Improving wound healing using electrical stimulation

The treatment of wounds using electrical stimulation is based on the fact that the skin has an electrical charge. An injury to the epithelium creates an electrical current that both triggers and subsequently maintains the body’s wound healing processes. Once epithelialisation is complete, this current flow can no longer be detected. In association with a wound healing disorder there is a change in the current flow, which can even be completely suspended, and the quantity of exudate can affect the presence and strength of the current. Therapeutically, the use of a special dressing technique can imitate the electrophysiological situation in acute wounds.

Demonstrated effects of electrical stimulation

Depending on the application, different biological effects can be described:

- Chemotaxis of macrophages1,2 and neutrophilic granulocytes3–5 to initiate wound cleaning
- Increased blood flow5–9
- Increased oxygen concentration around the wound5, 6
- Stimulus of granulation tissue formation3
- Increased synthesis of collagen and other components of the extracellular matrix3, 10–13
- Reorganisation of the extracellular matrix14–17
- Facilitation of angioneogenesis, activation of the production of growth factors (demonstrated for VEGF)3, 5, 18, 19
- Activation of re-epithelialisation using targeted migration of keratinocytes3, 20–24
- Antimicrobial effects, e.g., on Gram-positive (S. aureus, S. epidermidis, Enterococcus faecium) and Gram-negative (P. aeruginosa, E. coli, Klebsiella pneumoniae) bacteria (however, not with the strength of typical antiseptics)5, 25–29
- Reduction of oedema30–32
- Reduction of pain around wounds18
- Options for clinical application

A large number of clinical studies have confirmed that the use of electrical stimulation combined with standard wound care greatly accelerates wound healing compared to standard care alone. The investigators carrying out these studies used a wide range of electrical stimulation equipment and wave forms. These included:

- low-voltage monophasic pulsed current (LVMPC)
- low-voltage biphasic pulsed current (LVBPC)
- high-voltage monophasic pulsed current (HVMPC)
Different stimulation parameters, such as pulse amplitude, frequency and duration, were also used. Critics of the method have not infrequently insinuated that the evidence that supports this type of treatment is less valid because of the lack of consistency in the parameters selected.

However, what is often overlooked is that the common denominator is the electrical doses (charged quantity) applied to the wound tissue. The doses are applied in a comparable manner regardless of the technique used. Kloth LC (2009, JWT (6), 13–18) demonstrated that the dosage falls in a narrow range from 250 to 500 µC/s.

**Indications**

As expected, electric stimulation can achieve particularly good results when wounds are not very deep and a mean exudate quantity is not exceeded (grade I and II in the exudate quantity score according to Falanga). In principle, different types of wounds can be treated; primary indications include vascular leg ulcers (venous, arterial and mixed aetiology ulcer), pressure ulcers and wounds associated with diabetic foot disease. There is also an indication with wound conditioning and following plastic surgery on the skin, for post-surgery, secondary healing wounds such as suture ruptures or problematic acute wounds (e.g., burns, grazes). Infected wounds are not a contraindication.

As always in wound treatment, causal therapeutic approaches are imperative. Of course, even electrical stimulation cannot rectify the (untreated) cause of a wound, so it is essential to systematically comply with causal therapy.

**Contraindications**

Malignancies, that is, wounds containing malignant tissue or malignant tissue around the wound, are absolute contraindications. Contraindications such as metal implants close to the wound, pacemakers, wounds close to the heart, pregnancy, untreated deep vein thrombosis, nearby arterial occlusion or untreated osteomyelitis are accounted for by technology and electrophysiology. Patients must not be connected simultaneously to a surgical high-frequency device. The use of electrical stimulation directly over necrotic tissue in the wound or its immediate surroundings is also
contraindicated. Known allergies to components of the electrodes are likewise a general contraindication.

**Additional instructions for use**

Overall, the therapy is easy to implement. No additional knowledge is required to change the dressing. The treatment can be done both on an inpatient and an outpatient basis. Therapy started in the clinic can be very easily continued on an outpatient basis.

