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ORIGINAL ARTICLE

Effectiveness of laser therapy on diabetic foot ulcers: a study in a rehabilitation service, Matanzas

Efectividad de la laserterapia en úlceras del pie diabético: estudio en servicio de rehabilitación, Matanzas

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ABSTRACT

Introduction: Diabetic foot ulcers are a common complication of diabetes mellitus, with a high risk of infection and amputation. Low-level laser therapy has emerged as a promising adjuvant therapy.

Objective: To evaluate the benefits of laser therapy in reducing ulcer size and pain in patients with diabetic foot ulcers.

Methods: An observational, longitudinal, and prospective study was conducted in 39 patients with DFU treated with red laser point (670 nm, 10 J/cm², 14 sessions). Ulcer size (scale: good/bad) and pain (Likert scale) were assessed pre- and post-treatment.

Results: 69,2 % of patients were aged 51–79 years, and 61.5 % were men. Hypertension was the most common comorbidity (56,4 %). 53,8 % of the ulcers were located on the plantar region. After treatment, 46,1% showed a reduction in size to 1 cm, and 66,6 % reported no pain. Seventy-seven percent had a favorable clinical outcome.

Conclusion: Laser therapy significantly reduced ulcer size and pain, making it an effective therapeutic option for diabetic foot ulcers.

Keywords: Laser Therapy; Diabetic Foot Ulcer; Diabetes Mellitus; Wound Healing

RESUMEN

Introducción: las úlceras del pie diabético son una complicación frecuente de la diabetes mellitus, con alto riesgo de infección y amputación. La laserterapia de baja potencia ha emergido como una terapia adyuvante prometedora.

Objetivo: evaluar los beneficios de la laserterapia en la reducción del tamaño de las úlceras y el dolor en pacientes con úlceras del pie diabético.

Métodos: estudio observacional, longitudinal y prospectivo en 39 pacientes con UPD tratados con láser puntual rojo (670 nm, 10 J/cm², 14 sesiones). Se evaluó el tamaño de la úlcera (escala: bueno/malo) y el dolor (escala de Likert) pre y postratamiento.

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Resultados: el 69,2 % de los pacientes tenían entre 51-79 años, 61,5 % eran hombres. La hipertensión arterial fue la comorbilidad más frecuente (56,4 %). El 53,8 % de las úlceras se localizaron en la región plantar. Tras el tratamiento, el 46,1 % mostró reducción del tamaño a 1 cm, y el 66,6 % reportó ausencia de dolor. El 77 % tuvo evolución clínica favorable.

Conclusión: la laserterapia redujo significativamente el tamaño de las úlceras y el dolor, siendo una opción terapéutica efectiva para úlceras del pie diabético.

Palabras clave: Laserterapia; Úlcera Del Pie Diabético; Diabetes Mellitus; Cicatrización

INTRODUCTION

Diabetic foot is a multifactorial clinical complication that arises as a result of chronic hyperglycemia, which generates peripheral sensory neuropathy that decreases pain perception and the ability to detect trauma. In many cases, this process is aggravated by the presence of ischemia, which compromises tissue oxygenation. The combination of these factors, combined with mechanical trauma, triggers the formation of ulcerous lesions. (1)

This condition results from the interaction between systemic factors (such as immunosuppression and chronic inflammation) and local factors (such as abnormal pressure or infections), which not only predispose to the development of preulcerative lesions (calluses, fissures) but also promote progression to established ulcers, especially when aggravating factors such as infections or repetitive mechanical loading coexist. (2,3)

Despite the heterogeneity of the clinical manifestations of diabetic foot, the pathophysiology underlying the development of ulcers and their complications follows a common pattern, mediated by multiple interrelated factors. Predisposing factors include peripheral neuropathy—present in more than 90% of cases—macro- and microangiopathy, and diabetic arthropathy, which together create a substrate vulnerable to injury. These factors combine with precipitating factors, such as mechanical trauma (often unnoticed due to loss of sensation) and poor local hygiene, which trigger the ulcerative process. (4)

Finally, aggravating factors, particularly infection, amplify tissue damage, accelerate ulcer progression, and determine the functional prognosis of the limb. It should be noted that neuropathy plays a central role in this

pathophysiological cascade, not only as an initial facilitator of injury but also as a driver of its progression to severe complications. [5,6]

Infection in a diabetic foot with neuropathic and ischemic involvement represents a critical factor in disease progression, making risk factor control an essential therapeutic objective to prevent or delay its progression to amputation. It is important to emphasize that antibiotic treatment alone is insufficient to control the infectious process, requiring extensive surgical debridement to remove all necrotic tissue [7-9]. This combined approach seeks to interrupt the vicious cycle of infection-ischemia-neuropathy that characterizes severe forms of diabetic foot.

