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Comparative study of AC and DC fields on wound healing

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Abstract

The present study was conducted with an objective to observe the wound healing capacity under the influence of alternating current (AC) and direct current (DC) fields. To fulfil the aim of the study rats and rabbits were taken as experimental animals. These animals were divided into two groups i.e. experimental and control. Equal strength of animals were taken in each of the groups. During the study period It was observed that the surface area of the DC stimulated wound healed faster in comparison to AC stimulated wound. It was also found that the volume of AC stimulated wound healed faster than DC stimulated wound. Eventually, it was observed that stimulated wound healed rapidly in experimental animals in comparison to control group.

Keywords: ***AC Stimulation, contraction, DC stimulation, Healing, pulsed electromagnetic field, Wound***

Introduction

Healing process is completed in four steps injury, inflammation, proliferation, remodeling and contraction. Injury is the very beginning process of a wound. It results due to the damage of cells and small blood vessels. Inflammation is derived from Latin word means to burn. In this process, skin becomes hot, red, swollen and painful. Proliferation process is completed in three to four weeks. It includes reconstructing the tissues, resurfacing if necessary and giving strength to the wound. Remodelling and contraction process continues until the whole damaged area is replaced by new scar tissues. Carley & Wainapel (1985) studied on 30 patients with indolent ulcers located below the knee. They used a portable DC stimulator which was operated by a 9V battery. Stimulation was given two times for two hours daily with the gap of 2 to 4 hours for 5 days a week. The current of 300 µA- 500 µA was set for the patients with innervated tissues while for denervated skin patients it was 500 µA - 700 µA. He observed that polarities of electrodes were changed after 3 days of treatment. Reger *et al.* (1999) studied on electrical stimulation in ulcer wounds. During their study they created a tissue ulcer in the right greater trochanter of the femur of 30 mini-pigs with a 3 cm diameter spring compression indentor and then electrodes were kept near and the outer area of wound. Wounds were stimulated for 2 hrs./day, 5 days/week, up to 30 days. In their study the AC stimulation, current of 7-10 mA (pulsed width of 300µs) was given between the electrodes while in DC stimulation it was given as 0.6 mA. Trostel *et al.* (2003) studied the effect of pico tesla electromagnetic field (PTEMF) in full thickness skin wound. They took 64 male Fischer-344 rats and divided them into 2 wound groups (sutured and open). In sutured group, rats were divided into 2 sub-groups, sutured control and sutured PTEMF and in the second group, rats were also divided into sub- groups, open control and open PTEMF. In the rats of sutured group, a 3 cm linear incision was created while in open wound group, a skin wound of area 1 sq. cm was created and left open for further treatment. For the PTEF stimulation, a unit containing 3 coils of 10 feet diameter connected in series configuration, was set at 271 Hz frequency and 9.69 mV. Each rat was placed within this unit once per day. Rats from sutured control and opened control were placed in PTEMF unit daily for 2 hrs and 40 minutes but unit made deactivated for control group while rats from the remaining groups were placed in activated unit for 2 hrs and 40 minutes. These rats were divided into two groups, experimental and control group (each of the groups had 24 rats). A full thickness skin wound (2 sq. cm) was surgically created on the back of the rats of both the groups. All the rats were

