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The Effect of Polarized Light on Immune System in Major Burns

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ABSTRACT:

Background: Burn injuries are a major cause of morbidity and mortality worldwide. Major burns trigger immune dysregulation, increasing the risk of infection and delaying wound healing.

Aim: This study aimed to evaluate the efficacy of the polarized light therapy (BLT) on immunity in major burns.

Patients and Methods: Sixty patients who have partial thickness thermal or electrical burn affecting with the percentage of total body surface area (TBSA) ranging from 20% to 30% and after 14 days of burn. They participated in the study and recruited from the Electricity Hospital Burn Unit. Their ages ranged from 35 to 45 years, the patients randomly divided into two equal groups in number, (study group) (A) composed of thirty patients who received the bioptron hyperlight therapy and conservative treatment of the burn wound for two months and group (B) (control group) composed of thirty patients who received only conservative treatment routine for the burn wound for t wo months without any intervention modalities.: Blood cellular immunity T lymphocytes ,monocytes and colony count were assessed to detect spreads of germs and infection in wound and burn.

Results: The number of patients who had positive wound culture post treatment in study group was 3 (10%) and in control group was 11 (37%). There was a significant decrease in positive wound culture of study group compared with that of control group post treatment (p=0.01). The mean±SD monocytes pretreatment of study group was 1.25±0.36 103/uL and that post treatment was 0.69±0.27 103/uL. The mean difference between pre and post treatment was 0.56 103/uL and the percent of change was 44.80%. There was a significant decrease in monocytes in study group post treatment compared with pretreatment (p=0.001). The mean±SD T-lymphocytes post treatment of study group was 1.71±0.46 103/uLand that of control group was 2.12±0.51103/uL. The mean difference between groups was -0.41103/uL. There was a significant decrease in T-lymphocytes of study group compared with control group post treatment (p=0.002).

Conclusions: Polarized light therapy may facilitate the resolution of the post-burn inflammatory response, as reflected by the normalization of T-lymphocyte and monocyte counts during wound healing. These findings suggest that its benefit is related to modulating and resolving burn-induced immune activation rather than stimulating the immune system. Further studies using comprehensive immunological biomarkers are needed to confirm these effects and clarify the underlying mechanisms.

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1. INTRODUCTION

Burns and their treatment are a significant medical problem. The loss of the physical barrier function of the skin opens the door to microbial invasion and can lead to infection [1]. A burn injury results from skin contact with a heat source, the factors that can cause burn injuries include high temperature, electricity, friction, radiation and chemicals burn. [2].

Burn injuries can be classified according to a number of factors, including their depth, etiology and percentage of body surface area affected. The combination of the above classifications determines the degree of burn injury. Burns can be classified as "partial-thickness" and full-thickness [1].

In the immunological context, thermal insults have a significant comprehensive impact on the immune system, particularly the cellular immune response. Immune deficiency in burned patients is thought to be caused by impaired expression of bone marrow granulocyte colony-stimulating factor (G-CSF) receptors. While the loss of skin and the mechanical barrier facilitates infection in patients with burn injuries, it has long been known that impaired immune mechanisms are key factors in bacterial, viral and fungal infections following burn injury [3].

The purpose of the immune system is to protect cells from invasion by microorganisms; the body has three equally important interactive immune defense systems [4]. The adaptive immune system following burn injury adopts a suppressive phenotype with reported reduced T-helper 1 and cytotoxic T-cell responses and increased T-regulatory cell activity, similarly, trauma injury immune responses include increased T-regulatory activity and a reduced in T-helper 1 response [5].

When light is polarized, it causes the individual photons (light particles) to vibrate and travel in the same direction, theoretically allowing for deeper penetration into the body. Whilst most phototherapies such as low-level laser only utilize one specific wavelength (color) of light, biptron light therapy uses a broad spectrum more like natural daylight [6].

Several reports have suggested that low-energy lasers and polarized light may accelerate wound healing. As early as 1971 Mester demonstrated a so-called biostimulating effect of low-energy laser irradiation on cells. The polarization of the light to be the key factor of this effect and they successfully applied polarized light emission in the treatment of wounds. Polarized light was also found to trigger the cellular and humoral defense of the human organism [7].

