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REVIEW ARTICLE

The magnificent world of therapeutic applications of diode laser in dental practice

Miryan Margarita Grijalva-Palacios[1], Nathalie Steffy Ponce-Reyes[1], Jhoan Ariel Velasco-Ponce[1], Edwin Ismael Bedón-Cevallos[1]

[1]Universidad Regional Autónoma de los Andes, Ibarra. Ecuador.

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ABSTRACT

Introduction: diode laser has been consolidated as an innovative tool in dentistry, with therapeutic applications that encompass multiple procedures, improving the quality of clinical practice.
Objective: to analyze the main therapeutic applications of diode laser in dental practice.
Methods: a bibliographic review was conducted following the prisma methodology, with digital searches in different databases, using an algorithm that allowed the identification and selection of sources that met the inclusion criteria for final analysis, considering relevance, accessibility, and scientific reliability.
Development: the reviewed evidence shows that diode laser is effective in multiple areas (excision of benign soft tissue lesions, frenectomies, periodontal aesthetic procedures, and postoperative therapies). It has also been reported useful in reducing dentin hypersensitivity, controlling cariogenic bacteria, and supporting endodontic and orthodontic treatments. Its advantages include reduced bleeding, decreased postoperative pain, and antimicrobial effects, although limitations such as high equipment cost and risks of tissue desiccation or carbonization if not properly handled are noted. Current trends emphasize its use as a complement to conventional techniques, with superior clinical outcomes in specific contexts.
Conclusions: diode laser represents a versatile and beneficial technology for contemporary dentistry. Its implementation requires responsible operator training and constitutes a significant investment, but its contributions in precision, bacterial control, and aesthetic improvement make it a key resource for optimizing comprehensive dental care.

Keywords: Lasers, Semiconductor; Dentistry; Therapeutics.

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INTRODUCTION

Dentistry has evolved closely linked to technological advancements, which has driven the continuous incorporation of tools designed to optimize clinical practice. In this context, the diode laser has become a valuable resource, providing benefits in various specialties and functioning as a complement to or alternative to conventional procedures. Its scientific basis dates back to 1917, when Albert Einstein theoretically proposed the stimulated emission of light by electrons in response to an external intervention. Although the first contributions had little impact, the decisive breakthrough occurred on May 19, 1960, when Theodore Maiman developed the first functional laser, known as the ruby laser, at Hughes Laboratories, marking the beginning of its application in multiple fields, including dentistry.[1]

This revolutionary technology was initially used for military purposes, but its use gradually expanded to industrial activities, telecommunications, and, with great relevance, the health sector. In 1965, lasers began to be used in dentistry, and since then, their use has been in constant evolution and development, to the point of becoming a key tool in various dental treatments, due to their benefits and their high capacity to prevent bleeding, as well as their active bactericidal and sterilizing properties.[2]

Light is understood as the set of wavelengths that make up the electromagnetic spectrum, encompassing both radiation visible to the human eye and that which is not; the latter corresponds to the infrared and ultraviolet regions.[3] This spectrum determines the physical and biological properties of each type of radiation, as well as its interaction with tissues. In this sense, Mohan R et al.,[4] describe in their study the classification of light according to its wavelength and highlight its relevance for the clinical use of different types of lasers employed in dentistry (Table 1).

Table 1. Classification based on the light spectrum.

Type of light	Wavelength*	Use in Dentistry
Ultraviolet light	100-400	Not used in Dentistry
Visible light	400-750	Commonly used in Dentistry (Argon and Diagnodent Lasers)
Infrared light	750-10,000	Most lasers fall within this spectrum

Grades: *Unit of measurement (nanometers [nm])

They can originate from natural sources, such as the sun, or from artificial sources such as electronic devices, such as the diode laser; laser light is characterized by being amplified, monochromatic (all photons have the same wavelength/color), unidirectional preventing dispersion, and the coherence of its photons allows it to project longitudinally, as well as concentrate energy in specific areas.[3]

A diode laser is a semiconductor device consisting of a solid-state active part made of elements such as gallium, arsenic, aluminum, or indium, which can convert electrical energy into light energy. It operates in the 800nm to 980nm range.[5]Although there are variations that can work in lower ranges, they are not relevant to this study, since most studies using diode lasers focus on the aforementioned range.

