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Chronic and Diabetic Venous Wounds: Photobiomodulation as a Mechanism for Enhancing Healing - A Case Report

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Abstract

Venous ulcers are chronic wounds, common in the elderly, caused by venous insufficiency, which is often associated with conditions such as Diabetes Mellitus, Systemic Arterial Hypertension and a sedentary lifestyle. They affect the quality of life of patients due to pain, edema, infection and complications that may occur, such as the risk of amputation. Conventional treatment for venous ulcers includes compression therapy and dressings. In some cases, advanced therapies such as photobiomodulation are also used as treatment, where light accelerates healing. This study aimed to evaluate the effects of a photobiomodulation protocol with red light (660nm) in the treatment of a long-term chronic venous ulcer, present for ten years. The patient, a 63-year-old man with multiple comorbidities, was treated with weekly PBM sessions for nine months. The evaluation included pain assessment using the Visual Analog Scale and characteristics observed through photographs of the wound before, during and at the end of treatment. The results showed a significant reduction in pain and complete healing of the wound, highlighting the efficacy of PBM as a non-invasive, low-cost and effective treatment for complete healing of chronic venous ulcers. These findings reinforce the clinical relevance of photobiomodulation in the treatment of these wounds, suggesting the need for further studies to consolidate this approach as a widely used practice.

Keywords: Laser; Photobiomodulation; Healing; Venous ulcer; Type-I diabetes mellitus

Introduction

Venous ulcers are chronic lesions often found in the lower extremities, resulting from venous insufficiency. This condition is characterized by difficulty in venous return to the heart due to dysfunction in the veins of the legs, which generates increased pressure in the venous walls and can cause the rupture of blood vessels, favoring the formation of wounds that are difficult to heal. Factors such as systemic arterial hypertension and a sedentary lifestyle negatively affect blood circulation, increasing venous pressure and impairing valve function over time. Both conditions exacerbate the risk for venous insufficiency by creating an environment where blood is more likely to pool in the legs rather than being efficiently returned to the heart. Additionally, diabetes mellitus, smoking, alcoholism, and a sedentary lifestyle negatively interfere with the tissue healing process, compromising the quality of life of patients, especially the elderly [1].

Furthermore, venous ulcers often present symptoms such as pain, edema, hyperemia, odor and infections, constituting a public health problem that requires early diagnosis and appropriate treatment, thus avoiding complications and improving the prognosis. This condition mainly affects people over 65 years of age, representing a significant challenge for geriatric health. The lack of family support and financial resources contributes to the worsening of the condition, with an increase in depressive symptoms and, consequently, the failure to seek medical care [2].

Elderly patients with diabetes and chronic wounds should be treated with the goal of complete healing, except in cases of ischemia and osteomyelitis. These patients require daily monitoring and prompt treatment for new lesions. Although age-related conditions, chronic diseases, and nutritional deficiencies can compromise healing, appropriate interventions, such as the use of growth factors and cell therapy, can reverse altered physiological processes. Early treatment is essential, since elderly patients have greater difficulty compensating for the morbidities associated with chronic wounds [3].

Economically, treating patients with venous ulcers represents a high cost for health systems. In 2021, spending on care for these patients was estimated at US$966 billion, with a forecast increase of 316% over the next 15 years, according to data from the International Diabetes Federation [4].

Peripheral Arterial Disease (PAD) affects a total of 12% of adults, mainly males over the age of 50. Risk factors increase in people with Type II Diabetes Mellitus (T2DM), hypertension and other diseases such as dyslipidemia [5]. PAD often coexists with venous insufficiency, particularly in patients with shared risk factors like diabetes and hypertension. This overlap increases the likelihood of chronic venous ulcers or amputation if vascular treatment is not carried out [6]. In Primary Health Care (PHC), Brazil accounts for 2.9% of elderly people with venous ulcers, which is related to the population's lifestyle and clinical characteristics. It is crucial in PHC to recognize both PAD and venous insufficiency, as managing one does not address the other,

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necessitating a comprehensive approach for better outcomes [7].

Venous ulcers are characterized by lesions that have irregular edges, generally with yellowish exudate, in some cases the visualization of necrosis in the tissue [8]. Pathophysiologically, this chronic injury is caused by a deficiency in the valves of the leg veins in conjunction with the blood flow of the superficial veins, the inefficient physiological mechanism causes damage to the walls [9], which in addition to causing discomfort to the patient, causes a lot of pain [8].

