The Effect Of Polarized Light Therapy In Treatment Of Chronic Diabetic Foot Ulcers

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Abstract

Background/aim: Impaired healing is a problematic and common complication of chronic wounds. Although laser has been used in the treatment of chronic wounds with promising efficacy, its mechanism is still poorly characterized. The cost of wound care is significant. The most important components are the costs of wound-related hospitalisation and the opportunity cost of nurse time. The 32% of patients treated in hospital accounted for 63% of total costs. The use of polarized light in the treatment of wounds has provided conflicting data, with some studies reporting accelerated wound closure and increased tensile strength of scars while others have found no such improvement.The aim of this study was to determine the effect of polarized light therapy on wound surface area and wound volume of chronic diabetic foot ulcers.

Material and methods:

Sixty men patients with partial or full thickness diabetic foot ulcer complaining from delay healing of ulcer for more than three months participated in this study. Subjects were randomized into 2 groups equal in number, each group consisted of 20 patients. Group A was the Polarized light therapy group, included 30 men patients with foot ulcer and they received polarized light therapy with energy density of an average of 2.4 J/cm2 per minute for 8min, 3 sessions per week in addition to traditional medical treatment and Group B was the traditional medical treatment group, included 30 men patients with foot ulcer and they received traditional medical treatment only. All evaluations were applied by the same physiotherapist12 weeks.

Results: Wound Surface Area and Ulcer volume showed significant difference between the two groups in favor of group A, as p was ≤ 0.05 which was considered statistically significant.

Conclusion: We suggest that light therapy should be added to the treatment of chronic diabetic foot ulcers.

Key words: Diabetic foot, light therapy, ulcers.

1. Introduction

Chronic wounds may be due to arrest of wound healing in the state of chronic inflammation, with an imbalance between protease activity and growth factor expression. The chronic wound environment has an overload of matrix metalloproteases (MMPs), reduced amounts of tissue inhibitors of MMPs (TIMPS), senescent and dysfunctional cells with decreased proliferative and synthetic activities, and shortages in growth factors and growth factor receptors. This situation suppresses fibroblasts proliferation, motility and protein production so that the wound remain in a chronic state (1).

There are four types of skin ulcers: venous ulcers, arterial ulcers, neuropathic ulcers and pressure ulcers. The prevalence of pressure wounds may be more widespread than initially thought and it is estimated that 3 million Americans may have pressure ulcers (2).

Foot ulcers are defined as any break in the cutaneous barrier , but usually extend through the full thickness of the dermis . certain infections of the foot as cellulities or osteomylities can occur without break in the skin. A wound may be acute or chronic, the latter could be defined as a wound that is not continuously progress toward healing .any wound that remains unhealed after 4 weeks is a cause for concern , as it is associated with worse outcome , including amputation (3).

Foot ulcers and their sequelae are amajor source of morbidity and re source use for patients with diabetes (3).

The etiology of foot ulcers usually has many components. The presence of peripheral neuropathy, peripheral vascular disease, and poor glycemic control in conjunction with minor foot trauma increases the likelihood that patients with diabetes will develop foot ulcers. Ulcers, in turn, often progress to infections of the surrounding tissue, osteomyelitis, and amputation (4).

Multicenter study attributed 63 percent of diabetic foot ulcers to the critical triad of peripheral sensory neuropathy, trauma, and deformity. Other factors in ulceration are ischemia, callus formation, and edema. Although infection is rarely implicated in the etiology of diabetic foot ulcers, the ulcers are susceptible to infection once the wound is present. Many of the risk factors for foot ulcer are also predisposing factors for amputation, because ulcers are primary causes leading to amputation (5).

Approximately 15% to 25% of individuals with diabetes develop a foot ulcer at some point in their lifetime and an estimated 12% of those patients require lower extremity amputation. Diabetic foot ulcers account for nearly 2/3 of all nontraumatic amputations. The most common cause of lower extremity ulcers is venous insufficiency. This accounts for 70-90% of leg ulcers. Ulcers associated with peripheral artery disease, also commonly known as ischemic ulcers, account for approximately 10% of lower extremity ulcers (6).

