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Low Intensity Laser Therapy: A Review of Its Applications and Effectiveness in Health, General Dentistry and Endodontics

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Authors' contributions

This work was carried out in collaboration among all authors. Author BPS conducted the literature search, analyzed the data, designed the study and wrote the manuscript. Author JESF analyzed the data, contributed to the study design and edited the manuscript. Author AAD provided overall research guidance, analyzed the data, and both edited and reviewed the manuscript. All authors read and approved the final version of the manuscript.

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ABSTRACT

Aims: To evaluate the use of low-level laser therapy in endodontic treatment and its broader applicability in General Health and Dentistry.
Study Design: Literature review.
Place and Duration of Study: The study involved searching articles and book chapters in the Google Scholar and PubMed databases from 2018 to 2023, with the review concluding in 2024.
Methodology: The review used descriptors from the Brazilian Health Sciences Descriptors database: Laser Therapy, Low-Level Light Therapy, Endodontic Treatment, Dentistry, and their Portuguese equivalents. A total of 34 articles were selected, focusing exclusively on low-level laser therapy and its applications. Articles not addressing this specific therapy were excluded.
Results: Low-level laser therapy is frequently used as an adjunct in general health, dentistry and endodontic treatment. Clinical applications, such as postoperative pain control, root canal system disinfection, periapical surgery, and tissue repair, showed promising results. However, more theoretical and clinical evidence is still required to fully establish its efficacy. Further research is needed to strengthen the evidence base and optimize its clinical use.
Conclusion: Low-level laser therapy offers a potential non-invasive treatment option in endodontics, with satisfactory outcomes in various clinical applications.

Keywords: Low-level laser therapy; non-invasive treatment; dental treatment; general clinical applications; endodontics.

1. INTRODUCTION

The term laser originates from the expression "light amplification by stimulated emission of radiation" and low-intensity laser therapy is considered a potential non-invasive treatment Its physical properties allow it to emit radiation with high energy and low power, which contribute to biostimulation and biochemical reactions in cells through light interaction, depending on the wavelength used according to therapeutic needs [1-2].

The wavelength used in low-intensity laser therapy is 660nm for red light and 808nm for infrared light; this type of radiation has therapeutic effects on living tissues. The wavelength employed is directly proportional to the penetration it will have in the tissue, and the devices can be applied in continuous light or pulsed light mode, depending on their power [3]. Infrared laser has anti-inflammatory properties and greater tissue penetration. In contrast, red lasers are less penetrating than infrared [4].

The use of laser therapy has been frequently applied in Medicine, Dentistry, Speech Therapy, and other areas of human and animal health [5]. Low-power laser is used to stimulate tissue healing, possessing milliwatts of up to a maximum of 1W, which are not capable of causing tissue destruction [2]. Additionally, therapies associated with lasers can relieve pain, be anti-inflammatory, stimulate, improve local microcirculation, and reduce oedema [4].

In the field of Dentistry, the application of low-intensity laser is also quite common nowadays, due to its beneficial results in various situations. One of the most frequent applications is in aiding the treatment of recurrent and traumatic oral ulcerated lesions, as well as in the treatment of other oral diseases. The results of this therapy include pain relief and reduced discomfort for patients [4].

The relationship between low-intensity laser and Endodontics is being studied. Endodontic treatment must clean, shape, and seal the canals to eliminate or reduce the number of microorganisms present. The treatment consists of a good diagnosis, endodontic access, pulp removal, instrumentation, canal system filling, and patient follow-up [6]. Disinfection is performed using irrigating solutions in the root canal system, such as sodium hypochlorite or chlorhexidine gluconate, which act on microorganisms and organic and inorganic tissues, aiding in adequate antisepsis [7-8].

Thus, this article aims to report on the use of laser therapy in endodontic treatment and its applicability in other areas of health and Dentistry.

2. MATERIALS AND METHODS

The present study is a literature review, conducted by searching for articles and book chapters in the Google Scholar and PubMed databases in 2023, focusing on the last five years (2018–2023). In addition to this time range, the inclusion criteria allowed for the consideration of articles in both English and Portuguese.

