Effect of Monochromatic Infrared Energy on Wound Healing in Burned Patients

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Introduction:

A burn is a form of coagulative necrosis affecting the skin along with the underlying tissues. The majority of burns are not life-threatening; yet, each burn inflicts considerable pain on the

Abstract

Purpose: to find out the effectiveness of the monochromatic infrared energy on wound healing in burned. **Methods:** Forty patients suffering from thermal burn injuries on the dorsum of the leg were recruited from the OM-El-Misrieen burn unit. Diagnosis was conducted clinically by a physician. The patients were randomly divided into two equal groups. The first study group (A) consisted of 20 patients who were given the MIRE application 3 times per week over 12 weeks or until healing, whereas the control group (B) comprised 20 patients who were given traditional burn care, including cleaning, debridement, dressing, along with routine medical management of the burn wound over 12 weeks. **Results:** The results indicated that the MIRE application was successful in reducing burn surface area as well as colony count, while also enhancing the healing process of burned patients. **Conclusion:** Applications of MIRE were successful in accelerating the healing of burn patients' wounds.

Key words: Monochromatic infrared energy, Burn, wound surface area and Colony count.

patient and induces some level of psychological trauma for all parties involved. The process of regeneration as well as repair after injury constitutes a vital defensive mechanism of an organism against environmental harm. Biological processes including inflammation, proliferation, wound contraction, as well as remodeling contribute to scar formation [1].

The care of open skin wounds is a significant clinical challenge; electrical stimulation should be regarded as a viable therapeutic alternative for wound treatment. Numerous researchers have documented a positive outcome from the application of electrical stimulation in the treatment of various skin lesions [2].

Monochromatic Infrared Energy (MIRE™) emits infrared light at a wavelength of 890 nm and serves as a non-pharmacological treatment for both acute as well as chronic wounds, encompassing ulcers, diabetic wounds, abdominal wounds, as well as traumatic wounds, with a primary focus on more complex chronic wounds. MIRE™ is recommended for the treatment of stage 2 as well as stage 3 ulcers characterized by insufficient granulation tissue as well as excessive exudate [3].

MIRE therapy enhances granulation quality through revascularization as well as collagen synthesis via a specific sequence: the release of mediators triggers the secretion of cytokines (IL1&IL VI), which subsequently stimulates fibroblasts, augments collagen production, activates keratinocytes to promote epithelial formation, and stimulates endothelial cells, thereby facilitating angiogenesis. However, the release of growth factors results in an elevation in bFGF [4]. MIRE therapy promotes faster epithelialization by speeding up the migration as well as proliferation of epithelium cells, which may come from the wound bed or the wound periphery. Ultimately, these processes result in wound closure [5].

Despite multiple articles reporting beneficial clinical experiences, the mechanism of the biological impact of MIRE therapy on the complicated procedure of wound healing remains under investigation. The MIRE therapy is expected to reorganize the polar heads of the lipid bilayer in cell membranes, resulting in functional alterations [6].

Differential biological impacts have been noted following MIRE therapy, involving the stimulation of fibroblast proliferation, the release of growth factors, as well as the augmentation of collagen synthesis. Numerous clinical investigations have demonstrated expedited wound healing, enhanced epithelialization, as well as enhanced tensile strength of scars [7].

To the recent knowledge, there was no previous study assessed the impact of monochromatic infrared energy on wound healing in burned, therefore, the current study was designed to find out the impact of the monochromatic infrared energy on wound healing in burned.

Materials and methods

Study design

A double-blind, controlled investigation was conducted from July 2023 to March 2024, with participants randomly assigned from the OM-El-Misrieen burn unit, and diagnoses performed clinically by a physician. This study adhered to the Helsinki Declaration and received clearance from the ethics committee of the College of Physical Therapy, Cairo University (approval No.: P.T.REC/012/004320).

