ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2023; 9(3): 236-240

www.oraljournal.com
Received: 20-04-2023
Accepted: 22-05-2023

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Low-level laser therapy in dentistry

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DOI: https://doi.org/10.22271/oral.2023.v9.i3d.1811

Abstract
Introduction: Dental pain leads to reduced daily activities and poor quality of life, low level laser therapy (LLLT) is considered a recent technique in the dental field.
Objective: To analyze the literature about the use of LLLT, its applications for pain control, inflammation and the controversy of its benefits in the different branches of dentistry such as Endodontics, Periodontics, Orthodontics and Photobiomodulation.
Methodology: An extensive literature search was carried out in the PubMed, SCOPUS and Google Scholar databases, analyzing the keywords: LLLT, laser therapy, photodynamic therapy, phototherapy.
Results: Post-endodontic treatment pain manifests itself after root canal treatment, but the use of LLLT promotes analgesia, modulation of the inflammatory process, as well as healing of the surrounding tissues. Pain could be considered a major concern in orthodontic practice, the application of the LLLT to accelerate tooth movement is applied immediately after the application of force. Photodynamic therapy is a new alternative therapy in periodontal treatments, since it presents antimicrobial effects, elimination of endotoxins secreted by microorganisms and reduces the biological activity of cells responsible for the production of proinflammatory cytokines. At present, photobiomodulation is one of the fastest growing areas in biomedical science, laser light and LED induce an effect to accelerate healing, ATP synthesis and improve the differentiation capacity of cells.
Conclusion: In the area of dentistry, the therapeutic laser has biostimulating properties causing that post-treatment pain and surgical procedures present a significant decrease.

Keywords: LLLT, laser therapy, photodynamic therapy, photobiomodulation, phototherapy

1. Introduction
According to the International Association for the Study of Pain, it is defined as an unpleasant sensory and emotional experience, associated with actual or potential tissue damage [1]. The impact of dental pain shows a social gradient, inequalities between socioeconomic groups should be considered, as the impact of dental pain leads to reduced daily activities and poor quality of life [2].
Low Level Laser Therapy (LLLT) is considered a recent technique in the dental field, it is used by many clinicians in dentistry [3]. The first step on the path to laser development was a paper published in 1917 by Albert Einstein in which he presented the idea of "stimulated emission" as part of his quantum theory. Incoherent light is produced by the effort of electrons to spontaneously regress from an excited to a lower energy state and release energy in the form of photons [4]. LLLT, also known as "soft laser therapy," has been applied in medicine for more than three decades. Low-level lasers emit short-wavelength red or infrared light with low water absorption power that can reach a depth of 3 mm to 15 mm in both soft and hard tissues [5]. The laser could be defined as a device that produces light energy through a process of optical amplification according to the stimulated emission of electromagnetic radiation. It is considered a great innovation that serves many fields, including medicine, surgery, dentistry, and cosmetics [3].
In this work we analyzed the literature on the use of LLLT, its different applications for pain control, inflammation and the controversy of its benefits in different branches of dentistry such

as Endodontics, Periodontics, Orthodontics, as well as in Photobiomodulation.

2. Materials and Methods

Articles on the subject published through the PubMed, SCOPUS and Google Scholar databases were analyzed, with emphasis on the last 5 years. The quality of the articles was evaluated using guidelines, i.e., identification, review, choice and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews. The search was performed using Boolean logical operators AND, OR and NOT, with the keywords: "LLLT", "phototherapy", "photobiomodulation", "photodynamic", "laser therapy". The keywords were used individually, as well as each of them related to each other.

3. Results and Discussion

3.1 Endodontics

The success of endodontic treatment directly depends on a number of factors, including proper root canal disinfection [6].

3.1.1 LLLT in the inflammatory process

LLLT can modulate inflammatory processes and reduce acute inflammatory pain by reducing, in a dose-dependent manner, prostaglandin levels E2, IL1-beta, TNF-alpha, oxidative stress, edema and decreases the frequency of nociceptor activation of peripheral nerve signals [7].

Clinical reports and animal experiments indicate that laser therapy promotes wound healing by accelerating collagen synthesis [8,9]. This is consistent with previous reports that have demonstrated elevation of several metabolic rates of fibroblast proliferation of ATP synthesis and collagen synthesis, as well as increases in biomechanical rates of tissue healing [10,11].