The results of irradiation by linearly polarized, incoherent light in immunological tests proved to be nearly the same (80%) as the results of the He-Ne laser, which was also linearly polarized and emitting at the same wavelength. Irradiation facilitated a quantitative increase in immunoglobulins and other proteins, resulting in a higher rate of healing; Macrophages are key cells in wound healing and dermal repair. They assist in tissue debridement by phagocytosis and release chemotactic agents that attract fibroblasts and endothelial cells to wound site [8].

Bioptron Hyperlight therapy reinforces the immune system, increases the capacity to fight against disease and accelerates recovery, bioptron hyperlight therapy is a unique method of immunomodulation. It supports our body in case of immunodepression, for example, in a post-surgery period, in oncology patients or in the case of previous respiratory diseases - in the situations where the immune system is affected and unable to protect the organism adequately [9]. So, this study aimed to evaluate the therapeutic efficacy of bioptron hyperlight therapy on the immunomodulatory system such as activity of both T-lymphocytes and monocytes in the blood.

2. PATIENTS AND METHODS

This prospective randomized study included sixty patients with partial thickness thermal or electrical burn affecting (dermal burn) with the percentage of total body surface area (TBSA) ranged from 20% to 30% and after 14 days of burn, and they were recruited from the Electricity Hospital Burn Unit. The patients were randomly allocated into two equal groups (n=30 for each), group (A)(study group) composed of thirty patients who received the bioptron hyperlight therapy and conservative treatment (wound care, cleaning and antibiotics) for the burn wound for two months and group (B) (control group) composed of thirty patients who received only conservative treatment routine (wound care, cleaning and antibiotics) for the burn wound for two months.Participants were randomly allocated to the study groups using an odd- and even-number sequence generated by a blinded, independent researcher who was not involved in participant recruitment, treatment, or outcome assessment. Allocation was concealed until assignment.

This study included sixty patients of both sexes, aged 35 to 45 years, with partial thickness thermal or electrical burns affecting 20% to 30% of total body surface area (TBSA), who were conscious and had treatment initiated 14 days post-burn. Patients were excluded if they presented with skin abnormalities (such as skin malignancy in the treated area), anemia affecting monocytes and T-lymphocyte levels, associated inhalation injuries, life-threatening disorders (including renal failure or myocardial infarction), pregnancy, myasthenia gravis, hyperthyroidism, hemorrhage, acute viral disease, acute tuberculosis, mental disorders, or those with pacemakers.

2.1. Equipment and tools

Equipment in this study were divided into two main categories; measuring tools and therapeutic equipment.

2.1.1. Measuring tools

It was used pre-treatment and after 2 months of treatment (post-treatment) to measure colony count of the burn wound.

2.1.1.1. Colony count: Tools for taking swap

The microbiology of wounds is a key determinant in healing and clinicians generally accept that a level of microbial growth greater than 100,000 viable organisms per gram of tissue can be used to diagnose infection. The tools included sterile swab, media used for culture samples and gloves (Brinkmann et al., 2004).

2.1.1.2. Blood cellular immunity

Blood cellular immunity analysis evaluates the function of the cell-mediated immune system, focusing on T cells and phagocytic immune cells to determine not only cell counts but also their functional capacity in diagnosing immunodeficiency disorders and monitoring immune responses. T-lymphocytes (T cells) are white blood cells that play a critical role in protecting the body from infection, while monocytes -the largest type of white blood cell- are produced in the bone marrow, circulate in the blood, and upon migrating to tissues, differentiate into either macrophages or dendritic cells to fight infection, clear debris, and regulate immune responses (Barrick and Campbell, 2019).

2.1.2. Therapeutic equipment

The treatment protocol was achieved using the Bioptron Compact III light therapy system (model PAG-860), developed and produced by Bioptron AG company, Switzerland [10]. The device features a filter diameter of approximately 4 cm, operates on a power supply of 100-230 V at 50/60 Hz with a power consumption of 56 VA and a rated halogen power of 20 W. It has a protective class of Class II, IP 20, weighs 0.5 kg, and operates at ambient temperatures ranging from +10°C to +40°C (storage: +5°C to +45°C). The system emits wavelengths of 480-3400 nm with a degree of polarization exceeding 95% (590-1550 nm), a specific power density averaging 40 mW/cm², and light energy of approximately 2.4 Joules/cm² per minute. Additionally, protective eye glasses were worn during application to prevent permanent eye damage resulting from direct exposure to the beam.

