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ORIGINAL ARTICLE

The Value of Low-Level Laser Therapy on The Healing Process of Donor Site After Partial Thickness Skin Graft Surgery

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ABSTRACT

Background: Wound care begins with the acute phase and continues through the enhancement of scar tissue remodeling. To facilitate healing, the physician aims at enhancing wound care. Numerous clinical study investigators have documented the advantages of Low-level Laser Therapy (LLLT) on tissue healing which was described as a regenerative treatment to enhance wound healing at the site of a skin graft donor site. The present work aimed to achieve patient satisfaction and the aesthetic outcome of the donor site regarding wound healing.

Methods: This clinical trial study was conducted on 23 cases with raw area for split-thickness skin graft (STSG) within the period from December 2022 to November 2023. All participants were subjected to complete history taking, including personal, complaint, present, past, and family history. Patient Communication and explanation of the procedure and postoperative management. Full clinical examination, either general for all systems or local wound examination.

Results: Regarding 5th-day BWAT score items, there was no remarkable variance between the two groups (P >0.05). There was substantial variance between the groups concerning size and depth (p<0.05). There was substantial variation between the studied groups concerning 10th-day BWAT score items (Peripheral tissue edema, granulation tissue, and total score) (P<0.05).**Conclusions**: On the 10th day, the Laser group displayed better wound size and depth outcomes, along with favorable results in exudate quantity and type, skin color around the wound, peripheral tissue edema, granulation tissue, and overall wound assessment score compared to the Control group. These findings collectively suggest that laser therapy contributes to improved wound healing and scar management outcomes.

Keywords: Low-Level Laser Therapy; Healing Process, Partial Thickness Skin Graft.

INTRODUCTION

Low-level laser therapy (LLLT) has been in widespread use for more than 50 years. Low-Level Laser (LLL) is a unique kind of laser that uses non-thermal methods to affect biological systems [1]. Red near-infrared light (600–1100 nm) is used in LLLT. Its characteristics include a) Laser power output of 0.001–0.1 Watts. b) A wavelength between 300 and 10,600 nm. c)

Pulse rate, which ranges from 5000 Hertz (cycles per second) to 0, which is continuous. d) A dosage of 0.01 to 100 J/cm^2 and an intensity of 0.01 to 10 W/cm^2 [2].

Since its introduction, it has developed into an advanced instrument for treatment procedures and has been used in clinical settings to treat a variety of illnesses. Three principles support the treatments: reducing edema, inflammation, and chronic joint problems by focusing on the skin, brain, and joints; promoting wound healing of superficial and deeper tissues, neurological damage, etc.; and treating pain and neurological disorders [2].

As known, the wound healing process involves four distinct phases, which are inflammation, proliferation, hemostasis, and remodeling. Research has shown that the application of light to a wound can accelerate its healing process and improve its tensile strength. Investigations have demonstrated that photobiomodulation (PBM) has biostimulation impacts on wound healing, promoting the process by triggering cells like keratinocytes and fibroblasts to undergo differentiation, carry out their regular functions, and produce more collagen formation, growth factors, and angiogenesis [3].

A useful restorative procedure for quickening wound healing is the skin graft. A partial-thickness wound requiring management of pain, wound care, and healing time is created by the extraction of split-thickness skin grafts (STSG), which are composed of epidermal and dermal tissue [4].

After graft harvesting, donor site management is crucial, and frequently, cases experience greater pain there than at the recipient site. There are various dressing options available to hasten healing and improve donor site comfort [5].

The effects of various dressings on infection, discomfort, healing, pain, and cost-effectiveness have been compared in several investigations. While there are several contemporary dressings available to improve donor site comfort, employing wound healing acceleration strategies can improve case satisfaction [6].

The Low-level laser therapy beneficial advantages include accelerating tissue repair, promoting the growth of granulation tissue, aiding in wound contraction, reducing inflammation and regulation, and assisting in the alleviation of pain [7].

The present work aimed to achieve patient satisfaction and the aesthetic outcome of the donor site regarding wound healing.

METHODS

This clinical trial investigation was performed on 23 participants with raw area for STSG in the Department of Plastic And Reconstructive Surgery, Faculty of Medicine, Zagazig University, within the period from December 2022 to November 2023. Verbal and written informed consent was obtained from all participants after an explanation of the procedure and medical research. The research was conducted under the World Medical Association's Code of Ethics (Helsinki Declaration) for human research. This study was carried out after the approval of the Institutional Review Board (IRB#10206).

A total of 23 split-thickness donor sites were selected and allocated into 2 groups: Group 1 (Laser group), which received Low-Level Laser Therapy (18 cases), and Group 2 (control group), which received traditional dressing with only paraffin gauze over the surgical wound (5 cases).