The descriptors used were registered in the Brazilian Health Sciences Descriptors database: Laser Therapy, Low-Level Light Therapy, Endodontic Treatment, Dentistry, and their Portuguese equivalents. The Boolean operator "AND" was applied in both English and Portuguese research strategies as follows: "Low-Level Light Therapy" AND "Dentistry," and, in Portuguese, "Uso da Laserterapia" AND "Tratamento Endodôntico."

Based on this selection of articles, the research aimed to discuss and describe the use and effects of laser therapy in endodontic treatment. Positive results were found regarding the use of lasers, their applicability in clinical dental practice, and the benefits to patients. Articles that did not address the use of low-level lasers were excluded from the research.

As this study relied solely on already published material for analysis, prior evaluation by an Ethics Committee on Research with Human Subjects was not required.

3. RESULTS AND DISCUSSION

Applying the descriptors in the databases yielded the following categories and the corresponding number of articles found: (1) Low-level light therapy = 9,343, (2) Laser therapy = 108,316, (3) Low-level light therapy AND dentistry = 1,789, (4) Use of Laser Therapy in Endodontic Treatment = 1,139. The articles were evaluated, and 34 were selected to be included in this review. The results of the initial analysis of the selected articles are presented in Table 1, which includes information such as author(s)/year of publication, general objective, and main findings. Articles written in both English and Portuguese were included.

3.1 Laser in General Health

Low-level laser therapy (LLLT) is a non-invasive treatment that incorporates phototherapy principles and contributes to photobiomodulation, affecting cellular metabolism and local microcirculation. It promotes the production of prostaglandins (PGI2) for anti-inflammatory effects, inhibits pro-inflammatory factors, and eliminates pain-inducing substances such as histamine, substance P, and dopamine [32].

The mechanism of action of lasers is based on light absorption by chromophores, enhancing cellular respiration in mitochondria and increasing ATP formation through enzymatic reactions [24]. Research comparing Photodynamic Therapy (PDT) with photobiomodulation has shown that, while PDT requires a photosensitizing dye to generate biological responses, photobiomodulation relies on endogenous chromophores in the tissue, producing effects without exogenous dyes [5].

Photosensitizing oils extracted from plants and activated by light absorption have been used as early as 1400 BC by Asian cultures to treat conditions like vitiligo. Although the exact timeline of laser invention is unclear, modern applications of laser technology have demonstrated significant therapeutic relevance. In ancient medicine, sunlight combined with specific herbs was used to alleviate pain, hinting at the foundations of light-based therapies [18].

In the field of Speech-Language Pathology, red laser therapy has been effectively applied to patients suffering from oropharyngeal dysphagia, temporomandibular disorders, post-operative orthognathic surgery, facial paralysis, and prosthesis/implant irritations. It has also proven helpful for treating nipple fissures due to its analgesic and anti-inflammatory properties, contributing to symptom relief and patient recovery [3]. Intravascular Laser Irradiation of Blood (ILIB) involves irradiating blood via optical fiber in the radial artery using red and infrared laser light. This painless therapy does not cause burns and has shown benefits in post-operative recovery by reducing oedema [24].

Laser applications in Speech-Language Pathology have also been shown to reduce muscle fatigue, modulate salivary flow, and improve intraoral sensitivity, particularly in patients with neurological conditions or facial paralysis. Photobiomodulation therapy, known for its photochemical and photophysical effects, utilises non-ionizing light sources and has no side effects, making it a non-invasive technique aiding various therapeutic processes [24].

Table 1. Characterization of selected studies regarding authorship, year of publication, main objective and main results