2.2. Procedures of study

The experimental protocol was explained in details for every patient before starting the initial assessment, and a written consent form was signed by each patient before starting. The treated patients were instructed to report any side effects during the treatment sessions.

2.2.1. Measurements procedures

The measurement procedures involved colony count assessment and blood cellular immunity analysis. For colony count, a sterile cotton swab was rolled over the wound surface, emulsified in 5 ml of sterile 0.9% NaCl, and 3 serial 1:10 dilutions were prepared. A 0.1 ml aliquot from each dilution was spread on blood agar plates and incubated at 37°C for 24 hours. Colonies between 30 and 300 were counted, multiplied by the dilution factor, and preliminary identification was performed using Gram stain, oxidase, catalase tests, and colony morphology. However, the study acknowledged that laboratory tests such as WBC count, neutrophil percentage, ESR, and CRP levels are of low yield in detecting burn infections due to the inflammatory response associated with the burn itself [1]. For blood cellular immunity, a blood sample was drawn by a specialist, smeared on a glass slide, stained with dye to differentiate white blood cell types, and analyzed either manually or using automated techniques

employing electrical, laser, or photodetection methods to provide accurate cell counts, with abnormal increases in one cell type potentially causing decreases in another [11, 12].

2.2.2. Therapeutics procedures

All patients in both groups (A and B) received the same traditional physical therapy routine, conservative wound treatment, nursing care, medications, and prescribed diet, with wounds covered by sterile Vaseline gauze (Sofra-tulle dressing) changed once daily [13]. The study group (A) additionally received Bioptron light therapy (BLT) applied once daily, three times per week for two months. The preparatory phase included treating patients as inpatients with outpatient follow-up, providing information about procedures and BLT device irradiation, instructing patients to follow surgeon and therapist advice, and advising avoidance of predisposing factors such as UV rays, crowded or unhygienic places, hot/humid environments, and smoking. Patients were positioned comfortably, the device was checked and switched on, appropriate dose selected, and treatment applied for 10 minutes per session (day after day) for two months [14].

The application phase involved wound cleaning with hydrogen peroxide, saline rinse, and betadine; inserting the BLT plug into the main supply and setting parameters; positioning the device at a 90° angle perpendicular to the burn wound surface at a distance of 10 cm; applying BLT for approximately 10 minutes; and unplugging the device after use, with advisability to prolong treatment for one to two weeks if wound closure occurred early [15]. The therapy offers high patient throughput with rapid 4-10 minute full treatments applicable both in medical practice and at home [16].

2.3. Ethical Considerations

The study was conducted in agreement with the Declaration of Helsinki, following approval by IRB of the Faculty of Physical Therapy, Cairo University (P.T.REC/012/003473). A written informed consent was obtained from the included participants (cases and control) before enrolling in this study. All patients in this study were informed about the clinical research and were informed about how the operation is carried out. Patients felt free to withdraw from the study at any time without any consequences. The data collected were not and will not be used for any other purpose. All data was collected by the researcher himself.

2.4. Statistical Analysis

Sample size

The sample size was calculated using GPower software (version 3.1.9.7) for comparison of two independent groups. The calculation was based on the endpoint lymphocyte count reported by de Marchi et al. (2021) in a randomized placebo-controlled trial of photobiomodulation therapy. Based on the reported mean lymphocyte counts the estimated Cohen's effect size was 0.75. Assuming a two-tailed significance level of 0.05, a statistical power of 80%, and an allocation ratio of 1:1, the required sample size was approximately 30 participants per group.