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kept in wooden cages and then an antenna loop device was placed to produce pulsed electromagnetic field (PEMF of 12.5mT,3Hz) over the cage at a distance of 5 cm from the wound surface. The rats of the experimental group were stimulated by PEMF for 20 minutes daily while the rats of control group were not stimulated. Bayat *et al.* (2006) studied the effect of micro-amperage electrical stimulation (MES) on full thickness skin wound. They took 30 male adult white Dutch rabbits and randomly divided them into sham and experimental groups (each group had15 rabbits). In both groups, each rabbit was anesthetized and then a 3 cm full thickness skin incision was created which were sutured. In experimental group, a carbon rubberized electrodes were kept on the incision covered with sterile pads. After that a MES of 200μA was applied for 2 hrs./day by negative polarity. They changed the polarity after 3 days and for the sham group same procedure was applied but without current. Steven *et al.* (2008) conducted a study in which they created the wounds on the back of 33 Sprague- Dawley rats. They divided the rats into three groups and compared the rate of healing among the animals group. Goudarzi *et al.* (2010) in their study observed the effect of pulsed electromagnetic field (PEMF) on 28 male Wistar rats with full thickness dermal incision and then diabetes was injected in 14 rats by a single subcutaneous injection of the pancreatic β- cell toxin streptozotocin. Then, after one month all the rats were anaesthetized and a 35 mm full thickness incision was created at a distance of 1.5 cm on the right of the dorsal midline. All the rats were divided into 4 groups (7 rats in each). The treatment groups were stimulated by PEMF daily for 1hr per day for 10 days while the control group did not. Panicker *et al.* (2011) studied the effect of pulsed magnetic field on wound healing in12 rats that were divided into two groups, each of the groups had 6 rats. Rats were anaesthetized and a circular wound was created in both groups by a skin biopsy punch. The test group rats were stimulated by a pulsed magnetic field of ±250nT strength for 30 minutes per day up to 15 days for the observation of pulsed magnetic field's effect on wounds. Rodrigo *et al.* (2014) studied the effect of low level laser therapy and micro-current on skin burns in 30 rats that were divided into 3 groups (each group had 10 rats), control group, laser group and micro-current group. After anaesthetizing, thermal damage was given against the skin on the back of rats. The rats from the laser group were stimulated by a low level laser device whose wavelength was 660 nm. Rats from the micro-current group were given an incision on the back side. After that the micro-current produced by a micro-current simulator applied around the lesion for 15 minutes. The control group also followed the same procedure with no current stimulation. Zhao *et al.* (2017) studied the effect of static magnetic field on wound healing in 20 diabetic and 10 normal rats which were divided into three groups (each group had 10 rats) SMF group of diabetic rats, Sham exposure group of diabetic rats and normal control group. All the 30 rats were anaesthetized and a wound area of 4sq. cm was created surgically on the backs of rats. A magnetic disk of area 9 sq.cm was placed over the wound which produced the magnetic field of intensity 230±5 mT. Rats from the sham exposure group had non magnetized disk placed over the wound and the rats of the control group were left for the normal healing.

Results and Discussion

In the present study it was observed that the animals with low intensity direct current (LIDC) group healed 1.5 to 2.5 times faster in comparison to the animals of control group. During the course of study healing rate was observed significantly faster for experimental group and no statistical significant difference was found between experimental group and the control group's during the first 2 weeks of experiment. An enhanced significant difference was observed at third, fourth and fifth weeks of the experiment. Similary, Carley & Wainapel (1985) found significant difference in LIDC treatment on ulcer.During the 14th day of experiment in sutured group PTEF treated rat's wounds were found stronger and matured in comparison to control group while in open wound group, PTEF treated wounds of rats contracted faster at day 2 and 4 in comparison to control group. Our study is in agreement with Trostel, C. Todd (2003) who found that PTEF treated rats showed improved healing as early as day 4.During the study a significant acceleration of wound healing was observed in the experimental group in comparison to the control group on days 3, 6 and 9.

Similar work was done by several workers (Bayat *et al.*, 2006; Steven *et al.*, 2008) who found a qualitative improvement on wounds and observed that wound stimulated with magnetic fields healed significantly earlier than non-magnetically stimulated wounds.It was also observed that rats which were treated by PMF therapy healed faster while comparing to the control group. Mean value of the rate of healing of test and control group showed a small difference though this difference was not found statistically significant. In this study, it was observed that the duration of healing time in diabetic rats is significantly greater than normal. Goudarzi *et al.* (2010) found that PEMF stimulation significantly reduces healing time in diabetic rats.It was also observed that the both AC and DC stimulated wounds showed reduced healing time and increased perfusion in the early phases of healing in comparison to control group. Panicker *et al.* (2011) found that treatment with AC and DC fields indicates a higher rate of wound area reduction with DC than AC stimulation and the AC stimulation reduces wound's volume more rapidly than DC stimulation.Sun *et al.* (2012) found that exogenous and endogenous electric fields not only guide and promote the migration of cells but also they accelerate the wound healing process. Rodrigo *et al.* (2014) found that the mean number of fibroblasts and the mean of tensile strength was significantly higher for the experimental group compared to the sham group at the days 7 and 15 respectively. Zhao *et al.* (2017) in their study found that the reduction rate of wound area was significantly decreased in comparison to the control group in the diabetic rats. The diabetic rats which were treated at 230 mT of SMF exposure showed a significant acceleration in wound area reduction rate and gross time of wound closure was also decreased. Thus static magnetic field of 230 mT gave a positive response on promoting the skin wounds in diabetic rats.

Conclusion

On the basis of this study, it is concluded that healing rate is found more accelerated in electrically stimulated wound in comparison to normal healing. Moreover, it is also observed that DC stimulation reduces surface area of wound more rapidly than ac stimulated while AC stimulation reduces the volume (depth) of wound more rapidly than dc stimulation.

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