Authors and Year	Objective	Main Results
Lopes; Pereira; Bacelar, 2018 [2]	To assess the ability of low-power lasers to stimulate cellular activity and collagen production, and their application in aesthetic treatments.	Due to its safety and non-invasiveness, the laser is being used for cellulite, acne treatments, and rejuvenation without causing side effects or discomfort to the patient.
Metin et al., 2018 [9]	To analyse the use of low-level laser therapy (LLLT) in soft and hard tissue regeneration immediately after endodontic surgery.	LLLT showed favourable results in reducing pain and stimulating soft and hard tissue healing after endodontic surgery procedures.
Alonaizan; Alfawaz, 2019 [10]	To answer the PICOS question: In patients with postoperative endodontic pain (Population), what is the effect of phototherapy (Intervention) as compared to placebo (Comparator) on postoperative endodontic pain (Outcomes) considering only RCTs (Study design)?	It remains debatable whether phototherapy reduces post-operative endodontic pain after root canal therapy.
Caccianiga et al., 2019 [11]	To use photobiomodulation for post-surgical care of dental implants to alleviate side effects.	Studies confirm that photobiomodulation, used complementarily, reduces swelling and pain after implant surgery. Further studies are needed to compare spectral technology with photobiomodulation.
Kuzekanani et al., 2019 [12]	To evaluate the lasers most commonly applied in endodontics for root canal disinfection via laser-activated irrigation, dentine hypersensitivity, pulpectomy, photoactivated disinfection, and pulp encapsulation.	The primary and most significant focus of laser use is its capacity to disinfect canals through photoactivation. For access and preparation of root canals, mechanical instrumentation is superior compared to laser-assisted procedures.
Plotino et al., 2019 [13]	To review the use of laser therapy in the speciality of endodontics: reviewing its mechanism of action, limitations, and clinical cases in the literature.	Favourable results were obtained with in vitro samples. Photodynamic therapy proved to be an adjunct to conventional endodontic treatments for the reduction of persistent microorganisms.
Yoshinari et al., 2019 [14]	To assess postoperative pain at different times with and without photodynamic therapy in teeth with asymptomatic periodontitis.	Evaluated patients reported low levels of pain, indicating that the use of photodynamic therapy for post-operative pain treatment was not advantageous.
Anagnostaki et al., 2020 [15]	To evaluate the use of conventional lasers as adjuncts for canal disinfection, antimicrobial photodynamic therapy (aPDT), and the management of post-endodontic treatment pain, and assess their effectiveness as auxiliary therapies in endodontic treatment.	Conventional endodontic treatment remains the gold standard. However, due to its failure rates and post-treatment pain, there was a need for something complementary. The use of lasers can indeed complement conventional treatment.

Authors and Year	Objective	Main Results
Cardoso et al., 2020 [1]	To evaluate laser therapy as a method for controlling post-endodontic treatment pain.	Laser therapy reduces post-dental treatment pain, not only in endodontics.
Guerreiro et al., 2020 [16]	To investigate the effect of low-level laser therapy (LLLT) in reducing post-endodontic pain.	Most studies reported a lower pain rate after endodontic treatment using LLLT across various time periods. There was low evidence for endodontic surgeries and retreatment.
Karamifar et al., 2020 [17]	To analyze current methods for diagnosing and treating endodontic periradicular lesions, highlighting their advantages and disadvantages.	Despite various treatments for endodontically failed teeth, there is still a need for minimally invasive treatment for apical periodontitis and cysts.
Medeiros et al., 2020 [6]	To conduct a comparative analysis between conventional endodontic techniques and the use of photodynamic therapy with methylene blue in eliminating *Enterococcus faecalis* bacteria.	The use of antimicrobial photodynamic therapy positively demonstrated a reduction in *Enterococcus faecalis* bacteria in root canal systems with low cytotoxicity.
Silva Neto et al., 2020 [18]	To evaluate through an integrative review the applications of low-intensity laser in dentistry.	Laser is indispensable in dentistry, serving as an adjunct in various treatments and specialisations, with the added benefit of lacking side effects.
Tavares et al., 2020 [19]	To report a clinical case of a pulpal canal with apical periodontitis using guided endodontic treatment combined with photodynamic therapy (aPDT).	Positive results were obtained by combining the two techniques. The aPDT played an important role in the case, thus encouraging its use in cases with calcifications and without apical patency.
Figueirêdo-Júnior et al., 2021 [7]	To show an adjunctive method for disinfecting root canal systems using laser therapy through photodynamic therapy.	For root canal disinfection, aPDT provides a favorable resource to assist endodontic treatments.
Nogueira et al., 2021 [20]	To expose the cellular and molecular results of low-power laser use in dentistry.	When applied, the laser promotes cell regeneration and a rapid physiological response. There are still insufficient studies showing the biomodulation process of low-power laser with clinical trials.
Oliveira et al., 2021[a] [21]	To compare the use of low-level laser therapy with another postoperative method in patients undergoing third molar surgery, aiming to reduce edema, trismus, and pain.	Laser was effective in controlling pain, edema, and trismus after third molar extraction, benefiting different tissues. Laser enhances cellular mobility and adhesion, inhibiting apoptosis and producing cell development factors.
Oliveira et al., 2021[b] [22]	To explain to dentists the use of phototherapy associated with laser in endodontics and general aspects.	There is evidence that laser therapy is an adjunctive method for disinfecting root canals, but it requires professionals to have knowledge of its fundamentals and tissue interactions.

