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Effect of Polarized Light on Post Burn Hypertrophic Scars

Wpływ światła spolaryzowanego na przerostowe blizny pooparzeniowe

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Abstract

Background. Hypertrophic scar (HTS) formation after burn remains a major issue for burned patients and is considered a huge problem for clinicians because the hypertrophic scar is painful, reddish, elevated, pruritic, and aesthetically unacceptable. Purpose. To study the effect of polarized light therapy (PLT) on post burn HTS. Materials and Methods. Thirty patients complaining of HTS formation after thermal burn with ages ranged from 20 to 40 years shared in this study and were randomly distributed into two matching groups in number (15 patients for each group). Group A (Study group): received 10 min. PLT 3 sessions/week plus silicone gel sheet (SGS) kept for 12 hours/day, medical treatment such as (hydration creams and antihistamine drugs), and routine physical therapy (splinting, massage therapy, stretching exercises, and strengthening exercises) for 2 months. Group B (Control group): received SGS kept for 12 hours/day, medical treatment such as (hydration creams and antihistamine drugs), and routine physical therapy (splinting, massage therapy, stretching exercises, and strengthening exercises) for 2 months. Methods of evaluation included Vancouver scar scale (VSS) to measure four parameters of hypertrophic scar (height, vascularity, pigmentation, and pliability) and photographic method to allow for visual assessment of the scars. Results. Comparison between post-treatment and pre-treatment in the study group showed a significant decrease in height, vascularity, pigmentation, and pliability scores ($p > 0.01$). There was a significant decrease in height and pliability scores of the study group in comparison with that of the control group ($p < 0.01$), while there was no significant difference in vascularity and pigmentation between groups ($p > 0.05$). Conclusion. PLT is an effective, easy to apply, and non-invasive treatment modality in post burn HTS.

Key words:

Post burn hypertrophic scars and Polarized light

Streszczenie

Informacje wprowadzające. Blizna przerostowa (HTS) po oparzeniu stanowi główny problem dla poparzonych pacjentów i jest uważana za ogromny problem dla klinicystów, ponieważ jest bolesna, czerwonawa, uniesiona, swędząca i nie do zaakceptowania z estetycznego punktu widzenia. Cel. Badanie wpływu terapii światłem spolaryzowanym (PLT) na blizny przerostowe po oparzeniu. Materiały i metody. Trzydziestu pacjentów skarżących się na tworzenie blizn przerostowych po oparzeniu wysoką temperaturą w wieku od 20 do 40 lat podzielono losowo na dwie dopasowane liczebnie grupy (15 pacjentów w każdej grupie). Grupa A (Grupa badana): była poddawana leczeniu przy użyciu PLT przez 10 minut trzy razy w tygodniu oraz arkusza z żelem silikonowym (SGS) noszonego przez 12 godzin dziennie, leczeniu przy użyciu kremów nawilżających i leków przeciwhistaminowych oraz rutynowej fizjoterapii (szynowanie, masaże, ćwiczenia rozciągające i ćwiczenia wzmacniające) przez 2 miesiące. Grupa B (grupa kontrolna): nosiła arkusz SGS przez 12 godzin dziennie, była poddawana leczeniu przy użyciu kremów nawilżających i leków przeciwhistaminowych oraz rutynowej fizjoterapii (szynowanie, masaże, ćwiczenia rozciągające i ćwiczenia wzmacniające) przez 2 miesiące. Metody oceny obejmowały skalę oceny blizny Vancouver (VSS) do pomiaru czterech parametrów blizny przerostowej (wysokość, unaczynienie, pigmentacja i elastyczność) oraz metodę fotograficzną umożliwiającą wizualną ocenę blizn. Wyniki. Porównanie stanu po leczeniu i przed leczeniem w grupie badanej wykazało istotne zmniejszenie wysokości, unaczynienia, pigmentacji i elastyczności ($p > 0,01$). Stwierdzono istotne obniżenie wysokości i elastyczności w grupie badanej w porównaniu z grupą kontrolną ($p < 0,01$), natomiast nie było istotnej różnicy w unaczynieniu i pigmentacji ($p > 0,05$). Wniosek. PLT to skuteczna, łatwa do zastosowania i nieinwazyjna metoda leczenia blizn przerostowych po oparzeniach.