Subjects:

This study was performed on 40 patients suffering from thermal burn injuries on the dorsum of leg, they were recruited from OM-El-Misrieen burn unit, diagnosis was clinically by physician, **Inclusive criteria**: The patients were selected based on the subsequent criteria: both sexes, ages were ranged from 25 to 35 years, experienced dermal burns involving one of the leg dorsum, the burn was caused by thermal damage, conscious, TBSA of (15-25%), second degree burn. **Exclusive Criteria:** The following conditions were not considered for inclusion in this study: diabetes, abnormal skin (such as a malignancy in the treated area), anemia, inhalation injuries, post-skin grafting, potentially fatal conditions such as renal failure or a myocardial infarction, pregnancy, myasthenia gravis, hyperthyroidism, hemorrhage, acute viral disease, acute tuberculosis, mental disorders, or pacemakers.

The patients were randomly divided into two equal groups. The first study group (A) consisted of 20 patients who were given the MIRE application 3 times per week over 12 weeks or until healing, whereas the control group (B) comprised 20 patients who were given traditional burn care, including cleaning, debridement, dressing, along with routine medical management of the burn wound over 12 weeks.

The planimetry method and colony count were performed before to the initiation of treatment as an initial record and subsequently after the termination of the treatment as a final record [8].

Sample size calculation

A sample size of 40 patients was determined using G*POWER statistical software (version 3.1.9.4; Franz Faul, Universität Kiel, Germany) to provide sufficient statistical power. The sample size estimation was derived from burn surface area (BSA) data in a prior study by Voigt et al. (2020) [18], which demonstrated a substantial impact of MIRE on wound healing relative to usual care in burn patients. The necessary sample size was established at 20 participants per group. Based on a power of 85%, an effect size of 0.7, and a two-sided 5% significance level, the calculations were done.

Randomization

All participants received information on the research's characteristics, objectives, advantages, and their freedom to withdraw or decline participation at any time. Following the execution of the consent forms, demographic data were collected. An independent researcher utilized computer-generated random cards contained within sealed as well as opaque envelopes to randomly and equitably allocate the 40 participants to either Group A or Group B. The envelopes were sealed as well numbered in sequence to guarantee disguised distribution, leaving participants oblivious to their group assignments. The participant flow is represented in Figure 1 in accordance with the CONSORT 2010 principles [19].

