MedNEXT
Journal of Medical an Health Sciences

REVIEW ARTICLE

DOI: 10.54448/mdnt25S104

Clinical significance of laser therapy and osseointegration in implant dentistry: a systematic review

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DOI: https://doi.org/10.54448/mdnt25S104
Received: 10-23-2024; Revised: 02-17-2025; Accepted: 02-25-2025; Published: 02-28-2025; MedNEXT-id: e25S104

Editor: Dr. Mohammad Barakat Jamil Alnees MD.

Abstract

Introduction: Dental implants are widely used and have a success rate of around 96%. Good bone density is an essential factor for implant stability to resist mechanical forces against dental implants. As a treatment, low-level laser treatment (LLLT) is a type of phototherapy where infrared is absorbed by adjacent tissues, thus reducing the inflammatory response, stimulating osteoblastic activity around the application site, and increasing bone production. **Objective:** It was to carry out a concise systematic review of the main clinical findings of the use of laser therapy to improve dental implant practices through the optimization of osseointegration. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from November 2024 to January 2025 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 155 articles were found, and 23 articles were evaluated in full and 13 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 26 studies with a high risk of bias and 42 studies that did not meet GRADE and AMSTAR-2. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=82.7%>50%. It was concluded that low-intensity laser irradiation can significantly promote bone consolidation and accelerate the osseointegration process, emphasizing the biostimulating effect of the laser. The application of the 808 nm infrared laser for bone tissue and 630 nm for mucosal tissue in two sessions is considered an effective way to reduce inflammation and improve early healing. Literary findings point to the safety and effectiveness of low-power intravascular lasers in dental implant treatments. The low-power intravascular laser enables local and systemic treatment, optimizing the benefits of its use by dentists, mainly to improve the stabilization of osseointegrated implants and avoid or eliminate contamination.

Keywords: Laser therapy. Low-intensity laser. Intravascular laser irradiation. Osseointegration. Dental implants.

Introduction

Dental implants are widely used and have a success rate of around 96% [1-3]. The concept established by Brånemark et al. [4] is mainly responsible for the success of dental implants, stating that it is the interaction between the implant and the surrounding bone as structure and function. In this regard, several studies have reported that good bone density is an essential factor for implant stability to withstand mechanical forces against dental implants. This stability prevents disturbances in healing around the dental implant and osseointegration to provide a long-term survival rate for dental implants [5,6]. In this scenario, diabetic patients are prone to developing periodontitis and poor wound healing and are responsible for infections [7]. Persistent hyperglycemia for a long time inhibits bone osteoblastic activity and increases osteoclastic activities due to inflammatory responses.

Furthermore, it causes disturbances in the action of the parathyroid hormone, affecting the regulation of Ca and P, which will hurt bone consolidation around dental implants, affecting long-term implant survival in these patients [8,9].

As a treatment, low-level laser treatment (LLLT) is a type of phototherapy where infrared is absorbed by adjacent tissues, thus decreasing the inflammatory response, biostimulating osteoblastic activity around the application site, and increasing bone production [10]. The mechanism of photobiomodulation is linked to the penetration of the wavelength of light, where it has been hypothesized that wavelengths close to 800 nm can infiltrate more deeply, thus improving the photobiological process in the surrounding tissues [11].

Furthermore, in the context of implantology and osseointegration for the stabilization of dental implants, the use of intravascular laser (ILIB - Intravascular Laser Irradiation of Blood), or laser therapy (photobiomodulation), which uses non-ionizing or infrared light to stimulate tissues, cells and molecules at a systemic level, stands out [10]. This occurs through the application of ILIB in the radial artery, stimulating microcirculation with an increase in the production of adenosine triphosphate (ATP), nitric oxide (NO), and reactive oxygen species (ROS) [11]. In this sense, ILIB can be used with postoperative applications in the osseointegration and stability of dental implants [11]. Thus, the benefits in aiding patient comfort are evident, as it is a painless therapy compared to the application of high-intensity lasers. In this context, ILIB uses wavelengths of 633 and 685 nm [12,13]. This low-intensity application provides comfort to the patient due to the associated anti-inflammatory, analgesic, and healing properties [14].

