LOW LEVEL LASER THERAPY VERSUS POLARIZED LIGHT THERAPY ONWOUND HEALING POST BURN

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ABSTRACT

Background: *A significant fraction of patients who had larger burns, they had more prolonged period of hyper metabolism, chronic inflammation, and lean body mass wasting, all of which may impair wound healing. Low-level laser therapy and Polarized light therapy have proven that they are effective methods for accelerating wound healing.* ***Objective:*** *the purpose of the current study was to compare between therapeutic effect of low level laser therapy and polarized light therapy on the surface area of burn wound.* ***Methods:*** *sixty participants Suffering from full thickness upper limb burns (2nd degree burns) with burn total body surface area ranging from (20% to 35%). Their ages range from (20- 40) years, were divided in a random way into two groups of equal number. The experimental group (A)(n=30) received low level LASER therapy (with wavelength 650nm, power output of 150 mw, power density 0.6 w/cm2, continuous mode, 2 J/cm2 and time 90 sec/cm2), while the control group (B) (n=30) received Polarized light therapy (wavelength: 400–2000 nm; degree of polarization: 95%; power density: 40 mW cm2; light energy: 2.4 J cm2). Wound surface area using J image software were estimated at the initial time of the study and after 4 weeks.* ***Results:*** *revealed there were significant difference between both groups after 4 weeks as (p=0.001). The significance of improvement of wound surface area in experimental group was further than the control group at 4 weeks.* ***Conclusion:*** *This study supports that low level laser therapy had a superior effect on wound healing post burn as compared to polarized light therapy in patients with upper limb full thickness second degree burn.*

Key Words*: Burn wound healing, Low level laser therapy, polarized light therapy, wound surface area.*

INTRODUCTION

Every year, a huge number of individuals suffer from acute thermal injuries that need medical treatment 1. Potentially fatal complications for a burn sufferer include shock, infection, electrolyte imbalances, and respiratory failure, all of which are affected by the location and severity of the burn. Long-term hospitalization, scarring, and deformity caused by burns can cause not only physical issues, but also significant psychological and emotional pain. Over the last four decades, the survival rate for hospitalized burned individuals is continually getting better. This is mainly due to national reductions in burn size, advancements in burn critical care, and improvements in burn wound care and therapy guided by research2. It is beneficial to accelerate wound healing process and to reduce pain during healing process for several reasons including: earlier return to work, lower risk of wound infection, enhanced quality of life, and probably reduced need for analgesics 3. Wound healing a physiological process that consists of different stages from the initial reaction to the wound through the formation of new skin. Different stages of wound healing; hemostasis phase, inflammatory phase, proliferative phase, andwound remodeling phase, occur in all wounds 4. Full thickness burn wounds involve the destruction of all skin layers from the epidermis down to the subcutaneous tissue, and sometimes even into the fascia and muscle. Full-thickness repair involves many processes, but these phases—inflammation, proliferation, and remodelling—are typically considered to be the most important. Each phase builds upon the previous one, and the cells participating in one phase create the chemical stimuli that aid to advance the wound healing process into the next phase. Thus, a normal healing process is a complex and well organized sequence of activities 5.

Low level laser therapy (LLLT) has been utilized in numerous medical fields, particularly for wound and ulcer healing 6. When used properly, LLLT can speed up the healing process of wounds significantly. Some researchers suggest that LLLT has a positive effect on wound healing by increasing fibroblast proliferation, accelerating granulation tissue development, and enhancing inflammatory response 7. The effects of PLT include the following: enhancement of microcirculation, decreasing inflammation, and enhancement of tissue oxygenation, increasing cell proliferation (particularly in fibroblasts), increasing growth factor release, immunoglobulin and other proteins synthesis, collagen synthesis, wound epithelialization, and improving scar tensile strength 8. The Bioptron optical products are non-laser optical devices that emit polarized, non-coherent, polychromatic beams in a wavelength range that does not damage DNA or cause thermal damage 9. Extremely rare studies document the comparison effect of low level laser therapy and polarized light therapy on the surface area of burn wound.