Cases with the following criteria were included: all patients with raw area for STSG and their age from 10 to 70 years old.

Cases with the following characteristics were excluded: patients who required a full-thickness skin graft, individuals with systemic infection, those taking corticosteroids, those with immunosuppressive diseases that could delay wound healing, uncooperative, unstable ones, and those who refused to be enrolled in the study.

All participants were subjected to Complete history taking including personal, complaint, present, past, and family history. Patient Communication and explanation of the procedure and postoperative management. Full clinical examination, either general for all systems or local wound examination.

Technique:

Low-level laser therapy on the donor site after STSG was performed using α circle Low-Level Laser device (α circle MEDICAL EQUIPMENT CO. China), model: LLLT-2K-A1.

The LLLT was done on the 5th, 8th, and 10th post-operative days. The Portable Laser Probe (PLP), 250 mW, 650 nm, power density 0.6 W/cm^2, radiation area 0.25 cm^2, contact, continuous mode, and 2 J/cm^2, was used in the laser group in direct contact with the wound. To prevent infection of the donor site, sterile plastic wrap was placed over the probe. All dressings were taken off in a sterile manner in preparation for laser irradiation, and pictures were taken.

After the procedure, a paraffin gauze was placed over the entire non-adherent dressing that was applied to the donor site. Imaging was done in both laser and control groups on the 5th, 8th, and 10th days postoperatively, and to facilitate the calibration of each image, all photos were calibrated, and a ruler was placed next to the location of each incision. The image J program was used to analyze each image.

The modified Bates-Jensen Wound Assessment Tool (BWAT) has 13 items and addresses size, edges, depth, undermining, edema, the kind and the quantity of exudate and necrotic tissue, and distortion of the peripheral tissue, skin color encircling the wound, epithelialization, and granulation tissue was then used to assess donor sites in both groups.

Each item is evaluated on a five-point scale from 1 (best condition), 2 (good), 3 (neutral), 4 (poor), and 5 (worst condition). Higher scores indicate a worse state of the healing. The total is determined by adding up all of the items and can range between 13 and 65 points. When the wound heals, the item's size, edges, depth, and undermining receive a score of zero. Two other variables on the scale, location and shape, are not included in the final result [8].

The fifth, eighth, and tenth postoperative days were utilized to record pain using the visual analog scale (VAS). A 10 cm (100 mm) line is used to illustrate the scale, with 0 representing no pain, 1 to 3 representing minor pain that was manageable, 4 to 6 representing pain that interfered with sleep, and 7 to 10 representing activity and the highest level of pain that significantly interfered with appetite and sleep. Participants were asked to indicate on the line at the locations that corresponded to their pain during the previously specified times.

Late assessment of scar:

Six months later, it was completed using the Patient and Observer Scar Assessment Scale (POSAS) and the Vancouver Scar Scale (VSS). The vascularity, pliability, pigmentation, and height of the scars were the four factors used by Sullivan et al. [9] to rate them. There were ranking subscales for each parameter, which could be added together to

get a final score between 0 and 13, which corresponded to normal skin and the worst scar possible, respectively. Six characteristics of scars were included in the observer component of Draaijers et al.'s [10] development of POSAS: pigmentation thickness, vascularity, pliability, relief, and surface area. There were multiple categories for every parameter. Six factors made up the patient component: discomfort associated with scars, itching, color, rigidity, thickness, and irregularity. A 10-point grading system was utilized for each parameter; 1 represented normal skin, and 60 represented the worst possible scar [11].

STATISTICAL ANALYSIS

Data were analyzed using SPSS software version 25. Normality tests Kolmogorov-Smirnov & Shapiro-Wilk test were utilized with normally distributed data. Frequency and percentage were used to express qualitative data. The Chi-square test was employed to compare qualitative data. Continuous quantitative data were expressed as mean ± standard deviation or median and Interquartile range (Median with IQR). Differences between all groups were detected using the independent sample T test for parametric data and the Mann-Whitney U test for non-parametric data. P-value < 0.05 was considered significant.