Classification of ulcerations can facilitate a logical approach to treatment and aid in the prediction of outcome. Several wound classification systems have been created, based on parameters such as extent of infection, neuropathy, ischemia, depth or extent of tissue loss, and location (7).

The most widely accepted classification system for diabetic foot ulcers and lesions is the Wagner ulcer classification system, which is based on the depth of penetration, the presence of osteomyelitis or gangrene, and the extent of tissue necrosis (Appendix I). The drawback of the Wagner classification system is that it does not specifically address two critically important parameters: ischemia and infection (8).

Wound healing is a complex process that can be divided into at least 3 continuous and overlapping processes: an inflammatory reaction, a proliferative process leading to tissue restoration, and, eventually, tissue remodeling. Wound healing processes are strictly regulated by multiple growth factors and cytokines released at the wound site. Although the desirable

final result of coordinated healing would be the formation of tissue with a similar structure and comparable functions as with intact skin, regeneration is uncommon (with notable exceptions such as early fetal healing); healing however results in a structurally and functionally satisfactory but not identical outcome. Alterations that disrupt controlled healing processes would extend tissue damage and repair. The pathobiologic states may lead to chronic or nonhealing ulcers or excessive fibrosis (9).

The medical history should include an evaluation of the patient's current medical status (e.g., acute illness), significant past medical history (e.g., previous pressure ulcers and their treatment, dementia, diabetes, peripheral vascular disease, collagen vascular disease), medication review, and psychosocial assessment (e.g., substance abuse, alcoholism, social support system, financial constraints (10).

Good WAT should be easy to use, set goals for healing and planning care, monitoring of the healing process and guiding practice to optimizing wound care (11).

Uncontrolled and self-sustaining inflammatory mechanisms are considered responsible for the failure of chronic ulcers to heal. Bacterial concentrations exceeding 105 or 106 bacteria colony-forming units per gram of tissue, or any level of β-hemolytic streptococci, have been shown to impair wound healing and surgical closure (12).

Surgical debridement and topical antibiotics effectively lower the number of bacteria in chronic ulcers (13).

Debridement is required to remove necrotic tissue and excessive bacterial burden. The health care provider can choose from a number of debridement methods, including surgical, enzymatic, mechanical, biological, or autolytic. More than one debridement method may be appropriate. Sharp debridement is generally regarded as fast and effective particularly in cases of pressure, diabetic, and venous related ulceration (14).

Ulcers may be cleansed with water (run from a mains drinking supply) or sterile 0.9% sodium chloride (normal saline), according to the needs of the individual patient. Factors such as the age, type of surgery, wound classification, patient's immune status, size and position of the wound, presence of infection or debris and the quality of the water supply should be taken into account (15).

The choice of dressing will be influenced by type of wound, amount of exudate, location of the wound, skin condition of the patient, presence/absence of infection, condition of wound bed, characteristics of dressings available and treatment goals. Surgical wound dressings should be left dry and untouched for a minimum of 48 hrs post-op to allow for re-establishment of the natural bacteria-proof barrier, unless otherwise clinically indicated (16).

Polarized light therapy device emits light that is polarized, polychromatic, non-coherent and of low energy. The light emitted has a wide range of wavelengths (480-3400nm) and differs from laser light, which is mono-chromatic (of narrow wavelength), coherent, polarized and of high or low energy. Possible risk of burns is present with the laser therapy, while not possible with the polarized light therapy. User skills are essential in laser therapy, but not essential with the polarized light therapy. Higher costs are present with the laser therapy, but not with the polarized light therapy, in addition, treatment of large area is available with the polarized light therapy (17).

Polarized light therapy has a photo-biostimulation biological effect, causing various reactions within these tissues that may result in the reduction of pain and promotion of healing. Polarized light therapy is believed to reduce pain sensation in several ways; improving local blood supply and reducing muscle spasm, reducing the release of chemicals that stimulate pain receptors, inducing the release of endorphins and direct action on nerve fibers to prevent transmission of pain impulses to the brain (18).