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The light emitted by this laser is absorbed by the soft tissues of the oral cavity due to its affinity for hemoglobin and melanin. This range of light allows the laser to cut tissues, coagulate blood vessels to reduce blood loss, promote whitening processes, and perform antimicrobial functions.[6] The action of the laser is directly related to factors such as power and exposure time. At temperatures of 60 to 100 degrees, protein and collagen denaturation occurs, facilitating coagulation. At temperatures of 100 degrees or higher, tissue desiccation occurs, and finally, at 200 degrees, tissue carbonization or burning occurs.[7]

Regarding the thermal effects of diode lasers on tissues, several authors have established a classification based on the temperature ranges reached and the resulting biological responses.[3] This categorization allows us to understand how minimal variations in the applied energy can generate beneficial therapeutic effects or, conversely, cause tissue damage. Table 2 summarizes the main effects of diode lasers according to the recorded thermal increase and their impact on the exposed tissues.

Table 2. Effects of diode laser on tissues at different temperatures.

Temperature	Tissue effect
42-45°C	transient hyperemia
>65°C	Desiccation, protein denaturation and coagulation
70-90°C	Coagulation and tissue fusion
>100°C	Vaporization
>200°C	Carbonization

Given the increasing incorporation of diode lasers into various clinical procedures, it is essential to understand the true extent of their therapeutic benefits and their integration into contemporary dental practice. Their versatility, safety, and ability to selectively interact with tissues have driven their use in multiple specialties, from periodontics to oral surgery. In this context, the present research aimed to analyze the main therapeutic applications of diode lasers in dental practice.

METHODS

The study was designed as a qualitative literature review, based on documentary research and focused on the descriptive-analytical analysis of available evidence on the therapeutic applications of diode lasers in dentistry. A non-experimental, retrospective approach was adopted, following a timeline established between 2010 and 2024, with the aim of identifying, comparing, and synthesizing the relevant findings of studies published during that period.

The methodological process incorporated analytical, synthetic, and qualitative procedures: the analytical method allowed the scientific information to be broken down for rigorous evaluation; the synthetic method facilitated the integration of data into clear and coherent interpretations; and the qualitative approach favored the contextualization of the therapeutic applications of the diode laser in different dental interventions.

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Information sources included the PubMed, SciELO, ScienceDirect, Google Scholar, LILACS, and BVSALUD databases. Secondary references and grey literature were also reviewed when deemed relevant to complement the primary search. The search strategy was structured using an algorithm based on controlled descriptors and keywords combined with Boolean operators: ("Dentistry" OR "Odontology") AND ("Laser" AND "Diode") AND ("Applications" OR "Therapeutic use"). Articles published in Spanish, English, and Portuguese were included. Initially, 82 records were identified after applying the strategy without restrictions on study type.

The inclusion criteria encompassed articles published within the defined period, studies directly addressing the therapeutic use of diode lasers in dentistry, primary research and systematic reviews, documents with full access, and literature with verifiable scientific support. Duplicates, articles published before 2010, texts without full access, studies unrelated to the topic, publications in languages other than those considered, and documents lacking robust scientific evidence were excluded. After applying these criteria, 25 relevant articles were selected, distributed as follows: ScienceDirect (12 of 38 reviewed), PubMed (6 of 23), and SciELO (7 of 21).

The selection process was carried out in three stages: title reading, abstract review, and full-text evaluation. The progressive refinement of the records was documented using a PRISMA flow diagram, which provided transparency regarding the number of studies identified, evaluated, excluded, and ultimately included in the synthesis. Data extraction was performed using a matrix designed to collect variables. The information was integrated through a qualitative synthesis, as the heterogeneity of the designs and metrics precluded a meta-analysis (Fig. 1).

