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Evaluation of Low Level Laser Therapy using 785 nm Diode Laser on the Enhancement of Chronic Wound Healing

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Abstract: Low-intensity laser irradiation has been explored as an alternative, non-invasive method to encourage chronic wounds to heal. This study aimed to evaluate the effects of low level laser therapy (biostimulation) using semiconductor diode laser with wavelength (785 nm) on the enhancement of chronic wound healing. Fifty patients with chronic wounds were selected to be treated with Low Level Laser Therapy. Their ages ranged between 1 to 76 years. The wound sites were distributed in the lower limb, upper limb, trunk , perineum and head (70%,14%,12%,2%,2%, respectively). Application of laser therapy by noncontact method few millimeters from the skin for 15 minutes per one session twice weekly for two months ; ie,16 sessions for each patient. Results: The responses of wounds (56%), 12 patients with more than toward Low Level Laser Therapy LLLT were different as fallow; 28 patients had complete healing 50% healing (24%),8 patients with less than 50% healing (16%) and 2 of patients did not heal (4%).Conclusions: LLLT is an effective modality for treating chronic wounds. LLLT is an effective method in treating chronic wounds in patients with comorbidity and contraindications or precautions for surgery like epilepsy and chronic hepatitis carrier.

Introduction

Low-intensity laser irradiation has been explored as an alternative, non-invasive method to encourage chronic wounds have failed to proceed through an orderly and timely process to produce anatomic and functional integrity and wounds that do not heal within three months) to heal. The use of laser irradiation to speed wound healing first appeared in the human literature in 1971 (Mester E, 1971). Various mechanisms for the mitogenic effects of low intensity laser irradiation have been proposed, including absorption of light by mitochondrial enzymes with localized heating (Olson JE, 1981), photon absorption by flavins and cytochromes in the mitochondrial respiratory chain affecting electron transfer, production of singlet oxygen by excitation of endogenous porphyrins, and photoactivation of calcium channels resulting in increased intracellular calcium concentration and cellular proliferation .Studies of cultured fibroblasts reveal that 860 nm laser light stimulates cellular proliferation, 812 nm laser light increases DNA synthesis, 660 nm laser light up regulates production of basic fibroblastic growth factor, and 632.8 nm laser light can transform fibroblasts into myofibroblasts (Pourreau-Schneider N, et al., 1990). Studies of cultured keratinocytes reveal that 632.8nm laser light increases cellular proliferation, stimulates release of IL-1 and IL-8 and increases motility rate, and that 780nm laser light stimulates cellular proliferation. Macrophages are activated by 632.8 nm laser light, and various laser wavelengths are reported to increase growth factor secretion from cultured macrophages (Zheng H, et al., 1992). There are relatively less data on the effects of low-intensity laser irradiation on

vascular endothelial cells; however, increased vascular endothelial cell proliferation has been described in vitro (Pete Moore, 2005). In vitro data suggest that Low Level Laser Therapy (LLLT) facilitates collagen synthesis, keratinocyte cell motility, and growth factor release and transforms fibroblasts to myofibroblasts. Many authors of clinical studies reported the benefits of LLLT on tissue healing, but others showed no effect. These conflicting results are likely due to variations in treatment factors and limitations in experimental design, including comparison of heterogeneous clinical wounds, lack of control groups, and limited or no blinding of investigators (J. Ty Hopkins, 2004). A lack of understanding the importance of correct laser dosimetry and application protocols and poorly controlled studies and reporting have flawed the research literature in the past. Most of the studies supporting the effectiveness of LLLT in the treatment of wound ulceration consist of unreliable or poor reports (Australian Journal of Advanced Nursing 2013). Though the results have been noteworthy, they usually failed to establish standard criteria for the particular laser, dosage, number, frequency, or duration of treatment they involved small sample size or compromised clinical protocols. The recognition of these past shortcomings has produced an ever increasing number of positive, high quality, well designed studies in this emerging field of laser phototherapy over the past decade (Posten, W., et al., 2005).

