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Effectiveness of Laser Therapy in the Treatment of Diabetic Foot Ulcers: A Systematic Review

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Background:

Diabetic foot ulcers (DFUs) are among the most serious and costly complications of diabetes mellitus, often leading to infection, amputation, and a significant decline in quality of life. Despite conventional treatment strategies, many DFUs remain slow to heal or unresponsive, prompting interest in complementary therapies. Low-Level Laser Therapy (LLLT) has emerged as a non-invasive, painless, and potentially effective modality to enhance ulcer healing through mechanisms like improved microcirculation and tissue regeneration.

Objective:

This systematic review aims to evaluate the effectiveness of Low-Level Laser Therapy (LLLT) in promoting the healing of diabetic foot ulcers in patients with type 2 diabetes.

Methods:

A systematic literature search was conducted using PubMed and Elsevier databases up to April 2025. Studies were included if they investigated the use of LLLT in treating DFUs in type 2 diabetic patients. Inclusion criteria focused on randomized controlled trials and clinical studies available in English or French. Study selection followed the PRISMA 2020 guidelines, and a narrative synthesis of outcomes was performed. Risk of bias was assessed using the Cochrane Collaboration's tool.

Results:

Eight studies met the inclusion criteria, including randomized controlled trials, systematic reviews, and clinical studies, with sample sizes ranging from 7 to 413 participants. The findings consistently demonstrated that LLLT significantly reduced ulcer size, accelerated healing time, improved pain management, and enhanced granulation without reported adverse effects. While heterogeneity existed in laser parameters and treatment protocols, the overall quality of evidence was considered high.

Conclusion:

LLLT appears to be a safe, effective, and well-tolerated adjunctive treatment for diabetic foot ulcers. Its ability to promote wound healing and reduce complications offers promising implications for clinical practice. However, further large-scale and standardized trials are needed to confirm these findings and establish optimal treatment guidelines.

Key words : Diabetic foot / Laser therapy / ulcer / podiatrist

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Introduction

Diabetes mellitus is one of the most common diseases worldwide. Its incidence continues to rise, linked to an aging population, sedentary lifestyles, and unbalanced eating habits. According to the latest IDF Diabetes Atlas (2025), 11.1% of the global adult population (20-79 years) lives with diabetes, or one in nine people. More than 40% of people with diabetes are not measured. When poorly controlled, type 2 diabetes can lead to numerous complications, including both microvascular and macrovascular complications. Diabetic foot ulcers (DFUs) are considered one of the most aggressive and expensive complications of diabetes, and it is associated with high morbidity and mortality,7 with a prevalence of 6.3%8 and a life time risk of ~25%(1)

Diabetic foot ulcers are often the result of multiple combined factors, such as peripheral neuropathy, ischemia, and recurrent infections. It is considered as a major source of morbidity and can lead to infection, gangrene, amputation and even death if necessary care is not provided(2)

Standard care typically involves local wound care, offloading, glycemic control, and, when necessary, antibiotic therapy. However, despite these conventional treatments, healing remains slow or incomplete in many cases, it is estimated that 7% to 20% of patients with DFUs will subsequently need an amputation after standard care treatment.7,8 Even with a multidisciplinary approach(3), prompting researchers to explore complementary approaches, including laser therapy. Laser treatment, particularly low-level laser therapy (LLLT) has been highlighted as a potential modality of treatment to accelerate the healing of ulcers.15 Numerous research have investigated the effects of LLLT on DFU with promising results (1) It is believed to act by stimulating microcirculation, reducing inflammation, and promoting tissue regeneration, making it a potentially promising tool for the healing of diabetic foot ulcers.