Słowa kluczowe

Przerostowe blizny pooparzeniowe i światło spolaryzowane

Introduction

A burn is tissue destruction induced generally by thermal injury including flames, hot liquids, or hot solids. Other causes of burn injury are radiation, friction, electricity, or chemicals [1]. Wound healing is a normally complicated mechanism that is triggered in the injured area and composed of four phases: coagulating phase, inflammatory phase, proliferating phase, and remodeling phase. General failure in the mechanism of wound healing can lead to functionally debilitating hypertrophic scar (HTS) development [2]. HTSs possibly occur when any injury, particularly burns, affect the deep dermis layer and they do not expand beyond the original injury boundaries. Typically, hypertrophic scars happen within few weeks of the original injury, develop powerfully for a few months, and spontaneously begin to revert within a year. They are often linear scars affecting any area of the body and can develop contracture when joint regions are affected [3]. HTS is more common with slower healing (e.g., burn injuries that take 3 weeks or more to heal) than those which heal more rapidly [4]. Incidences have been stated for HTS, with rates from 40% to 70% after surgeries and up to 90% following burn injuries, relying on the depth of tissue destruction. HTS has equivalent sex distribution with the highest occurrence in the second and third decades [5].

Polarized light therapy (PLT) is a common sort of restricted light therapy method. Polarized light (PL) corresponds to a portion of electromagnetic waves generated directly by the sun without critical ultraviolet (UV) radiation. Bioptron Light Therapy (BLT) devices emit light with a span of wavelengths (480 nm-3400 nm) that corresponds to the visible light in addition to infrared radiation, both of which have been stated to animate the physiological response [6]. PL is generated by light beam filters to be oriented in a single plane. PL can reach the tissues at a greater depth than the unpolarized light. It is distinguished from various types of light therapy because it has a broader spectrum of wavelength than other types such as ultraviolet (UV) or low-level light therapy (LLLT). BLT devices are usually cost-effective and quite simple to apply. Numerous diseases such as wound healing, skin diseases, skin ulcers, burns, musculoskeletal injuries, pain, and inflammatory arthritis have been treated with PLT [7]. It was concluded that PLT is effective in reducing scars following pediatric burn and enhancing its appearance [8].

Silicone gel sheet (SGS) is a topical, semi-occlusive, and self-adhesive sheet used to prevent and treat pathological scars. SGS is also durable and simple to handle. SGS is intended to be applied only on intact skin and is contraindicated in patients with skin diseases (e.g., severe acne or psoriasis) that affect skin integrity [9].

Material and Methods

Design of the study

The study was designed as a prospective, randomized, double blind, pre- post-test, controlled trial. The study's protocol was confirmed by the ethical committee of faculty of physical therapy Cairo University, Egypt [NO: P.T.REC/012/002763]. Each subject gave an informed consent before the study beginning.

Participants

Thirty patients diagnosed as hypertrophic scar post burned patients by a burn care specialist participated in this study. They were chosen under the following criteria: Both genders (males and females) shared in this study, patients with age from 20-40 years, all patients had hypertrophic scars due to thermal burn injuries, all patients obtained the same medications, all patients were conscious and the therapeutic intervention for all patients began ≥2 months post wound healing. Excluded from the sample were those who had open wound at or near the treatment site, skin abnormalities (i.e: psoriasis or carcinoma of the skin), autoimmune disease or any pathological conditions which may influence the outcomes, keloids, chemical or electrical burns, or major burns covering more than 20% of TBSA.

Randomization

It was carried out using odd and even numbers for random distribution of included patients into two groups of 15 patients each: Group A (study group) or Group B (control group) by a blinded and independent researcher. They were analyzed as no participants drop out of the sample after being randomly assigned.