Statistical analysis was performed using the Statistical Package for Social Studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA). Normal distribution of data was checked using the Shapiro-Wilk test, and Levene's test for homogeneity of variances was conducted to test homogeneity between groups. Descriptive statistics and unpaired t-tests were conducted for comparison of age between groups, while Chi-squared tests were carried out for comparison of sex and wound culture distribution between groups. Unpaired t-tests were used to compare T-lymphocyte and monocyte counts between groups, and paired t-tests were conducted for comparison of T-lymphocyte and monocyte counts between pre- and post-treatment within each group. McNemar tests were conducted for comparison of wound culture distribution between pre- and post-treatment in each group. The level of significance for all statistical tests was set at $p < 0.05$.

3. RESULTS

Table (1) demonstrates that there was no statistically significant difference between study group and control group regarding age, sex and T-Lymphocytes Pre-treatment (p=0.26, 0.59 & 0.57 respectively). Table (2) shows significant improvement in T-lymphocyte levels after two months of treatment in both groups (p=0.001 for each), indicating that conservative burn care alone effectively reduces immune cell activation as the wound heals. However, the study group exhibited a superior response, with a greater percentage of change (49.41%) compared to the control group (35.17%), and a significantly lower post-treatment T-lymphocyte count (1.71 vs. 2.12 × 10^3/uL, p=0.002).

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Table (3) shows significant reductions in monocyte counts following treatment (p=0.001 for both), reflecting the natural resolution of the inflammatory response as burn wounds heal. However, the study group showed markedly superior outcomes, with a greater percentage of change (44.80%) compared to the control group (30.33%), and significantly lower post-treatment monocyte levels (0.69 vs. 0.85 × 10^3/uL, p=0.01).

Table (4) demonstrates that both groups had comparable positive wound culture rates before treatment (73% vs. 67%, p=0.57), confirming the homogeneity of the study population. However, after two months of treatment, the study group receiving Bioptron hyperlight therapy showed a dramatic reduction in positive wound cultures from 73% to only 10%, compared to the control group which decreased from 67% to 37%. The significant difference between groups post-treatment (p=0.01) indicates that polarized light therapy exerts a powerful antibacterial and immunomodulatory effect, effectively reducing wound infection rates in major burn patients.

Table (1): Demographic Characteristics and Pre-treatment T-Lymphocyte Values of Study and Control Groups

Parameter	Study Group (n=30)	Control Group (n=30)	MD	t/χ^2 value	p-value
Age (years)					
Mean±SD	39.30±2.98	40.13±2.71	-0.83	-1.13*	0.26
Maximum	44	45			
Minimum	35	36			
Sex Distribution					
Female	10 (33%)	12 (40%)		0.28**	0.59
Male	20 (67%)	18 (60%)			
T-Lymphocytes Pre-treatment (10^3/uL)					
Mean±SD	3.38±0.78	3.27±0.70	0.11	0.58*	0.57

MD: Mean Difference, SD: Standard Deviation, *Unpaired t-test value, **Chi-squared test value

Table(2): T-Lymphocytes Pre- and Post-Treatment Comparison of Study and Control Groups

Parameter	Study Group (n=30)	Control Group (n=30)	MD	t-value	p-value
Pre-Treatment (10^3/uL)	3.38±0.78	3.27±0.70	0.11	0.58	0.57
Post-Treatment (10^3/uL)	1.71±0.46	2.12±0.51	-0.41	-3.21	0.002
MD (Pre-Post)	1.67	1.15			
% of Change	49.41%	35.17%			
Paired t-value	11.47	10.31			
Paired p-value	0.001	0.001			

SD: Standard Deviation, MD: Mean Difference, t-value: Paired t value

Table (3): Monocytes Pre- and Post-Treatment Comparison of Study and Control Groups

Parameter	Study Group (n=30)	Control Group (n=30)	MD	t-value	p-value
Pre-Treatment (10^3/uL)	1.25±0.36	1.22±0.40	0.03	0.24	0.81
Post-Treatment (10^3/uL)	0.69±0.27	0.85±0.23	-0.16	-2.45	0.01

MD (Pre-Post)	0.56	0.37			
% of Change	44.80%	30.33%			
Paired t-value	7.79	5.36			
Paired p-value	0.001	0.001			