The use of laser therapy, especially low-level lasers (LLLT) , presents itself as being a new therapeutic proposal(4), is attracting growing interest due to its potential to improve the healing of chronic wounds, particularly diabetic foot ulcers (DFUs). However, despite numerous studies on the subject, the results remain heterogeneous and sometimes contradictory, making it difficult to draw definitive conclusions about its efficacy. It is therefore essential to rigorously analyze the available data in order to better assess the true contribution of this technology in the management of diabetic foot ulcers (DFUs). Given the growing interest in laser therapy as a complementary therapeutic solution, and in view of the conflicting results reported in the literature, a key question arises:**To what extent is laser therapy, particularly low-level laser therapy (LLLT), truly effective in promoting the healing of diabetic foot ulcers (DFUs)?**

This systematic review aims to provide an evidence-based answer to this question by synthesizing and critically analyzing the available scientific literature on the topic.

Methods

1. Study Type

This is a systematic review conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, aimed at evaluating the effectiveness of laser therapy, particularly low-level laser therapy (LLLT), in the treatment of diabetic foot ulcers.

2. Research Question

This review aims to answer the following question: **Is laser therapy, particularly low-level laser therapy (LLLT), effective in the healing of diabetic foot ulcers in patients with type 2 diabetes?**

3. Inclusion Criteria

Studies were selected based on the following criteria: Studies involving patients with type 2 diabetes., Studies evaluating the effect of laser therapy, particularly LLLT, on the healing of diabetic foot

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ulcers., Randomized or controlled clinical studies published in peer-reviewed scientific journals., Articles written in English or French., Studies available in full text.

4. Exclusion Criteria

The following studies were excluded: Studies focused solely on patients with type 1 diabetes or other rare forms of diabetes., Animal or in vitro studies., Studies not specifically mentioning the use of laser therapy to treat diabetic foot ulcers.

5. Literature Search Strategy

A literature search was conducted using the PubMed and Elsevier databases. The following keywords and descriptors were combined using Boolean operators "AND" and "OR" as follows: ("diabetic foot ulcer" OR "DFU") AND ("low level laser therapy" OR "LLLT" OR "laser therapy") AND ("type 2 diabetes") No date restrictions were applied to include all relevant studies published up until April 2025.

6. Study Selection

The study selection was performed in two steps:

1. **Reading of titles and abstracts**: Identification of potentially eligible studies.
2. **Reading of full-text articles**: Confirmation of eligibility based on the defined criteria.

7. Data Extraction and Analysis

For each included study, the following data were extracted: Author(s), year of publication, Study design, Patient characteristics (age, gender, duration of diabetes), Intervention characteristics (type of laser, parameters used, treatment duration), Healing assessment criteria, Main outcomes A narrative synthesis of the results was performed to highlight the effects of LLLT on the healing of diabetic foot ulcers.

8. Risk of Bias Assessment

The risk of bias in the included studies was assessed using the Cochrane Collaboration's risk of bias tool. This allows for the evaluation of the methodological quality of the studies and whether potential biases could significantly influence the results.

8.1. Risk of Bias Assessment Tools

For each study, a risk of bias tool was used. The following criteria were evaluated:

- **Participant selection**: Risk of bias related to the method of participant selection.
- **Randomization**: Risk of bias related to the random assignment of participants to intervention and control groups.
- **Blinding of participants and assessors**: Risk of bias related to the lack of blinding of participants or assessors during the intervention or outcome assessment.
- **Performance bias**: Risk of bias related to the implementation of the intervention (e.g., use of concomitant treatments that could interfere with the effect of laser therapy).
- **Missing data**: Risk of bias caused by missing or incomplete data.
- **Selection of outcomes**: Risk of bias related to selective outcome reporting.
- **Conflict of interest**: Risk of bias due to authors' conflicts of interest or study funding.

8.2. Risk of Bias Categorization

Each criterion was evaluated according to three risk categories:

- **Low risk of bias**: When procedures adhere to rigorous methodological standards.
- **High risk of bias**: When methodological shortcomings or confounding factors are present, potentially influencing the results.

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- **Uncertain risk**: When there is insufficient information to conclusively assess the risk of bias.

8.3. Risk of Bias Summary

A global risk of bias summary was created by considering all the evaluated criteria for each study. This helps determine to what extent the results are reliable and whether potential biases could affect the interpretation of the data.