Among these adjuvant therapies, low-level laser therapy (LLLT) stands out for its photobiomodulatory mechanism of action. This technique uses light energy generated by atomic excitation (emission of photons), constituting a noninvasive, painless, and easy-to-use clinical method. Depending on their power, lasers are classified as high-power (with thermal and ablative effects) and low-power (where energy dispersion promotes biological effects without thermal damage). [10]

LLLT has been shown in clinical studies to stimulate key processes in the management of diabetic foot: tissue regeneration (through increased fibroblast proliferation and collagen synthesis), accelerated healing (via neoangiogenesis), modulation of the inflammatory response (reduction of proinflammatory cytokines), and analgesic effect (through normalization of neuronal membrane potential). [11]

Its safety profile—with minimal reported adverse effects—and its proven efficacy in multiple pathologies position it as a valuable therapeutic alternative in the multidisciplinary approach to diabetic ulcers, particularly in complex cases that respond poorly to conventional treatments. [12]

Low-level laser therapy induces therapeutic effects through biophysical phenomena when interacting with the skin. Laser light, due to its coherent and monochromatic nature [13, 14], selectively acts on specific molecules and key metabolic pathways, generating three primary effects: biochemical, bioelectrical, and bioenergetic. [15, 16] These trigger indirect effects such as circulatory improvement and edema reduction, culminating in fundamental therapeutic actions: tissue regeneration, anti-inflammation, and analgesia. [17, 18]

Diabetic foot affects 25% of patients with diabetes (global prevalence of 19%), and its ulcers represent high healthcare costs, both direct (treatment) and indirect (loss of productivity). LLLT is emerging as an adjuvant therapy in multidisciplinary management, accelerating healing through its impact on microcirculation and collagen synthesis. [19, 20]

The high prevalence of neuroischemic ulcers in patients with diabetic foot (25%) and their elevated risk of amputation (40-60% at 5 years) [19, 20] contrast with the limitations of conventional treatments in restoring compromised microcirculation, controlling chronic inflammation, and accelerating tissue regeneration in hypoxic tissues.

Although low-level laser therapy (LLLT) has demonstrated photobiomodulatory effects in controlled studies, its true efficacy in patients with comorbidities typical of hospital settings, its clinical impact on advanced ulcers, and its cost-effectiveness in resource-limited healthcare systems are unknown. These knowledge gaps hinder its protocolized implementation in hospital institutions, where optimal management of these ulcers could significantly reduce amputations and associated costs.

For this reason, this study aimed to determine the benefits of laser therapy on diabetic foot ulcers in patients treated at the Faustino Pérez Hospital in Matanzas from October 2023 to March 2024.

MATERIALS AND METHODS

A prospective, longitudinal, observational study was conducted in the rehabilitation service of the Faustino Pérez Provincial Clinical and Surgical Teaching Hospital in the Province of Matanzas, from October 2023 to March 2024.

The universe and sample were consistent and consisted of 39 patients with diabetic foot ulcers who met the following criteria:

Inclusion criteria: Patients who agreed to participate in the study. Patients with metabolically compensated ulcers. Patients whose ulcer size did not exceed 5 cm in diameter.

Exclusion criteria: Patients with conditions that contraindicate laser treatment (recent hematoma, presence of a pacemaker, acute infectious processes, neoclassical processes, heart disease in the stages of decompensation, hyperthyroidism, pregnancy, epilepsy, history of photosensitivity). Patients with psychiatric illnesses that prevent them from complying with treatment

(mental retardation, loss of mental faculties). Patients receiving treatment with Heberprot P

All patients in this study completed a data collection form, including an examination of the lesion characteristics, and a qualitative Likert scale was used to measure pain intensity at the beginning and end of treatment.