SD: Standard Deviation, MD: Mean Difference, t-value: Paired t value

Table(4): Comparison of wound culture distribution Pre- and Post-Treatment between study and control groups

Parameter	Study Group (n=30)	Control Group (n=30)	χ^2 value	p-value
Pre-Treatment				
Positive	22 (73%)	20 (67%)	0.32	0.57
Negative	8 (27%)	10 (33%)		
Post-Treatment				
Positive	3 (10%)	11 (37%)	5.96	0.01
Negative	27 (90%)	19 (63%)		

χ^2: Chi-square test

Table (5) shows that the number of patients who had positive wound culture pre treatment in study group was 22 (73%), while post treatment was 3 (10%). There was a significant decrease in positive wound culture post treatment compared with that pre treatment of study group (p=0.001). The number of patients who had positive wound culture pre treatment in control group was 20 (67%), while post treatment was 11 (37%). There was a significant decrease in positive wound culture post treatment compared with that pre treatment of control group (p=0.004).

Tables (5): Pre- and Post-Treatment Wound Culture Distribution Within both groups

Parameter	Pre-Treatment	Post-Treatment	χ^2 value	p-value
Study Group (n=30)				
Positive	22 (73%)	3 (10%)	17.05	0.001
Negative	8 (27%)	27 (90%)		
Control Group (n=30)				
Positive	20 (67%)	11 (37%)	7.11	0.004
Negative	10 (33%)	19 (63%)		

χ^2: Chi-squared value

4. DISCUSSION

The impact of burns may spread beyond the areas of direct injury. Indeed, severe burns, regardless of origin, trigger a systemic inflammatory response. The effects exhibited within each organ system are both the result of the burn injury, as well as the response from that organ system to it. The threshold for eliciting a systemic response is estimated at 20% or more of TBSA burned severely beyond superficial depth, multiple organ systems are involved, with an emphasis on the circulatory system causing hemodynamic shifts, the respiratory system with increased respiratory rates or work of breathing, the endocrine system with hypermetabolism and hyperglycemic states, and alterations of frequency and function of the immune system. Systemic responses to burns range from a near-normal basal metabolic rate (BMR) at TBSA of <10%, increase with severity, until plateauing at nearly doubled normal BMR with a TBSA of 40% and beyond [17]. This study investigates the immunomodulatory

effects of polychromatic Polarized Light Therapy (PLT) on human immune cells. While there is some evidence demonstrating a clinical effect in the treatment of certain conditions, there is little research into its mechanism of action [18].

Polarized light from low power lasers and non-laser devices has been used as a non-invasive therapy in the treatment of various musculoskeletal disorders, acceleration of wound healing and treatment of skin ulcers. Although the polarized light is known to have numerous photobiostimulatory effects including cell proliferation, enhanced collagen synthesis, changes to the circulatory system and anti-inflammatory actions, the precise mechanism of its action still remains unclear. The available non-laser optical devices are the Bioptron products which emit a wide beam of polarized, non-coherent, polychromatic, low energy light that contain wavelengths from the visible spectrum (480-700nm) and infrared radiation (700-3400nm); this range provides optimal penetration and stimulation of the tissues without the risk of DNA damage [10].

Patients with burn are at risk of developing local factors (growth factors, edema, ischemia low oxygen tension, and infection), regional factors (arterial insufficiency, venous insufficiency and neuropathy), systemic factors (in adequate perfusion and metabolic diseases), and other miscellaneous factors, such as nutritional state, preexisting illnesses, exposure to radiation therapy, and smoking development [16].

Blood differential was tested by specialist to check white blood cells levels by testing a sample of blood, this test is often performed at an outpatient or inpatients clinical laboratory in the hospital; the healthcare provider at the lab uses a small needle to draw blood from arm or hand. No special preparation before the test is necessary; a laboratory specialist puts a drop of blood from blood sample on a clear glass slide and smears it to spread the blood around. then, stain the blood smear with a dye that helps to differentiate the types of white blood cells in the sample [12].

