

Recharging Our Batteries

By Cynthia Recendez

Have you ever seen the movie, “The Matrix?” If so, you might remember that the plot involves machines imprisoning humans in electricity harvesting farms, while making them believe they are living a regular life, when in fact, they are in a simulation of real life. They are each being harvested for energy in a human farm, connected to wires that are sucking out their natural electrical energy. Although a movie, humans actually do have natural electrical energy and it is used for most cellular functions in the body, including for wound healing. Rather than imprisoning humans to suck out their energy, scientists are wondering if there is a way to create energy to administer to humans to perhaps enhance the wound healing process. So, *IS* there a way to use energy to help people with chronic wounds or severe wounds heal faster? Electric Field (EF) Stimulation/Therapy says yes, there is.

Electric Fields in the Body

The human body is like a battery, especially in how it conserves energy. Bioelectricity is highly conserved in animals and plants (1). But... what is electricity? Electricity is a type of energy often involving the movement of small particles called electrons (i.e., electric charges) (2). This type of energy is applicable not only in electrical appliances and electrical wires, but in living organisms as well! This type of energy happens all the time in our bodies. But rather than these electrical charges moving via electrons, as they do in electrical appliances and wires, the movement of electric charges in our bodies are carried through ions, such as Cl^- , Na^+ , K^+ , etc. These ions passing through our tissues, fluids, and cells, are the charge carriers in our bodies.

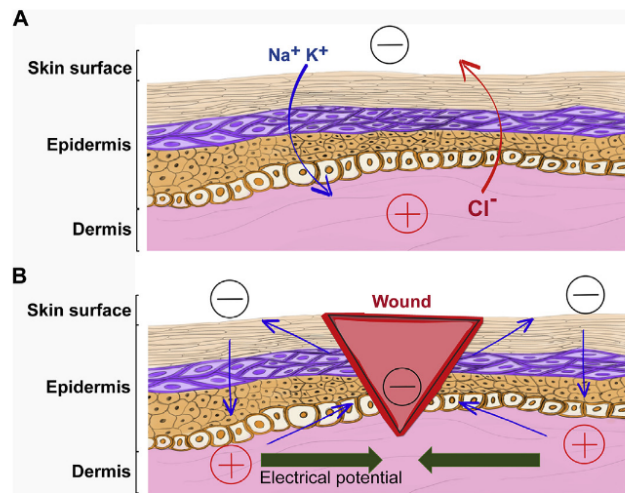


Figure 1: Electric Field of healthy skin: (A) Unbroken skin layers of the epidermis and dermis maintain the skin battery across the body through ionic movement of Na^+ , K^+ , and Cl^- , generating a polarity with positive (+) and negative (-) poles. (B) When skin is wounded, the current flows out of the wound (blue arrows), generating an endogenous electrical potential (black arrows) with the negative pole (-) in the wound center and the positive pole (+) away from the wound (+).

Adapted with permission from Hunckler J, de Mel A. A current affair: electrotherapy in wound healing. *J Multidiscip Healthc* 2017;10:179e194. (3)

Cells are constantly moving positive and negative charges in and out of themselves and each other. Electric fields (EF) have been proven in scientific literature through use of micro-glass electrodes and vibrating probes (1). These probes and electrodes have shown constant changes in EFs inside of cells and have also been found to be present

in biological processes ranging from embryo development, limb regeneration, and wound healing (1). So, since there are internal EFs (as shown in figure 1), then what would happen if there were to be external EF cell stimulation applied during a biological process like wound healing? Would external EF help influence the internal EF and perhaps be able to improve the wound healing rate in a person or animal? EF stimulation therapy says yes, we can cause improvement.

Dr. Min Zhao's lab at the University of California, Davis experiments with EF stimulation and different types of cells and tissues. The overall goal of our experiments is to assess the effectiveness of EF stimulation on wound healing, to see if it in fact enhances the wound healing time. Different bioelectrical voltages are tested in order to optimize the electrical current needed to manipulate cell movement in directions that may improve wound healing (e.g. corneal wounds).

Corneal Wounds

Corneal wounds are of special significance because the cornea is essential for clear vision. Wound healing in corneal injuries involves re-establishing the "barrier function" of the cornea, which is needed for healthy eye vision. Corneal wounds are typically caused by physical or chemical injuries, surgery, infections, or underlying diseases. Limbal epithelial stem cells (LESCs) within the eye are critical for homeostasis and regeneration of corneal tissue. Unfortunately, through these injuries, the LESCC population can become deficient, resulting in detrimental corneal wound healing. LESCC deficiency can then result in vision impairment or even blindness.

Electric Field Treatment in Corneal Wounds

When the cornea is wounded, the barrier that normally helps maintain the EF in and out of the cornea is disrupted. Previous studies have shown that external application of EF can take a role in enhancing wound healing, especially where migration of cells is required. When a wound occurs, the natural occurring EF is disrupted, as shown in Figure 1B. Intriguingly, previous studies have shown that external EF application can enhance cell migration to increase the healing rate of epithelial wounds of the cornea in rats. Our hopes are to combine EF treatment and replenish the LESCC population in corneal wounds. Hopefully, a combination of both treatments can make it seem as if the corneal wound never happened, bettering the lives of many people with damaged corneal wounds.

References

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