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Major clinical outcomes of laser therapy in endodontic treatments: a systematic review

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Abstract

Introduction: In the setting of endodontic treatment, postoperative pain continues to be a problem in up to 58% of patients. This is due to the release of inflammatory mediators whenever the pulp or periradicular tissues are injured during root canal treatment or retreatment. The application of lasers in endodontics has increased due to their safety and effectiveness in dental treatments. **Objective:** It was to develop a systematic review to present the main clinical outcomes of the use of laser therapy in endodontic treatments. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from December 2023 to January 2024 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 98 articles were found, 35 articles were evaluated in full and 20 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 21 studies with a high risk of bias and 26 studies that did not meet GRADE and AMSTAR-2. Most studies did not show homogeneity in their results, with X^2=72.7% <50%. It was concluded that low-level laser therapy has been used in endodontics to promote analgesia, modulation of inflammation, and tissue healing. Analgesia mediated by low-level laser therapy results in vasodilation, and increased levels of adenosine triphosphate and cortisol, inhibiting the production of inflammatory factors. Recent studies reported that the use of low-level lasers enabled the treatment of post-endodontic pain compared to control. Furthermore, studies have shown that laser therapy can increase collagen synthesis and, concerning bone, modulate inflammation, accelerate cell proliferation, as well as stimulate bone stem cells, and accelerate their repair process.

Keywords: Endodontic treatment. Laser therapy. Low-intensity laser. Healing. Pain.

Introduction

In the setting of endodontic treatment, postoperative pain continues to be a problem in up to 58% of patients. This is due to the release of inflammatory mediators whenever the pulp or periradicular tissues are injured during root canal treatment or retreatment [1].

As a way of treating this, in 1970, laser therapy was introduced. The application of laser in endodontics has increased due to its safety and effectiveness in dental treatments, involving dentin hypersensitivity, removal of decayed tissues, dental preparations, pulp capping or pulpotomy, and root canal treatment [2,3]. In this context, the search for new devices and technologies for endodontic procedures has always been challenging. With the development of thinner, flexible, and durable laser fibers, laser applications in endodontics have increased [4].

In this scenario, the application of laser in endodontics for apicoectomy also stands out, including the effect on apical sealing, effect on dentin permeability, effect on postoperative pain, effect on fissure formation, effect on root morphology, effect on treatment outcome, and connective tissue response to laser-treated dentin [1,5].

The etiology of postoperative endodontic pain is multifactorial and can be induced by inflammatory mediators produced by chemicals, and mechanical or microbial injuries to the pulp and periapical tissues. Low-level laser therapy has been used in dentistry to promote analgesia, modulate inflammation, and tissue healing. Analgesia mediated by low-level laser therapy results in vasodilation, and increased levels of adenosine triphosphate (ATP) and cortisol, inhibiting the production of inflammatory factors. There is also an increase in the synthesis of endogenous endorphins, a reduction in the synthesis of bradykinin, a reduction in the release of histamine, and changes in the synthesis of prostaglandin. Recent studies reported that the use of low-level lasers enabled the treatment of post-endodontic pain compared to control [6].

Still in this context, the use of laser therapy (photobiomodulation), which uses non-ionizing, or infrared, light to stimulate tissues, cells, and molecules at a systemic level, stimulates microcirculation with an increase in the production of ATP, nitric oxide (NO) and reactive oxygen species (ROS) [7,8]. This low-intensity application provides patient comfort due to the associated anti-inflammatory, analgesic, and healing properties [9-11].

Thus, the effect of laser therapy improves vascularization, increases collagen synthesis, and, concerning bone, modulates inflammation and accelerates cell proliferation [1]. Also, it has been shown that laser therapy stimulates bone stem cells and accelerates their repair process [12]. However, to make laser therapy more promising, it is important to limit its exposure time [1].

Therefore, the present study aimed to develop a systematic review to present the main clinical outcomes of the use of laser therapy in endodontic treatments.

Methods

Study Design

The present study followed the international systematic review model, following the rules of PRISMA (preferred reporting items for systematic reviews and meta-analysis). Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 01/20/2024. The methodological quality standards of AMSTAR-2 (Assessing the methodological quality of systematic reviews) were also followed. Available at: https://amstar.ca/. Accessed on: 01/20/2024.

Data Sources and Research Strategy

The literary search process was carried out from December 2023 to January 2024 and was developed based on Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various eras to the present. The descriptors (MeSH Terms) were used: *"Endodontic treatment. Laser therapy. Low-intensity laser. Healing. Pain"*, and using the Boolean "and" between the MeSH terms and "or" between historical discoveries.