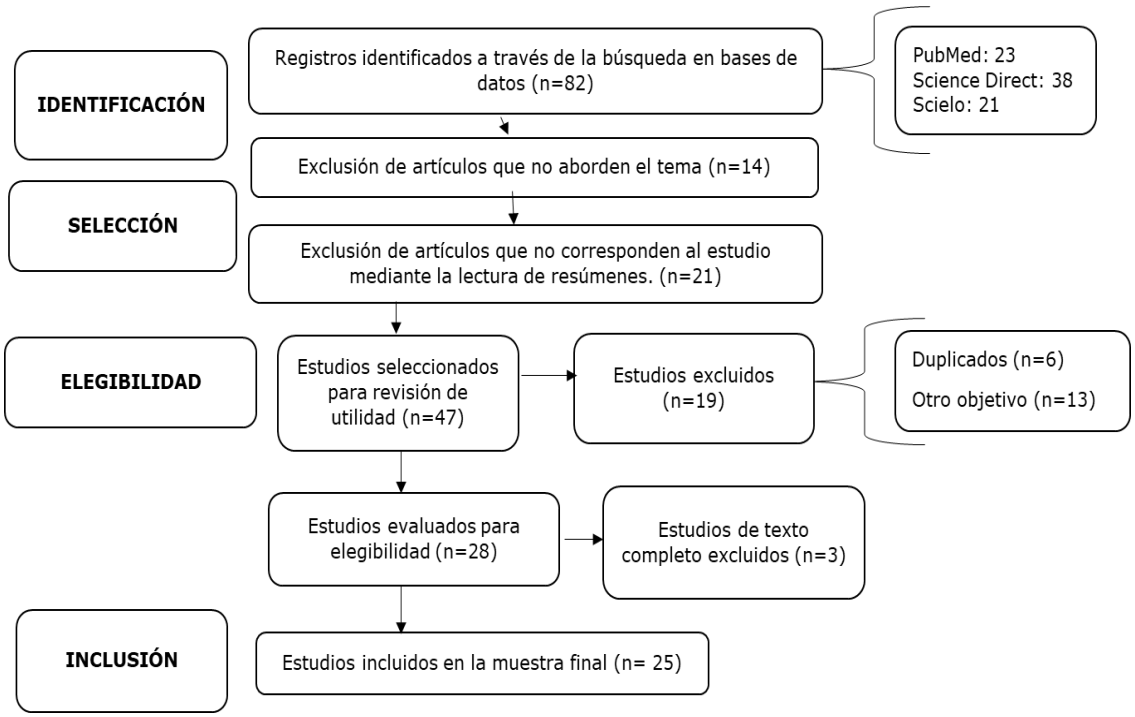

Fig. 1 Article search flowchart.

The selected studies were organized and synthesized according to the parameters established in the methodology, allowing for a structured and coherent classification of the available evidence. This phase included the critical appraisal of each article based on its design, thematic relevance, and contributions to the understanding of the therapeutic applications of diode lasers in dentistry.

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DEVELOPMENT

This article comprehensively examines the therapeutic applications of diode lasers in dentistry, contextualizing their technological basis and clinical relevance. This type of laser, based on semiconductor materials with compounds such as gallium, arsenide, aluminum, or indium, has the ability to convert electrical energy into coherent and highly focused light radiation. Its operation is predominantly within a wavelength range of 800 to 980 nm, the spectrum in which most clinical and experimental studies related to its dental use are concentrated. Table 3 presents the evidence from the previously identified and selected studies.

Table 3. Scientific evidence on the clinical use of diode lasers in dentistry.

Fountain	Results
Sufiawati I et al.,[8]	Diode laser is emerging as a highly effective method for excisional biopsy of benign oral soft tissue masses, providing intraoperative and postoperative advantages over scalpel surgery.
Alshamrani AS[9]	This study explored the effect of laser treatment combined with topical fluoride on the surface microhardness of primary tooth enamel. The use of a diode laser (Quanta System, Italy) with a fluoride varnish applied to the enamel surface had a greater effect on enamel resistance to caries.
Doppalapudi H et al.,[10]	Within the parameters of the study design, a combination of diode laser and Novamin & Pro-argin desensitizing toothpaste showed better results for dentin tubule occlusion compared to other groups. Furthermore, the use of the laser group as a desensitizing agent demonstrated significantly improved dentin tubule occlusion compared to the Novamin and Pro-argin groups.
Atieh M et al.,[11]	In the treatment of peri-implant mucositis, the combined use of a diode laser and mechanical debridement did not provide any additional clinical advantage over mechanical debridement alone. Well-designed, long-term randomized controlled trials (RCTs) are still needed.
Agop-Forna D et al.,[12]	The clinical application of the diode laser in frenectomy was easy to use, efficient, safe, and can be considered a valid alternative surgical procedure to the classic surgical procedure.
AL-Ashou et al.,[13]	The diode laser significantly increased the bond strength of self-adhesive systems to dentin; diode laser irradiation after placement of the self-etching adhesive system and before photopolymerization could be considered a promising additional clinical step in an attempt to improve bonding and preserve the durability of the composite adhesion.
Kunarti S et al.,[14]	Preconditioning with LLLT (Low-level laser therapy) decreases pain sensitivity by increasing the pain threshold.(14)which has an effect on substance P (neuropeptide, neurotransmitter and neuromodulator) and interleukin-10 (anti-inflammatory protein)
Hussein A et al.,[15]	Although LLLT reduced the overall duration of pain after distalization of the upper first molar, it was not effective during periods of peak pain. Therefore, further research is needed to determine the optimal conditions and mechanisms of action of LLLT for effective orthodontic pain relief.
Giudice A et al.,[16]	LLLT is effective in relieving the intensity and duration of pain experienced by patients after placement of thebowof alignment. However, there is no specific indication for the use of LLLT based on the amount of overcrowding.
Cifter M et al.,[17]	Although frequent laser applications and surgical interventions are not preferred methods in the course oftreatmentIn orthodontic treatments, these methods may be preferred if a shorter treatment period is desired. Consequently, we believe that the results of this study, which compare the