Pain in patients with chronic ulcers is intense and can lead to emotional symptoms such as depression, anxiety and sleep disorders, influencing quality of life [7]. The VAS score ranges from values above 4 points – poorly controlled and significant pain. This pain can affect the frequency of treatment, delay in wound healing and the patient's quality of life [10].

In addition to the pain being frequent and the sensation of varying intensity during the physical examination, skin changes such as hyperpigmentation, eczema and itching will be present, as well as dehydrated integumentary tissue [8]. To alleviate these undesirable effects on the skin barrier, the application of vegetable oils with anti-inflammatory action is associated with repair [11], one example of pharmacological products is sunflower seed vegetable oils to promote wound healing [12].

Conventional treatments are based on compression (using bandages or stockings), topical dressings, vacuum therapies, low-frequency ultrasound treatment, electrostimulation (electric current), hydrotherapy, and infrared radiation filtered by water [13]. These compression therapies tend to be used to reduce hypertension and improve blood flow circulation [11].

New LASER and LED technologies promote a set of benefits in tissue oxygenation, in addition to leading to the formation of cytotoxic effects in the region to inhibit infection, contributing to the treatment of wounds and healing of chronic venous ulcers [14]. According to Carbinatto et al. [6], LLLT (low-level laser therapy) is necessary to assist in the wound healing process due to biomodulation at the cellular level, with the biological action being favored by the activation of cytochrome oxidase photons, activating the production of mitochondria, providing tissue repair due to protein synthesis.

This methodology for the proliferation and activation of the immune system (lymphocytes and macrophages) with the secretion of growth factors and increased neocollagenesis helps in the evolution of wound healing and inhibition of bacterial resistance [15].

Therefore, the objective of this study includes a clinical case report in a patient with a chronic venous ulcer - for more than 10 years - of the lower limb being treated with a new non-invasive red light method in the affected region.

Methodology

This is a case report of a 63-year-old male patient with a medical diagnosis of venous ulcer and a history of type 1 diabetes mellitus, hypertension, dyslipidemia, and a stroke and acute myocardial infarction. He had a lesion on his left lower limb, in the medial region of the ankle, which had been open for 10 years. The patient sought care at the Photodynamic Therapy Unit, located at Santa Casa de Misericórdia de São Carlos (CAAE: 30625714.2.0000.5380).

Initially, a detailed anamnesis of the patient and a clinical evaluation of the wound were carried out, which presented no odor or clinical signs of infection. A cluster-type device was used, equipped with three LED emitters arranged in a triangular shape, with an area of 5 cm in length. The equipment operated at a wavelength of 660nm, a power of 100mW and an energy emission capacity equivalent to 18 Joules per minute, per LED emitter.

The therapeutic protocol began with cleaning the lesion using 0.9% saline solution. Then, red light was applied using the cluster-type device for a total initial time of 12 minutes, distributed in 3 minutes in each area of the lesion, corresponding to a dose of 54 Joules per area. After the application of the light, sunflower oil, which has healing properties, was used, followed by occlusion of the wound with non-adherent gauze and fixation with a bandage. As the lesion showed a reduction in size, the total time of light application was adjusted proportionally, maintaining the protocol of 3 minutes per treated area. During the treatment, guidance was provided to the patient, including care for the injured area, adequate frequency of dressing changes, improvement of nutrition and attendance at consultations. The protocol was carried out from September 2023 to June 2024, with a frequency of twice a week.

The evaluation criteria used included the analysis of dated photographs of the lesion, the monthly application of the visual analogue pain scale (VAS) and the observation of the characteristics of the injured tissue. Initially, a photograph of the lesion was taken before the start of the phototherapy protocol. During the sessions, the patient reported no discomfort or sensation of heat during the procedure, in addition to an improvement in local sensitivity, with a reduction in the perception of pain. The evolution of the lesion tissues was monitored throughout the treatment with photographs.

Results

The research conducted in this study aimed to evaluate the effects of photobiomodulation on pain reduction and chronic wound healing. The application of the photobiomodulation protocol in this study resulted in a significant improvement in patient-reported pain, evidenced by the reduction in Visual Analog Scale (VAS) values over the months (Figure 1).