The aim of the study was to compare between the effect of low level LASER therapy and effect of polarized light therapy on the surface area of a full thickness second degree burn wound

MATERIALS AND METHODS

Participants

A single-blind randomized controlled trial was done between April 2023 and August 2023. Participants were recruited from the EL-Shiekh Zayed Al-Nahyan hospital, Egypt. All participants underwent history taking and clinical assessment. Participants who accomplish the following criteria were eligible for enrollment in the study; participants were ranged from (20-40) years. Patients suffering from full thickness

upper limb burns (2nd degree burns) with TBSA for burns ranging from (20% to 35%). Reasons for exclusion were; Patients with associated diseases (Diabetes mellitus, infectious diseases, autoimmune disease) that interfere with the healing process, Patients taking medication that alter the healing process (e.g., corticosteroids, chemotherapy or radiation), Pregnancy or epilepsy. Participants were randomly divided into 2 equal groups; group A (n=30) who received LLLT (red laser probe), and group B (n=30) who received polarized light therapy (Bioptron). The study had given approval by the ethical committee of Faculty of Physical Therapy, Cairo University, Egypt (number P.T.REC/012/004820).

Randomization:

An unbiased patient selected the patients' groups (A) (n = 30) and (B) (n = 30) by blind drawing numbers out of sealed envelopes produced by a random number generator. To guarantee that the numbers allotted to groups A and B were equal, the randomization was limited to permuted blocks. Sequences

allotted to patients were put in envelopes with the allocations to each group inside of them. Eligible patients were informed about the purpose and methods of the study.

Treatment procedures:

Patients were randomly divided into 2 equal groups; group A (n=30) who received LLLT (red laser probe) with wavelength 650nm, power output of 150 mw, power density 0.6 w/cm2, continuous mode, 2 J/cm2 and time 90 sec/cm2 plus regular wound care (debridement, Local antimicrobial drug and betadine). Non-contact laser irradiation was done to avoid contamination. Then, non-adherent dressing and the paraffin gauze over it placed on the burn site. Laser irradiation was done 1 session per day, 3 sessions per week, for 4 weeks 10, and group B (n=30) who received polarized light therapy

RESULTS

(Bioptron) with the following technical characteristics was used: wavelength: 400–2000 nm; degree of polarization: 95%; power density: 40 mW cm2; light energy: 2.4 J cm2 plus regular wound care (debridement, Local antimicrobial drug and betadine).Polarized-light therapy was given for 6 min daily at a distance of 10 cm, and the wound was then dressed with Vaseline gauze in combination with silver sulphadiazine (Flamazine) in addition to their conventional medical treatment and traditional care (dressing) 11.

Measurement procedures:

Data was collected through individual interviews and physical assessment Measurement were done for all patients in experimental group (A) and control group(B). Wound surface area was estimated initially while starting the study (pre) and after4 weeks of treatment (post). The outcome measure was wound surface area.

Wound surface area measurement procedure was used to guarantee accuracy. Suitable positions for the patients were assigned. To get a good picture of the burn, we put it under a light and set up a digital camera so that it was 50 cm perpendicular to the wound. Calibration was performed with a ruler. The patients and the apparatus must be in the same locations and at the same distances for every assessment.

Photographs were taken placing a ruler next to the wound in parallel with the healthy skin. The original photographs were then copied into a new folder. The digital photographs were visualized with Image J software (National Institutes of Health, Rockville, MD; http://image j. net/Image J). Wound area measurement was carried out as follows: Open Image J software, File>Open

(Drag and drop the picture into the software can alternatively be used. A segment was drawn along the ruler using "straight line" tool. The examiners always drew a distance of 1 cm along the ruler. The software calculates the distance in pixels of the segment. Analyze menu>set scale>known distance (we use 10) > unit of length (mm). The software automatically recalculates the number of pixels/mm. Wound outline was created using "Freehand selections" tool and tracing the wound shape with the computer mouse in cases of desktop computers or track pad in cases of laptops. Analyze menu>measure. The area in mm2 was then calculated. We took a screenshot of the picture including the measurement window to save in our database 12 (Fig. 1).

Fig. 1: Measurement of wound surface area.