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	effects and efficacy of both methods, will be beneficial in selecting the most appropriate method for a specific patient.
Prasanth T et al.,[18]	The laser can be used for a better periodontal aesthetic procedure than the standard scalpel technique, although repigmentation was reported in both groups. However, a delay in healing occurred on the laser side due to the thermal effect of the laser on the adjacent tissues. The provision of such advanced instruments todental surgeryIt can give patients greater satisfaction in terms of good aesthetic results.
Ahn JH, et al.,[19]	Dental laser soft tissue surgery is considered safe and effective, and potentially offers advantages over conventional surgery in the field of orthodontics in terms of treatment outcomes and patient management.
El Mobadder M, et al.,[20]	In conclusion, the retrospective study confirms that after conventional non-surgical mechanical debridement, irrigation with 3% hydrogen peroxide followed by 980 nm diode laser irradiation under our specific irradiation conditions can provide a significant reduction in the total bacterial count in periodontal pockets larger than 5 mm within a six-month follow-up.
Hama D et al.,[21]	Our findings indicated a significant decrease in colony-forming units (CFU) in the laser group due to the direct delivery of laser energy through the thin-diameter (200–320 µm) optical cable used, which allowed for efficient delivery of laser light deep into the root canal. The bacteria absorbed the laser energy, resulting in a photothermal interaction that had a bactericidal effect. Because the diode laser has high permeability and minimal interaction with dentin, it is effective against germs that have reached the dentinal tubules.
Jomaa K et al.,[22]	The application of an 810 nm diode laser, alone or in combination with sodium fluoride gel, is effective in treating dentin hypersensitivity. Similarly, the application of a 650 nm diode laser, alone or in combination with sodium fluoride gel, has slight efficacy in treating dentin hypersensitivity.
Yadav S et al.,[23]	Aesthetic demands require a cosmetic gingival depigmentation procedure. Diode laser photoablation has proven to be an effective and reliable technique for achieving this.
Robati M et al.,[24]	The diode laser (980 nm) is highly effective in reducing the growth of S. mutans and L. acidophilus at different times and doses, and a significant decrease in CFU/ml of both microorganisms was observed immediately and 24 hours after irradiation.
Gogoi A et al.,[25]	The application of diode lasers for the removal of mucosal lesions in the oral cavity is relatively new and a viable and superior alternative to previous methods. Additional advantages of using a laser include less bleeding, improved or reduced healing time, and its affinity for melatonin, which prevents further or recurrent pigmentation.
Etemadi A et al.,[26]	The use of phycocyanin (a photoreceptor protein with antimicrobial properties) alone and antimicrobial photodynamic therapy (aPDT) with a 635 nm diode laser and phycocyanin can significantly reduce the P. gingivalis count in vitro. Given the conservative nature of this modality, it could be used as an adjunct treatment for the decontamination of implant surfaces and peri-implant areas.
Zumba J, et al.,[27]	The most frequently reported advantage in this review was the reduction of intraoperative bleeding, thanks to the photocoagulation capabilities of the diode laser, which denature hemoglobin, causing tissue ischemia and ultimately coagulation. On the other hand, the main disadvantages were the high cost of the equipment and the desiccation and/or charring of tissues when temperatures exceed 65°C.
Kaplan T et al.,[28]	The application of a diode laser after conventional irrigation can reduce postoperative pain in single-rooted necrotic teeth with a periapical index (PAI) score of 3 or 4 following root canal treatment performed in two visits. These