RESULTS

Concerning gender, 12 patients in the Laser group (66.7%) were males, and 6 were females (33.3%); the Control group consisted of 5 females (100%); there was a marked variation between the two groups (P = 0.008). Regarding age, there was no substantial variance between the mean ± SD of the Laser group (33.9 ±14.7) and that of the control group (40.2 ±7.2) (P = 0.14). As regards wound size measurement on the 10th day, there was a remarkable (P= 0.001) decrease in the Laser group (Median = 1.85 cm2, IQR = 0 – 5.5) when compared with the control group (Median = 17.9 cm2, IQR = 15.5 – 30.2). Concerning 5th-day VAS, 2 patients of the Laser group (11.1%) had pain affecting their sleep, 16 patients (88.9%) had maximum pain in the control group, 5 patients (100%) had maximum pain; there was no remarkable variance between groups (P = 0.44). Finally, as regards 10^{th}-day VAS, there were 6 patients (33.3%) in the Laser group with no pain, 7 patients (38.9%) with mild pain, and 5 patients (27.8%) with pain affecting sleep. However, in the control group, there were 2 patients (40%) with pain affecting sleep and 3 patients (60%) with maximum pain; there was a substantial variance between the groups (P = 0.002). (Table 1).

Concerning vascularity, there was a marked difference between the two groups concerning vascularity, height, and Vancouver total score ($p<0.05$) (Table 2).

Regarding size, in the Laser group, there were 4 cases (22.2%) with grade 3, 10 cases (55.6%) with grade 4, and 4 cases (22.2%) with grade 5. While in the control group, there was one case (20%) with grade 3, 3 cases (60%) with grade 4, and one case (20%) with grade 5; there was no remarkable variation between the two groups (P = 0.9). Nevertheless, depth and edges were grade 2 in all patients of Laser and control groups. Regarding undermining, all patients (100%) of the Laser group and control group were grade 1 (Table 3).

Regarding 5^{th}-day BWAT score items (necrotic tissue and exudate kind and quantity and skin color around the wound), no marked variance between the two groups was detected (P >0.05) (Table 4).

There was no substantial variation between

the studied groups regarding 5th-day BWAT score items (peripheral tissue edema and induration, epithelialization, granulation tissue, and total score) (Table 5).

There was substantial variance between the studied groups concerning size and depth ($p<0.05$) (Supplementary Table 1). There was substantial variation between the studied groups concerning 10th-day BWAT score items (Peripheral tissue edema. Granulation tissue, and total score) ($P<0.05$) (Supplementary Table 2).

Case (1): the patient was a 46-year-old male with no other known comorbidities. He presented with a crushing rotatory injury at the lower limb with the raw area over the plantar surface of the right foot. To close the wound, a STSG was taken from his left thigh. The donor site for the skin graft received low-level laser treatment on the 5th,8th, and 10th day to facilitate wound healing, and then follow-up was done after 6 months (Fig. 1).

Case (2): A42-year-old female presented with wound dehiscence and necrosis after breast reduction mammoplasty. To close the wound, a STSG was taken from his left thigh. The donor site for the skin graft received low-level laser treatment on the 5th,8th, and 10th day to facilitate wound healing, and then follow-up was done after 6 months (Fig. 2).

Table (1): Comparison of the studied groups as regard demographic data, donor site, wound size, and VAS in 5th and 10th days.

			Laser (n = 18)		Control (n = 5)		X^2/T	P-value
Gender		Male	12	66.7%	0	0.0%	X^2 = 6.9	0.008 S
		Female	6	33.3%	5	100%		
Age		Mean ± SD	33.9±14.7		40.2 ±7.2		T= -0.9	0.14 NS
Donor site		Rt thigh	11	61.1%	0	0%	X^2 = 5.9	0.02 S
		Lt thigh	7	38.9%	5	100 %		
Wound Size (cm^2)	M1 (5th day)	Median	51.3		60.2		MW= 30	0.26 NS
		IQR	38.5 – 79.3		57 – 101			
	M2 (10th day)	Median	1.85		17.9		MW= 0	0.001 S
		IQR	0 – 5.5		15.5 – 30.2			
VAS 5th day		No pain	0	0%	0	0%	0.6	0.44 NS
		Mild pain	0	0%	0	0%		
		Pain affecting sleep	2	11.1%	0	0%		
		Maximum pain	16	88.9%	5	100%		
VAS 10th day		No pain	6	33.3%	0	0	14.6	0.002 S

		Laser (n = 18)		Control (n = 5)		X^2/T	P-value
	Mild pain	7	38.9%	0	0		
	Pain affecting sleep	5	27.8%	2	40%		
	Maximum pain	0	0%	3	60%		

X^2: Chi-square test. T: independent sample T test. MW: Mann Whitney U test. NS: p-value > 0.05 is considered non-significant. S: p-value < 0.05 is considered significant.

Table (2): Comparison of the studied groups as regard Vancouver scar scale.

