other complication, despite the fact that no painkiller or antibiotic drugs had been administered. WMCS technology seems an effective therapeutic option for firework skin burns.

Keywords—fireworks, burn, wireless micro current, wound healing, pain relief at-home applications.

I. INTRODUCTION

Skin burns are of the most shocking physical injuries a person can experience and are generally followed by psychological implications as well. Thus, they are considered a serious public health problem globally [1]. Skin burns may result from exposure to several possible heat sources, including hot water or steam, hot objects or flames, chemicals, electricity, or overexposure to the sun [2]. Moderate to severe burns can cause a number of serious complications - potentially life-threatening infections included - and usually require urgent treatment.

Fireworks are used worldwide during national and cultural celebrations, but they often cause moderate to severe injuries to active users or bystanders [3, 4]. The upper extremities (*i.e.*, head, neck and arms) are the most common body area involved. In Greece, fireworks are responsible for a small, but quite

noticeable, fraction of injuries [5]. Such injuries in many cases lead to permanent disabilities, such as amputation or blindness, resulting in life-long problems [6, 7]. Considering the heavy burden of the care provided by the families, medical staff, and society, several researchers have studied firework-related injuries in different countries throughout the world. Goals of burn treatment include survival of the patient with rapid wound healing, recovery of full functionality of the injured part, minimal scarring and abnormal pigmentation, and cost-effectiveness. The optimal outcome is the restoration to the pre-burn quality of health and psychological wellbeing-or to the nearest possible standard.

The recognition of bioelectricity's role in tissue healing provides a rationale for the therapeutic application of electrical stimulation (ES), particularly in cases where natural repair processes have paused. There is a considerable and growing body of evidence in the last decade on the indication of ES in wound healing [8, 9]. ES works by mimicking the natural "current of injury" which occurs in the injured skin. It enhances the healing process by: a) increasing blood flow and oxygen uptake around wounded cells, b) directing cell migration and other components of the extracellular matrix, c) stimulating the growth of granulating tissues- with an additional bactericidal effect [8, 10-13]. 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. Despite the beneficial effects on the healing rate of chronic wounds, this method has not been widely adopted, due to disadvantages related with the positioning of the electrodes at the tissue next to the wound area. As a result of this contact, increased risk of infection and pain to the patient has been reported [14-16].

Wireless Micro Current Stimulation (WMCS) (Fig.1) is an innovative, noninvasive technology to transfer current wirelessly to a surface wound site; it disposes of contact electrodes and thus solves the major issue of infection risk during therapeutic sessions in extended and deep wounds, burns and ulcers, while also tackling the just as important one of pain and discomfort. The WMCS turns atmospheric gases (either Oxygen or Nitrogen) to ions and sprays them onto the receiving tissue, while an adjustable flexible bracelet (neutral electrode), worn around a healthy wrist or ankle of the subject, closes the circuit with no physical contact to the wound. Thanks to its spray effect, it offers a radical advantage compared to other currently used ES techniques. Evident improvement or clear progression of healing of chronic wounds and a significant reduction of pain (even within 1-2 weeks since the first application) when using the WMCS method have been observed. Up to now, the WMCS has been successfully tested in chronic wounds and ulcers (including diabetic feet) [17-19]. Here we extend our results in clinical applications of WMCS technology to firework burns, by reporting an interesting case of a burn trauma.

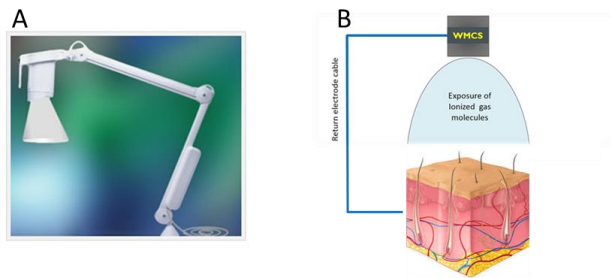


Figure 1. Wireless Microcurrent Stimulation Technology. A: The WMCS device (Wetling-200). B: Schematic diagram of the WMCS device (Wetling-200) application.