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	findings indicate that diode lasers can be used as part of routine root canal treatment, especially in infected cases, to ensure patient comfort.
Gadzhula N et al.,[29]	The study results indicate that laser therapy for chronic gingivitis is more effective than conventional drug treatment, reduces the time required to completely eliminate the inflammatory process, and halts its further progression.
Vinothkumar T et al.,[30]	Diode lasers could be used as a complementary tool to reduce remaining bacteria within dentinal tubules. A combination of diode lasers with an output power of 1.5 W and a 2% chlorhexidine gluconate solution as a surface pretreatment regimen could potentially control a broad spectrum of remaining bacteria in dentinal tubules, such as Streptococcus mutans, Lactobacillus casei, and Actinomyces naeslundii.
Ghodke PS, et al.,[31]	The two main results of the study after using an 810 nm diode laser around the implant were: 1) a drastic reduction in the total bacterial count and 2) a significant reduction in the P. gingivalis count as assessed by real-time PCR. These two results show that an 810 nm diode laser can be used as a regular tool for implant maintenance without harmful effects or damage to the implant or surrounding tissues.
Peimani A et al.,[32]	Low-level laser radiation may accelerate the healing process of the tooth socket, which was particularly noticeable with 5-minute irradiations over 3 days. The use of a low-level laser can be helpful in accelerating tooth socket healing and reducing complications after tooth extraction.

Due to the wide and diverse application of the diode laser in dentistry for therapeutic purposes, it has been decided to analyze the results based on 5 specific dimensions, which are reflected in Table 4.

Table 4. Application of diode lasers in dentistry for therapeutic purposes.

Work areas	Uses
Surgical applications	It has been found to be effective for the excision of soft, benign masses in the oral cavity. Regarding the treatment of peri-implant mucositis, no additional notable benefits are mentioned. Frenectomy is a common procedure in dentistry, which is made easier when performed with a diode laser and is considered an effective alternative to classic surgical procedures. The application of diode lasers in periodontal aesthetics is favored in terms of precision, but delays in healing are mentioned. In orthodontics, laser diode surgery for the exposure of impacted teeth is considered an advantageous technique in terms of results and patient management, and its application by healthcare professionals is expected to become more common. Laser treatment is effective for removing mucosal lesions in the oral cavity, offering a new and viable alternative with advantages such as precision, reduced bleeding, shorter healing time, and prevention of pigmentation through interaction with melatonin.
Treatment of pathologies and postoperative therapies	The application of antiseptics along with diode laser irradiation has been beneficial in the rapid resolution of gingival inflammation at the level of periodontal pockets. The diode laser is effective in gingival depigmentation, all through photoablation. Diode laser irradiation can reduce postoperative pain from endodontic treatments, as well as reduce and eliminate microorganisms present.