Red laser treatment was performed at various points along the edge of the ulcer, with a distance of 2 cm between each point, at a dose of 10 J/cm2, and completed in 14 sessions from Monday to Saturday. The Lasermed 670 device, developed by Cuban companies, was used by TECESA.

After completing the 14 treatment sessions, patients were evaluated for ulcer size using a scale of good (if the ulcer size decreased between 50% and 75%), poor (if the ulcer size decreased less than 50%), and pain using a qualitative Likert scale: good (no pain, mild or moderate pain), or poor (severe and unbearable pain).

The data were processed using SPSS version 15, using descriptive statistics (absolute and relative frequencies). The results are presented in frequency distribution tables and graphical representations, with measures of central tendency for quantitative variables.

The research protocol was approved by the institution's Research Ethics Committee (Record No. 3/Agreement No. 5/2023), in compliance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants.

RESULTS

The location of the lesions is shown in Table 1, where the plantar region was the most common, with a total of 21 patients, representing 53.8%.

Table 1. Distribution of patients according to ulcer location

Location	No.	%
Dorsal region of the foot	12	30,7
Plantar region	21	53,8
Calcaneal region	6	15,3

Source: Data collection form

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Table 2 shows the results according to the duration of the ulcer. The most significant difference was between 3 months and one year, with a total of 15, representing 38.4%.

Table 2. Distribution according to the duration of the ulcer.

Time of evolution of the ulcer	No.	%
Less than 1 month	2	5,1
Between 1 and 3 months	13	33,3
From 3 months to 1 year	15	38,4
More than 1 year	9	23,0
Total	**39**	**100**

Source: Data collection form

Table 3 shows the results for ulcer size before treatment. The most significant difference was for ulcers measuring 2 cm or larger, with a total of 27, representing 69.2%. After treatment, only 9 ulcers measuring 2 cm or larger remained, representing 23%.

Table 3. Distribution by ulcer size before and after treatment

Size of the ulcer	Before treatment		After treatment	
	No.	%	No.	%
1 cm	12	30,7	0	0
2 cm and more (do not exceed 5 cm)	27	69,2	9	23
Total	**39**	**100**	**9**	**23**

Source: Data collection form

Table 4 shows the pain outcomes. The most notable finding was that 9 patients had no pain before treatment, representing 23.1%. After treatment, 26 patients had no pain, representing 66.6%. Before treatment, 2 patients had unbearable pain, representing 5.1%, and after treatment, no patients had unbearable pain.

Table 4. Distribution by pain intensity

Pain intensity	Before treatment		After treatment	
	No.	%	No.	%
Absence of pain	9	23,1	26	66,6
Mild pain	15	32,4	9	23,1

Moderate pain	6	15,3	4	10,2
Severe pain	7	17,9	-	-
Unbearable pain	2	5,1	-	-
Total	**39**	**100**	**39**	**100**

Source: Data collection form

Table 5 shows the final outcome of the patients, with a total of 33 patients receiving a positive evaluation, representing 84.6%.

Table 5. Distribution by final outcome.

Final evolution	No.	%
Good	33	84,6
Bad	6	15,3
Total	39	100

Source: Data collection form.

DISSCUSION

This study determined the benefits of laser therapy on diabetic foot ulcers. The results show significant improvement in ulcer size and pain intensity.

Various literature reports that plantar pressure measurement is essential for determining the distribution of forces on the sole of the foot. This is important for the diagnosis and treatment of various pathologies, such as aggravated pressure ulcers in patients with diabetes mellitus. [2,3]

According to Bavaresco et al., [10] static plantar pressure is transmitted along both lower extremities, with 50% of its total value reaching each foot, toward the heel and forefoot; the toes have weak support. This load distribution results in higher pressure in the heel and forefoot areas, making them more common areas for ulcer development.

In the study by Hernández Pérez [22], the different patterns during gait are shown. Plantar pressures are distributed differently, distinguishing four patterns: medial pattern (greatest support on the 3rd, 1st, and 2nd metatarsals); medial-central pattern (greatest support on the 2nd and 3rd metatarsals, followed by the 1st); central pattern (greatest support on the 2nd and 3rd metatarsals, followed by the 4th); and central-lateral pattern (greatest support on the 3rd, 4th, and 5th metatarsals). The authors also

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consider that various factors influence the distribution of plantar pressures, such as weight, age, sex, and walking speed.