Study Quality and Risk of Bias

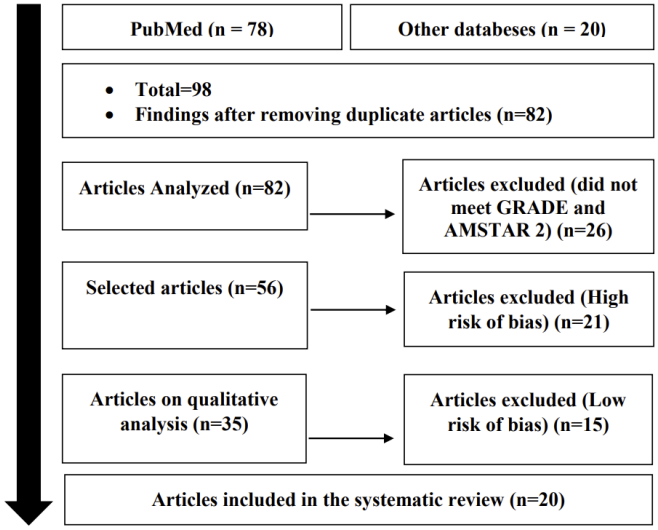
Quality was classified as high, moderate, low, or very low in terms of risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. The 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 the Cohen test (d).

Results and Discussion

Summary of Findings

A total of 98 articles were found that were subjected to eligibility analysis, with 20 final studies being 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. The biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies showed homogeneity in their results, with X^2=72.7%<50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 21 studies with a high risk of bias and 26 studies that did not meet GRADE and AMSTAR-2.

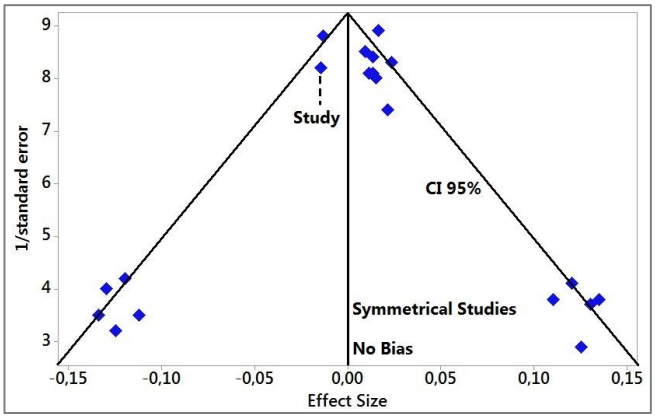
Figure 1. Article selection - exclusion process.



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 the Cohen 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 between studies with a small sample size (lower precision) that are shown at the bottom of the graph and in studies with a large sample size that are presented at the top.

Figure 2. The symmetric funnel plot suggests no risk of bias among the small sample size studies that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n=20 studies).



Source: Own authorship.

Major Clinical Outcomes

As a corollary of the literary findings, it was evidenced that regenerative endodontic procedures were used to recover the vitality of the dental pulp, to avoid the undesirable results of conventional endodontic treatment, and to promote the formation of dentin. Photobiomodulation therapy offers photobiological and photochemical effects to improve root canal conditions by compensating oxidative stress increasing blood supply to implanted stem cells and improving their survival. Photobiomodulation therapy can modulate the differentiation, proliferation, and activity of human dental pulp stem cells, and subsequent tissue activation [13].

Furthermore, cases of root canal retreatment are associated with several iatrogenic errors, such as edge formation, incomplete biomechanical preparation, file separation, and incomplete filling. These iatrogenic errors lead to defective niches within the root canals that can act as reservoirs for various viable microorganisms, causing postoperative pain even after complete debridement and remodeling of the canals. Prevention of postoperative pain in retreatment cases and prognosis are effectively managed by photobiomodulation therapy. Thus, a systematic review study indicated a positive impact by significantly reducing postoperative pain in cases of root canal retreatment when treated with photobiomodulation. Photobiomodulation or low-level laser therapy has shown superior results compared to the conventional pharmacological approach in treating postoperative pain in cases of root canal retreatment [14].

