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REVIEW ARTICLE

Use of low-level laser in analgesia and dental movement with orthodontics

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ABSTRACT

Introduction: contemporary dentistry faces the challenge of optimizing endodontic and orthodontic treatments by reducing pain, clinical time, and risk of complications through the use of complementary technologies and medications.
Objective: to analyze the role of low-level laser therapy, apical locators, and calcium hydroxide as auxiliary resources in orthodontics and endodontics.
Methods: a bibliographic review was conducted in different databases, using a search algorithm that allowed the identification of current and highly relevant sources on the subject. These sources met the established selection criteria and were subsequently analyzed.
Development: the literature shows that photobiomodulation with low-level laser therapy promotes bone remodeling and decreases pain perception in orthodontics, accelerating tooth movement without invasive effects. Apical locators, in turn, have demonstrated high accuracy in determining working length in endodontics, reducing reliance on radiographs and improving procedural safety, although they present limitations in cases of calcified canals or patients with pacemakers. Finally, calcium hydroxide is confirmed as an effective intracanal medication, with antimicrobial, remineralizing, and anti-inflammatory properties.
Conclusions: the integration of therapeutic laser, apical locators, and calcium hydroxide medication provides substantial benefits in orthodontics and endodontics. These resources enhance therapeutic efficacy, reduce complications, and optimize patient experience, consolidating themselves as safe and complementary strategies for innovation in dental care.

Keywords: Analgesia; Orthodontics; Tooth Movement Techniques; Low-Level Light Therapy.

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INTRODUCTION

For over half a century of uninterrupted research, a significant amount of evidence on the clinical effects of laser light on oral tissues has been accumulated. There are many successful cases of various oral clinical conditions that help mitigate aphthous ulcers, treat dentin hypersensitivity, accelerate dental movement, and control pain during orthodontic treatment, achieving a high rate of promising results.[1,2]

The mechanisms associated with photobiomodulation (PBM) work at the systemic, regional, and local levels, producing an increase in mitochondrial metabolism as an intracellular response. This increase results in an increase in the production of adenosine triphosphate (ATP), nitric oxide (NO), and reactive oxygen species (ROS). It has been studied that a photoactivated ROS stress response may be associated with laser - induced analgesia. Laser therapy has characteristics of analgesia, anti - inflammation, and tissue repair, so it was initially applied in the medical field for skin use and was later introduced to dentistry.[3,4]

Orthodontic dental movement brings about physical and biological effects that can be observed prematurely since they affect the extracellular matrix, the cells present in the cancellous bone, and the periodontal ligament. The cells affected are granulocytes, fibroblasts, osteoclasts, and osteoblasts. These cells change the synthesis and release of cytokines, growth factors, and chemotactic factors. During the first 24 hours, the pain caused is maintained because there is prostaglandin production. When there is hyperalgesia, it would be a discouraging circumstance for orthodontic treatment. Studies have been conducted to evaluate pain perception during dental movement when using orthodontic separators, assessing the use of anti - inflammatories, analgesics, low - level laser irradiation, and other therapies.[5,6]

The benefits obtained with PBM are associated with the ability of this therapy to penetrate tissues, selective absorption, and the production of important biological effects in inflammation and tissue repair. Some therapies promote the stimulation of the periodontal ligament, achieving an increase in the quality and speed of the bone remodeling process. Low - level laser improves repair in the final phases of the inflammatory process, so it is considered very effective for controlling pain after orthodontic treatment activation without altering the mechanics of the treatment since it is not an invasive application. It is painless and aseptic, produces photochemical reactions in cells, helps collagen production, and changes protein synthesis.[7,8]

According to Fujita et al.,[9] Diode lasers induce osteoblastic activity on the tension side and osteoclastic stimulation on the compression site to promote bone remodeling. A proposed mechanism for osteoclastogenesis is through the modification of the RANK/RANKL/OPG system, which results in accelerated dental movement since the laser is based on two determinants: the type of absorption (intermediate) and the wavelength responsible for penetration depth. Consequently, the present research was developed, which aimed to analyze the role of low - intensity laser, apex locators, and calcium hydroxide as auxiliary resources in orthodontics and endodontics.

METHODS

This was a documentary, retrospective study based on the principles of exploratory systematic reviews as established by the PRISMA Extension for Scoping Reviews (PRISMA - ScR) checklist. Publications of studies on the use of low - intensity laser in accelerating movement during orthodontic treatment were analyzed.

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Search Strategy and Eligibility Criteria for Studies
Searches were conducted in specialized electronic health science databases, including PubMed / Medline, Tripdatabase, LILACS, ScienceDirect, and Epistemonikos. In addition, a search was performed in the bibliographic references of the articles found to ensure the inclusion of relevant articles for this review. The searches were conducted in English, Spanish, and Portuguese.

Search Keywords in English: "photobiomodulation in orthodontics"; "accelerated tooth movement", "orthodontic movement", "accelerated movement in orthodontics", "photobiomodulation" "orthodontics", "anchorage in orthodontics", "dental laser", "wavelength". Search Keywords in Spanish: "fotobiomodulacion en ortodoncia", "movimiento dental acelerado", "movimiento ortodontico", "movimiento acelerado en ortodoncia", "fotobiomodulacion", "ortodoncia", "laser dental", "longitud de onda".