As shown in the graph above, the lesion - open for 10 years - caused intense local pain. The disappearance of pain at the end of treatment suggests not only symptomatic relief, but also structural improvement of the lesion and the tissue microenvironment.

In the present study, the wound, which had remained open for 10 years prior to the start of the protocol, healed completely after nine months of photobiomodulation treatment, as can be seen in the photographs below, totaling 74 sessions performed twice a week. This case demonstrates the potential of photobiomodulation as an effective treatment for chronic wounds, especially in patients with risk factors for impaired healing (Figure 2).

In this clinical case report, we present a summary the outcomes of treating a chronic venous ulcer using photobiomodulation therapy in the Table 1.

Discussion

Venous ulcers are skin lesions resulting from reflux or obstruction in the peripheral venous system, with a high prevalence in individuals over 65 years of age [16]. Their pathophysiology involves a reduction in the angiogenic response, which compromises tissue regeneration and results in delayed healing, especially in patients with diabetes mellitus (DM). DM is defined by the International Diabetes Federation (IDF) as a chronic disease caused by dysfunction in the production or use of

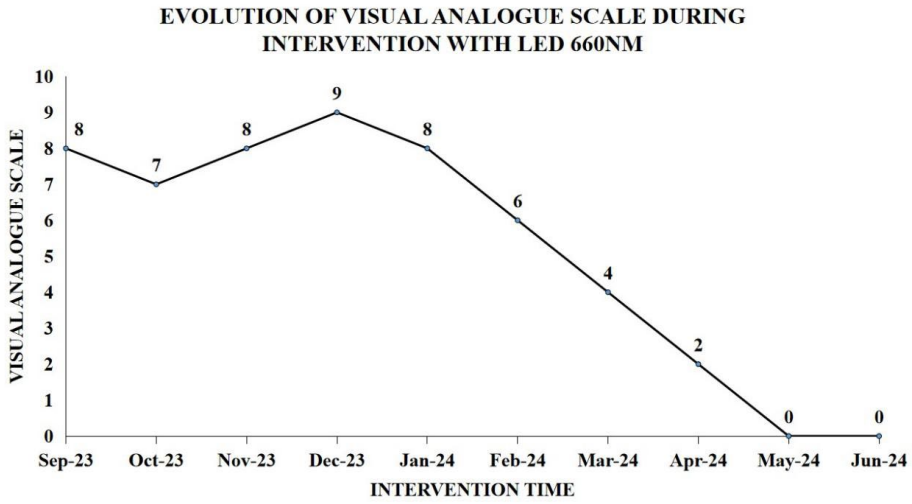

Figure 1: Visual Analogue Scale analized during intervention time, between September/23 and June/24.

Table 1: Summary of Key Metrics.

Metric	Description/Outcomes
Wound Size Reduction	The wound healed completely after nine months of treatment.
Visual Analogue Scale	Significant reduction in pain was observed, but specific scores were not detailed.
Treatment Duration	9 months (74 sessions).
Protocol Details	Twice weekly sessions with red light therapy and wound care.

Figure 2: Evolution of chronic venous wound. A) Before treatment, B) During treatment and C) end of treatment.

insulin, recognized in 2013 as a global public health problem, with 382 million cases registered worldwide [17].

Patients with diabetes mellitus (DM) often face difficulties in the healing process, especially in injuries, due to a prolonged exacerbation of the inflammatory phase, which can lead to chronicity of wounds and, consequently, the development of ulcers [18]. These patients are at greater risk of serious complications, such as infections, abscesses and osteomyelitis, which not only require more intensive care, but also significantly impact their quality of life. Despite treatment, the regeneration of these ulcers can take weeks, months and even years, as in the case presented above. In addition, angiopathy and neuropathy associated with DM contribute to sensory loss in the lower extremities, which makes it difficult to perceive small injuries. These wounds, when not detected early, evolve into chronic ulcers that are difficult to heal [17].