Vancouver Scar Scale		Laser (n = 18)		Control (n = 5)		Stat. test	P-value
Vascularity	Normal	7	38.9%	0	0%	X^2= 8.3	0.04 S
	Pink	6	33.3%	0	0%		
	Red	2	11.1%	2	40%		
	Purple	3	16.7%	3	60%		
Pigmentation	Normal	6	33.3%	0	0%	X^2= 45	0.1 NS
	Hypopigmentation	4	22.2%	0	0%		
	Hyperpigmentation	8	44.4%	5	100%		
Pliability	Normal	7	38.9%	0	0%	X^2= 12	0.34 NS
	Supple	6	33.3%	1	20%		
	Yielding	1	5.6%	1	20%		
	Firm	3	16.7%	0	0%		
	Ropes	1	5.6%	1	20%		
	Contracture	0	0.0%	2	40%		
Height	Flat	13	72.2%	0	0%	X^2= 12.7	0.005 S
	<2	3	16.7%	1	20%		
	2~5	2	11.1%	2	40%		
	>5	0	0.0%	2	40%		
Total score	Median	3		11		MW= 6	0.004 S
	IQR	0.8 – 5.3		7.5 – 12.5			

Table (3): Comparison of the studied groups as regard 5th day BWAT score items (size, depth, edges and undermining).

5th day BWAT score Item		Laser (n = 18)		Control (n = 5)		X^2	P-value
Size	Grade 1	0	0%	0	0%	0.03	0.9 NS
	Grade 2	0	0%	0	0%		
	Grade 3	4	22.2%	1	20%		
	Grade 4	10	55.6%	3	60%		
	Grade 5	4	22.2%	1	20%		
Depth	Grade 1	0	0%	0	0%	-------	-------
	Grade 2	18	100%	5	100%		
	Grade 3	0	0%	0	0%		
	Grade 4	0	0%	0	0%		
	Grade 5	0	0%	0	0%		
Edges	Grade 1	0	0%	0	0%	-------	-------
	Grade 2	18	100%	5	100%		
	Grade 3	0	0%	0	0%		
	Grade 4	0	0%	0	0%		
	Grade 5	0	0%	0	0%		
Undermining	Grade 1	18	100%	5	100%	-------	-------
	Grade 2	0	0%	0	0%		
	Grade 3	0	0%	0	0%		
	Grade 4	0	0%	0	0%		
	Grade 5	0	0%	0	0%		

X^2: Chi-square test. NS: p-value > 0.05 is considered non-significant.

Table (4): Comparison of the studied groups as regard 5th and 10th day BWAT score items (necrotic tissue type, necrotic tissue amount, exudate type, exudate amount and skin color surrounding the wound).

		Laser (n = 18)		Control (n = 5)		X^2	P-value
5th day BWAT score Item							
Necrotic Tissue Type	Grade 1	18	100%	5	100%	-------	-------
Necrotic Tissue Amount	Grade 1	18	100%	5	100%	-------	-------
Exudate Type	Grade 1	5	27.8%	0	0%	2.4	0.3 NS
	Grade 2	10	55.6%	3	60%		
	Grade 3	3	16.7%	2	40%		
Exudate amount	Grade 1	5	27.8%	0	0%	0.2	0.6 NS
	Grade 2	5	27.8%	2	40%		
	Grade 3	4	22.2%	2	40%		
	Grade 4	4	22.2%	1	20%		
Skin color surrounding	Grade 1	4	22.2%	0	0%	1.9	0.6 NS

		Laser (n = 18)		Control (n = 5)		X^2	P-value
	Grade 2	5	27.8%	1	20%		
	Grade 3	3	16.7%	1	20%		
	Grade 4	6	33.3%	3	60%		
10^{th} day BWAT score item							
Necrotic Tissue Type	Grade 1	18	100%	5	100%	-----	-----
Necrotic tissue amount	Grade 1	18	100%	5	100%	-----	-----
Exudate type	Grade 1	18	100%	2	40%	12.4	< 0.001 HS
	Grade 2	0	0%	3	60%		
Exudate amount	Grade 1	18	100%	3	60%	7.9	0.005 S
	Grade 2	0	0%	2	40%		
Skin color surrounding wound	Grade 1	14	77.8%	1	20%	5.8	0.02 S
	Grade 2	4	22.2%	4	80%		

X^2: Chi-square test. NS: p-value > 0.05 is considered non-significant. S: p-value < 0.05 is considered significant.