Data analysis

G*Power was used as the statistical software for sample size calculation (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany). According to the results, a total of 60 participants (about 30 in each group) was the optimal size for this study. It used for calculations with a significance level of 0.05, 80% power, and an effect size of 0.25. Unpaired t-test was conducted for comparison of age between groups. Chi- squared test was conducted for comparison of sex distribution between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to ensure the homogeneity between groups. Unpaired t-test was conducted to compare mean values of wound surface area between groups. Paired t-test was conducted for comparison between pre and post treatment in each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Out of the initial recruitment of 71 patients screened for eligibility, 60 patients were randomly assigned into one of the two intervention groups, Notably, there were no reported side effects associated with the intervention, Figure 2.

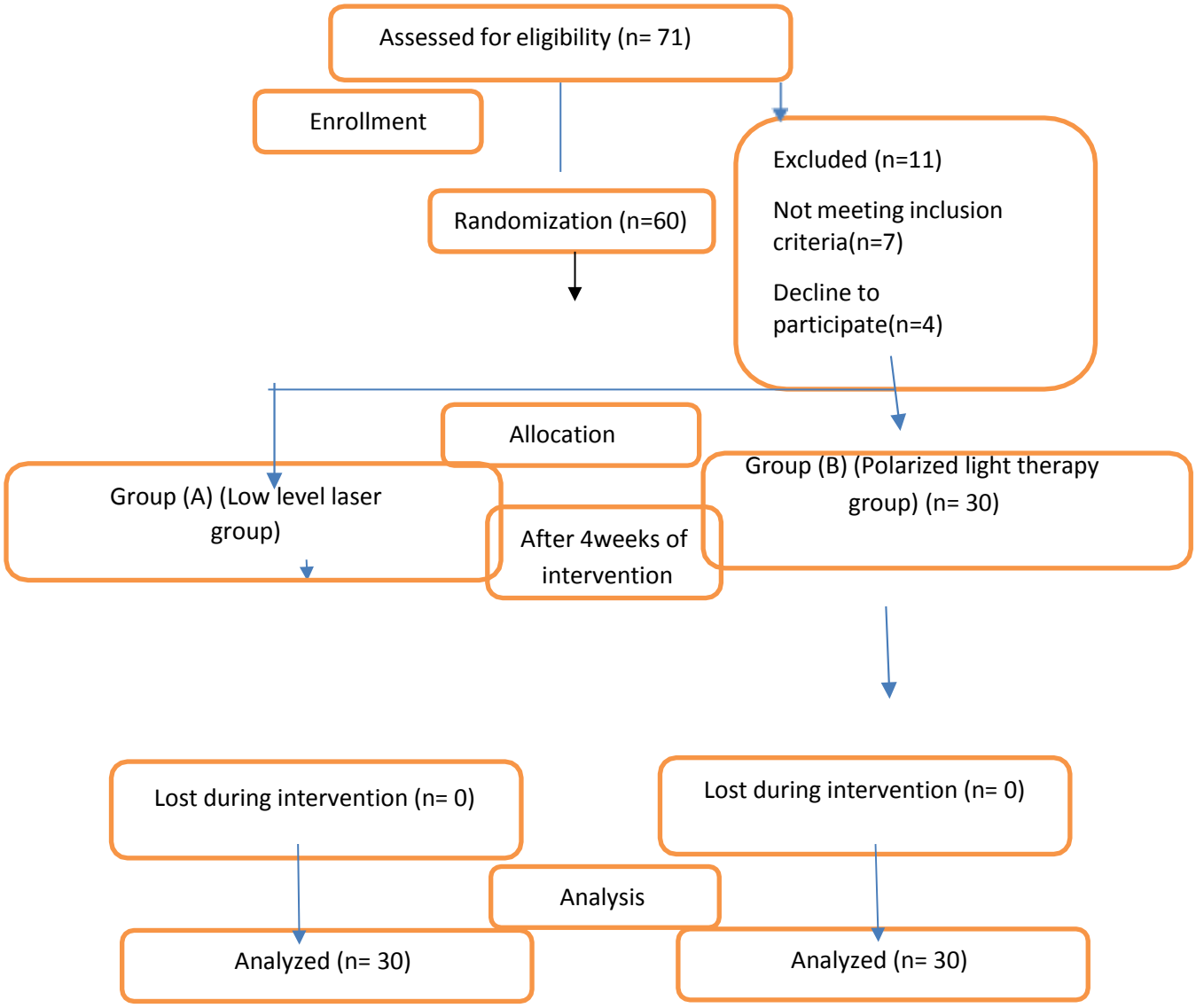

Figure (2): Flow diagram presenting the progression of subjects at for each stage of the clinical trial.