The following inclusion criteria were established:

- Type of publication: article published in a peer - reviewed journal.
- Year of publication: period between 2013 and 2023.
- Study design: randomized clinical trials, systematic reviews with meta - analysis, systematic reviews without meta - analysis, narrative reviews, comparative studies, cohort studies, case - control studies, and cross - sectional studies.

During the initial search, 832 potential articles were located. The screening process led to the rejection of the majority. In the eligibility phase, 96 full - text publications were evaluated, but 85 were discarded. The reasons for discarding articles throughout the entire process were as follows: duplicate articles, non - correspondence with the study objective or variables, inability to access the full text, and non - compliance with the previously defined inclusion criteria (Fig. 1).

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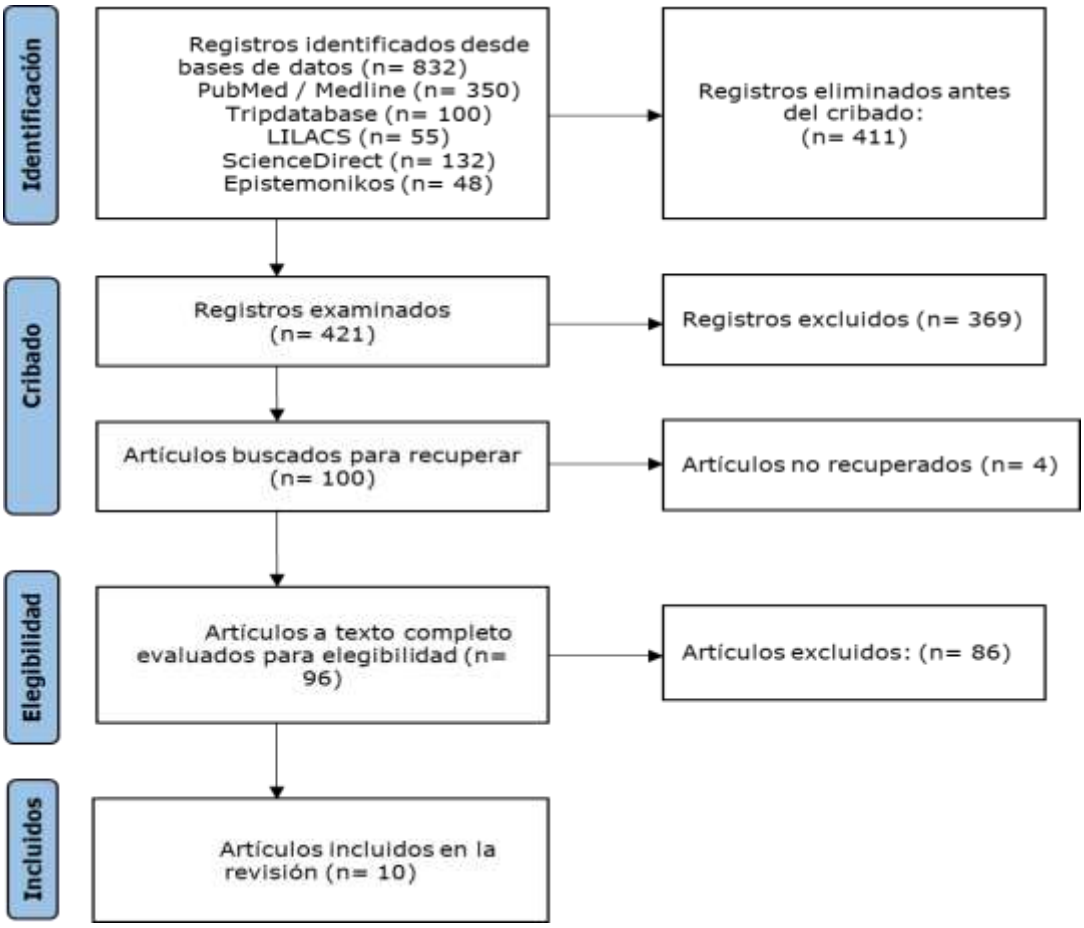

Fig. 1 Flowchart of the review developed.

DEVELOPMENT

The mechanical stress applied to the dental crown during orthodontic treatment triggers a series of biological responses in the periodontal tissues. This mechanical stimulus causes remodeling of the periodontal ligament and alveolar bone, processes essential for dental movement to occur. The pressure applied in certain areas generates osteoclastic activity responsible for bone resorption, while in areas of tension, osteoblastic activity is stimulated, favoring the formation of new bone tissue.[10]

From a biological perspective, remodeling induced by orthodontic forces is regulated by a complex network of inflammatory mediators secreted mainly by fibroblasts and periodontal ligament cells. Cytokines such as IL - 1β, IL - 6, TNF - α, and prostaglandin E2 (PGE2) play an essential role in osteoclastic activation and in modulating the balance between bone resorption and apposition, thus facilitating controlled dental movement. These mechanisms have been widely described in the literature, confirming the involvement of the inflammatory system and cellular signaling in periodontal remodeling induced by mechanical forces.[11,12]