Added to this, low-intensity laser can be used to treat muscle fatigue due to its ability to produce reactive oxygen species and improve the function of mitochondria. A randomized clinical study analyzed the effectiveness of low-level laser therapy in managing masticatory muscle fatigue caused after long endodontic procedures under local anesthesia. A total of 44 patients complaining of reduced mouth opening and pain during mouth opening after long endodontic therapy were included. In the study group, the low-power laser was applied while patients in the control group did not receive any therapy. When the two groups were compared, a statistically significant reduction in fatigue was found. Low-power laser can be a useful procedure immediately after prolonged endodontic procedures causing masticatory muscle fatigue [15].

The authors Karkehabadi et al. (2023) [16] evaluated the effects of laser therapy and photobiomodulation on the proliferation and differentiation of human dental pulp stem cells through a systematic review. The results indicated the useful effect of low-level laser therapy on human dental pulp stem cells.

Also, a randomized clinical study compared the effect of ozone and low-level laser therapy (LLLT) on postoperative pain after root canal treatment in symptomatic apical periodontitis in vital teeth. A total of 80 patients were divided into four groups [LLLT placebo (simulation of laser therapy)], LLLT, ozone placebo, and Ozone. Postoperative pain levels for 7 days after treatment and percussion pain levels on the 7th day were recorded on the visual analog scale. Pain in the lower jaw is higher than in the upper jaw. There was a difference between the groups regarding postoperative pain on days 1, 2, and 3; however, there was no significant difference on other days. The LLLT and ozone groups had less postoperative pain and percussion pain [17].

A prospective study of 76 patients analyzed the possible benefits of low-level laser therapy on soft and hard tissue healing after endodontic surgery. The laser group showed better results in edema, wound healing, and the number of analgesic tablets used on the 1st, 3rd, and 7th postoperative days. A significant reduction in bruising was observed in the laser group on the 3rd

and 7th postoperative days. Patients had significantly less pain on the first and third postoperative days in the laser group. Therefore, laser therapy improved the healing of soft and hard tissues after endodontic surgery and also showed favorable effects on patients' pain and quality of life, especially in the early phase of the healing period [18].

Furthermore, new alternative treatment modalities have been proposed, including high-power lasers and antimicrobial photodynamic therapy (aPDT). Therefore, a systematic review study evaluated the outcome of root canal disinfection about the effectiveness of various treatment modalities. The study concluded that combining aPDT with antimicrobial irrigants can provide a synergistic effect. However, there is a lack of standardized protocols [18].

Added to this, a study investigated the effect of a placebo, intracanal diode laser application, and low-level laser therapy on changing the total amount of calcitonin gene-related peptide (CGRP) in gingival fluid (GCF) in the placebo group, changes of total CGRP level in GCF before and after treatment were significantly greater for experimental teeth than for control teeth. However, there was no significant difference between the experimental and control teeth in the intracanal laser application and low-intensity laser groups. Thus, intracanal laser application and low-intensity laser therapy have immunomodulatory effects linked to the modulation of the total amount of CGRP in the GCF [19].

A study evaluated and compared the clinical and radiographic success rates of low-intensity laser therapy and formocresol (FC) for pulpotomy in primary teeth. A total of 106 primary molars from 36 children aged five to eight years were included. At six months, the clinical success rate was 98 percent for each group. Radiographic success was 100% for the low-intensity laser group and 98% for the FC group. At 12 months, both groups showed a clinical success rate of 96.1%. Radiographic success at 12 months was 100% and 98% for low-level laser and FC, respectively. Thus, both low-level laser therapy and formocresol pulpotomy techniques have shown favorable clinical and radiographic results in human primary molar teeth over 12 months [20].

Finally, a systematic review study evaluated the influence of low-intensity laser therapy on postoperative pain after endodontic treatment. Twelve studies were included in the qualitative synthesis. Six studies evaluated postoperative pain after primary root canal treatment, two studies after root canal retreatment, and four after periapical surgery. Most studies reported significantly less postoperative pain after low-level laser therapy at different periods [6].

Conclusion

It was concluded that low-level laser therapy has been used in endodontics to promote analgesia, modulation of inflammation, and tissue healing. Analgesia mediated by low-level laser therapy results in vasodilation, and increased levels of adenosine triphosphate and cortisol, inhibiting the production of inflammatory factors. Recent studies reported that the use of low-level lasers enabled the treatment of post-endodontic pain compared to control. Furthermore, studies have shown that laser therapy can increase collagen synthesis and, concerning bone, modulate inflammation, accelerate cell proliferation, as well as stimulate bone stem cells, and accelerate their repair process.

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Not applicable.

Ethical Approval

Not applicable.

Informed consent

Not applicable.

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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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