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Wound closure under the influence of DC field

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Abstract

A possible mechanism of wound closure by direct current (DC) field is studied. DC stimulation reduces the surface area of a wound more rapidly in comparison to the other stimulations (Reger et al. 1999). It orients new collagen formation even in the absence of neural influences. Such type of stimulation enhances the tissue perfusion in the early phase of healing more significantly.

Keywords: DC field, fibroblasts, wound healing

Introduction

Wound healing is a complicated process. It recruits at least four different cell types. This process is commonly referred to as occurring in phases. The main phases of wound healing include coagulation, which begins immediately after injury. After this the inflammation begins shortly. After this, a migratory and proliferative process begins within days and includes the major processes of healing. Finally, remodeling process takes place and it may last for up to a year and is responsible for the scar tissue formation and the development of new skin. Wound healing is affected by several factors such as local factors (e.g. growth factors, edema and ischemia, low oxygen tension and infection), regional factors (arterial insufficiency, venous insufficiency and neuropathy), systemic factors (insufficient perfusion and metabolic disease) and other miscellaneous factors such as nutritional state, preexisting illnesses, exposure to radiation therapy and smoking (Hunt et al., 2000). Normal tissue, under normal circumstances, will spontaneously heal when injured. Normal uninjured tissue has an endogenous electrical steady state with a baseline electric potential. When skin is injured it changes its electrical balance. An injury to tissue converts the local environment to a more electronegative state. Microcurrents of the order of 100 mV/mm approximately, are generated at the site of injury. It is seen that this flux on the local biocurrent is the stimulus to heal.

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Rapid fibroblast in growth and collagen deposition occurs in a reconstituted type collagen matrix that is implanted on full thickness excised animal dermal wounds. Earlier studies suggest that fibroblast ingrowth and collagen sponges stimulated with direct currents between 20 and 100 μA. According to Michael et al. (1988), maximum fibroblast ingrowth into the collagen fibre alignment are increased collagen sponge is observed near the cathode at a current of 100 μA. They suggested that electrical stimulation combined with a collagen matrix may be a method to enhance the healing of chronic dermal wounds.

Materials and Method

In the experimental study of Chapman Jones and Hill (2002), the negative electrode was kept at the centre of the wound while the positive electrode at the wound edge. In normal, uninjured human skin, a difference in ionic concentrations is actively maintained between the upper and lower epidermal layer, which can be measured as a difference of electrical potentials, ranging between 10 and 60 mV on different locations at the surface of body. The positive terminal of this is called epidermal battery. It is placed at the inside surface of the living layer of the epidermis (Barker et al., 1982). After wounding, when the skin layers are interrupted, the epidermal battery is short circuited at the wound site. In this way conducting pathway is produced. This pathway allows ionic current to flow through the subepidermal region out of the wound and return to the battery by flowing through the region between the dermis and living layer. Cukjati et al. (2001) confirmed that the injury current can only flow as long as the surface of wound is moist. The active role of endogenous electrical phenomena in wound healing is indirectly confirmed by the fact that healing rate is more successful in those wounds whose surface is kept moist and the healing rate is lower in those wounds whose surface is kept dry. Modeling of wound edge has shown relatively steep lateral voltage gradient across the edge, it means that the cells on the wound edge are situated in an electric field (Karba et al. 1997). Electric fields of the order of 100-200 mV/mm have been measured lateral to wounds in mammalian epidermis. Endogenous wound induced electric fields present in the cornea plays a role in the healing process by helping guide the cellular movements which close wounds. Robinson (1985) has been shown that externally applied electrical fields of such physiological intensities can affect orientation, migration and proliferation of cells. These are of key importance for healing, such as fibroblasts and keratinocytes (Sheridan et al. 1996, Nishimura et al. 1996, Farboud et al. 2000 & Pullar et al. 2001). Several studies have confirmed that externally induced electrical fields with endogenous electrical conditions, positive electrode on the wound surface and negative on the healthy skin around the wound, accelerate wound healing. Electrical currents were in the range from 0.2 mA to 1 mA. According to Wolcott et al. (1969) & Gault and Galens (1976), on using the negative electrode at the surface of wound, it has antimicrobial effect. It is stipulated to be useful in initial age of treatment. Zhao et al. (1999) have confirmed that the cells closest to the wound edge where the field is highest are orientated most strongly by the field and in addition to influencing the orientation of cell division. Song et al. (2002) found that the wound fields also affect the rate at which a wound closes. Iqbal et al. (2012) found that presowing magnetic field treatment significantly enhances the seedling length, dry and fress mass in comparison to the controls. Sanati et al. (2011) took 30 healthy male Sprague Dawley rats. They divided these rats into three groups one for control and two for laser. They found that Ga-As laser is more effective on wound closure and on returning the injury potential to normal level than the He-Ne laser. Verma et al. (2013) found that flowers extract accelerates the wound contraction and breaking strength and it also decreases the epithelialisation period and scar area in wound healing process.

Result and Discussion

The present study confirms that wound healing rate becomes faster under the influence of DC field in comparison to normal wound. It is also observed that surface area of the wound reduces more rapidly by DC field in comparison to AC field. Morever, AC field reduces the volume of wound more rapidly than DC. The DC treated wound gets the more decrement in its epithelialization period in comparison to normal wound. The scar area is also reduced faster than normal wound. Nuccitelli (1988) observed that in DC wound, our skin is polarized, multilayered epithelium that generates a transepithelial potential of 20-50 mV across itself. Wounds in this organ generate a low resistance pathway through which current will flow. This flow of current from all regions around the wound generates a lateral electric field which points toward the wound from every direction around it. The magnitude of this lateral field ranges between 48-200 mV/mm in mammalian wounds but there are still no reliable measurements of the lateral electric field near human skin wounds.

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