The lab specialist then counts the number of each white blood cell type, then the specialist may do a manual blood count, visually identifying the number and size of cells on the slide, specialist might also use an automated blood count, in this case, a machine analyzes white blood cells based on automated measurement techniques, automated count technology uses electrical, laser, or photodetection methods to provide a highly accurate portrait of the size, shape, and number of blood cells in the sample, an abnormal increase in one kind of white blood cell can cause a decrease in another kind, both abnormal results can be due to the same underlying condition, lab values may vary the percentages of white blood cells [11].

Cells in healthy people are as follows 25 to 30 % lymphocytes and 0 to 9 % monocytes. As well as it compared between the two different groups of the study (group A and group B) on improving the immunity of the burn surface area wounded that Bioptron Hyperlight therapy reinforces the immune system, increases the capacity to fight against disease and accelerates recovery [19].

The comparison of results between two groups values of numbers of monocytes and T- lymphocytes and the wound cultures samples of both groups after two months of treatment revealed significance difference in favor of group A more negative results in wound infection cultures than the group B that showed more positive infection wound cultures results.

The observed reduction in T-lymphocyte and monocyte counts after two months of polarized light therapy suggests an accelerated resolution of the post-burn inflammatory response rather than stimulation of the immune system. This finding may reflect improved wound healing and reduced inflammatory cell recruitment as tissue repair progresses. Our results are consistent with previous studies reporting that polarized light therapy enhances wound healing by modulating inflammation, promoting tissue regeneration, and improving the local healing environment. There was a significant decrease in t-lymphocytes in study group post treatment. The number of patients who had positive wound culture pretreatment in study group was 22 (73%), while post treatment was 3 (10%). There was a significant decrease in positive wound culture post treatment compared with that pretreatment of study group.

This improvement may be due to polarized light from low power lasers and as a non-invasive therapy in the treatment of various musculoskeletal disorders, acceleration of wound healing and treatment of skin ulcers, although the polarized light is known to have numerous photo-biostimulatory effects including cell proliferation, enhanced collagen synthesis, changes to the circulatory system and anti- inflammatory actions [20].

The polarization of the light to be the key factor of this effect and they successfully applied polarized light emission in the treatment of wounds. Polarized light was also found to trigger the cellular and humoral defense of the human organism [21].

The linearly polarized light interacts with the polar heads of the lipid double layer of the cell membrane in which the biologically active proteins are incorporated. Due to the interaction with polarized light, structural changes may occur to give the membrane a reordered distribution of the surface charges and to modify the lipid–protein connections. This conformation change may influence the cellular processes connected with the cell membrane: receptor function, energy production, immune responses, and enzyme reactions [22].

This improvement may base on the theoretical basis of phototherapy involves the use of light to induce physiological change within a target tissue with subsequent therapeutic effects. There are several types of phototherapies differentiated by the specific physical qualities of the light used, with the most common being low-level laser therapy (LLLT) [20].

Burns produce changes in the pattern of the immune response of the patient, both represented by stimulating the production of genes related to innate immune response and suppression of genes related to adaptive immune responses, especially those related to antigen presentation and activation of T-lymphocytes [23]. The bioptron quantum hyperlight spectrum promotes a series of soothing processes in the skin Improvement of microcirculation, the 590 nm and 840 nm stimulate the formation of new blood vessels, the 900 nm promote peripheral vasodilatation, improving deep skin circulation. Increased cell activity, the 633/640 nm stimulate the production of adenosine triphosphate (ATP), the molecule that transfers energy to cells [20].

The increase in cell activity stimulates skin repair and regeneration processes and combats the appearance of fine wrinkles, better skin hydration, the 590 nm helps the skin to maintain moisture and retain its elasticity, stimulation of elastin and collagen synthesis, the 660 nm stimulates collagen production and thus contributes to tighter, firmer skin and reduces the traces of ageing. Higher degree of tissue repair, the 830 nm provide strengthening the immune system, the quantum hyperlight wavelengths of more than 400 nm penetrate into the layers of the dermis and epidermis by interacting with lymphocytes, strengthening the immune system as well as skin repair processes, Regeneration and tensioning the skin for a visibly younger appearance [24].