Treatment of chronic ulcers currently includes compression therapy and different types of dressings. However, these methods have limitations, such as high cost, difficult access and the presence of bacterial biofilm on wound surfaces, which can hinder the healing process. In a case study, Carbinatto et al. (2018) sought to investigate the efficiency of a treatment for chronic venous and arterial ulcers in a 50-year-old patient. The study demonstrated significant improvement in wound healing after 90 days of an innovative treatment that combined photobiomodulation (PBM), application of cellulose biomembrane and photodynamic therapy. As in the present study, which highlights the efficacy of the protocol used, which promoted tissue repair of a chronic lesion in a patient with multiple comorbidities, including type 1 diabetes mellitus, arterial hypertension and heart disease. The stimulation of the mechanisms of cell proliferation, migration and endothelial organization for angiogenesis and collagen remodeling by the red light emitted by the equipment used were decisive for the closure of the lesion [6,19].

PBM has a biological effect directly linked to radiation in cellular

processes, unrelated to heating. Several clinical studies, conducted in animal and human models, have demonstrated the positive effects of photobiomodulation in accelerating the healing of difficult-to-heal diabetic ulcers. This technology stimulates the activation of photons of cytochrome oxidase, promoting energy production in mitochondria and the synthesis of proteins essential for cellular repair. In addition, it enhances cell growth and differentiation, as well as the synthesis of prostaglandins, while increasing the proliferation and activation of lymphocytes, phagocytosis in macrophages and the secretion of growth factors. These mechanisms result in greater uptake of fibrin and collagen, epithelialization and formation of granulation tissue, in addition to reducing oxidative stress and regulating inflammatory processes, which significantly accelerates the wound healing process [6,17].

In addition to wound healing, this study also sought to assess the presence and intensity of pain using a visual analogue score. The results demonstrated a significant reduction in pain scores, reaching cessation in June 2024, as shown in Graph 1. According to a study conducted by Vitse et al. (2017) [20], it was observed that photobiomodulation resulted in a significant reduction in ulcer pain over 12 weeks of treatment.

The results revealed in this study corroborate previous clinical studies and show that photobiomodulation is a promising and highly effective therapeutic modality for wound treatment, demonstrating positive results in tissue repair and pain reduction, with well-established molecular mechanisms and clinical applications. Patient adherence plays a crucial role in the success of such treatments, as consistent application can significantly influence both clinical outcomes and molecular responses. The study also recognizes the need for further research in the area so that PBM is widely accepted as a treatment for venous and diabetic ulcers, through larger clinical studies and a rigorous methodological approach.

As observed in Figure 1 and Figure 2, progressive recovery of the skin was evidenced over time. According to Osanai et al., [21], irradiation with red light on the integumentary tissue promotes an increase in the synthesis of fibroblast growth factor, mediated by the activation of photoactivated macrophages. In addition, in vitro studies using this same irradiation demonstrated an increase of up to four times in the synthesis of procollagen. In both contexts, a beneficial effect on the immune system was observed [22].

Conclusion

Finally, this clinical case study allows us to observe and conclude that leg ulcers represent a highly prevalent and concerning problem in the elderly population. They are often caused by underlying conditions such as venous insufficiency, peripheral arterial disease, connective tissue diseases, autoimmune conditions and diabetes, all of which are more common in older adults. In addition, elderly patients are at high risk of developing complications such as infection, cellulitis and amputation, which significantly impact their quality of life and functional capacity. Early identification and appropriate management of these underlying conditions are essential to promote effective ulcer healing and avoid related complications [14].

This case study, therefore, demonstrated the effectiveness of the proposed protocol using 660 nm wavelength laser (red light emission) in the treatment of chronic venous ulcers that had been open for more than ten years. The non-invasive method promoted the activation of neocollagenesis throughout the treatment, resulting in effective tissue recovery, complete healing of the lesion, in addition to providing pain relief during the follow-up period.

The technology used proved to be appropriate, highlighting the absence of pain during the application sessions, the absence of clinical complications related to bacterial or fungal infections and its potential as a low-cost alternative. Thus, the findings of this study support the clinical relevance of the treatment evaluated. Future studies may explore the potential of combining photobiomodulation with other therapeutic approaches, such as systemic medications or advanced wound care products, to enhance healing outcomes for patients with chronic venous ulcers. Additionally, researchers might investigate the use of antimicrobial photodynamic therapy (aPDT) in conjunction with photobiomodulation to address both infection and inflammation simultaneously. Exploring these combinations could lead to more effective treatment regimens that not only promote wound closure but also reduce the risk of complications such as bacterial or fungal infections. These efforts aim to expand treatment options and improve outcomes for patients with chronic venous ulcers.

Conflict of interest

The authors declare no conflict of interest.

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