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	Laser therapy for chronic gingivitis surpasses conventional drug treatment by reducing the time it takes to clear the inflammatory process and halting its progression. Diode lasers could be implemented as a complementary tool in the elimination of microorganisms associated with cardiogenic diseases when applied together with chlorhexidine, eliminating remaining bacteria in the dentinal tubules. The use of diode lasers proved beneficial in accelerating the healing of the dental alveolus, as well as reducing potential complications.
Relationship with biomaterials	Topical fluoride application combined with laser irradiation improves the resistance of tooth enamel to cavities. It also improves the appearance of white spots on tooth enamel. Beneficial results were found when combining laser treatment with desensitizing toothpaste, thus promoting the occlusion of the dentinal tubules and consequently reducing sensitivity. The diode laser significantly increases the bond strength of self-adhesive systems to dentin. Laser irradiation should be performed immediately after adhesive application and prior to light curing. This is considered a potential new step in dental operative protocols. The application of the diode laser alone or in combination with sodium fluoride gel is effective in treating dentin hypersensitivity
Biomodulation	Laser irradiation is considered a preconditioning step before any dental instrumentation, as it increases the pain threshold by interacting with neuropeptides and anti-inflammatory proteins. In orthodontics, there is a general reduction in pain related to distalization and other tooth movement procedures. Similarly, there is a decrease in the intensity and duration of pain after the placement or change of the archwire, although there are no specific indications for its application. Furthermore, it may shorten the duration of orthodontic treatment by inducing osteoclast production. The diode laser enables photocoagulation by denaturing hemoglobin, causing tissue ischemia and ultimately coagulation. Disadvantages include the high cost of this equipment and its susceptibility to operator error.
Antimicrobial action	The application of the diode laser in conjunction with the irrigation of antiseptic agents causes a significant reduction in the amount of bacteria present in periodontal pockets larger than 5mm Laser irradiation of endodontic canals showed photothermal bactericidal effects with additional benefits such as the scope of its action, being effective even against germs that have reached the dentinal tubules The diode laser is highly effective in reducing the growth of S. mutans and L. acidophilus, with an immediate and prolonged effect lasting up to 24 hours. The use of phycocyanin in conjunction with laser irradiation significantly reduces the P. gingivalis count and could be implemented as a decontamination protocol for implant surfaces and peri-implant areas. Laser therapy can be implemented as a regular tool in the maintenance of a dental implant, as it causes a drastic reduction in bacteria, with particular relevance to the P. gingivalis count.

Overall, beneficial factors were found regarding the performance of various surgical interventions at the stomatognathic level, highlighting the precision of the interventions, reduction of bleeding, and good interaction with soft tissues, which improves the patient experience when undergoing this type of treatment. However, it is necessary to emphasize the need for the laser operator to have the necessary experience and knowledge for its correct use. [8,12,19,23,25] This coincides with the findings of Bahrololoomi et al.,[33] who postulate that the application of the diode laser has become an ideal alternative for our dental field, especially in the surgical environment, but it is

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not just a matter of pressing a button; it also involves the research and development of ideal techniques.

Regarding the treatment of pathologies and its use as postoperative therapies, it presents considerable benefits, since interventions performed with a diode laser reduce postoperative symptoms and shorten recovery times, except in cases where the laser equipment is not handled correctly. [18,28,30,31,32] Finally, it is confirmed that the treatment of pathologies is favored when performed with a laser because it is less invasive, which is related to the information that confirms the following: the diode laser has analgesic, antimicrobial and cyto-modulatory effects,[34,35,36,37] which makes it an ideal candidate for the treatment of various pathologies and postoperative therapies.

The findings of this study confirm the existence of a good correlation between the different biomaterials focused on both the aesthetic and physiological aspects with the diode laser; in general, the benefits are focused on favoring aspects such as their absorption by the oral tissues and therefore maximizing their effect. [9,10,13,22] This is closely related to the conclusion of Bahrololoomi et al.,[33] who, in relation to remineralizing agents, confirm that laser irradiation improves the effectiveness of these compounds containing calcium, fluoride, and phosphorus, thus improving the microhardness of the enamel.

Irradiation of oral tissues with diode laser has a number of benefits in terms of patient experience with different treatments, causing a decrease in inflammatory processes and the perception of pain, in addition to promoting cell renewal, having a cytomodulatory effect, [14,15,16,17] related to what Medhat et al. mention,[35] concluding that the diode laser has favorable effects on cell proliferation and differentiation as is the case of osteogenic cells, thus decreasing recovery periods and promoting proper cell regeneration.

Several studies confirm the effectiveness of the laser diode as a therapy for the reduction or elimination of pathogenic microorganisms, since when irradiated on microorganisms especially bacteria it has a bactericidal effect, and when used in conjunction with antimicrobial agents, its action is enhanced,[20,21,24,26,30] coinciding with the conclusion of Sarda et al.,[34] where he confirms that the combination of an irradiating solution or photoactivated disinfection alone provides better efficacy in terms of reducing pathogen count.

CONCLUSION

Evidence indicates that diode lasers have broad and widely accepted therapeutic applications in dentistry, highlighting their usefulness in minimally invasive soft tissue procedures, their biomodulatory effect, their favorable interaction with various biomaterials, and their antimicrobial properties. While offering significant clinical benefits, their use requires adequate training to avoid tissue damage, and their implementation involves a considerable investment. Overall, the diode laser represents an effective and high-potential tool in current dental practice.

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