Authors and Year	Objective	Main Results
Ren et al., 2021 [23]	To determine how laser therapy can help in treating pain caused by temporomandibular joint dysfunction (TMD) using various wavelengths and transcutaneous electrical nerve stimulation (TENS).	In patients with TMD, laser therapy has shown to be more effective in short-term pain reduction, using wavelengths from 910 nm to 1100 nm.
Santos; Sousa, 2021 [24]	To analyse what are the main contributions of laser therapy as a resource for the benefit of speech therapy.	Laser therapy has been found beneficial in speech therapy, enhancing performance in muscles involved in speech and chewing. More studies are needed regarding laser therapy in speech therapy.
Simões; Catão, 2021 [25]	To analyse the forms of laser therapy applications in clinical practice through scientific publications.	Laser use in clinical practice to alleviate post-endodontic treatment pain and clean root canals has yielded satisfactory results.
Souza et al., *2021* [4]	To present low-level laser therapy and its modes of action in treating trigeminal nerve lesions in dental procedures.	When performing procedures near nerves, care must be taken to avoid nerve injuries. Laser therapy presents benefits in regenerative, anti-inflammatory, and analgesic processes.
Bansal; Sandhu, 2022 [26]	To analyse how laser-assisted irrigation in endodontics works within root canals.	Laser-activated irrigation is a novel method for root canal disinfection. Its results, when combining laser energy, show that laser radiation creates cavitations in the irrigant solution.
Liu; Zhang; Zhou 2022 [27]	To examine the functioning of periodontal endodontic therapy associated with diode laser (DL) therapy.	Using DL in periodontal tissue proves effective in tissue healing, reducing periodontal pockets, and alleviating dental pain.
Lopes et al., 2022 [28]	To discuss the clinical use of photodynamic therapy in endodontics.	The use of antimicrobial photodynamic therapy in endodontics showed high levels of clinical evidence. Two studies that were determined had clinical recommendations of A1A and an evidence level of A.
Pandit et al., 2022 [29]	To apply laser in endodontics: for pulp diagnosis, pulp capping, pulpotomy, root canal disinfection, dentin hypersensitivity, canal shaping and obturation, and apicoectomy.	The use of lasers in endodontics is expected to become more common due to advances in very fine, elastic, and long fibres. Nd:YAG laser was efficient in common procedures.
Moreira, Teixeira, Lyon, 2022 [5]	To discuss concepts to better understand physiotherapeutic techniques and expand their clinical applications.	Comparatively, the use of photobiomodulation in human medicine is well-established, unlike in veterinary medicine. Devices are becoming more accessible, expanding to more clinics, favouring application.