- Subject characteristics:

Table (1) shows the subject characteristics of both groups which shows that there was no significant difference between groups in age and sex distribution ($p > 0.05$).

Table (1): Comparison of subject characteristics between group A and B:

	Group A	Group B	p-value
	Mean ± SD	Mean ± SD	
Age (years)	30.83 ± 6.81	29.27 ± 6.01	0.34
Sex			
Females	19 (63%)	18 (60%)	0.79
Males	11 (37%)	12 (40%)	0.79

SD, Standard deviations; MD, mean difference; $\chi 2$, Chi squared value p value, Probability value.

-Within group comparison

There was a significant decrease in wound surface area of right and left upper limb post treatment compared with that pretreatment in group A and B ($p > 0.001$). The percent of change in wound surface area of right and left upper limb in group A was 64.10 and 60.14% respectively, while that in group B was

37.53 and 43.48% respectively (table 2).

- Between groups comparison

There was no significant difference between groups pre-treatment ($p > 0.05$). Comparison between groups post treatment revealed a significant decrease in right and left upper limb of group A compared with that of group B ($p > 0.001$) (Table 2).

Table 2: Mean wound surface area pre and post treatment of group A and B

Wound surface area (cm^2)	**Group A**	**Group B**			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p value**
Right upper limb					
Pre treatment	35.15 ± 15.40	33.92 ± 13.87	1.23	0.33	0.74
Post treatment	12.62 ± 5.40	21.19 ± 6.86	-8.57	-5.37	0.001
MD	22.53	12.73			
% of change	64.10	37.53			
t- value	10.42	8.35			
	p = 0.001	***p = 0.001***			
Left upper limb					
Pre treatment	34.07 ± 13.24	36.18 ± 13.44	-2.11	-0.61	0.54
Post treatment	13.58 ± 5.40	20.45 ± 6.67	-6.87	-4.38	0.001
MD	20.49	15.73			
% of change	60.14	43.48			
t- value	11.42	10.36			
	p = 0.001	***p = 0.001***			

SD, standard deviation; MD, mean difference; p-value, probability Value

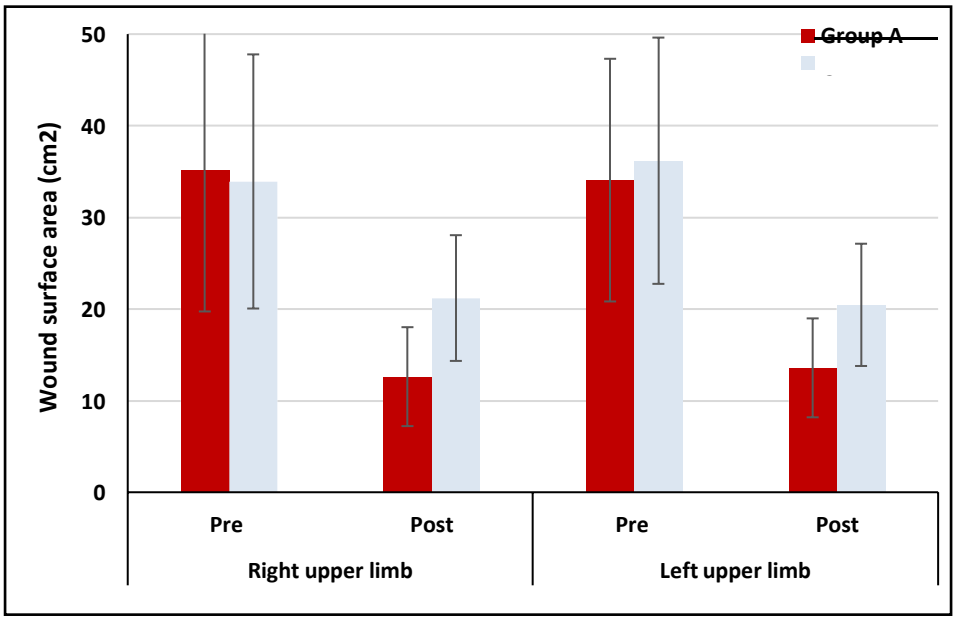

Fig. 3: Mean wound surface area pre and post treatment of group A and B.