Patients, Materials and Method

A total number of 50 patients with chronic wound were treated by using semiconductor diode laser (785 nm), in University of Kufa Medical College in the Laser Research Unit, the patients were from Al-Sadar Teaching Hospital, Al- Hakeem General Hospital and from private clinics. Twenty six of the patients included in the study were female (52%) and twenty four were male (48%). These patients sustained chronic wounds more than 12 weeks without significant signs of healing. These ulcers were not infected with different sizes.

Their ages ranged from 1to76 years with a mean of 40 years. Their ages were distributed as follows: six patients were less than 10 years (12%), between 11 and 50 years twenty-five patients (50%) and above 50 years nineteen patients (38%). The wounds were distributed in the lower limb in 35 patients (70%), seven patients in the upper limb (14%), in the trunk six patients (12%), in the face in our patients (2%) and 1 in the perineum in our patients (2%). The causes of wounds were post burn 18 (36%), arterial 10 (20%), venous 3 (6%), neuropathic 6 (12%) and post traumatic 13 (26%). Regarding their previous clinical history, 6 patients were type I diabetic (12%), 2 of them epileptic (4%), 2 were chronic viral hepatitis (4%) and 2 of them were steroid dependent because of rheumatoid arthritis (4%) while the remaining patients (38) were free of co morbidity disease.

Table (1): Shows the age groups

Age	NO.	%
Less than 10 years	6	12
11-50	25	50
More than 50 years	19	38

Table (2): Shows the causes of ulcers

Causes	NO.	%
Post burn	18	38
Arterial	10	20
Venous	3	6
Neuropathic	6	12
Post traumatic	13	26

Procedure

All patients were subjected to wound preparation by wound debridement once before laser therapy, preparation of wound edge from necrotic tissue cleaning the wound base by curettage finally dressing by gauze soaked with saline only there was no local treatment or antibiotic used during the period of laser application. Application of laser therapy by noncontact method to prevent contamination of the wound few millimeters from the treatment area for 15 minutes per one session twice weekly for eight weeks; ie,16 sessions for each patient. Photograph was taken for each patient before the start of treatment and then 8 sessions after and at the end of 16 sessions. Also, there was a clinical assessment of the wounds and the wound area was measured by a ruler.

Fig.(1): Power Twin 21Laser Shower

Laser Parameters

Wavelength 785nm, Total power1050 mW(21x50mW), Total area 4.12 cm^2(there is no more than 5 cm ulcer), Time of exposure 15 minutes, Operation mode CW, Spot area diameter 5 mm, Power density 0.255W/cm^2.Figure 1

Results

The healing response of wounds was significantly ($p<0.001$; $\chi 2 = 29.68$) improved after low level laser irradiation. The response of wound toward LLLT were different as follows; 28 patients had complete healing (56%), 12 patients with more than 50% healing (24%),8 patients with less than 50% healing (16%), 2 patients had no improvement (4%) as shown in Figure 2.The causes of the ulcers that completely healed in response to LLLT were as follows; 4 with diabetic ulcer (66%), 1 with venous ulcer (33%), 5 with arterial ulcer (50%), 10 with post burn ulcer (55.5%) and 8 with post traumatic ulcer (61.5%). Table (3.a) shows the response of chronic wound to laser. Table (3.b) shows the response of chronic wound to laser

Table (3.a): Shows the response of chronic wound to laser.