Most patients presented with a lesion progression between 3 months and 1 year, and 9 of them had had the ulcer for more than a year. This was a factor that was considered to be able to diminish the effects of treatment; however, when laser therapy was started, the majority of patients showed good progress; therefore, it did not constitute a mitigating factor for treatment in the majority of cases.

Lazzarini PA et al., [23] in their investigation of an ulcer on the left big toe accompanied by osteomyelitis, applied laser therapy with a 250 mW continuous wave diode laser (wavelength 670 nm; at an intensity of 60 mW/cm 2 and a dose of 30 J/cm 2) three times per week. After a total of 16 sessions of low-level laser therapy within a 4-week period, the ulcer healed completely.

Quemba Mesa et al., [3] reported in their study that laser therapy consisted of 658 nm, 30 mW of power, and 80 s of application time (4 J/cm²). Twelve sessions were conducted in total (4 weeks), corresponding to three weekly sessions, and after 30 days, the ulcers of the patients treated with laser therapy were observed to have virtually healed.

In a study conducted in Brazil, diabetic foot ulcers healed within a three-week period after laser treatment. [24]

In another study conducted by Lira JA et al., [25] laser treatment was applied to diabetic foot ulcers, resulting in accelerated healing and decreased inflammation after three months of treatment.

The authors consider that successful treatment alone is not always sufficient; rather, it must be combined with other factors such as physical activity according to each person's health status and an appropriate diet.

Several studies reviewed found that chronic ulcers of the lower limbs are highly prevalent, have diverse etiologies, and are difficult to heal. [22-24]

Regarding ulcer size reduction, it was observed that after treatment only 9 patients had lesions measuring 2 cm or larger.

According to Batista et al., [26] laser therapy, in addition to reducing the lesion area and accelerating the healing process, has the advantage of being easy to

administer. These benefits help improve the patient's quality of life and minimize potential complications.

Regarding the size of ulcers and laser application, the benefits have been demonstrated, as collagen is the essential protein required to replace old tissue and heal wounds. As a result, laser therapy is effective on open wounds and burns. At the same time, it reduces the formation of adipose tissue that occurs in cuts, scrapes, and burns. [10,13]

Pain intensity in the study group varied; however, the majority had mild pain at baseline, and satisfactory progress was seen in this variable after treatment.

Laser therapy helps reduce pain by stimulating the release of neurotransmitters that block pain signals in the nervous system. (10) Other authors suggest that it acts at the cellular level, reducing inflammation and accelerating the recovery of affected tissues. [22]

According to Carro GV et al., [27] laser therapy offers higher dosage levels capable of penetrating deeper into damaged cells, relieving inflammation, increasing blood flow and lymphatic drainage, stimulating nerve regeneration, muscle relaxation, collagen production, and immune system response, and increasing range of motion.

For the final outcome assessment, the authors considered the reduction in ulcer size and improvement in pain intensity (measured using a Likert scale) as the main criteria. The findings showed that the majority of patients achieved a clinical categorization of "good." These results confirm the efficacy of laser therapy as an adjuvant treatment in the favorable outcome of patients with diabetic foot ulcers.

Anichini R et al. [28] used these low-level laser modalities in diabetic patients with plantar ulcers in conjunction with standard treatment (dressings, debridement, etc.) and demonstrated accelerated healing.

Aguilera R et al. [29] presented the benefits of laser therapy, including accelerated healing, analgesic, anti-inflammatory effects, and tissue regeneration.

CONCLUSIONS

The program proved effective in improving functional capacity, psychosocial health, and cardiovascular health in patients with post-COVID-19 sequelae. It is recommended that these interventions be widely implemented in rehabilitation services to optimize survivors' recovery and quality of life.

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STATEMENT OF AUTHORSHIP

YMRA: conceptualization, data curation, funding acquisition, research, methodology, project administration, resources, software, supervision, validation, visualization, drafting, writing, reviewing, and editing the final manuscript.

MGS: conceptualization, data curation, research, methodology, supervision, validation, visualization.

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LMHF: conceptualization, data curation, research, methodology, supervision, validation, visualization.

DCS: conceptualization, data curation, research, methodology, supervision, validation, visualization.

GGP: conceptualization, data curation, research, methodology, supervision, validation, visualization.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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