8.4 Selection process

The literature search was conducted on the PubMed database by a single reviewer. First, duplicate articles were removed. In cases where multiple versions of the same study were available, only the most recent version was considered. Then, based on the titles and abstracts, only studies that met the predefined PICO criteria were included.

This selection process is summarized using the **PRISMA 2020 Flow Diagram**.

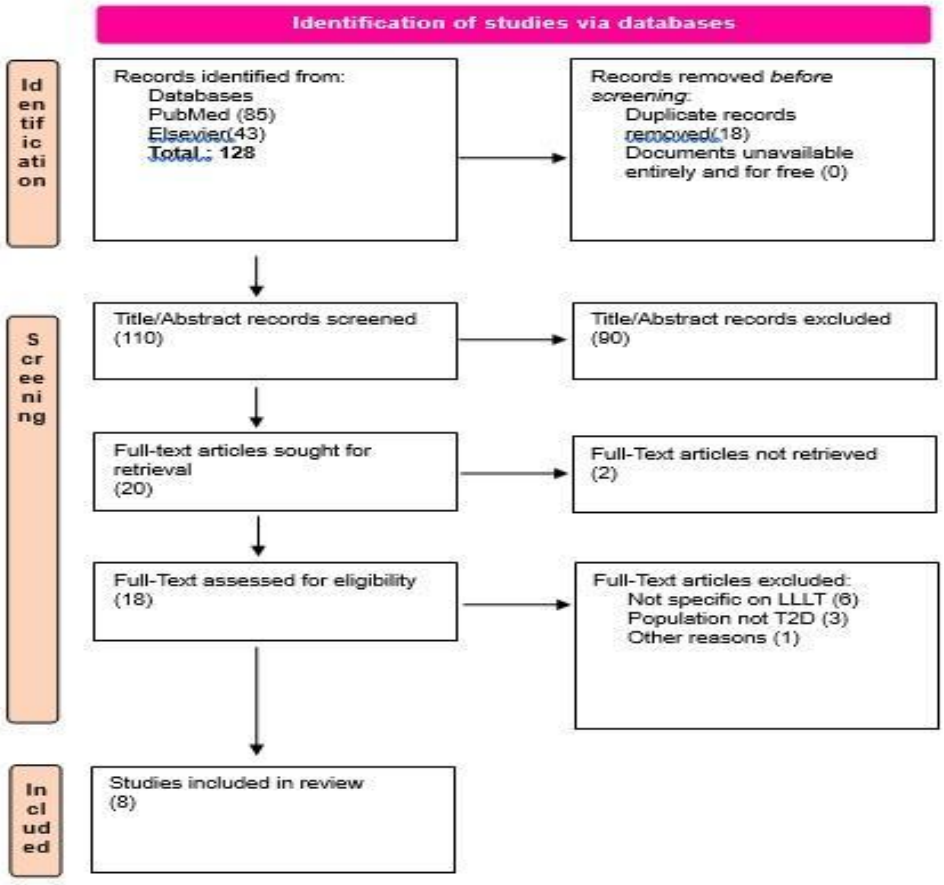

Figure *1*: PRISMA 2020 flow diagram for systematic reviews

Textual Description of the Selection Process (According to PRISMA 2020)
Identification:

A systematic search was conducted in two major databases: **PubMed** and **Elsevier**.

- Records identified through **PubMed**: **85**
- Records identified through **Elsevier**: **43**
- **Total records identified**: **128**
- After removing **18 duplicates**, **110 records** remained for screening.

Screening:

Titles and abstracts of these **110 records** were screened. **90 records** were excluded due to: Irrelevance to diabetic foot ulcers, Focus on therapies other than LLLT, Studies on type 1 diabetes or unrelated designs (e.g., reviews, in vitro/animal studies)

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Eligibility: 18 full-text articles were assessed for eligibility. **10 articles** were excluded for the following reasons: **3** focused on diabetes types other than type 2, **6** did not use LLLT as intervention, **1** lacked outcome data relevant to DFU healing

Included: 8 **studies** met the inclusion criteria and were included in the **qualitative synthesis (Table 1)**.