Table (5): Comparison of the studied groups as regard 5^{th} day BWAT score items

BWAT score Item		Laser (n = 18)		Control (n = 5)		Stat. test	P-value
Peripheral tissue edema	Grade 1	11	61.1%	1	20%	2.7	0.3 NS
	Grade 2	4	22.2%	2	40%		
	Grade 3	3	16.7%	2	40%		
Peripheral tissue induration	Grade 1	8	44.4%	2	40%	0.3	0.9 NS
	Grade 2	5	27.8%	2	40%		
	Grade 3	5	27.8%	1	20%		
Granulation tissue	Grade 3	4	22.2%	1	20%	0.1	0.9 NS
	Grade 4	7	38.9%	2	40%		
	Grade 5	7	38.9%	2	40%		
Epithelialization	Grade 4	7	38.9%	3	60%	0.7	0.4 NS
	Grade 5	11	61.1%	2	40%		
Total score	Mean ± SD	34 ± 14.7		40 ± 7.2		T= -0.9	0.14 NS

X^2: Chi-square test. NS: p-value > 0.05 is considered non-significant. T: independent sample T test.

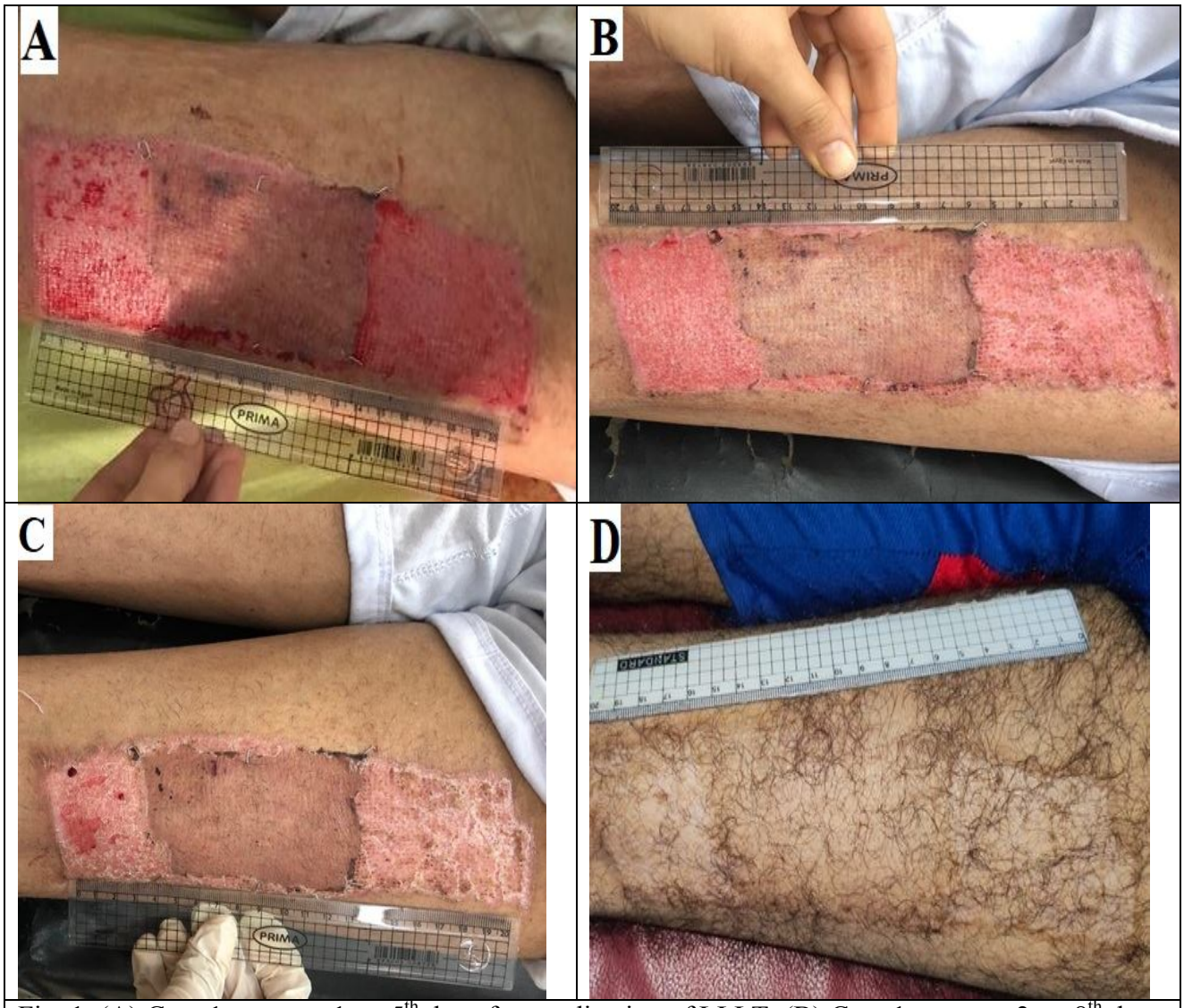

Fig. 1. (A) Case 1 measure 1 on 5th day after application of LLLT. (B) Case 1 measure 2 on 8th day after application of LLLT. (C) Case 1 measure 3 on 10th day after application of LLLT. (D) Late assessment of case 1 after 6 months.