Intervention

Group A (Study group): included (10 females, 5 males) received 10 min. polarized light therapy 3 sessions/week plus silicone gel sheet (SGS) kept for 12 hours/day, medical treatment such as (hydration creams and antihistamine drugs), and routine physical therapy (splinting, massage therapy, stretching exercises, and strengthening exercises) for 2 months. Group B (Control group): included (9 females, 6 males) received SGS kept for 12 hours/day, medical treatment such as (hydration creams and antihistamine drugs), and routine physical therapy (splinting, massage therapy, stretching exercises, and strengthening exercises) for 2 months.

Polarized light therapy (PLT) (Bioptron compact III light therapy system (PAG-860) by bioptron AG, Switzerland)

The device safety measures were checked before the start of the sessions. The patient was in a relaxed position. PLT was set with the next parameters: wavelength 480–3,400 nm, light energy per minute 2.4 J/cm^2, degree of polarization > 95%, specific power density 40 mW/cm^2. Then the PL beam was pointed to the post burned scar areas. The Bioptron device was held perpendicular and at 10 cm from the treated area. PLT was applied for 10 minutes per session, 3 sessions per week, and continued for 2 months. The device was unplugged after use [10].

Silicone gel sheet application procedures

The patient was resting in a relaxed position. Cica-care silicone sheet was trimmed few millimeters from the edges of the scars, adjusted, and applied to the site of the scar. It was maintained with a cloth tape for 12 hours per day and remained for 2 months and was removed for washing by water and soap and then reapplied after drying. It is essential to clean the silicone sheet and the underlying skin every day to avoid irritation and heat rash [11].

Traditional physical therapy program

- Stretching exercises for the tightened muscles by using hold relax technique. To achieve this the limb was placed in pain free range and an isometric contraction was sustained (for 5 to 10 seconds) followed by a voluntary relaxation of the tightened muscles. The limb was then passively moved into the new range and sustained the stretch for 30 seconds for 3 repetitions at each time.
- Strengthening exercises by using dolerme technique by applying resistance to the weakened muscles for 3 sets of 10 repetitions maximum.
- Deep friction massage therapy.
- Splinting.

Outcome measures

Methods of assessment pre-treatment and 2 months post-treatment for both groups included VSS to measure four parameters of hypertrophic scar (height, vascularity, pigmentation, and pliability) and photographic method for visual assessment of the scar.

Vancouver scar scale (VSS)

It was conducted before and after two months of the treatment to assess 4 variables of scar characteristics: vascularity, thickness, pliability, and pigmentation. VSS was explained for every patient. A specific mark was put on the ranking for each point of the four parameters.

Photographic method

All patients were photographed before and after the 2 months of the treatment. Sony digital camera (Sony DSC-W800 digital camera, 20.1 megapixels 5× optical zoom lens with a 35 mm equivalent focal length of 26-130mm) was placed vertically to the scar area. The lights of the room were perfect to get a good picture. At each evaluation time, the digital camera was at a fixed distance from each patient's scar, and all factors such as lighting, magnification, background, and film exposure were the same for each patient. The picture was taken facing the affected surface while the patient was lying in a relaxed position [12].

Statistical analysis

Descriptive statistics and unpaired t-test were conducted for comparison of age between groups. Chi-squared was carried out for comparison of sex distribution between groups. VSS scores were compared between groups by Mann–Whitney U test and between pre-and post-treatment in each group by Wilcoxon Signed Ranks. 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).

Results

Subject characteristics

Table 1 showed the subject characteristics of the study and control groups. There was no significant difference between groups in age and sex distribution ($p > 0.05$).

Table 1. Basic participants characteristics

	Study group Mean ± SD	Control group Mean ± SD	p-value
Age (years)	31.4 ± 5.66	30.13 ± 5.59	0.54
Sex, n (%):			
Females	10 (67%)	9 (60%)	0.7
Males	5 (33%)	6 (40%)	

SD, standard deviation; p-value, level of significance

Effect of treatment on VSS

There was a significant decrease in height, vascularity, pigmentation, and pliability scores post-treatment compared with that pre-treatment in the study group ($p > 0.01$). In the control group there was a significant decrease in height, vascularity, and pliability scores post-treatment compared with that pre-treatment ($p > 0.01$), while there was no significant change in pigmentation score ($p > 0.05$). (Table 2).