DISCUSSION

Severe burn injuries are the most traumatic and physically devastating injuries, impacting almost every system of organs and leading to significant morbidity and mortality. it is necessary to accelerate local wound recovery. Despite the progress in practices such as early burn wound excision and skin grafting to improve outcomes for severely burned patients by lowering death rate and length of hospital stay , the risk of developing wound healing complications still a challenging problem 13. In the current study two physical therapy modalities have been used, Low level laser therapy, and polarized light therapy. To the best of our knowledge, however, no study has precisely conducted the comparison between the impact of Low level laser therapy and polarized light therapy in improving wound healing process and to conclude which one is more efficient in improving wound healing post burn. The results of our trial were agreed with those of other studies which concluded that each of Low level laser therapy and polarized light therapy had beneficial therapeutic effect on wound healing and burn14,15

Our results revealed an improvement in the measurement outcome in both groups post treatment and this improvement in favor of group A (who received LLLT) with 64.10% in Rt upper limb and 60.14% in Lt upper limb.

The therapeutic effects of low level laser on reducing surface area and accelerating wound healing is suggested that it might be due to the increased cellular proliferation, collagen biosynthesis, reduced swelling and anti-inflammatory effect.

Moreover, laser enhances healing of damaged wounds as measured by the increase in wound tensile characteristics, wound collagen formation, and collagen maturation 14.

Regarding, to anti-inflammatory effect of laser, the inflammatory process (hemorrhage, edema, necrosis, neutrophil cell inflow) can be attributed to LLLT's modulatory effects on inflammatory markers (TNF-, IL-1, PGE2, plasminogen activator), leukocyte activity (macrophages, lymphocytes, neutrophils) and cellular proliferation 16.

Also, other studies founded that applying LLLT to a cutaneous wound greatly accelerated the healing process. DNA, total protein, hydroxyproline, and hexosamine levels all increased, indicating increased cellular proliferation and collagen synthesis. Strength to the newly formed tissue is provided by an increase in hydroxyproline and hexosamine content in burn wounds treated with LLLT17.

According to 18 laser irradiation triggers cell networks, photo-biomodulation of the cytokines, growth factor receptor, cellular, and nuclear factors to accelerate wound repair, there was a reduction in wound surface area. In addition to reducing the inflammatory response, cellular proliferation, collagen synthesis, and wound contraction are all aided by LLLT, making it an effective treatment for burn wounds. This research explains how LLLT accelerate the healing process for burn wounds.

In disagreement with our study, the results of a study that presents the effects of two different doses of low-level laser therapy on healing of deep second degree burns. Burns were left untreated in the control group, while they were irradiated with low-level helium-neon lasers at energy densities of 1.2 and 2.4 J/cm2 on a daily basis in the two laser treatment groups. Topical 0.2% nitrofurazone cream was used daily to the burns of the fourth group. After treatment with LLLT at energy densities of 1.2 or 2.4 J/cm2, it was determined that the number of macrophages; which play an important role in dermal restoration because they help remove damaged tissue, release chemotactic

chemicals that recruit fibroblasts and endothelial cells, and secrete lactate that prompts fibroblasts to produce collagen; did not increase, nor did the healing of profound second-degree burns 19.

Also, a study by 20 who concluded that LLLT may not hasten the healing of the burns as the pathophysiology of burns is characterized by inflammatory reactions leading to fast edema formation, increased tissue necrosis. Therefore, it appears that the remaining few surviving cells, including macrophages, fibroblasts, capillaries, and blood vessels, did not have an optimal milieu in which LLLT might be effective.

