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APPLICATIONS AND EFFECTIVENESS OF LASERS IN PERIODONTOLOGY. A NARRATIVE REVIEW.

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Abstract
Lasers have developed to be a significant part in periodontal therapy. Its applications encompass many procedures such as removing calculus using Er: YAG and Er, Cr: YSGG lasers, excising and ablating soft tissue, making incisions, decontaminating root and implant surfaces, promoting tissue healing, reducing bacterial presence, and performing osseous surgery. Lasers offer a viable alternative for the simultaneous removal of damaged soft tissues, targeting micro-organisms, and stimulating wound healing. This study provides a comprehensive analysis of the utilization of lasers in dentistry practice and periodontics. It examines the benefits and drawbacks associated with their use, as well as the potential risks involved with employing lasers. The authors conducted a search on PubMed/Medline, Scopus, Embase, Cochrane Central, and Web of Science from the year 2013 to 2013.A total of 762 articles were retrieved and after exclusion, 13 relevant articles were included in the study.This sector is filled with numerous interesting opportunities for investigation and has the potential to be highly valuable in the context of Periodontics.
Keywords: Laser, periodontics, bacterial reduction, periodontal pocket

Introduction

The theoretical foundations for laser were established by Albert Einstein in 1917. The first working laser which was termed ruby laser was operated by Theodor Maiman in 1960 (Frame., 1985).The term "laser" is derived from the abbreviation "Light Amplification by Stimulated Emission of Radiation." Photonic therapy lasers have been utilized in periodontics since the 1980s, initially documented for their application in periodontal surgery (Nazemisalman et al., 2015). Periodontic lasers are categorized into two groups: high-power lasers and low-power lasers. High-power lasers (HPL) have applications in soft tissue and bone periodontal surgery, as well as for sulcular debridement of periodontal pockets and root cleansing. They can also be utilized as a technique for scaling and root planing (SRP). The lasers most commonly recommended for non-surgical periodontal treatment are neodymium-doped yttrium/aluminum/garnet (Nd: YAG; 1,064 nm), erbium-doped yttrium/aluminum/garnet (Er:YAG; 2,940 nm), erbium, chromium-doped yttrium/scandium/gallium/garnet (Er,Cr:YSGG; 2,780 nm), and high power semiconductor diode laser (DL) (808-904 nm). The impact on root surfaces has been investigated in many research using carbon dioxide lasers (CO2), Nd:YAG, diode laser, Er: YAG, and Er,Cr:YSGG (Bains et al., 2010). Low-level lasers (LLL) are extensively employed in periodontics for their ability to induce tissue photobiomodulation (PBM), which aims to decrease inflammation, expedite surgical wound healing, and alleviate pain. Furthermore, they serve as a light source to stimulate the photosensitizing dyes (photosensitizers) employed in antibiotic Photodynamic Therapy (APDT), a treatment that has been extensively utilized in periodontics since the 2000s. Photobiomodulation (PBM) is a therapeutic approach that utilizes light within the visible or infrared range, generated by a laser or LED, to diminish inflammation, manage pain, and accelerate the healing process.The main impact of this substance is observed in the cellular respiratory chain, leading to enhanced vascularization (angiogenesis), regulation of the immunoinflammatory response, and expedited healing in the treated region (Coluzzi et al., 2005). Despite the global prevalence of lasers in periodontal treatment for various conditions, multiple systematic review studies have failed to establish their clinical benefits (Petrovic et al., 2018). Additionally, other studies have raised doubts about their effectiveness and clinical advantages, particularly when used as a supplementary procedure (Aoki et al., 2008). These studies have found no significant long-term clinical benefits in terms of improving periodontal clinical parameters, leading to a recommendation against their use in periodontics. This article aims to examine the primary scientific evidence about the utilization of various lasers in periodontics and assess the level of scientific evidence in studies that have evaluated the usage of lasers in this field. Hence, the objective is to elucidate the benefits and constraints of employing photonic therapy in periodontal treatment to the scientific community. When utilized with appropriate parameters, this therapy can serve as a viable alternative or supplementary treatment option due to its high clinical applicability, safety, and ease of use for healthcare professionals.

Methodology

The search method was established by defining the keywords using searches in the MESH descriptors. The authors conducted a search on PubMed/Medline, Scopus, Embase, Cochrane Central, and Web of Science using various terms and combinations such as "Periodontitis," "Chronic Periodontitis," "Periodontal disease," "Photochemotherapy," "Photodynamic therapy," "Lasers," "Photobiomodulation Therapy," "Low-Level Laser Therapy," "Nd-YAG lasers," "CO2 lasers," "Carbon dioxide laser," "Er-YAG laser," "YSGG laser," and "diode lasers." A comprehensive examination of the studies was conducted for each topic and type of laser or periodontal treatment. Additionally, a thorough examination of the systematic reviews and meta-analysis publications was conducted spanning from 2010 to August 2023. A total of 762 articles were retrieved and after exclusion, 13 relevant articles were included in the study.