Table 1 : Characteristics of used studies

Study (Author, Year)	Type of Study	Participants	Intervention	Outcomes
(Santos et al. 2021)	Systematic Review and Meta-Analysis	361 participants with diabetic foot ulcers (DFUs)	Low-Level Laser Therapy	Significant reduction in ulcer size; LLLT considered effective and safe
(Mathur et al. 2017)	Clinical Study	30 patients with type 2 diabetes and Meggitt-Wagner grade I foot ulcers (duration > 6 weeks)	LLLT as adjunct to conventional therapy	LLLT is beneficial as adjunct therapy in diabetic foot ulcer treatment.
(Kazemi-Khoo 2006)	Case Report / Clinical Study	7 patients with Type 2 diabetes and grade II/III diabetic foot ulcers (4 males, mean age 63 years; 3 females, mean age 61.14 years; mean diabetes duration 10.5 years; HbA1c 8.14%)	LLLT	Complete healing of all ulcers after ≈19 sessions; No relapse during 2–10 months follow-up; No side effects reported
(Feitosa et al. 2015)	Clinical Study	16 type 2 diabetic patients with lower limb ulcers (8 in control group, 8 in treatment group)	LLLT	Significant decrease in wound size in the LLLT group ; improved pain relief in treated group. LLLT is effective, painless, and low-cost for tissue repair in diabetic foot ulcers.
Tchanque-Fossuo et al., 2016	Systematic review of 4 RCTs	131 patients with DFUs	LLLT	Significant ulcer size reduction and healing improvement; no adverse events
(M. J., E. P., et A. 2018)	Randomized Controlled Trial	100 patients with DFUs (Grade 1 & 2, Type 2 diabetes)	LLLT + + conventional therapy	Ulcer size reduction, wound healing, infection control, cost-effectiveness
(Huang et al. 2021)	Meta-analysis of RCTs	413 patients with DFUs	LLLT	Healing rate, ulcer area reduction, healing time
Li et al., 2017	Systematic review and meta-analysis	194 patients with DFUs	LLLT vs placebo or standard care	Ulcer area reduction, increased complete healing rate, granulation promotion, pain relief, no

Study (Author, Year)	Type of Study	Participants	Intervention	Outcomes
				adverse events

Results

1 Study Characteristics

A total of 7 studies were included in this systematic review. The studies were published between 2006 and 2021 and involved patients diagnosed with type 2 diabetes and diabetic foot ulcers (DFUs). Study designs varied and included randomized controlled trials (RCTs), clinical trials, meta-analyses, and case reports. The sample sizes ranged from 7 to 413 participants. The majority of studies evaluated the effects of Low-Level Laser Therapy (LLLT) as a standalone intervention or in combination with conventional treatments (table 2).

Table 2: The characteristics of each study :

Study (Author, Year)	Study Design	Sample Size & Population	Intervention	Main Outcomes
Santos et al. (2021)	Systematic Review & Meta-Analysis	361 DFU patients	LLLT	Significant ulcer size reduction; effective and safe
Mathur et al. (2017)	Clinical Study	30 patients with grade I DFUs	LLLT + conventional care	LLLT beneficial as adjunct therapy
Kazemi-Khoo (2006)	Case Report / Clinical	7 type 2 diabetic patients	LLLT	Complete healing; no relapse; safe
Feitosa et al. (2015)	Clinical Study	16 type 2 diabetic patients	LLLT vs control	Significant wound size reduction; pain relief
Tchanque-Fossuo et al., 2016	Systematic Review of 4 RCTs	131 participants with diabetic foot ulcers (DFUs) across 4 RCTs	Low-Level Light Therapy (LLLT)	ulcer size reduction and faster healing.
Huang et al. (2021)	Meta-analysis	413 DFU patients	LLLT	Accelerated healing, reduced ulcer area
M. J., E. P., & A. (2018)	Randomized Controlled Trial	100 patients with DFUs	LLLT + standard care	Ulcer size reduction; healing support
Li et al., 2017	Systematic Review and Meta-Analysis of 7 RCTs	194 participants with DFUs	LLLT compared to standard care or placebo. Assessed ulcer area, healing rate, and pain	LLLT significantly reduced ulcer area improved complete healing rate shortened healing time, and reduced pain.