The improvement of wound surface area in group B (who received PLT) with37.53 % in Rt upper limb and 43.48 % in Lt upper limb. The therapeutic effects of polarized light therapy on reducing surface area and accelerating wound healing is suggested that it might be due to a variety of biological mechanisms, such as changes in the levels of cytokines and growth factors, which are responsible for the various stages of wound healing. Also, PLT has been shown to promote cytokines and growth factors.

Cytokines initiate the inflammatory phase of wound healing and promote fibroblast proliferation and migration. Growth factors responsible for neovascularization and stimulating collagen synthesis from fibroblasts, both are required for wound healing 15.

Regarding to decrease burn extent, the polarized light therapy experienced lower levels of hyperemia and edema. So, it leads to improve re-epithelialization and revascularization. There is sufficient evidence to suggest that polarized light therapy has a beneficial effect on healing time 21.

Some studies were in disagreement with our study, one of them concluded that effect of polarized light therapy as an additional treatment to the regular wound care (debridement, Local antimicrobial drug and betadine) 5 sessions per week for 3 weeks, for deep partial thickness second degree burn wound in pediatrics. There was a small enhancement in wound healing, according to the results. Both groups' burn wound surface areas decreased significantly, with no statistically significant difference between the two groups 22.

Another study was revealed that, the polarized light begins to lose its polarization direction once it has penetrated the tissue. There are a number of potential causes for polarization loss in tissue, including blood movement in capillaries, birefringent medium properties, and multi-scattering from static tissue components 23.

The study has some limitations. First, the relatively small sample size. So, a bigger sample size is required to investigate the results of this investigation. Second, the inability to conduct a strong statistical analysis due to the absence of long-term follow-up for both groups. Therefore, more research is required to evaluate the long-term benefits of low level laser therapy and polarized light therapy in the treatment of wound post burn.

In view of the results revealed by this study, it could be concluded that both of low level laser therapy and polarized light therapy are effective in management wound post burn, and low level laser therapy had a superior effect on wound surface area post burn as compared to Polarized light therapy in patients with upper limb full thickness second degree burn.