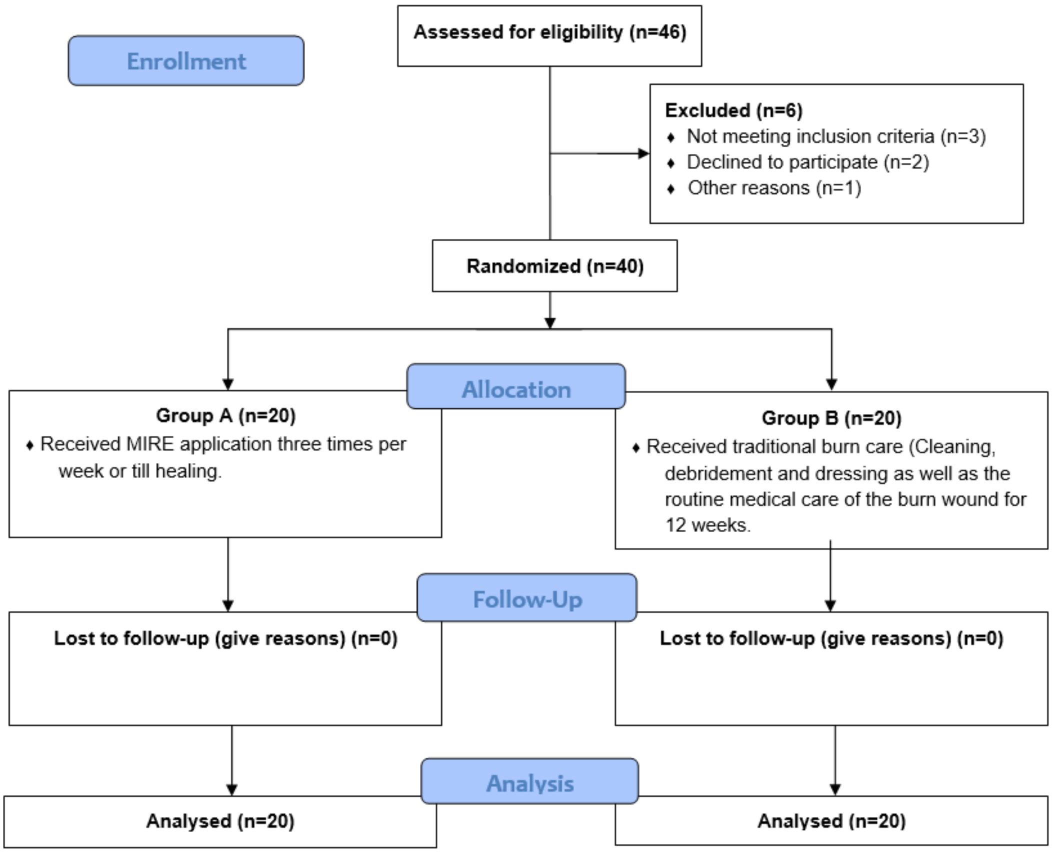

Figure (1): Study flow chart

Procedures:

Measurement procedures:

A. Planimetery method: The wound surface area was measured using the planimeter method, which involved applying a sterilized transparency film over the burn and using a fine-tipped transparency marker to trace the burn perimeter on the film. For every burn, a different transparency was utilized. Afterward, the tracing is placed on metric graph paper, and the number of 1mm squares within the perimeter is tallied. The area is then converted to square centimeters. Burn area measurements are conducted prior to the commencement of study and at the conclusion of the third month of therapy [9].

B: Colony count: Gloves, culture sample media, plus a sterile swab are the necessary tools for taking swaps. A sterile cotton swab was thoroughly rolled over BSA. The swab sample was effectively emulsified in 5 ml of sterile 0.9% NaCl solution. 3 serials 1:10 dilutions of the suspension were prepared using 0.5 ml aliquots combined with 4.5 ml of sterile saline for each aliquot. A 0.1 ml aliquot of the basic suspension then each dilution was applied to the surface of the blood agar plate. All plates were incubated at 37°C for 24 hours. Colony counts ranging from 30 to 300 were used to determine the number of organisms per milliliter of swab suspension. The dilution factor was multiplied by the colony counts in step 6, and the total number of colonies on the plate was then calculated. Each colony count was completed independently. To get a rough idea of how many colonies there were, we used Gram stain and some important tests including oxidase and catalase tests, in addition to looking at the shape of the colonies [10].

1. Treatment procedures:

Group A: The Anodyne® Therapy System, model 480 (Anodyne Therapy, LLC, Tampa, FL), was employed to deliver the MIRE intervention. The device was composed of a base power unit as well as eight therapy pads, each of which contained sixty gallium aluminum arsenide diodes. The total intervention area was 180cm2, with a 22.5cm2 area of light-emitting diodes for each therapy pad. The average energy density of the diodes was 16 joules/cm2/min, which delivered MIRE pulses at a wavelength of 890nm at a frequency of 292Hz [11]. The treatment plan used in this study was described as follows: Patients received inpatient treatment and were informed about the measurement along with treatment protocols, including the MIRE application, prior to the commencement of therapy. They were instructed to adhere to the guidelines provided by the surgeon and physical therapist, and to avoid risk factors such as UV exposure, crowded and unsanitary environments, hot and humid conditions, and smoking. Measurement procedures were conducted for each patient as outlined in the measurement section. Prior to therapy, all patients were provided with a form of written consent for the MIRE treatment. Place the patient in a comfortable position. Before starting the treatment, make sure the device is turned off. Then, turn it on. Finally, turn it off. After cleaning the treated area, apply the MIRE to the dorsum of the affected leg for 10 minutes each day, three times a week, for a total of three months [12].