3.1.2 Post-treatment pain

Post-endodontic pain is considered to be that discomfort that manifests after root canal treatment and that can affect between 3 -58% of patients [12]. The etiology is variable, caused by mediators of inflammation due to chemical, mechanical factors or injuries to periapical tissues but the use of LLLT promotes analgesia, modulation of the inflammatory process, as well as healing of surrounding tissues [13], reduces postoperative pain in retreatment [14], and has been used after endodontic surgery having a statistically significant effect on the reduction of postoperative pain [15].

3.1.3 Photodynamic therapy

Photodynamic Therapy (PDT) provides advantages such as immediate effect, selectivity, scope to complex anatomical areas and lower risk of bacteremia [16], can provide maximum disinfection in the root canal and reducing the bacterial load between 91.3% and 100% [17].

Combining PDT with conventional root canal treatment can shorten the healing period of periapical lesions while reducing the need to apply calcium hydroxide [18].

LLLT therapy promotes a repair of periapical tissues and thus prevent the patient from presenting symptoms after endodontic treatment thanks to its anti-inflammatory properties and pain control.

3.2 Orthodontics

3.2.1 Pain

Patients undergoing orthodontic treatment may also experience significant levels of pain because it is a fixed braces therapy [19]. The assessment of pain levels using the visual analogue scale is a subjective method, but it is also one of the best available methods for assessing pain perception, used in several studies in the literature. The analogue pain scale is a widely accepted, sensitive and reliable method for measuring pain intensity [20]. Pain could be considered a major concern in orthodontic practice, as it can discourage patients from treatment [21]. In addition, orthodontic pain seems to be unavoidable, as it is induced by the movement of the teeth during treatment. Although analgesics appear to be an effective method for pain control, pharmacological actions and adverse effects should be of concern [22].

The diode laser wavelength of 658nm to 980nm were the most found ranges in the literature however the most common was 810nm and in clinical terms the follow-up application was at 3, 7 and 14 days for the first month and then every 15 days. The radiation points were variable from 2 to 10 points, where 10 points was the most common making an application on the buccal and lingual/palatine surface and the exposure time was variable from 10 to 300sec and the emitted energy of 25 J/cm2 [23].

3.2.2 Acceleration of orthodontic movement

The application of LLLT to accelerate tooth movement was applied immediately after the application of force. The radiation points for each point were variable according to the literature from 2 to 16 where 6 and 10 points were the most common [23].

Application of low-level laser therapy to the condylar regions accelerated functional treatment in patients with skeletal class II malocclusion by approximately 45% and increased bone growth and mandibular length [24]. The combination of laser irradiation for surgical exposure of impacted teeth can provide a successful approach and better periodontal, occlusal and aesthetic outcomes can be achieved, especially in young patients [25].

3.2.3 Uses in surgery

LLLT in its orthognathic surgery applications, it was possible to determine the effect of the laser on pain control after surgery since in evaluated studies they observed a positive effect, however, there was a discrepancy regarding the laser application protocols [26].

The use of laser in orthodontics can help patients who suffer from pain during their treatment due to the force that is generated to the periodontal ligament derived from the different types of appliances that are used; thus reducing the discomfort generated by the patient.

3.3 Periodontics

Periodontitis is an inflammatory disease of the gingiva and periradicular tissues initiated by pathogenic bacteria present in biofilms, releasing enzymes and triggering an immune mechanism, causing host-parasite interaction and subsequently, loss of attachment and bone loss [27]. It was found that if proper parameters are used when incorporating LLLT treatment such as photodynamic therapy they can be useful as an alternative therapy for periodontal disease [28].

3.3.1 Antimicrobial effect

Lately, the use of laser treatment as an adjuvant treatment modality combined with non-surgical periodontal therapy has gained importance and one of the treatments that can be used is PDT based on the activation of photosensitizing agents to produce oxygen free radicals and kill pathogens [29]. PDT not

only presents antimicrobial effects but also elimination of endotoxins secreted by Gram-negative microorganisms such as lipolysaccharides (*A. actinomycetemcomitans*) and also tends to reduce the biological and mononuclear activity of cells responsible for proinflammatory cytokine production [30].