2. Materials and methods

Sixty men patients who have foot ulcer in the stage of superficial diabetic ulcer (partial or full thickness), they were complaining from delay healing of ulcer for more than three months participated in this study. The patients were selected from El-Agouza Police Hospital, Diagnosis was made clinically by a physician.

1. Inclusion Criteria:

Subjects were selected according to the following criteria:

- The patients' ages was ranged from 30 to 50 years.
- The subjects were chosen from men.
- The subjects had controlled diabetes (confirmed by HbA1c before and after treatment).
- The duration of ulcer more than three months and less than 1 year.
- Grade 1 according to Wagner ulcer classification system.

2. Exclusion Criteria:

The patients were examined by a physician before the study and the following patients were excluded from this study:

- The patients who had skin malignancy in the area to be treated.
- Patients with ulcer extension to ligament, tendon, joint capsule, or deep fascia.
- Patients with abscess or osteomyelitis or joint sepsis
- Patients with acute infection in the area treated.

- Patients suffering from psychological problems.

Each patient received detailed explanation of procedures of the program of treatment and measurement devices. All patients did not receive any kind of physical therapy before the application of the program. The purpose of the treatment was explained for each patient. Written informed consent was obtained from each subject. of the subjects were recorded. The study was designed as a prospective randomised clinical trial.

Subjectswere randomized into 2 groups equal in number, each group consisted of 20 patients. Group A was the Polarized light therapy group, included 30 men patients with foot ulcer and they received polarized light therapy with energy density of an average of 2.4 J/cm2 per minute for 8min, 3 sessions per week for 12 weeks in addition to traditional medical treatment (19).

Group B was the traditional medical treatment group, included 30 men patients with foot ulcer and they received traditional medical treatment only for 12 weeks. All evaluations were applied by the same physiotherapist.

Procedure:

1. For Evaluation:

a) Wound Surface Area (WSA):

This parameter was measured using sterilized transparent sheet, permanent fine-tipped marker pen, metric graph paper (1 mm), carbon paper, and white paper.

The measurement of wound surface area was conducted by tracing method according to Bryant et al. (20), using the following steps:

- A sterilized transparency film was placed on the wound.
- The wound perimeter was traced using the fine-tipped marker pen.
- Each wound area was traced three times to establish measurement reliability.
- After tracing, the transparency sheet face, which faced the wound, was cleaned by a piece of cotton and alcohol.
- A separate transparency sheet was used for each wound. The tracing was then placed over the metric graph paper and the number of square millimeters inside the trace perimeter was only counted and the area was then converted to cm^2.
- The measurements of wound surface area was conducted on intervals of pre-treatment and post-treatment.

b) Ulcer volume assessment:

Using a syringe of five cubic centimeters and Terramycin ointment.

- Using sterilized syringe and Terramycin ointment.
- Filing the sterilized syringe of 5 cm3 with Terramycin ointment.
- Then filing the wound by the kwon volume of the Terramycin ointment.
- It is an easy accurate method for wound volume estimation.

2. For treatment:

Bioptron Pro 1 Class II, (Made by Bioptron AG, Wollerau, Switzerland) device with floor stand emitted polarized light lamp with wavelengths ranged from 480–3400 nm (Fig. 1) was used in treatment of group A patients in this study.

Figure (1): Bioptron Pro 1 Class II polarized light device.

Polarized Light Therapy Technical Steps (19):

- Patient was lying in comfortable position.
- The head of the device was directed perpendicular to the ulcer area with a distance of 10 cm.
- The degree of polarization was > 95%.

- The power density of the polarized light therapy was approximately 40 mW/cm^2, which was equivalent to an energy density of an average of 2.4 J/cm^2 per minute.
- Start the treatment.
- End the treatment after 8 min and dismiss the patient.

Each patient received polarized light therapy, 3 times per week day after day for a total of consecutive 12 weeks.

Statistics

The descriptive statistics (the mean and the standard deviation,) was calculated for all subjects in both groups of the study for all variables. Comparisons were made by independent sample t-test to compare the variables between the two groups of the study. Paired t- test to compare before and after treatment in the same group. A value of $p \leq 0.05$ was considered statistically significant (21).