II. MATERIALS & METHODS

A. Patient(s)

A 23-year-old male patient presented with partial thickness second degree burn and blisters to his right arm (sized 13×3 cm) as a consequence of a firework accident by a smoke flare canister of distress type (Fig. 2A) during the 2014 Carnival of Patras. Immediately following the injury, he had put his hand in a bucket of water. The red, partial thickness wound was clean, with no infection noted. The wound was very painful on first inspection- pain was rated as 8 out of 10 on the Numeric Rating Scale (NRS). No other concomitant injuries or health issues were noted.

The study protocol conformed to the ethical guidelines of the Declaration of Helsinki. Written informed consent was obtained from the patient. He was subsequently subjected to daily WMCS treatment by the WMCS W200 device, producing and spraying ions of Oxygen (Wetling health, Fredensborg, Denmark). Each daily WMCS session (total 10 sessions) was for 60 minutes with the device tuned to an output of 1.5 microampere (μA) current. After each session, the wound was covered with moist sterilized

gauze for the first 5 sessions, and thereafter it was left uncovered. No antibiotics, neither *per os*, nor topical were administered during the courses of treatment. With respect to ethical principles, this study was done to observe burn (*i.e.* wound) conditions and healing rate and properties and not to create additional wounds for a control group for establishing comparative healing parameters.

B. The wireless microcurrent stimulation device

The WMCS device utilizes the current-carrying capacity of charged air gases, based on the ability of O_2 and N_2 to accept or donate electrons, respectively, thus “spraying” airborne O_2^- to the skin with the aid of an accelerator subsystem. 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 capable of producing charged particles at a specific rate, keeping thus covered the treated area; in this way a micro-current of 0.5-4.0 μA intensity is generated.

C. The WMCS set-up

The patient, lying in electrically isolated bed, is connected back to the device through a flexible neutral electrode wrapped around his wrist (or ankle). A control box allows the adjustment of the current (0.5 - 4.0 μA by 0.5 μA pace) and of the treatment duration (1 - 99 min). Each WMCS session during the treatment was for 60 minutes with the device tuned to 1.5 μA output. The WMCS device was adjusted to a distance of about 10-15 cm vertical to the wound by the attending physician and a specialized nurse. Standardized photography was used to record the wounds prior to treatment and after sessions.

III. RESULTS

Initially, a rapid improvement was seen almost immediately after 1-2 sessions (Fig. 2B), which progressed after 3-6 sessions (Fig. 2C-D, respectively), while after a total of 8-10 sessions, the wound was almost completely healed (Fig. 2E-F, respectively). The burn was completely healed at day 12. A topical moisturizer was recommended. Pain relief was almost immediate after every session; specifically, the intensity of pain dropped during the first two sessions from 8 out of 10 on the NRS to 4 out of 10. Attending staff was very impressed with the ease of application and immediate pain relief. The patient felt comfortable during treatment, and there was no infection during the courses of treatment. Fig. 2G was taken 1 week after the last session (day 15), showing the latest condition of the arm, with a satisfactory result, while Fig. 2H was taken approximately 1 month after last WMCS treatment.



Figure 2. Photographs illustrating the burn 1 hour post injury (A) and following WMCS treatment (B, C, D, E, F, G and H). B: Day 2, (after 1 session). C: Day 4 (after 3 sessions), D: Day 5 (after 6 sessions), E: Day 9 (after 8 sessions), F: Day 11 (after 10 sessions), G: 1 week after last WMCS sessions (i.e. 1 week after Day 11), H: 1 month after WMCS sessions.