**Scientific background**

**Evidence for electrical stimulation in wound treatment**

The effects of electrical stimulation in wound treatment have been described in more than 500 scientific studies and 2 meta-analyses with an impressive overall level of evidence which appears almost unbelievable for applications in the area of wound treatment, a very difficult topic in terms of evidence.

In a number of guidelines for the treatment of leg ulcers, pressure ulcers and diabetic foot disease, the therapeutic efficacy of electrical stimulation was graded with the highest level of evidence (Ia) according to evidence-based medicine in light of its rigorous scientific background.

**Meta-analyses of electrical stimulation**

Two meta-analyses have provided convincing proof of the efficacy of electrical stimulation to improve wound healing. For their meta-analysis Gardner et al. selected 15 studies on the healing of chronic wounds which included placebo-controlled randomised studies (n=8), non-randomised studies (n=5), a non-randomised placebo-controlled study (n=1) and a study with a descriptive design (n=1). The data from these studies included 24 random samples for electrical stimulation (591 wounds) and 15 control samples (212 wounds). They calculated the mean healing rate per week for the test and the control samples and established that the healing rate per week was 22% for the electrical stimulation samples but only 9% for the control samples. The effective consequence of electrical stimulation of chronic wounds was reported as a mean healing rate per week of 13.5%, representing a 144% increase in the healing of wounds treated with electrical stimulation compared to control wounds.

The studies therefore revealed a 90% probability that the effective healing of electrical stimulation is 3.7% per week or more, which conservatively means an increase of 90% or more compared to the control groups. These findings were similar for placebo-controlled studies and all the studies considered, including the non-placebo controlled studies.40 Similar results were reported by Houghton et al. (2007).41
Figure 2: Electrophysiological status near a wound. A wound severs the natural isolators and cellular membranes of the skin and thus ’short circuits’ the potentials. The resulting current flow is associated with a movement of charge and the wound thus, from an electrophysical point of view, becomes a cathode. The resulting electrical field greatly influences the distribution, orientation and migration of the tissue cells, capillary endothelial cells, nerve cells, etc. that are important for wound healing.

**Further evidence**

According to a recent report, Koel analysed 13 clinical studies in which chronic skin wounds were treated with electrical stimulation. In the 13 studies wounds from 741 patients were treated either with standard wound care and active electrical stimulation or with standard wound care and placebo. The mean treatment period for these studies was 6.8 weeks, and the resulting parameters were assessed at the end of the treatment period.

The number of healed ulcers in the group treated with active electrical stimulation was 167 of 361 wounds, that is, the probability of an ulcer healing during the treatment period was 46.2%. In the control group 73 wounds (26.8%) healed. This means that treatment of chronic wounds using electrical stimulation increases the probability of wound closure by 74%.

**Referenzen:**


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3 Pullar CE: The biological basis for Electric Stimulation as a therapy to heal chronic wounds. Journal of Wound Technology 2009; 22555-22562

4 Zhao M et al: Electrical signals control wound healing through phosphatidylinositol-3-OH kinase-gamma and PTEN. Nature 2006; 442: 457-460


12 Canseven AG, Atalay NS: Is it possible to trigger collagen synthesis by electric current in skin wounds? Indian J Biochem Biophys 1996; 33: 223-227


16 Cruz NI, Bayron FE, Suarez AJ: Accelerated healing of full-thickness burns by the use of high-voltage pulsed galvanic stimulation in the pig. Ann Plast Surg 1989; 23: 49-55


21 Nishimura, KY, Isseroff RR, Nuccitelli R: Human keratinocytes migrate to the negative pole in direct current electric fields comparable to those measured in mammalian wounds. J Cell Sci 1996; 109: (Pt 1), 199-207


Plastische Chirurgie

Translated article from www.universmed.com (Origin: German language)


30 Taylor K et al: Effect of high-voltage pulsed current and alternating current on macromolecular leakage in hamster cheek pouch microcirculation. Phys Ther 1997; 77: 1729-1740

31 Reed BV: Effect of high voltage pulsed electrical stimulation on microvascular permeability to plasma proteins. A possible mechanism in minimizing edema. Phys Ther 1998; 68: 491-495


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