- **Results**

No study participant left the research project for any reason. No side effects or complications were observed during the assessment procedure.

Wound Surface Area andUlcer volume showed significant difference between the two groups in favor of group A, as p was ≤ 0.05 which was considered statistically significant.

4. Discussion

Ulcers result from breaks in the dermal barrier,with subsequent erosion of underlying subcutaneous tissue. In severe cases, the breach may extend to muscle and bone. Primary care providers are often the first to evaluate nonhealing pedal ulcers. Early recognition of the cause and prompt management of ulcers are essential for a good functional outcome. In many cases,

successful salvage of an extremity depends on a multidisciplinary team of specialists, and timely consultation is warranted (22).

The aim of this study was to determine the effect of polarized light therapy on wound surface area and wound volume of chronic diabetic foot ulcers.

This finding of lordotic angle is consistent with the results of Monstrey et al., who reported that polarized light therapy resulted in significant acceleration of wound healing, low incidence of hypertrophic scarring and optimal functional and aesthetic results. Polarized light therapy reduces the need for surgery in the treatment of deep dermal burns (23).

The results of the current study revealed that there was significant improvement in Wound Surface Area and Ulcer volume between the two groups in favor of group A, as p was $\leq$ 0.05 which was considered statistically significant.

These results agree with Iordanou et al., who reported that polarized light therapy showed statistically significantly faster epithelialization as well as better quality of the healing process in full-thickness skin wounds in rats (17).

A novel and accurate technique of computerised photographic wound measurement developed by Shetty et al. (2012) in his comparative study of 10 patients whose ulcers were measured by three techniques, i.e. ruler, graph and the new computerised photographic wound measurement technique. The graph method was taken as the control measurement. The extent of deviation in wound measurements with the new method was compared with the standard technique. Results of the ruler method was highly inaccurate and overestimated the wound size by nearly 50%. The new technique remained consistent and accurate with the percentage of over or underestimation being 2-4% in comparison with the graph method. The new computerised photographic wound measurement is simple and accurate and is an inexpensive and non-invasive method to accurately measure ulcers (24).

Wound-assessment tool (WATs), should help identifying the number and location of ulcers; the grade of the wound/s – colour and/or numerical grading tools may be used; the size of the wound – dimensions (length and breadth) can be measured using a plastic ruler – which should be disinfected – or approximated from a tracing on a proprietary measuring grid; The nature of any wound fluid – is it exudate, serous fluid or pus; the cause, nature and severity of any pain related to the wound. There are many causes of wound pain, which may be determined using a pain assessment scale (25).

Polarized light therapy devices emit light containing a range of wavelengths that correspond to visible light plus infrared radiation, both of which have been reported to stimulate the biological reactions and importantly no harmful ultraviolet radiation is present in the polarized light therapy (26).

Unfortunately, there is no research in this regard and these findings cannot be compared to any similar results.

References:

1. Behm, B., Babilas, P., Landthaler, M. and Schreml, S. (2012): Cytokines, chemokines and growth factors in wound healing. Journal of the European Academy of Dermatology and Venereology, 26(7), 812-820.

2. Greer, N., Foman, N. A., MacDonald, R., Dorrian, J., Fitzgerald, P., et al. (2013): Advanced wound care therapies for nonhealing diabetic, venous, and arterial ulcers: A systematic review. Annals of Internal Medicine, 159(8), 532-542.

3. Gist, S., Tio-Matos, I., Falzgraf, S., Cameron, S. and Beebe, M. (2009): Wound care in the geriatric client. Clin Interv Aging, 4(1), 269-287.

4. Frykberg, R. G. (2002): Diabetic foot ulcers: Pathogenesis and management. American Family Physician, 66(9), 1655-1662.

5. Frykberg, R. G., Zgonis, T., Armstrong, D. G., Driver, V. R., Giurini, J. M., et al. (2006): Diabetic foot disorders: A clinical practice guideline (2006 revision). The Journal of Foot and Ankle Surgery, 45(5), S1-S66.