The results of this study are in agreement with their studies reported by Douaiher et al., [25], Dovi et al., [26], Lever [27] and Fenyö et al., [9] that effect of polarized light on the musculoskeletal system had found that investigating the relationship between polarized light in skeletal, skin and burns are poor in terms of treatment as monotherapy but how it can be used as monotherapy and / or as adjunctive therapy to treat pain. It is supported in a study on how phototherapy including low-level lasers as a cohesive light source and polarized UV-free multicolored without coherent light is recommended as a non-aggressive, safe and cost-effective treatment option for the treatment of various musculoskeletal disorders and skin conditions.

Generally known from studies in the literature to date on this topic, refer to a pilot study by Huang et al., [28] how the use of polarized multicolored non-cohesive light is a respectable treatment in musculoskeletal in Acute epicondylitis in the elbow, but nevertheless refers to this study how while Bioptron light is a reliable, safe and effective treatment option in pregnant patients, it is necessary to perform controlled clinical trials in order to determine the absolute and relative effective HLA this intervention. Stasinopoulos et al., [29] reported that polarized light had effects on elbow tendonitis and ankle sprains.Othman et al., [30] reported thatpolarized light therapy (Bioptron phototherapy) is an effective, easy to apply, and noninvasive treatment modality in post burn hypertrophic scars.

The difference in improvement of the immunity modulation of blood monocytes and t-lymphocytes and wound cultures samples between the two groups of the study has several potential advantages as bioptron hyperlight therapy had a big effect in increase the wound healing, bioptron had a great benefit is in immunomodulation of the burned area, and good conservative burn care with the bioptron therapy have an increase in the negative results of burned wound area culture. On the other hand, there are little studies showed no benefits of bioptron light therapy with burn patients and didn't support the hypothesis.

Jeschke et al., [16] supported that sunlight not only provides warmth and food to the planet but also to the human beings. The different radiations that constitute the sunlight have impacts on mammalian cells, particularly on skin cells, since these are the naturally exposed cells. These effects are multiple and include DNA damage reactive oxygen species (ROS) production mitochondrial alterations matrix metalloproteases expression and complex immune system changes, which are discussed in detail in this chapter. Many of these effects are specifically mediated through UV radiation, but visible light and infrared radiation also mediate cellular alterations and human skin exposure to sunlight has a range of effects on health, both beneficial and detrimental and not only cutaneous but also systemic.

4.1. CONCLUSION

Polarized light therapy, specifically the Bioptron hyperlight therapy system, appears to facilitate resolution of post-burn immune activation and reduce wound infection rates in major burns, supporting its use as an adjunctive modality for improving clinical outcomes in burn patients.

4.2. LIMITATIONS

This study had several limitations that should be acknowledged. The relatively small sample size (60 patients) may limit the generalizability of the findings, and the short follow-up duration of two months may not capture long-term outcomes or potential late complications such as hypertrophic scarring. Also, the lack of blinding for both patients and assessors could introduce bias, as patients receiving Bioptron therapy were aware of their treatment, potentially influencing subjective outcomes. Individual variations in wound healing rates, nutritional status, and psychological factors may have affected the results, despite efforts to standardize care across both groups. Additionally, the study did not assess the optimal dosage, duration, or frequency of polarized light application, and the specific mechanism of action at the molecular level was not investigated. Future studies with larger sample sizes, longer follow-up periods, and randomized double-blind designs are recommended to confirm these findings and establish standardized treatment protocols[31].

4.3. RECOMMENDATIONS

It is recommended that Bioptron hyperlight therapy (polarized light therapy) be incorporated as an adjunctive treatment in standard burn care protocols, particularly for patients with major burns (TBSA 20-30%), to enhance immunomodulation and reduce wound infection rates. Future research should focus on larger multicenter trials with extended follow-up periods to confirm these findings, investigate optimal treatment parameters (dose, frequency, duration), and explore the long-term benefits of polarized light therapy on scar formation, wound healing quality, and prevention of complications. Additionally, comparative studies between polarized light therapy and low-level laser therapy (LLLT) are warranted to determine the most effective phototherapy approach for burn patients.

CONFLICT OF INTEREST

All authors have no conflicts of interest that are directly relevant to the content of this review.

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