In this scenario, the success of implants depends mainly on successful osseointegration, and this can be optimized with the use of Low-Level Laser Treatment (LLLT). The effect of LLLT improves vascularization, increases collagen synthesis in the bone, modulates inflammation, and accelerates cell proliferation [10]. Thus, it has been demonstrated that LLLT stimulates bone stem cells and accelerates their repair process, improving the bone environment for immediate implant loading, and avoiding the need for a second surgery [6].

Also, to make laser therapy more promising, it is important to limit its exposure time [10,14]. Also, when using the appropriate wavelength, titanium does not absorb but reflects the laser energy. Another excellent use of the laser is for the removal of any peri-implant hyperplastic tissue [14,15].

Therefore, the present study carried out a concise systematic review of the main clinical findings of the use of laser therapy to improve dental implant practices through the optimization of osseointegration.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 01/18/2025. The AMSTAR 2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed on: 01/18/2025.

Search Strategy and Search Sources

The literature search process was carried out from November 2024 to January 2025 and developed based on Web of Science, Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The following descriptors (DeCS /MeSH Terms) were used: *Laser therapy. Low-intensity laser. Intravascular laser irradiation. Osseointegration. Dental implants*, and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

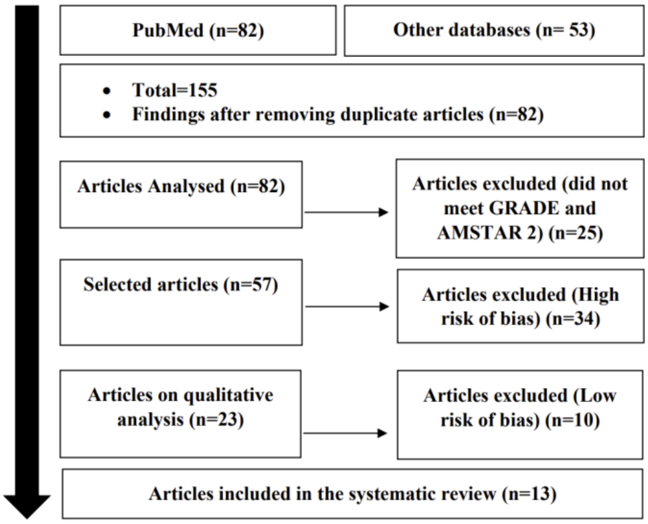
Quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's d test.

Results and Discussion

Summary of Findings

As a corollary of the literature search system, a total of 155 articles were found that were submitted to eligibility analysis, 23 articles were evaluated in full and 13 final studies were selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational studies. Biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=82.7%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 34 studies with a high risk of bias and 25 studies that did not meet GRADE and AMSTAR-2.

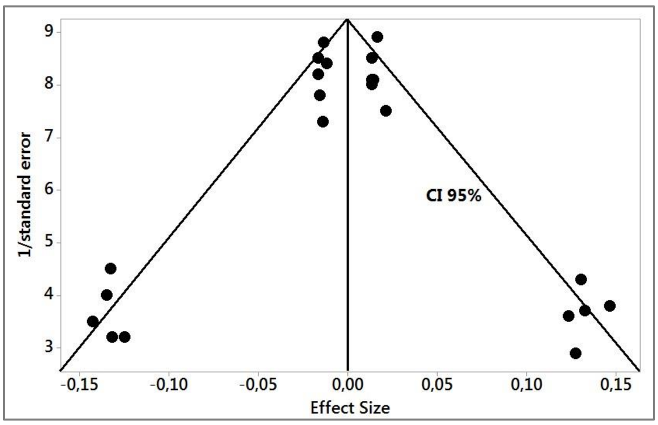
Figure 1. Flowchart showing the article selection process.



Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample sizes (lower precision) that are shown at the base of the graph and in studies with large sample sizes that are shown at the top.

Figure 2. The symmetrical funnel plot does not suggest a risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. Studies with high confidence and high recommendation are shown above the graph (n=13 studies).



Source: Own Authorship.