Group (B): received the same routine medical care of the burn wound for three months or until wound healing. All patients in the two groups received identical treatment, which consisted of sterile Vaseline gauze (Sofra-tulle dressing), with the dressings being changed daily at the termination of each session [13].

Data analysis:

BSA as well as colony count were assessed prior to treatment as an initial measurement and after three months of intervention as a final measurement in both groups. The information gathered were entered into a computer for statistical analysis; descriptive statistics, including mean, standard deviation, minimum, as well as maximum, were computed for each group. The t-test was conducted to examine the mean differences among the two groups prior to and following the application, as well as within each group. An alpha level of 0.05 was employed as the threshold for significance [14].

Results:

Demographic data:

As presented in table (1): The study group (A) and (B) had an age sum of 614.00 years, with mean values of 30.700 + 3.114 and 30.750 + 3.226 years, standard error values of 0.696 and 0.721, variance values of 9.695 and 10.408, coefficient of variance of 10.14 and 10.49, and range values of 10.00 and 10.00.

Table (1): Demographic data of study participants:

	Group (B)	Group (A)
Mean of AGE in years	**30.750**	**30.7000**
± standard deviation	**3.2261**	**3.1136**
Standard error	**0.7214**	**0.6962**
Mean difference	**0.05000**	
T - value	**0.18**	
p. value	**0.858**	
Level of significance	**Non significant**	

As shown in table (2), the mean value of the **Burn surface area (BSA) in cm²** prior to treatment was (9.23421 ± 0.41455) for the MIRE group, whereas following treatment was (2.2600 ± 0.78901) **cm²**. These findings revealed a highly substantial decline ($P < 0.0001$). whereas in the Traditional care group, the mean value of the BSA prior to treatment was (9.22430 ± 0.32121) **cm²**, whereas following treatment was (9.22330 ± 0.32141) **cm²µg**. These findings also showed non-substantial difference regarding the BSA ($P > 0.05$).

Table (1): Comparison of the mean values of the Burn surface area (BSA) in cm² before and after treatment in the two groups

	Before treatment		After treatment		Mean difference	T-value	P.value	Level of significance
	Mean	**SD**	**Mean**	**SD**				
MIRE Group	**9.23421**	**0.41455**	**2.2600**	**0.78901**	**6.97421**	**34.99**	**0.0001**	**Highly significant decrease**

Ttraditional burn care Group	**9.22430**	**0.32121**	**9.22330**	**0.32141**	**0.001000**	**0.01**	**0.992**	**Non-significant difference**

As shown in table (2), the mean value of the colony count (CC) **in Cell** prior to treatment was (23640.0 ± 6665.5) for the MIRE group, whereas following treatment was (251.5 ± 105.8). These findings revealed a highly substantial decline, (P > 0.0001), whereas in the traditional care group, the mean value of the CC **in Cell** prior to treatment was (23651.5. ± 6656.2), whereas following treatment was (23652.0 ± 6655.9), these findings showed a non-substantial difference of the colony count (CC) **in Cell** (P > 0.05).

Table (2): Comparison of the mean values of the colony count (CC) in Cell before and after treatment in the two groups

	Before treatment		**After treatment**		**Mean difference**	**T-value**	**P.value**	**Level of significance**
	Mean	**SD**	**Mean**	**SD**				
MIRE Group	**23640.0**	**6665.5**	**251.5**	**105.8**	**23388.5**	**15.69**	**0.0001**	**Highly significant decrease**
Traditional care Group	**23651.5**	**6656.2**	**23652.0**	**6655.9**	**-0.50000**	**-0.00**	**1.000**	**Non-significant difference**

Discussion:

The study's main findings revealed that Monochromatic Infrared Energy have significant effect on Wound Healing in Burned Patients. A substantial reduction was observed among the means of the second BSA record (following 12 weeks of MIRE application) as well as the first BSA record (P < 0.0001). A extremely significant reduction was seen among the means of the second record CC (following 12 weeks of MIRE administration) as well as the first record CC (P< 0.0001).