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REFERENCES

1. Gibran, N. S., Wiechman, S., Meyer, W., Edelman, L., Fauerbach, J., Gibbons, L., & Wiggins, B.: Summary of the 2012 ABA burn quality consensus conference. Journal of Burn Care & Research; 2013, 34(4), 361-385.
2. Rowan M P, Cancio L C, Elster E A, Burmeister D M, Rose L F, Natesan S, Chung K K: Burn wound healing and treatment: review and advancements. Critical care; 2015, 19(1), 1-12.
1. Porter C, Hurren NM, Herndon DN, Borsheim E.: Whole body and skeletal muscle protein turnover in recovery from burns. Int J Burns Trauma; 2013, 3:9–17.
2. Chetter I, Arundel C, Bell K, Buckley H,Claxton K,Corbacho and Martin B: " The epidemiology management and impact of surgical wounds healing by secondary intention of a research programme including the SWHSI feasibility RCT". Programme Grants For Applied Research; 2020, 8(7):1-122.
3. Cameron, A. M., Ruzehaji, N., & Cowin, A. J.: "Burn wound management: a surgical perspective". Wound Practice & Research: Journal of the Australian Wound Management Association;2010, 18(1)..
4. Vaghardoost R, Momeni M, Kazemikhoo N, Mokmeli S, Dahmardehei M and Ansari F: "Effect of low-level laser therapy on the healing process of donor site in patients with grade 3 burn ulcer after skin graft surgery (a randomized clinical trial)". Lasers In Med Sci ; 2018, 33(3) : 603-607.
5. Hawkins, D, Houreld, N, & Abrahamse H: Low level laser therapy (LLLT) as an effective therapeutic modality for delayed wound healing. Annals of the New York Academy of Sciences; 2005, 1056(1): 486-493.
6. Da Silva DF, Vidal BC, Zezell DM, Zorn TM, Núñez SC, Ribeiro MS: "Collagen birefringence in skin repair in response to red polarized-laser therapy". J Biomed Opt; 2006, 11(2):1- 6.
7. Ballyzek, M, Vesovic-Potic, V, He, X., & Johnston, A: Efficacy of polarized, polychromatic, non-coherent light in the treatment of chronic musculoskeletal neck and shoulder pain. BIOPTRON AG, Wollerau, Switzerland,2005.
8. Vaghardoost R, Momeni M, Kazemikhoo N, Mokmeli S, Dahmardehei M and Ansari F: "Effect of low-level laser therapy on the healing process of donor site in patients with grade 3 burn ulcer after skin graft surgery (a randomized clinical trial)". Lasers In Med Sci ; 2018, 33(3) : 603-607.
9. Monstrey, S. J., Hoeksema, H., Saelens, H., Depuydt, K., Hamdi, M., Van Landuyt, K., & Blondeel, P. N.: A conservative approach for deep dermal burn wounds using polarised-light therapy. British journal of plastic surgery; 2002, 55(5): 420-426.
10. Mohafez, H., Ahmad, S. A., Roohi, S. A., & Hadizadeh, M.: Wound healing assessment using digital photography: a review. Journal of biomedical engineering and medical imaging; 2016, 3(5), 01.
11. Wood F M (2014): "Skin regeneration: the complexities of translation into clinical practice". Int.
12. J. Biochem. Cell Biol; 56: 133–140.
13. de Moraes, J. M., Eterno de Oliveira Mendonça, D., Moura, V. B. L., Oliveira, M. A. P., Afonso, C. L., Vinaud, M. C., ... & de Souza Lino, R.: Anti-inflammatory effect of low- intensity laser on the healing of third-degree burn wounds in rats. Lasers in medical science; 2013, 28: 1169-1176.
14. Poon VK, Huang L, and Burd A.: Biostimulation of dermal fibroblast by sublethal Q-switched Nd: YAG 532 nm laser: collagen remodeling and pigmentation, J Photochem Photobiol B; 2005, 81(1): 1-8.
15. Correa, F., Martins, R. A. B. L., Correa, J. C., Iversen, V. V., Joenson, J., & Bjordal, J. M.: Low-level laser therapy (GaAs λ= 904 nm) reduces inflammatory cell migration in mice with lipopolysaccharide-induced peritonitis. Photomedicine and laser surgery; 2007, 25(4), 245-249.

16. Matic, M., Lazetic, B., Poljacki, M., Djuran, V., Matic, A., & Gajinov, Z.: Influence of different types of electromagnetic fields on skin reparatory processes in experimental animals. Lasers in medical science; 2009, 24, 321-327.
17. Gupta, A., Keshri, G. K., Yadav, A., Gola, S., Chauhan, S., Salhan, A. K., & Bala Singh, S.: Superpulsed (Ga- As, 904 nm) low- level laser therapy (LLLT) attenuates inflammatory response and enhances healing of burn wounds. Journal of biophotonics; 2015, 8(6), 489-501.
18. Bayat, M., Vasheghani, M. M., Razavi, N., Taheri, S., & Rakhshan, M.: Effect of low-level laser therapy on the healing of second-degree burns in rats: a histological and microbiological study. Journal of Photochemistry and Photobiology B: Biology; 2005, 78(2), 171-177.
19. Vorauer- Uhl K., Fürnschlief E., Wagner A., Ferko B., & Katinger H.: Reepithelialization of experimental scalds affected by topically applied superoxide dismutase: controlled animal studies. Wound repair and Regeneration; 2002, 10(6), 366-371.
20. Karadag CA, Birtane M, Aygit AC, Uzunca K, Doganay L.: The efficacy of linear polarized polychromatic light on burn wound healing: an experimental study on rats. J Burn Care Res; 2007, 28(2):291- 298.
21. Abdel-Mageed, S. M., Selim, A. O., Ghafar, M. A. A., & Ali, R. R.: A description of the effect of polarized light as an adjuvant therapy on wound healing process in pediatrics. Age (years); 2015, 15: 2-6.
22. Hoeksema HG, Monstrey SA and Saelens HU: Efficacy of polarized light therapy in the conservative treatment of deep dermal burns. Br J Plastic Surg; 2002, 55(5):420-426.