Main Clinical Findings – Laser Therapy and Implant Dentistry

It was found that despite high success rates, peri-implantitis can affect the stability and function of dental implants. The literature presents several articles that evaluated osseointegration in peri-implantitis sites after laser therapy or antimicrobial photodynamic therapy (aPDT), reporting a higher degree of osseointegration after implant treatment with laser therapy. These results suggest that laser decontamination shows potential to improve osseointegration, particularly with the Er: YAG laser, which effectively decontaminates implant surfaces [16]. In this sense, the authors Camolesi et al. (2023) [17] designed a randomized clinical trial to evaluate the effect of diode laser photobiomodulation (PBM) on postsurgical healing, inflammation, and implant stability. A total of 40 dental implants were inserted in 13 patients. The implants were randomly divided into two groups. The test group (PBM+) underwent two PBM sessions (combined diode laser of 630 and 808 nm), the first after surgery and the second 7 days after the surgical procedure. The control group (PBM-) received sham laser treatment. The implant stability quotient (ISQ) was determined immediately after the surgical procedure and 7 days, 4, and 8 weeks later. Healing was calculated using the healing index (HI). No differences were found in terms of the mean implant stability values between the test and control groups over time. Only two of the implants (18.2%) in the PBM- group were classified with the maximum healing index (HI = 5), while in the PBM+ group, nine implants (45%) were classified with this index ($p < 0.0001$). Using logistic regression, it was determined that the non-application of laser in the PBM- group caused an OR of 4.333 times of inflammation presentation (95% CI 1.150-16.323; P = 0.030).

Besides, osteoprotegerin (OPG) has been described as a marker of bone remodeling to determine the prognosis of the implant. A randomized clinical study conducted by the authors Attia et al. (2023) [18] evaluated the effect of low-level laser therapy (LLLT) on bone density (BD) and osteoprotegerin levels in the peri-implant crevicular fluid (PICF) in type 2 diabetic patients (T2DM). This study included 40 individuals with T2DM. Implants were randomly placed in 20 patients with T2DM without laser (control) and 20 patients with T2DM with laser (LLLT group). In the follow-up stages, the levels of BD and OPG in the PICF were evaluated in both groups. Results Significant variations were demonstrated between the control and LLLT groups regarding the level of OPG and BD ($p \leq 0.001$). OPG decreased significantly with follow-up points ($p \leq 0.001$). There was a significant decrease in

OPG with time in both groups, with a greater decrease in the control group. Conclusion LLLT holds promise in patients with controlled T2DM due to its notable influence on BD and estimated crevicular OPG levels. Regarding its clinical significance, LLLT significantly improved bone quality during osseointegration in dental implants in T2DM. LLLT is considered to be potentially important for patients with T2DM during implant placement.

In addition, the authors Mikhail et al. (2018) [6] analyzed the radiodensitometric effect of low-level laser therapy on osseointegration of immediately loaded dental implants in patients under vitamin C, omega-3, and calcium therapy. A single implant was placed in the lower first molar region of twenty patients who were equally divided into two groups. In the non-laser group, the healing phase was allowed to progress spontaneously without any intervention, while in the laser group, it was augmented with low-intensity laser therapy of wavelength 904 nm in contact mode, continuous wave, output power of 20 mW and exposure time of 30 seconds with a dose of 4.7 J/cm2. Patients in both groups received vitamin C, calcium, and omega-3 starting one month before surgery. Postoperative digital panoramas were obtained immediately after surgery, 1.5 months, and 6 months postoperatively. Significant augmented differences were observed on the mesial, distal, and apical sides around the implants of both groups by time. However, the augmentation rate was significantly higher in the laser group. The mean difference on the mesial side after 6 months was 21.99 ± 5.48 in the laser group and 14.21 ± 4.95 in the non-laser group, while it was 21.74 ± 3.56 in the laser group and 10.78 ± 3.90 in the non-laser group on the distal side and was 18.90 ± 5.91 in the laser group and 10.39 ± 3.49 in the non-laser group on the apical side. Significance was recorded at p=0.004, p=0.0001, and 0.001 on the mesial, distal, and apical sides, respectively.

With the use of intravascular laser (ILIB - Intravascular Laser Irradiation of Blood), several bone regeneration factors can be promoted and optimized for implantology. In this context, the use of ILIB is associated with the reduction of wounds in the mouth region and the reduction of inflammation (inhibition of cyclooxygenase). Furthermore, the success of the application of the ILIB laser is related to the size of the surface, that is, it must be small for the result to be satisfactory [10,11]. Other authors have shown that ILIB therapy has oral sterilization properties, facilitating tissue healing after surgical procedures and the osseointegration process for the placement of stable implants [19,20]. In addition, photobiomodulation has benefits related to the reduction of oral mucositis in patients with head and neck cancer [12,13]. Other authors have shown that the postoperative application of laser therapy is positive for osseointegration and stability of dental implants [11]. These findings demonstrate the effects related to anti-inflammatory, analgesic, and healing capabilities with the application of low-intensity laser. Despite this, low-intensity laser irradiation may have limitations, as it requires specific dosimetry and few published studies on the use of ILIB in Dentistry [11,14].