6. Ayello, E. A. (2005): What does the wound say?: Why determining etiology is essential for appropriate wound care. Advances in Skin & Wound Care, 18(2), 98-109.

7. Gul, A., Basit, A., Ali, S. M., Ahmadani, M. Y. and Miyan, Z. (2006): Role of wound classification in predicting the outcome of diabetic foot ulcer. JPMA. The Journal of the Pakistan Medical Association, 56(10), 444.

8. Doupis, J. and Veves, A. (2008): classification, diagnosis, and treatment of diabetic foot ulcers. Wounds: a compendium of clinical research and practice, 20(5), 117-126.

9. Li, J., Chen, J. and Kirsner, R. (2007): Pathophysiology of acute wound healing. Clinics in Dermatology, 25(1), 9-18.

10. Jaul, E. (2010): Assessment and management of pressure ulcers in the elderly. Drugs & aging, 27(4), 311-325.

11. Lipsky, B. A., Berendt, A. R., Deery, H. G., Embil, J. M., Joseph, W. S., et al. (2004): Diagnosis and treatment of diabetic foot infections. Clinical Infectious Diseases, 39(7), 885-910.

12. Werdin, F., Tennenhaus, M., Schaller, H.-E. and Rennekampff, H.-O. (2009): Evidence-based management strategies for treatment of chronic wounds. Eplasty, 9(19), 169-179.

13. Edwards, R. and Harding, K. G. (2004): Bacteria and wound healing. Current Opinion in Infectious Diseases, 17(2), 91-96.

14. Steed, D. L., Attinger, C., Colaizzi, T., Crossland, M., Franz, M., et al. (2006): Guidelines for the treatment of diabetic ulcers. Wound Repair and Regeneration, 14(6), 680-692.

15. Falabella, A. F. (2006): Debridement and wound bed preparation. Dermatologic Therapy, 19(6), 317-325.

16. Moore, Z. and O'brien, J. J. (2011): Wound dressings–an overview. Acta Medica Croatica, 65(Supl 2), 69-73.

17. Iordanou, P., Lykoudis, E. G., Athanasiou, A., Koniaris, E., Papaevangelou, M., et al. (2009): Effect of visible and infrared polarized light on the healing process of full-thickness skin wounds: An experimental study. Photomedicine and Laser Surgery, 27(2), 261-267.

18. Begic-Rahic, J. and Vranic, S. (2010): The application of bioptron light therapy in dermatology and wound healing. European Dermatology, 5.

19. BaheyEl-Deen, H., Fahmy, S., Ali, S. and El-Sayed, W. (2014): Polarized light versus light-emitting diode on healing of chronic diabetic foot ulcer. Romanian Journal of Biophysics, 24(2), 117–132.

20. Bryant, J., Brooks, T., Schmidt, B. and Mostow, E. (2001): Reliability of wound measuring techniques in an outpatient wound center. Ostomy/Wound Management, 47(4), 44-51.

21. Field, A. P. (2013): Discovering statistics using IBM SPSS statistics (Vol. 4th). pp. London: SAGE.

22. Meah, Y. S., Gliatto, P. M., Ko, F. C. and Skovran, D. (2016): Wound care in home-based settings. In J. L. Hayashi and B. Leff (Eds.), Geriatric home-based medical care. (pp. 195-236). New York: Springer.

23. Monstrey, S., Hoeksema, H., Depuydt, K., Van Maele, G., Van Landuyt, K., et al. (2002): The effect of polarized light on wound healing. European Journal of Plastic Surgery, 24(8), 377-382.

24. Shetty, R., Sreekar, H., Lamba, S. and Gupta, A. K. (2012): A novel and accurate technique of photographic wound measurement. Indian journal of plastic surgery: official publication of the Association of Plastic Surgeons of India, 45(2), 425.

25. Collier, M. (2003): The elements of wound assessment. Nurs Times, 99(13), 48-49.

26. Zhevago, N. A., Samoilova, K. A. and Obolenskaya, K. D. (2004): The regulatory effect of polychromatic (visible and infrared) light on human humoral immunity. Photochemical & Photobiological Sciences, 3(1), 102-108.