There was no significant difference between groups pre-treatment ($p > 0.05$). Comparison between the study and control groups post-treatment revealed a significant decrease in height and pliability scores of the study group compared with that of the control group ($p < 0.01$), while there was no significant difference in vascularity and pigmentation between groups ($p > 0.05$). (Table 2).

Table 2. Median values of VSS scores pre-and post-treatment of control and study groups

VSS Scales		Pretreatment Mean ± SD	Posttreatment Mean ± SD	Mean Difference	% of change
Height	Pre-treatment	3 (3-2)	3 (3-2)	105	0.71
	Post-treatment	1 (1-1)	2 (2-1)	52.5	0.001
	Z- value	3.5	3.77		
		P = 0.001	P = 0.001		
Vascularity	Pre-treatment	2 (2-2)	2 (2-2)	105	0.63
	Post-treatment	0 (1-0)	1 (1-0)	75	0.07
	Z- value	3.5	3.69		
		P = 0.001	P = 0.001		
Pigmentation	Pre-treatment	2 (2-2)	2 (2-2)	105.5	
	Post-treatment	0 (2-0)	2 (2-0)	89.5	0.65
	Z- value	2.53	1.73		0.28
		P = 0.01	P = 0.08		
Pliability	Pre-treatment	4 (4-3)	4 (4-3)	81	
	Post-treatment	1 (1-0)	2 (2-1)	51	0.14
	Z- value	3.53	3.48		0.008
		P = 0.001	P = 0.001		

IQR, interquartile range; U-value, Mann-Whitney test value; Z-value, Wilcoxon signed ranks test value; p-value, level of significance

Photographs of the study group showed more improvement in scar appearance (Figures 3 & 4). Compared with the control group, the findings were worse (Figure 1-3).

Figure 1. Changes in scar appearance in the study group; (A): before treatment & (B): after treatment

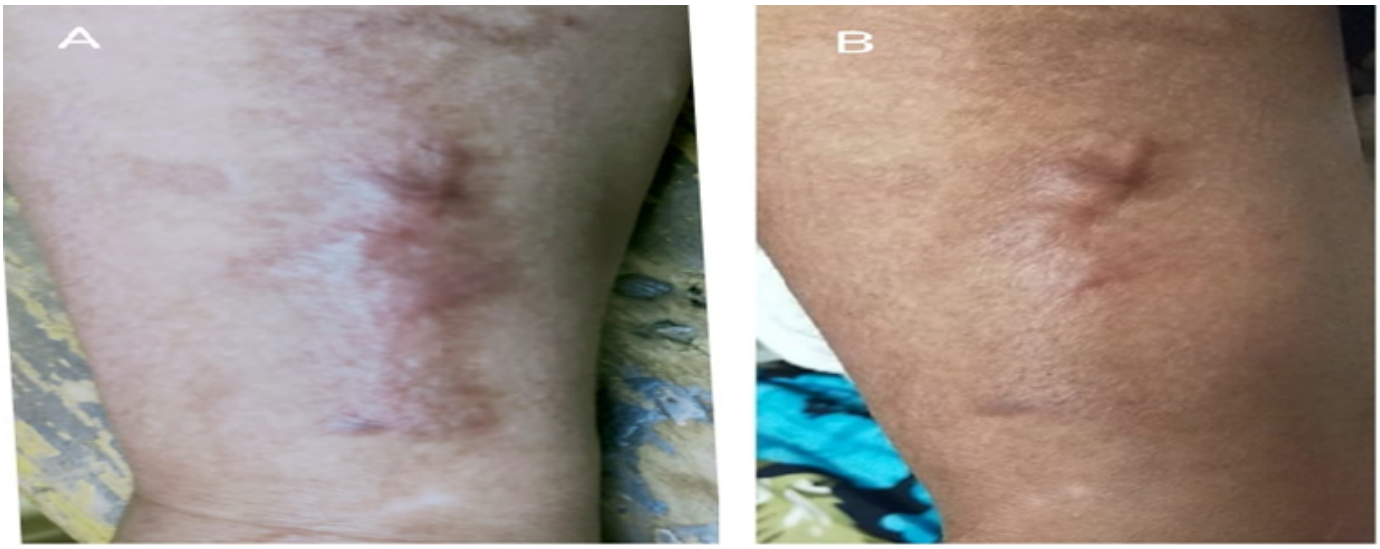

Figure 2. Changes in scar appearance in the study group; (A): before treatment & (B): after treatment