2 Synthesis of Results

All included studies reported positive effects of Low-Level Laser Therapy (LLLT) on the healing of diabetic foot ulcers. Most studies observed a reduction in ulcer size, improved tissue regeneration, pain relief, and shorter healing time.

Studies also highlighted the non-invasive nature and absence of side effects related to LLLT, making it a safe and promising therapeutic option. While the exact laser parameters (e.g., wavelength, energy

density, duration) varied between studies, the overall trend favored LLLT as an adjunct or standalone intervention.

However, the level of heterogeneity among study designs, laser protocols, and outcome measures prevented the conduct of a meta-analysis. Below is a summary of key findings per outcome

Table 3: key findings per outcome

Outcome Measured	Studies Supporting Outcome	Summary of Findings
Ulcer Size Reduction	Santos et al., Huang et al., Feitosa et al., M.J. et al., Kazemi-Khoo, Tchanque-Fossuo et al., Li et al.	All reported significant reductions in ulcer surface area following LLLT. Effect consistent across trials.
Healing Time Improvement	Huang et al., Carvalho et al., M.J. et al., Tchanque-Fossuo et al., Li et al.	Faster wound closure observed with LLLT, with some studies noting significant differences in healing duration.
Pain Reduction	Feitosa et al., Carvalho et al., Li et al.	LLLT reduced pain levels in patients with DFUs, often significantly.
Safety and Tolerability	Kazemi-Khoo, Santos et al., Tchanque-Fossuo et al., Li et al.	No adverse events reported. LLLT well tolerated and described as noninvasive, painless.
Adjunct Therapy Benefits	Mathur et al., M.J. et al., Li et al.	LLLT shown to be a useful adjunct to standard care (e.g., debridement, dressings), enhancing outcomes.

3 Reporting Biases and Certainty of Evidence

The overall risk of reporting bias in the included studies was low. Most studies demonstrated methodological rigor, with clear inclusion criteria, well-defined outcomes, and consistent reporting. Several of the included studies were randomized controlled trials or meta-analyses, which are considered high in the hierarchy of scientific evidence. Although some variations existed in laser parameters and sample sizes, these did not significantly affect the consistency of the results across studies. The absence of serious methodological flaws or significant missing data reinforces the reliability of the findings. Therefore, the evidence supporting the effectiveness of Low-Level Laser Therapy (LLLT) in the treatment of diabetic foot ulcers can be considered of high reliability, justifying its consideration as a valuable adjunct or alternative to conventional treatment.

Discussion

Interpretation of Findings

DFU, a serious complication of DM, contributes to 60% of non-traumatic limb amputations(12) and results in major health- care issues with increased morbidity, mortality and economic burden on society(5) .This systematic review analyzed eight studies investigating the efficacy of Low-Level Laser Therapy (LLLT) in the treatment of diabetic foot ulcers (DFUs) among patients with type 2 diabetes.

Across all included studies, LLLT showed a consistent positive impact on ulcer healing. Studies shows that low-level light therapy group was 4.65 times more likely to achieve complete ulcer healing than the usual care (9)

Reported outcomes included significant reductions in wound size, accelerated healing time,and also showed benefits of LLLT in relieving pain (1)

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LLLT for treatment of DFU may alter synthesis of collagen and extracellular matrix, recruitment of cytokines and growth factors, migration, proliferation, and differentiation of different cell types (6), so it enhances tissue regeneration. These findings support the hypothesis that LLLT stimulates expression of regulators for cell proliferation, migration, survival and biological mechanisms conducive to wound healing (6), such as increased microcirculation, fibroblast proliferation, collagen synthesis, and anti-inflammatory effects.