In this context, a study evaluated primary and secondary stabilization and bone density in the peri-implant zone after the ILIB protocol (635 nm diode laser). The research included 40 implants placed in the posterior region of a mandible in 24 patients (8 women and 16 men; age: 46.7 ± 8.7 years). The patients were randomly divided into 2 groups G1 (n = 12, 18 implants) and G2 (n = 12, 22 implants). As a result, the mean stability of the implant showed greater stability after 635 nm laser irradiation compared to a control group, in the first week. After 12 weeks, no differences were observed between the groups. The mean grayscale value at the apical, mid, and cervical levels of titanium implants showed a reduction in the pixel grayscale value after 2 weeks, being lower for group G1 compared to group G2. On the other hand, the grayscale value after 12 weeks was significantly higher at the mid and apical level of implants in group G1 compared to group G2. Thus, the application of ILIB improved secondary implant stability and bone density [21].

A randomized controlled trial evaluated the efficacy of using a 940 nm diode laser in second-stage implant surgery compared to a conventional scalpel approach. A total of 21 patients with a total of 112 dental implants were identified as having osseointegrated dental implants. The use of ILIB resulted in little postoperative pain, decreased edema with less inflammatory response, increased homeostasis, and regular wound healing. It also decreased the time required for final impression making and improved patient quality of life compared with conventional scalpel surgical exposure [22].

Finally, a recent randomized clinical trial evaluated the effect of low-level laser therapy (LLLT) on osseointegration of implants immediately loaded with a connective tissue graft (CTG). Patients in the intervention group received LLLT with a 940 nm gallium-aluminum-arsenide laser, while those in the control group received placebo irradiation. Primary implant stability was measured before delivery of the customized abutment, while secondary implant stability was measured after 12 weeks by Osstell® and reported as the implant stability quotient (ISQ). In the intervention group, a significant difference was found between primary and secondary ISQ in the buccolingual dimension ($p<0.05$), but not in the mesiodistal dimension ($p>0.05$). LLLT had a significant positive efficacy for increasing the secondary stability of implants in the buccolingual dimension. CTG showed optimal efficacy for the treatment of buccal bone dehiscence [23].

Conclusion

It was concluded that low-intensity laser irradiation can significantly promote bone consolidation and accelerate the osseointegration process, emphasizing the biostimulating effect of the laser. The application of an 808 nm infrared laser for bone tissue and 630 nm for mucosal tissue in two sessions is considered an effective way to reduce inflammation and improve early healing. Furthermore, the literary findings point to the safety and efficacy of low-power intravascular lasers in dental implant treatments. Low-power intravascular laser allows local and systemic treatment, optimizing the benefits of its use by dentists, mainly to improve the stabilization of osseointegrated implants and avoid or eliminate contamination.

CRediT

Author contributions: **Conceptualization-** Caroline Mazaro Lourenção, Cristiane Barboza Santos, Spencer Tovar Gonçalves Guerra; **Formal Analysis-** Caroline Mazaro Lourenção, Cristiane Barboza Santos, Spencer Tovar Gonçalves Guerra; **Investigation-** Caroline Mazaro Lourenção, Cristiane Barboza Santos, Spencer Tovar Gonçalves Guerra; **Methodology-** Caroline Mazaro Lourenção, Cristiane Barboza Santos, Spencer Tovar Gonçalves Guerra; **Project administration-** Andreia Borges Scriboni; **Supervision-** Andreia Borges Scriboni; **Writing - original draft-** Caroline Mazaro Lourenção, Cristiane Barboza Santos, Spencer Tovar Gonçalves Guerra, Andreia Borges Scriboni; **Writing-review & editing-** Caroline Mazaro Lourenção, Cristiane Barboza Santos, Spencer Tovar Gonçalves Guerra, Andreia Borges Scriboni.

Acknowledgment

Not applicable.

Ethical Approval

Not applicable.

Informed Consent

Not applicable.

Funding

Not applicable.

Data Sharing Statement

No additional data are available.

Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate@.

Peer Review Process

It was performed.

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