Wound healing encompasses a complicated set of physiological processes controlled by various cellular as well as humoral factors. MIRE therapy enhances endogenous purification by eliminating infectious microorganisms and cellular debris through several mechanisms: augmenting macrophage stimulation, enhancing bacterial phagocytosis activity and capacity by promoting scavenger cell formation, increasing neutrophil stimulation, along with elevating both the quantity of neutrophils and their phagocytic activity [18].

MIPE may alleviate pain by facilitating the release of nitric oxide in the endothelium [19]. Nitric oxide induces relaxation of smooth muscle cells in arteries, veins, capillaries, as well

as lymphatic vessels, leading to vasodilation and enhanced circulation [20]. MIPE treatment enhances local blood circulation by 400% following a 20–30-minute session. Phototherapy induces alterations in cell membrane permeability, leading to augmented endorphin production, heightened nerve cell potential, and consequent analgesia [21]. Consequently, the release of nitric oxide alleviates pain and enhances the functional capacity of the knee joint.
Tarek (2014) conducted a study comparing the impacts of MIPE as well as LLLT on pain as well as function among sixty individuals with KO. Statistically substantial enhancements in pain intensity as well as lower extremity functional scale scores ($p<0.05$) were observed in each group. Nevertheless, no statistically substantial differences were observed among the groups ($p>0.05$) [22]

Ahmed et al. (2019) carried out a study. The objective is to assess the impact of MIRE on individuals with pressure ulcers. The measurement of wound volume using saline and a sterilized syringe indicated that polarized light therapy was efficient in enhancing wound healing in pressure ulcers, as demonstrated by a statistically significant reduction in wound volume [23]

The findings of this study corroborate the hypothesis that the administration of MIRE significantly enhances burn healing, as demonstrated by the substantial reductions in BSA as well as CC among burned patients.
The Anodyne device received FDA clearance for enhancing circulation as well as alleviating pain. The MIRE technology (890nm infrared radiation) induces the photo dissociation of nitric oxide (NO) from endothelial cells at the treatment site as well as hemoglobin in red blood cells (RBC). The ongoing administration of RBCs maintains the localized elevation of NO during Anodyne therapy, leading to vasodilation that can indirectly alleviate pain resulting from insufficient blood flow [24 ,25,26,27]. NO serves as a neurotransmitter as well as vasodilator, resulting in a substantial increase in microcirculation [28, 29]. NO also promotes angiogenesis, functions as an anti-inflammatory agent, and enhances osteoblastic cell activity as well as collagen synthesis, so speeding up wound healing.
In a study conducted by Thomasson [30], the results of 563 patients who were diagnosed with tendinitis of the trapezius, splenius capitis, temporomandibular capsulitis, or myofascial pain and who were treated with skin contact MIRE were reported. Eleven patients underwent one to twelve sessions of skin contact MIRE treatment. The researchers indicate an improvement rate of 88% to 90% across each diagnostic group. Nevertheless, neither a control group nor an explanation of the method used to measure treatment response were present.

Mitchell et al., 2010 determined that the secondary potential mechanism of MIRE therapy involves the absorption of energy by mitochondria; this may initiate a series of chemical reactions, resulting in enhanced cellular energy and stimulation of nucleic acid synthesis, which is crucial for wound healing [31]

The third hypothesized mechanism is derived from infrared-like radiation, which triggers a reaction at the membrane level, likely through photophysical effects on calcium channels. MIRE therapy has demonstrated the ability to induce the release of growth factors from irradiated cells. Growth factors promote angiogenesis, the synthesis and breakdown of the extracellular matrix, as well as the release of cytokines. Fibroblasts and keratinocytes are the main cells involved in skin ulcer contraction as well as collagen formation [32, 33].

Conclusion:

The application of MIRE had beneficial healing effects on burn healing, as indicated by the statistically significant reductions in BSA and CC among burned patients.

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