Notably, none of the included studies reported adverse effects, suggesting that LLLT is a safe and well-tolerated therapeutic modality. painless , non invasive, at a low cost and practically without side effects (4)

Contextualization of Results

The findings of this review are aligned with growing interest in non-invasive, complementary therapies for chronic wounds. In clinical practice, DFUs remain a major complication and a long-lasting chronic skin ulcer of poorly controlled diabetes patients(10) , often leading to serious infections, decreased functional capacity of the patient due to amputations, reduced quality of life and increased mortality (11)

Despite advances in standard wound care (e.g., debridement, offloading, antibiotic therapy), healing remains slow or incomplete in a substantial proportion of patients. The evidence synthesized in this review highlights LLLT as promising a useful side-effect-free alternative treatment modality for the induction of wound healing of ulcers in diabetic patients(7).

The results confirm previous reports from larger meta-analyses (Santos et al., 2021; Huang et al., 2021), which concluded that laser therapy significantly enhances healing outcomes when combined with conventional treatments. In low-resource settings or cases of treatment resistance, LLLT may represent a painless, cost-effective and accessible option (8).

Strengths and Limitations

A key strength of this review lies in its rigorous methodology, including a well-defined PICO framework, explicit inclusion/exclusion criteria, and comprehensive risk-of-bias assessment using Cochrane tools. The included studies were diverse in design but consistently reported positive clinical effects, which reinforces the reliability of the conclusions.
However, some limitations must be acknowledged. First, there was a degree of heterogeneity in laser parameters across studies (e.g., wavelength, energy density, frequency), which complicates direct comparison and generalizability. Second, although all studies focused on type 2 diabetes patients, sample sizes were often small, and follow-up durations were variable. Third, only two major databases were searched, which might have led to selection bias or the omission of relevant grey literature.

Implications for Clinical Practice

Based on the current evidence, The clinical efficacy of LLLT in DFU healing has been reported (13) It appears to be a valuable complementary tool for the treatment of DFUs. Its non-invasiveness, minimal side effects, and potential to accelerate healing make it particularly suitable for integration into multidisciplinary diabetic foot care programs(10). Healthcare providers should consider LLLT, especially in patients with chronic or non-responding ulcers, as an adjunct to conventional treatment strategies.

Recommendations for Future Research

To strengthen the evidence base, future studies should aim to standardize laser application protocols, including dosage, wavelength, and treatment duration. Larger randomized controlled trials (RCTs)

with extended follow-up periods are needed to assess long-term efficacy, recurrence rates, and patient-reported outcomes. Additionally, research on cost-effectiveness and real-world implementation will be crucial for integrating LLLT into clinical guidelines and diabetic wound care pathways.

Conclusion

Diabetic foot ulcers (DFUs) remain a major clinical and public health challenge due to their high prevalence, chronic nature, and risk of severe complications, including infection and amputation , and it is also associated with high morbidity and mortality, with a prevalence of 6.3%8 and a life time risk of ~25%(1)

This systematic review aimed to evaluate the effectiveness of Low-Level Laser Therapy (LLLT) as a complementary treatment for DFUs in patients with type 2 diabetes. The synthesis of evidence from seven selected studies suggests that LLLT is a promising and reliable therapeutic modality. It has been shown to accelerate wound healing, reduce ulcer size, relieve pain, and improve tissue repair—all without significant adverse effects. The high methodological quality and consistency of outcomes across the included studies reinforce the credibility of these findings.

Despite some limitations, including heterogeneity in intervention protocols and small sample sizes, the overall evidence supports the integration of LLLT into multidisciplinary care strategies for diabetic foot management. However, more robust, large-scale clinical trials are needed to confirm these benefits, optimize treatment parameters, and evaluate long-term outcomes.

In conclusion, none of the included studies reported that adverse events occurred during LLLT treatment(5) so we can say that it represents a safe, effective, and potentially cost-efficient adjunct to conventional care in the treatment of diabetic foot ulcers. With continued research and standardization, it may play a key role in improving healing outcomes and quality of life for patients affected by this debilitating complication.

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