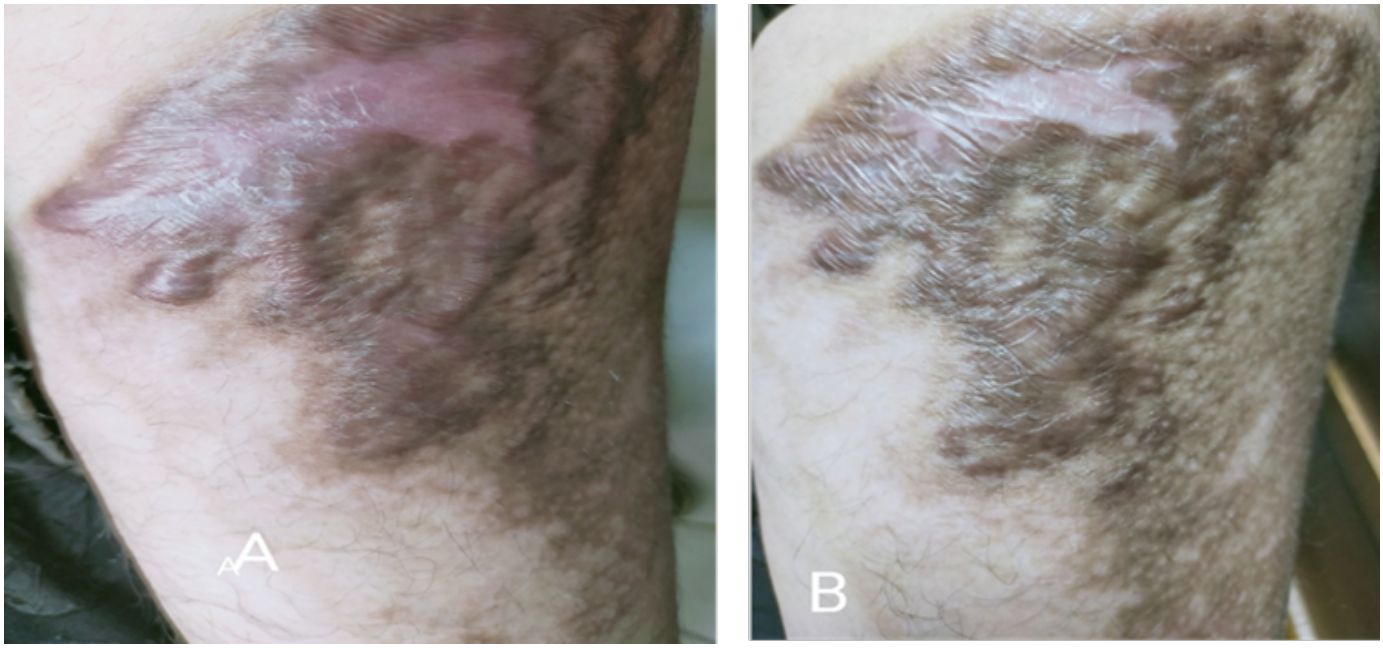

Figure 3. Changes in scar appearance in the control group; (A): before treatment & (B): after treatment

Discussion

Hypertrophic scar (HTS) post burned patients usually suffer from scar contractures, itchiness, tenderness, pain, sleep disturbance, depression, anxiety, and loss of self-esteem that severely affect their daily activities [13].

The current study was performed to study the effect of PLT on post burn HTS. In this study, comparison between post-treatment and pre-treatment in the study group showed a significant decrease in height, vascularity, pigmentation, and pliability scores ($p > 0.01$). When comparing between the two groups, there was a significant decrease in height and pliability scores of the study group compared with that of the control group ($p < 0.01$), but there was no significant difference in vascularity and pigmentation between groups ($p > 0.05$).