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Photobiomodulation has gained a prominent role in various clinical areas due to its ability to modulate biological processes without generating thermal damage. This type of laser, also known as bio - stimulation laser, therapeutic laser, cold laser, or soft tissue laser, acts through the interaction of light with cellular components, promoting specific physiological responses. Its theoretical basis is the Arndt - Schultz law, which states that low - intensity stimuli produce bio - stimulatory effects, while high doses produce inhibitory effects. In the dental context, this dose - response relationship has allowed an understanding of how light energy can trigger regulated and beneficial processes in periodontal tissues.[13,14]

Numerous studies have shown that low - intensity laser therapy (LILT), also known as low - level laser therapy, contributes to accelerating orthodontic dental movement by optimizing bone remodeling mechanisms. Among the most relevant effects are the increase in the number of osteoclasts in pressure areas, greater proliferation of periodontal ligament cells, and stimulation in the formation of mineralized bone in tension areas. These changes favor a more dynamic remodeling of the alveolar bone, thereby reducing the total time required to achieve controlled dental movements. The evidence cited by Dantas et al.,[15] supports that photobiomodulation acts as an effective adjunct in orthodontics by improving the biological response of periodontal tissue to sustained mechanical forces.

The results of clinical trials of bio - stimulation and LILT radiation showed a reduction in discomfort and pain, accelerated healing of wounds and bones, and effective prevention of inflammatory processes. Clinical studies with LILT in orthodontic treatment have demonstrated accelerated dental movement and reduced orthodontic treatment time.[16,17,18] The effect of LILT irradiation in the orthodontic treatment of mice with suture - oriented expansion showed a maxillary regeneration of 20 % to 40 % compared to LILT intervention. This result largely depends on the dose, frequency of use, and treatment. Other studies have shown that molar movement interferes with LILT 30 % faster than LILT irradiation due to greater activity of bone remodeling cells.

El - sayed et al.,[19] conducted a clinical study evaluating gingival crevicular fluid with LILT to assess RANKL and OPG levels and found a slight improvement in OTM. They noted an increase in tooth movement at the beginning of their observation period, with a decrease to a slower rate than their control group at 30 - 45 days. Overall, the laser group exhibited greater accumulated tooth movement with a change in movement rate similar to that observed in animal studies.

Various researchers have employed a broad spectrum of wavelengths in laser therapy for orthodontic applications, generally within the range of 600 to 1000 nm, using devices such as diode lasers, Ga - Al - As lasers, and He - Ne lasers. These devices have been applied with energy densities varying between 0,04 and 60 J/cm², reflecting the heterogeneity of existing protocols. Despite these variations in operating parameters, studies coincide in reporting favorable results both in pain modulation and in facilitating dental movement, suggesting that laser - induced bio - stimulation is effective within a relatively wide range of doses and wavelengths.[20,21]

Recent advances in photobiomodulation have allowed a more precise understanding of how light energy interacts with mineralized tissues, which has direct implications for orthodontic dental movement. The systematic review by Lopes et al. demonstrated that photobiomodulation favors human bone regeneration by increasing cell proliferation, osteoblastic differentiation, and mineral matrix deposition. These effects depend on specific parameters such as wavelength, energy density, and application frequency, confirming that light acts on key intracellular pathways, particularly the activation of cytochrome c oxidase and the increase in mitochondrial ATP. Together, these mechanisms support the ability of photobiomodulation to optimize physiological bone remodeling, an essential process for efficient dental movement.[22]

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In a broader clinical context, Glass,[14] highlights that photobiomodulation is capable of modulating complex tissue responses, including reducing edema, improving cellular metabolism, and accelerating the repair of soft and hard tissues. This author emphasizes that low - intensity light therapy not only promotes faster recovery but also reduces the need for pharmacological analgesic interventions. Applied to the orthodontic context, these findings explain why patients subjected to laser irradiation experience less pain perception and a more controlled inflammatory response, factors that contribute to a more comfortable clinical experience and improved patient cooperation during treatment.

Finally, the convergence between experimental, clinical, and systematic review evidence suggests that photobiomodulation constitutes a promising adjunctive tool for modern orthodontics. Its ability to accelerate bone remodeling, modulate pain, and improve healing positions this technology as a high - value therapeutic complement, provided that appropriate dosimetric parameters and standardized protocols are used.[13,15,16]

The methodological limitations still present in the literature, such as dosing heterogeneity and small sample size in some studies, indicate the need for more robust research. However, the current consensus points to the fact that photobiomodulation can provide clinically significant benefits when properly integrated into orthodontic treatment plans.

CONCLUSIONS

This study demonstrates that low - intensity laser has obtained promising results in reducing orthodontic treatment time due to accelerated dental movement, as well as benefits in pain relief. It is considered a non - invasive and safe therapy. Therefore, low - intensity laser as an aid to good orthodontic mechanics will lead to a successful treatment.

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