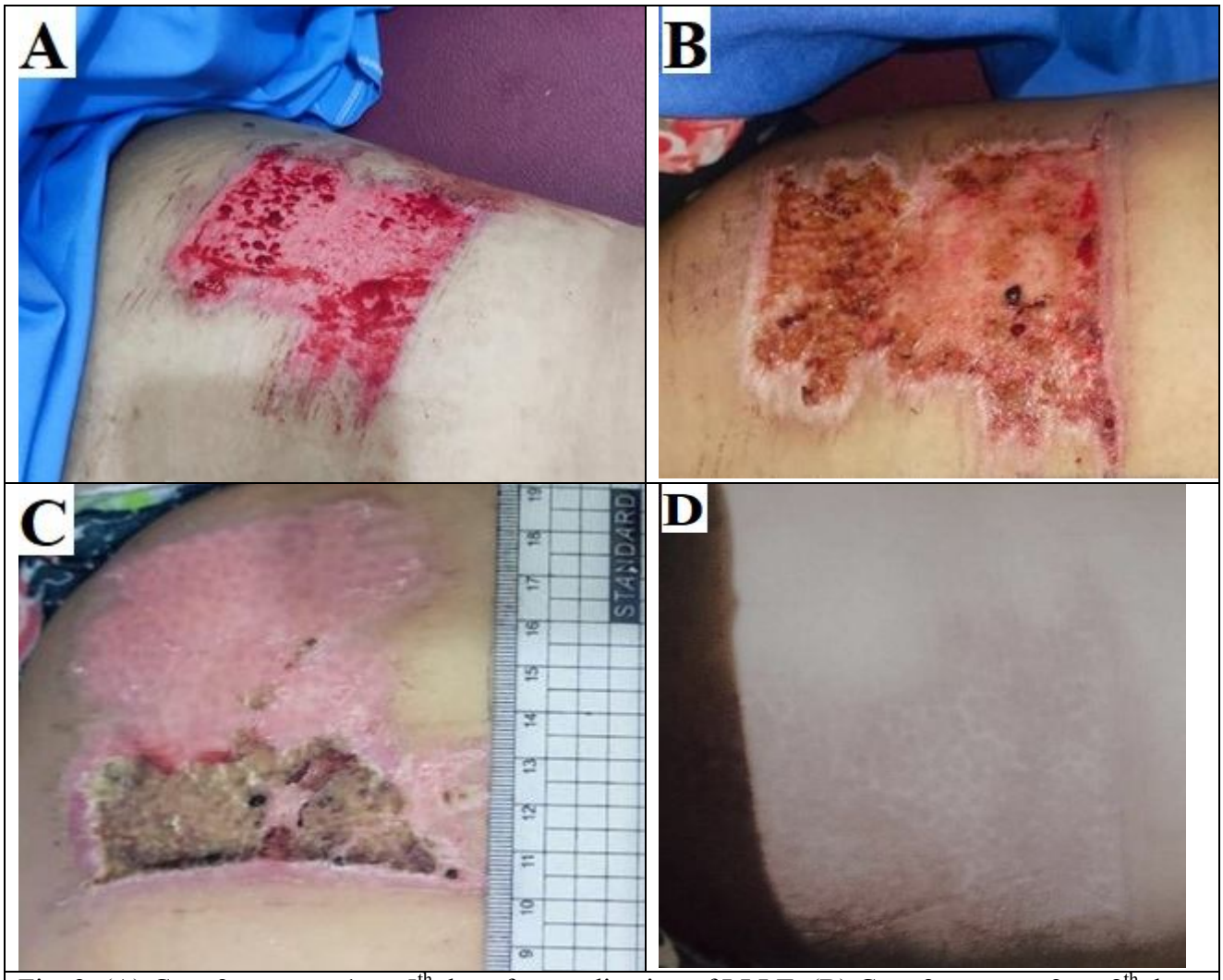

Fig. 2. (A) Case 2 measure 1 on 5th day after application of LLLT. (B) Case 2 measure 2 on 8th day after application of LLLT. (C) Case 2 measure 3 on 10th day after application of LLLT. (D) Case 2 late assessment after 6 months

DISCUSSION

In our study, a total of 23 participants were enrolled in this study and were allocated to Group 1 (Laser group), comprising 18 cases, received Low-Level Laser Therapy. In contrast, Group 2 (control group), consisting of 5 cases, received traditional dressing with only paraffin gauze over the surgical wound.