Authors and Year	Objective	Main Results
Oliveira et al., 2022 [30]	To investigate the action of photodynamic therapy for pain control in teeth with pulp involvement.	There is currently insufficient evidence to support the use of photodynamic therapy for controlling endodontic-origin pain. However, there is better support for its use in root canal disinfection.
Brasil et al., 2023 [31]	To report a clinical case and literature review on the effects of laser in facial harmonization due to its bio-stimulating and tissue repair effects.	Laser as an auxiliary tool in disease treatment and aesthetics is gaining ground for its efficiency and enhancement in facial harmonization.
Ismail; Obeid; Hassanien, 2023 [32]	To compare two distinct methods: low-power laser therapy and laser-activated irrigation, for managing post-endodontic treatment pain using low-intensity diode laser.	Both methods yielded positive results; however, laser-activated irrigation proves more effective due to its antibacterial effects, moderate cost, and wider adoption in general practice.
Rubio et al., 2023 [33]	To present two cases of teeth with asymptomatic apical periodontal involvement and pulp necrosis, disinfected using 940nm diode laser and photobiomodulation therapy.	Diode laser in periodontal tissues compromised by periodontitis aids in tissue healing, noting low-intensity laser as complementary to conventional endodontic treatment.
Huang et al., 2023 [34]	To show the various ways laser can be applied, the types of lasers, and their wavelengths for different situations.	There remains a gap in determining the type of laser and parameters to be used in clinical practice. Additionally, its applications are costly and may cause erythema, skin hyperpigmentation, burns, and ocular injuries.
Lima et al., 2023 [35]	To discuss the significance of laser therapy in various pathologies and periradicular lesions of endodontic origin.	Further theoretical refinement is necessary to substantiate research claims.
Yong et al., 2023 [36]	To explain the use of regenerative endodontic procedures and applications of laser irradiation and photobiomodulation therapy in endodontics.	There is insufficient specific evidence explaining how photodynamic therapy will act in regenerative endodontic procedures (REPs), but it may serve as a complementary approach for the future of endodontics and REPs.

Source: Authorship (2024)

3.2 Laser in General Dentistry

Early laser research in Dentistry began with ruby-type lasers used "in vitro," which caused tissue burns due to high heat at the point of exposure. However, subsequent research has demonstrated the positive effects of low-intensity lasers, which are well-focused, monochromatic light beams capable of deep tissue penetration. These have led to bio-stimulation, pain relief, and anti-inflammatory effects, revolutionising dental treatments [18].

In Dentistry, low-level laser therapy (LLLT) is used to treat various conditions such as aphthous ulcers, temporomandibular disorders (TMD), dentine hypersensitivity, mucositis, dry mouth, osteoradionecrosis, and post-surgical complications. Its analgesic properties help alleviate or eliminate pain, offering a non-traumatic, minimally invasive, and non-toxic treatment option for healthy cells [18].

For patients with dentine hypersensitivity, low-level laser therapy (LLLT) effectively reduces pain through its bio-stimulating action on nerve endings. Similarly, in dental bleaching, the application of infrared light beams at wavelengths of 660 and 810 nm has led to improved desensitisation outcomes [18]. Furthermore, in the treatment of periodontitis, laser therapy has proven to be a beneficial adjunct, particularly for diabetic patients, as it enhances access to areas that mechanical methods may struggle to reach, such as root bifurcations and periodontal pockets, all while maintaining low tissue temperatures [27].

Orthodontic procedures also benefit from laser therapy, aiding bone rehabilitation and reducing discomfort during tooth movement with separators [18]. Post-operative issues following molar extractions, including oedema, trismus, and pain, are alleviated by applying LLLT with specific wavelengths and fluence. Research highlights the effectiveness of laser therapy in reducing post-operative discomfort, particularly in implant surgery [21].

The use of LLLT in orofacial harmonisation procedures promotes healing and addresses inflammation, offering promising results for facial rejuvenation by stimulating cellular processes [31].

3.3 Laser in Endodontics

Anatomical variations in root canals pose challenges for instruments and irrigating solutions, often leaving behind imperfections and microorganisms even after thorough chemomechanical preparation [7]. Laser therapy enhances root canal disinfection by applying light at a specific wavelength, which stimulates a dye to induce oxidation in the presence of oxygen, resulting in bacterial cell death [22].

Anagnostaki et al. [15] highlighted the significance of laser use in endodontics, particularly in conjunction with ultrasonic irrigation techniques. While the publication primarily discusses low-power laser therapy, it mentions a 2,940 nm laser, which is classified as a high-power laser. The primary interaction between near-infrared (NIR) wavelengths (810–1064 nm) and host tissues is photothermal, with lasers penetrating dentinal tubules that act as "light guides" due to their substantial penetration depth in dental tissues. However, in vitro tests have shown that while laser-activated irrigation (LAI) with a 2,940 nm wavelength using saline did not completely eliminate microorganisms, LAI with NaOCl did, suggesting that diode lasers should serve as an adjunct rather than a replacement for conventional methods.