IV. DISCUSSION

Chemical burns are extremely painful and their causative agent might be life-threatening. Although the usual agent in flares is potassium perchlorate, the white smoke flares are routinely charged with white phosphorus which is a chemical weapon proper if used on living subjects/targets. Firework burns have several implications for the individual, as they affect quality of life, cause pain and loss of functional mobility, limit daily activities, and diminish productivity at work.

The present study outlines the use of an innovative device in the treatment of firework burns. WMCS provided an impressively rapid, uncomplicated healing of a quite severe firework burn. Costs remained low as there were no consumables and treatment *per se* didn't require expensive additional medication. Furthermore, procedures were simple and non-contaminating, minimizing the related dangers for infections; the absence of surface electrode pads in contact with the wound served in preventing hospital-acquired infections.

The attending personnel, having treated burns in numerous cases, was impressed by the analgesic effect of the WMCS

treatment, which made bandage change easy and painless, in an otherwise nightmarishly painful wound. As the pain is a focal point in burns, there is limited experience with contact ES modalities in such cases, apart from the fact that their regenerative action is beneficial. The WMCS proved not only a painless but also a fast, inexpensive, easy to apply healing method with no side-effects, zero risk and the prospect to be used as stand-alone treatment, enhanced by only the most basic of burn wound care and without use of antibiotics.

Based on our preliminary *in vitro* studies regarding the cellular and molecular events underlying the mechanism of action of WMCS, we hypothesize that it is based on the physiological fact that skin and epithelia act as batteries and have electric potentials. When an injury occurs in the epithelium, an electric leak occurs that short-circuits the skin battery, allowing current to flow out of the wound, giving rise to the "current of injury". The latter signals to the healing epithelial cells to migrate into the wound, initiating an endogenous healing processes. The WMCS technology seems to increase blood flow and thus the oxygen content in the wound tissue, promotes angiogenesis, stimulates the synthesis of collagen, activates the re-epithelialization by directed migration of keratinocytes and reduces edema and pain. After complete healing of the epithelial layer, no current flow is detectable any more. As part of a wound/burn healing disorder, the current flow diminishes and may even subside completely before healing is achieved. Consequently, WMCS is applied as an external source of current, to restart the wound-healing process by mimicking the "current of injury", or to reestablish it back to spontaneous flow levels. This "tissue electrical rebooting" is achieved either by the application of a field, which causes the initiation of a current ("inductive coupling") or by actually routing low-level current through the injured tissue as part of an electric circuit ("conductive coupling"), which is the *modus operandi* of WMCS.

V. CONCLUSIONS

The WMCS therapy is a novel, pain- and risk- free method of treating not only chronic and difficult-to-treat ulcers, but also burns, including the rather trickier chemical ones which entail more extensive tissue damage and necrosis. The absence of contact electrodes constitutes the main novelty of the method as it eliminates all risk of contamination and electrochemical reactions and, just as important, makes away with any pain/itch/discomfort issues perplexing regimens with contact electrodes. The very low amperage used, in order to imitate as close as possible the current of injury ($5 \mu\text{A}$) [20], is the lowest in literature. Being an order of magnitude lower than MET formats, ensures utmost safety and zero side-effects, provided that the – rather strict- restrictions set for electrostimulation in general are enforced (no exposure of pregnant, no direct exposure of malignant tissue etc.). Moreover, the energy finally absorbed by the tissue is a fraction of the one transmitted, due to the different geometries of the receiving surface and the footprint of the spraying head; this is the reason for the display of the charge received and routed back through the neutral electrode at the control panel, instead of the spraying intensity which is set at the beginning of the treatment [21]. The current application allows flexible session programming, sessions at home or at private practitioners' establishments, is pain-free and offers fast

recovery and even faster pain relief, without administering systematic regimens. Different treatment settings may have even more impressive potential in burn care, which, combined with the stand-alone prospect of the device and its portability and low energy uptake show promise for expedient and massive casualty treatment in cases of arson or other mass burn incidents in both set and disaster-relief contexts.

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