Silicone gel sheet was used as a control for both groups because silicone products including silicone gel sheets (SGS) are considered as the gold standard and non-invasive treatment methods for preventing and treating hypertrophic scars. These silicone products can be applied in conjunction with other invasive and non-invasive care methods to achieve better results [14].

Bleasdale et al. [15] attributed the effectiveness of SGS to its ability to promote occlusion and hydration to the skin which aids in preserving optimum water levels. So, in the treated scars using SGS, fibroblast proliferation and collagen synthesis are decreased. Passing tension from the sides of wound bed to SGS also decreases abnormal scars formations rate. SGS was also reported to suppress the normal response of the body to improve blood circulation through hyperemia which causes enhancement of scar appearance by minimizing the blood flow to the site of HTS and decreasing worsening of the wound healing process. A rise in temperature increases the activity of collagenase and therefore silicone reduces hypertrophic scars by breaking down collagen fibers.

Our results come in agreement with Barolet and Boucher [16]; Ma et al. [17]; Abd Elrashid et al. [8]; Mowafy et al. [18]; Choi et al. [19]; Akilbekova et al. [2]; and Abdel-Mageed et al. [20].

Barolet and Boucher [16] applied low-level light therapy (LLLT) on pathological scarring by the following parameters (805 nm at 30 mW/cm2), daily for one month. VSS and photographic clinical evaluation were used in the evaluation and a significant difference was found. As LLLT can activate normal intracellular photobiochemical reactions responsible for Wound healing, including modulation of TGFBI. The absorbed red visible light or near-infrared (NIR) light converted into chemical kinetic energy creates changes in the cell membrane permeability, enhances signals between mitochondria, nucleus, and cytoplasm, nitric oxide formation, and generates more adenosine triphosphate (ATP) through oxidative metabolism, at last, cell function is normalized.

Ma et al. [17] reported that red visible light or near-infrared light can inhibit fibroblast activity.

Abd Elrashid et al. [8] studied the effectiveness of polarized light therapy (PLT) on scars in pediatric burns. This study included thirty children with HTS aged 3 to 7 years. They were subdivided into two matching groups. The treatment sessions began two months after healing the burn wound. Study group obtained the traditional protocol of scar treatment such as (pulsed U.S, massage therapy, and ROM ex.) and PLT for 3 times/week for 4 weeks while the control group obtained only the traditional protocol of scar treatment such as (pulsed U.S, massage therapy, and ROM ex.). Based on VSS before treatment sessions and after 4 weeks of treatment, the findings demonstrated a statistically significant improvement in the four characteristics of HTS (pigmentation, pliability, height, and vascularity). Concluded that PLT is effective on pediatric scar.

Mowafy et al. [18] evaluated the efficacy of PLT on thirty women suffering from pain and fibrous scars after mammoplasty surgery. They were distributed into two groups. Study group got PLT (10 minutes, day after day for 6 months) plus routine physical therapy program and a control group got only routine physical therapy program for 6 months. Evaluations were performed by visual analog scale (VAS) and ultrasonography measurements. A statistically significant decrease in pain and fibrous scarring after mammoplasty were observed in study group after PLT application.

Choi et al. [19] reported that polarized light (PL) had an anti-inflammatory effect in many studies and illustrated that there was a decrease in the concentration of elevated proinflammatory cytokines such as interleukin-2 (IL-2), tumor necrosis factor-alpha (TNF-α), and interferon-gamma (IFN-γ) and a raise in the anti-inflammatory factor concentration after PLT application.

Akilbekova et al. [2] stated that PLT can activate humoral and cellular defensive processes and regulate matrix deposition and collagen fiber alignment. So PLT is effective to fasten the healing process and minimize pathological scar formation.

Abdel-Mageed et al. [20] demonstrated that the findings may be due to the hypothesized interaction between PLT and the polar heads of the cell membrane resulting in cell membrane charges redistributions and lipoprotein connectivity alteration which affects all biological processes of the cell membrane. The primary limitation of the current study was the lack of follow up to examine the long-term effect of polarized light therapy (PLT) on post burn HTS.

Conclusion

Polarized light therapy is an effective, easy to apply, and non-invasive treatment modality in post burn hypertrophic scars.

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