Auxiliary procedures such as laser therapy can be crucial for achieving swift root canal disinfection, given their broad antimicrobial activity [7]. Laser therapy has been utilised in endodontics to improve the elimination of microorganisms left after chemomechanical preparation, providing ease and rapid clinical applicability [22].

Sodium hypochlorite is widely used as an irrigating solution in endodontics due to its ability to dissolve organic matter and part of the smear layer. However, improper use can lead to complications, such as pain caused by the extrusion of liquid beyond the apical foramen. Low-intensity laser therapy has been proposed to alleviate such pain due to its analgesic and anti-inflammatory effects [1]. The addition of EDTA enhances root canal disinfection by demineralising dentin and removing the smear layer. When combined with laser treatment, EDTA has proven effective in reducing microorganisms, particularly Enterococcus faecalis [22].

The use of diode lasers (DL) for treating periapical lesions has gained popularity due to their wide applicability and accessibility. Several studies have demonstrated DL's effectiveness in biostimulating periapical bone tissue and

providing photothermal disinfection. Its antimicrobial action is based on its direct photothermal effect on pigmented bacterial membranes. The wavelengths used (810, 940, and 980 nm) are not absorbed by water, allowing light to reach microorganisms deep within dentinal tubules. LLLT serves as a valuable alternative for addressing infections in hard-to-reach areas [33].

Research by Medeiros et al. [6] and Rubio et al. [33] supports the efficacy of laser therapy in reducing Enterococcus faecalis in root canals. These findings suggest that photodynamic therapy (PDT) could become a valuable addition to routine endodontic practice, despite the additional time it may require, due to its improved bacterial elimination.

Laser-induced photobiomodulation therapy (PBMT) has also been proposed as an adjunctive therapy that can enhance dental pulp tissue regeneration. When applied with appropriate parameters, PBMT stimulates cell proliferation and differentiation, ATP production, mitochondrial respiration, protein synthesis, and osteoblast formation—all essential for tissue repair. Cellular sources for pulp regeneration include dental pulp stem cells (DPSCs), stem cells from the apical papilla (SCAPs), and bone marrow stem cells (BMSCs).

PBMT operates through photochemical mechanisms via electromagnetic radiation and is widely accepted in endodontics for its anti-inflammatory, analgesic, and regenerative effects.It assists in pain relief, disinfection, reduction of dentin sensitivity, and stimulation of dentin formation in root canals. Red and infrared light emitted by PBMT is absorbed by mitochondria, initiating a cascade of photochemical and photoelectric reactions that stimulate stem cell proliferation and trigger subsequent effects [36].

Photodynamic therapy (PDT) using low-intensity lasers achieves excellent results in controlling endodontic infections. It not only enhances postoperative comfort compared to conventional treatments but also effectively manages post-endodontic pain. Low-intensity lasers can also be employed postoperatively for repair and stimulation. Their use extends across various endodontic procedures, including bone repair acceleration, analgesia, tissue repair, biostimulation, pulp capping, enhanced root canal preparation, root canal disinfection, obturation, adhesion of sealers, and aiding in periapical surgery and repair [1].

4. CONCLUSION

In various fields, such as postoperative pain management, the disinfection of root canal systems, periapical surgery, and postoperative tissue repair, the clinical use of laser as an adjunct to conventional endodontic treatment has shown satisfactory results. However, it is essential that laser therapy be prescribed and performed according to established protocols to ensure its safety and efficacy for dental surgery. Although scientific and technological advancements have been made in the field of Endodontics, the persistence of microbial factors still leads to failures. A significant challenge that has motivated researchers is the development of new technologies to eliminate these resistant microorganisms, with the use of lasers representing one of the most promising areas.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that the AI technology, GPT-4o, has been used fairly and solely for the rewriting and editing of this manuscript, specifically for the purpose of correcting the English grammar of the translated text, which was initially written in Brazilian Portuguese.

Details of the AI usage are given below:

1. The original manuscript, written in Brazilian Portuguese, was translated into English, and the AI was employed to ensure that the final text met the grammatical standards of academic English.
2. Specific prompts were designed to guide the AI in providing grammatical corrections. For instance, the AI was instructed to adjust the text's grammar to align with academic conventions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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