Cause of the wound	Healed	Total patients	Percentage
Diabetic	4	6	66.6%
Venous	1	3	33%
Arterial	5	10	50%
Post burn	10	18	55.5%
Post traumatic	8	13	61.5%
Total	28	50	

Table (3.b): the healing response according to specific cause

Healing response	Number of patients	Percentage of healing
Completely healed	28	56%
More than 50% healed	12	24%
Less than 50% healed	8	16%
Not respond to treatment	2	4%
Total	50	100%

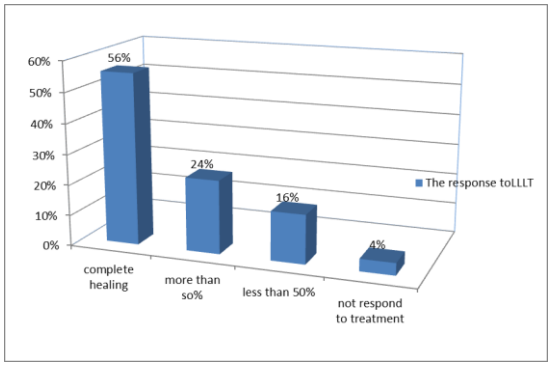

Fig.(2): Percentage of healing response

Discussion

Chronic wounds that are major source of morbidity lead to considerable disability and are associated with increased mortality. Therefore, they have a significant impact on public health and expenditure of health care resources. The laser use is reported to have a beneficial effect on wound healing by stimulating the immune system, increase various cytokines and leukocytes population arresting bacterial growth increase the total amount of collagen and skin circulation and by accelerating the regeneration process (Tibbles, PM. 1969, Kawalec J ,et al., 2004). Although the low level laser was used in management of chronic wound over two decades in many medical center in the world but there is controversy regarding the laser systems (He-Ne laser, A1GaS, In GaAIP), laser parameters (wavelength, power density, energy density, pulse duration),and irradiation condition (exposure time, frequency and duration of treatment). In this study, the use of semiconductor diode laser with wavelength 785 nm as a source of LLLT was on the

fallowing bases: LLLT has been thought to have an influence on the rate of wound healing. The 'laser catalyzed reactions' include: acceleration of the inflammatory phase of wound healing (Beckerman H, et al., 1990), enhanced prostaglandin concentration (Enwemeka CS. 1988), enhanced ATP synthesis, enhanced collagen synthesis, enhanced fibroblast proliferation (Kert J, Rose L. 1989), enhanced phagocytosis of macrophages (Karu T. 1989), activation of the immune system and growth factors release (Rochkind S, 1989), and stimulation of resorption and diffusion resulting in cellular proliferation and acceleration of the wound healing process. Many studies regarding LLLT effect on wound healing are based on many parameters as: the degree of tenderness, edema and swelling (Tuoner, J, 2011), increased fibroblast proliferation and inflammatory infiltrate the effect of laser on wound size (Rocha AM, 2006),, the effect of laser on fibroblast culture (Woodruff et al. 2004) and significant rise in skin temperature (Vinck EM, et al., 2003). In this study, the evaluation of LLLT on chronic wound healing depending mainly on quantitative measurement of the area of the wound by measuring it by a ruler. Reduction in the area of the wound in response to LLLT in this study is correlated to Hopkins et al (2004) who assess healing by measurement in terms of wound contraction, facilitated wound contraction also supported by Pourreau-Schneider et al, and Spector, and Axford (1999) who reported that laser irradiation transforms fibroblasts into myofibroblasts. The majority of patients (80%) that included in this study show reduction in wound size ie; more than 50% of its original size to complete healing that is correlated to Farouk et al who shows (80%) of reduction in wound size by using diode laser (785 nm) (Pourreau-Schneider N, 1990). Soheila Mokmeli et al showed that 74.4% got more than 50% to complete healing, while in this study 80% of patients got more than 50% to complete healing, (Lucas et al., 2003, Byrnes et al 2004) they all use LLLT for wound healing promotion in pulsed mode of action, who find a promising results of progression of wound healing process while in this study the mode of action was continuous wave (CW) with better results in wound healing enhancement as Al-Watban (Al-Watban FA, et al., 2004) who compare between pulsed and continuous wave.In this study the power output of the diode laser (1050 mW) which is correlated to Tunér and Hode, (2002).The open wound needs a lower dosage than the skin-covered periphery as the laser light is not reflected or scattered but rather absorbed by the skin in the unprotected wound since it hits the uncovered cells directly. This is correlated to Mendez TM, et al., (2004), who use high power density (0.79 W/cm2) while in this study the power density was 0.225 W/cm2 to deal with open wound and ulcer.Karu and Kolyakov, (2005) reported that phototherapy using a wavelength of near infrared region gives the best result in phototherapy and wound healing which correlates with this study where was the wave length 785 nm.In this study it can be seen that the signs and symptoms of inflammatory reaction(tenderness, edema and swelling)were reduced dramatically after the exposure to the LLLT this proves that the laser irradiation can cause diminished inflammatory reaction and this in agreement with Inoue, et al., (1989) and Mester (1989) who suggested that laser light therapy might affect the immune component cells by suppressing some undesirable immunoreactions and so contribute to the stimulation of wound healing. Regarding the pain relief and patients satisfaction (it is a qualitative parameter not included) and this is in agreement with Walker (1983) and Zarkovic, et al, (1989) that can be explained by the effect of LLLT on the level of serotonin and acetylcholine which play an important role in the analgesic effect. In this study the use of cluster diode laser system is in the agreement of El Sayed and Dyson (1990) who showed that the effects of a cluster probe in experimental conditions are greater than those of individual single probe irradiation. In this study the treatment of chronic wounds by LLLT only without adjunctive treatment this is in contrast with Zvi Landau et al (1989) who use topical hyperbaric oxygen with LLLT so that we can assess the effect of LLLT and its influence in wound healing and regeneration.