This also was in line with Vaghardoost et al. [12]; following the surgeon's graft of the burned area, eighteen donor sites were arbitrarily split into two groups: the laser group (A) and the control group (B).

Also, another study by MOGAHED and BESHR [13] was conducted at Cairo University Hospitals over a period of six months from 1/1/2018 to 30/6/2018. In this study, 30 cases with 3rd-degree burns grafted after early excision were allocated equally in a random manner into laser and control groups.

As regards demographic data, we found that there was a remarkable variance in gender distribution between the Laser and Control groups (P = 0.008). The Laser group had a higher percentage of males (66.7%), while the Control group consisted entirely of females. This may be attributed to random sample collection. However, there was no marked variation in age between the groups (P = 0.14). The mean age in the Laser group was 33.9 ± 14.7, while in the Control group, it was 40.2 ± 7.2.

However, in the investigation by M. A. Nilforoushzadeh et al. [14], a more balanced gender distribution was noted among the ten recruited patients, with 70% males and 30% females. Additionally, In Nilforoushzadeh et al.'s [14] study, the mean age was 47±12.96years, ranging from 30 to 68 years.

Similarly, the study by Vaghardoost et al. [12] included 18 donor sites from 11 participants, with 27.3% females and 72.7% males completing the investigation. The mean age was 31.64 ± 11.74 years, and the mean burn percentage was 23.73%.

In our study, a noteworthy dissimilarity was evident in the allocation of donor sites between the laser and control groups. Specifically, the Laser group featured a combination of right and left thigh donors, whereas the Control group exclusively utilized left thigh donors (P = 0.02). While no substantial variance in wound dimensions was noted on the 5th day, the Laser group exhibited a notable decrease in wound size on the 8th and 10th days compared to the Control group (P <0.01).

The current findings were in line with Vaghardoost et al. [12], who found that donor site size significantly decreased in both the Laser and Control groups after one week (P < 0.01). Notably, the lowering in size was remarkably elevated in the Laser group compared to the control (P = 0.01). This suggests that LLLT contributes to a more effective reduction in donor site size.

However, in Kaviani et al. [15], Two weeks following the start of the study, the LLLT group had a greater decrease in wound size than the placebo group (47.5% vs. 29.4%). However, the variation was not substantial (p = 0.125). However, four weeks following the therapy, the LLLT group's ulcer size decrease from baseline to the long term was substantially greater than that of the placebo group (73.7% vs. 47.3%; p = 0.03).

Our study suggests that the Laser group exhibited lower pain scores on the 8th and 10th days compared to the Control group, highlighting the potential effectiveness of

laser therapy in reducing pain. Enwemeka et al. [16] reported that LLLT was a very successful therapy in reducing pain and hastening tissue healing.

Another study by Sadighi et al. [17], although it was a different study but, investigated the pain-relieving effects of LLLT. The investigation focused on assessing patients' pain levels over two weeks following orthognathic surgery. Interestingly, the study revealed a significant reduction in pain with LLLT compared to a placebo, specifically on the fourth postoperative day.

However, our results were in disagreement with Minatel et al. [18], who observed that certain participants in the LLLT group reported transient pain during treatment. Specifically, the treatment of nine patients was deemed ineffective in alleviating pain. The authors suggested that, in routine circumstances, wounds typically heal within days with regular dressing, rendering laser treatment unnecessary for such cases. Thus, barring infection, laser therapy would not make a variation in the healing rates and in pain control.

In a previous study [19] comparing a control group (n = 9) to a laser group (n = 9) based on VAS scores, the data suggests that the laser group exhibited slightly lower mean VAS scores across the four weeks. However, the p-values (Two-sided exact p) for each week (Week 1: p = 0.258083, Week 2: p = 0.436281, Week 3: p = 0.730440, Week 4: p = 0.222419) indicate that these variations were not remarkable. This suggests that, based on this study's findings, laser therapy did not demonstrate a significant and beneficial impact on pain reduction compared to the control group.

In our study, the Laser group exhibited lower vascularity (P = 0.04) and height (P = 0.005), coupled with a reduced VAS score (P = 0.004), suggesting a more favorable scar formation process compared to the Control group. Substantial variance in pigmentation and total score on the Observer component of the POSAS (P = 0.02) indicated better scar appearance in the Laser group. Additionally, on the Patient component, significant differences in scar stiffness (P = 0.04) and total score (P = 0.03) revealed improved patient-reported outcomes in the Laser group.

Studies conducted in vivo and in vitro show that laser therapy substantially enhances scar appearance and tensile strength while also hastening wound healing [20–22].