3.3.2 Peri-implantitis

Peri-implantitis is a common complication after implant therapy and is the most important reason for dental implant failure. As there are few blood vessels in the connective tissue around the implant, the inflammatory reaction occurs as an immune response process, once the bacteria invade and break through the epithelial seal, it can reach the bone surface, causing the bone resorption to or migration of the implant [31]. Disinfection of the implant surface is considered a susceptible step in treatment, however, traditional mechanical instruments cannot fully contact the implant thread structures therefore it is difficult to achieve a satisfactory curative effect [31].

Current evidence shows that LLLT therapy in combination with surgical/non-surgical therapy provided good benefit in reduction in probing depth, clinical gain, improvement in recession and reduction in plaque index in the treatment of peri-implant disease [32].

Currently periodontal disease is very common in the population and is one of the main causes for which patients present loss of dental organs, the use of LLLT and its biostimulant properties together with the patient's good hygiene habits, helps the periodontal disease is controlled more effectively.

3.4 Photobiomodulation

Photobiomodulation (PBM) is now one of the fastest growing areas in biomedical science today. What used to be known as "low level laser therapy" was discovered over 50 years ago in 1967 by Endre Mester, working in Hungary [33].

3.4.1 Cellular effect

Laser and LED light induces a PBM effect that is used to accelerate healing, as it increases cell viability by stimulating ATP synthesis in mitochondrial and cell membrane photoreceptors [33]. Increased mitochondria membrane transport (ΔΨm), reactive oxygen species (ROS) and vesicles at a fluence of 5 J/cm2 in irradiated human adipose mesenchymal stem cells (hADSC). These results illustrated the regulation of cellular responses with respect to ΔΨm, ROS, and vesicle transport in irradiated hADSCs, which have potential in cell proliferation, migration, and differentiation in cell-based therapy [34]. PBM can enhance the differentiation capabilities of periodontal ligament cells. Using a near infrared wavelength of 940nm can produce a significant favorable result compared to the 630 to 830nm range which did as well. [35,36].

3.4.2 PBM and pain

A combination of LLLT and LED radiation on pain, swelling, and trismus after surgery on impacted third molars where pain levels on days 3 and 7 were significantly reduced. The level of trismus was lower on day 3 and inflammation was also lower between day 3 and 7 [37]. Photobiomodulation Therapy (PBMT) helps promote relief of postoperative pain and inflammation after surgical extraction of impacted mandibular molars. The results suggested that there may be a link between a decrease in salivary sIgA levels and a decrease in inflammatory processes after PBMT [38].

3.4.3 Implants LLL

PBM therapy shows a positive effect on implant stability at different intervals, especially during the early stages of healing, and is worth considering for dental implant patients. With laser becoming one of the most popular modalities in clinical dentistry and being available for many clinical settings now, its use to improve implant stability and healing can be of great benefit in implant dentistry [39].

3.4.4 Laser in oncology

The possibility of preventive use of the laser before and during chemotherapy and radiotherapy performed on the whole mucosa, significantly reduces the risk of advanced oral mucositis and reduces its duration. The proposed protocol: laser power of 10 to 150 mW, energy density of 2 to 4 J/cm^2 (no more than 6 J/cm^2), and exposure time of 20 to 60 s per point [40].

3.4.5. Tooth sensitivity

Dentinal hypersensitivity is an unpleasant experience characterized by brief, sharp dental pain in response to external stimuli [41]. Pain from dentin hypersensitivity often impedes oral hygiene and leads to plaque buildup and subsequent periodontal problems. Diode laser irradiation significantly reduced dentin hypersensitivity pain immediately after bonding, but no significant change was observed at 3 or 6 months [41]. LLLT may be indicated in the management of hypersensitivity in an adolescent with severe incisor-molar hypomineralization to control pain and improve their oral health-related quality of life [42].

PBM provides a non-invasive solution for a wide variety of pain management and applications using procedures that are quick, easy, and patient-acceptable.

4. Conclusions

In the area of dentistry, LLLT promotes tissue repair because PBM provides a non-invasive solution. It presents biostimulant properties in the areas of Endodontics, Orthodontics and Periodontics, promoting that post-treatment pain and surgical procedures are significantly decreased or null.

4.1 Conflict of Interest

Not available

4.2 Financial Support

Not available

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How to Cite This Article
JR Rivera, SE Nakagoshi Cepeda, JAG Longoria, JYG Silva, JE Arizpe Coronado, AL Reyes, EO Ortiz, JM Solis Soto. A comparison of DMFT, ICDAS II and CAST. International Journal of Applied Dental Sciences. 2023;9(3):236-240.