Conclusion

Low level laser therapy is an effective modality for treating chronic wounds. This type of treatment showed a positive effect in speeding up tissue proliferation, increasing local vascularization and forming a more

organized granulation tissue. LLLT is an effective method in treating chronic wounds in patients with co morbidity and contraindications or precautions for surgery like epilepsy and chronic hepatitis carrier.

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تقييم العلاج بليزر واطئ القدرة بأستخدام ليزر الدايود (785 نانومتر) في تحسين شفاء الجروح المزمنة

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الخلاصة: تمت دراسة التشعيع بليزر واطئ الشدة كطريقة بديلة وغير مباشرة في تحفيز الجروح المزمنة للشفاء. هذه الدراسة هدفت لتقييم تأثيرات العلاج بليزر واطئ القدرة (التحفيز البايولوجي) بأستخدام ليزر الدايود (الطول الموجي 785 نانومتر) في تحسين شفاء الجروح المزمنة. خمسون مريضا بالجروح المزمنة تم أختيارهم للعلاج بليزر واطئ القدرة. أعمارهم تراوحت بين (1 الى 76) سنة. مواقع الجروح توزعت بين الأطراف العليا والسفلى والبدن والعجان والرأس (70% ، 14% ، 12% ، 2%) بالتتابع. طريقة العلاج بالليزر تمت بطريقة عدم التماس، اي تبتعد عدة مليمترات عن الجلد لمدة (15) دقيقة لكل جلسة مرتين بالأسبوع لفترة شهرين، بعبارة أخرى 16 جلسة لكل مريض. النتائج: أستجابة الجروح للعلاج تباينت (56%) مرضى عدد 12 أكثر بأتجاه العلاج بليزر واطئ القدرة (LLLT) وقد أختلفت كالاتي : 28 مريض بشفاء كامل، شفاء 50% (24%) ثمانية مرضى أقل من 50% (16%) ومرضى عدد أثنان لم يتم شفاؤهم (4%). الأستنتاجات: LLLT هي طريقة فعالة في شفاء الجروح المزمنة . LLLT هي أيضا طريقة فعالة في علاج مرضى اللذين بعانون من الأعتلال المشترك وموانع أو تحذيرات من الجراحة مثل الصرع وحاملي ألتهاب الكبد الفايروسي المزمن.