In contrast, Gaida et al. [23] showed that LLLT had potential effects on cases with burn scars appearance. Seventeen out of the 19 lesions exhibited notable macroscopic improvement following the treatment, as evidenced by a decrease in VSS points. The average score for scars, initially classified at 7.10 points on the VSS before treatment, significantly decreased to 4.68 points post-treatment. This outcome suggests a favorable response to the intervention, underscoring its efficacy in reducing the severity of scars.

Similarly, In the study by Sobanko et al. [24], there was no marked variance between scar halves one week after the operation, just before laser therapy, as indicated by comparable VSS scores in both control and treatment groups (P > 0.05). However, three months following laser treatment, a notable improvement in both overall VSS and three out of four individual parameters of the scale was observed in both the control and treated halves of the scar. This suggests a positive and lasting impact of the laser treatment on the appearance of the scar.

Vazquez-Martinez et al. [25] also reported that the control group had a baseline VSS of

2, while the treatment group had a baseline VSS score of 4. No substantial variation was observed between the groups initially. After 45 days, the control group showed a trend toward improvement, with the VSS score decreasing from 2 to 1.3 (P = 0.056). In contrast, the treatment group, following laser sessions, exhibited a significant reduction in VSS score from 4 (3) to 1 (2) at 45 days (P = 0.005). These findings suggest a notable positive effect of laser treatment on scar improvement compared to the control group.

However, by the 10th day, the Laser group demonstrated superior outcomes in terms of both wound size and depth compared to the Control group. Additionally, remarkable disparities were detected in exudate type and quantity and the skin color surrounding the wound, all indicative of more favorable results in the Laser group.

Furthermore, the Laser group exhibited enhanced outcomes in peripheral tissue edema, granulation tissue, and overall wound assessment scores in comparison to the Control group. This comprehensive assessment confirms the potential efficacy of LLLT in promoting a more favorable wound-healing environment.

Dantas et al. [26] demonstrated that the combination of LLLT and a sodium alginate/chitosan film promoted accelerated epithelialization, angiogenesis, and collagen synthesis in burn ulcers. Additionally, Ezzati et al. [27] found that laser irradiation contributed to enhanced healing of 3rd degree burn ulcers. These studies collectively suggest the potential benefits of laser therapy in promoting wound healing and tissue repair in the context of burn injuries.

A previous meta-analysis by Huang et al. [28] demonstrated that LLLT was found to have a substantial impact on the complete healing rate (P <.00001), ulcer area reduction (P =.0002), and mean healing time reduction (P <.00001).

The results of the study conducted by Nilforoushzadeh et al. [14], focusing on the treatment of grade III burn wounds in diabetic cases, were notably promising. The mean pre-treatment wound size was 16.28 cm2, and following the intervention involving LLLT followed by Autologous Fibroblast Transplantation, all patients' burn wounds achieved complete healing within 10-12 weeks.

There are few studies for evaluating the value of LLLT on the healing process of donor sites after partial thickness skin graft surgery.

Vaghardoost et al. [12] findings assumed that combining laser therapy with skin transplant surgery enhances both the surgical prognosis and the healing process.

Similarly, the Kazemikhoo et al. [20] study focused on assessing the impact of LLLT on the healing process following skin graft surgery in burned cases and revealed compelling results. The research demonstrated a remarkably reduced rate of wound dehiscence in the group treated with laser therapy compared to the control group, which received conventional dressing alone (P=0.019). These findings highlight LLLT as a safe and effective method, showcasing its potential to enhance graft survival, expedite the process of wound healing, and, importantly, reduce the occurrence of wound dehiscence in individuals with deep burn ulcers. The study confirms the clinical significance of incorporating LLLT into postoperative care strategies for patients undergoing skin graft surgery, providing valuable insights into its positive impact on the outcomes of this critical aspect of burn wound management.

CONCLUSIONS

In conclusion, our study demonstrated a significant gender distribution variance between the Laser and Control groups, with a higher percentage of males in the Laser group. Despite this, there was no remarkable age variation between the two groups. The Laser group exhibited advantages in various aspects, including reduced wound size on the 8th and 10th days, lower pain scores on the 8th and 10th days, and superior outcomes in scar appearance and patient-reported scar stiffness. Additionally, significant differences favoring the Laser group were observed in vascularity, height, and total scores of the VSS. On the 10th day, the Laser group displayed better wound size and depth outcomes, along with favorable results in exudate type and quantity, tissue edema, skin color encircling the wound, tissue granulation, and overall wound assessment score compared to the Control group. These findings collectively suggest that laser therapy contributes to improved wound healing and scar management outcomes.

Declaration of interest

The authors report no conflicts of interest.
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