Discussion

The use of lasers in dentistry is extensive and extends beyond dentists alone. Oral and maxillofacial surgeons, ear nose throat surgeons, and dermatologists frequently utilize it, particularly in cases involving many disciplines. Researchers have observed that the utilization of lasers decreases the proliferation of harmful bacteria in periodontal pockets and diseased areas, as well as a decrease in swelling (Green et al., 2011). The qualities of a laser that determine its impact on tissues are reflection, transmission, absorption, and scattering. Reflection and scattering pose a risk to the operator's eyes, perhaps leading to harm. Transmission occurs from a superficial layer of tissue to a more profound region. Improper usage of this can potentially cause harm to the tissues beneath. The intended outcome is the absorption of energy in laser treatment of specific tissues, where the energy is efficiently absorbed due to the collimation property as it propagates as a focused beam. The absorption will also be influenced by the presence of chromophores, such as water or pigment. The laser primarily induces an oxidative-reduction reaction, resembling the liberation of free radicals, resulting in cellular alkalinization and the restoration of normal morphological features.The fundamental role in every cellular action is the augmentation of adenosine triphosphate synthesis within the mitochondria, which serves as the reservoir of energy in eukaryotic cells. This is achieved by the inhibition of cytochrome by nitric oxide. The low-level laser treatment involves supplying laser energy to stimulate cellular production of adenosine triphosphate (ATP), which serves as the foundation of the photochemical theory and is presently widely accepted. The laser energy's capacity to stimulate the generation of photoreceptors, specifically cytochrome c-oxidase, will result in an augmentation of ATP synthesis (Martens et al., 2011). Laser technology is currently employed throughout a spectrum of wavelengths, spanning from 488 to 10,600nm, all falling within the nonionizing radiation category (Dang et al., 2013). The lasers have advantageous effects and do not cause harm, such as tissue death, genetic changes in DNA, and breakdown of materials outside of cells. A subset of the lasers operates within the range of wavelengths that are detectable by the human eye, known as the visible spectrum. Argon emits light with a wavelength of 488nm, resulting in a blue color. It is employed in the process of teeth bleaching. It emits light at a wavelength of 514nm, which corresponds to the color green (Da Micheli et al., 2011). The Nd:YAG laser emits light at wavelengths of 532nm and 655nm, which appear as green light. Additionally, it can generate blue light for the purpose of detecting caries. Diodes operate within a wavelength spectrum of 810, 930, 980, and 1064nm. The 810nm surgical diode laser falls within the wavelength range of 800 to 830nm. The erbium YAG laser operates at a wavelength of 2940nm, while the Er, Cr:YSGG laser operates at a wavelength of 2780nm. The carbon dioxide (CO_2) and the nonionized variant operate at wavelengths of 10,600 and 9,300 nanometers, respectively.

Laser-assisted gingivectomy and osteotomy:

Laser-assisted gingivectomy is advocated for the dual aims of enhancing appearance and facilitating dental restoration. Out of the publications that were obtained, 8 research employed high intensity lasers for gingivectomy. Four studies utilized a 940 nm diode laser for gingivectomy. These studies revealed successful healing, reduced pain and discomfort, decreased bleeding, with minimal requirement for sutures and painkillers, and maintenance of stable soft tissue margins. A study examined the potential harm caused to pulp tissue by a 940 nm diode laser. It found that the rise in pulpal temperature remained below the critical threshold throughout laser exposure lasting 10, 20, and 40 seconds. Among the two trials that utilized an 810 nm diode laser, one study found no notable distinction between laser-assisted gingivectomy and conventional gingivectomy (Straussa et al., 2006). However, when compared to a group receiving non-surgical treatment, the laser group exhibited a substantial reduction in periodontal pocket depth after a 6-month period. Relapse occurred after 3 months in the group that did not get surgical treatment. A different study series found no instances of significant bleeding and observed minimal pain levels in the group treated with a 940 nm diode laser. A different study conducted a case series using a diode laser with dual wavelengths (810 + 980 nm) and found that patients experienced low discomfort, experienced excellent recovery, and achieved a satisfactory esthetic result (Yan et al., 2018). Two more investigations employed 808 nm and 975 nm diode lasers and documented successful healing with minimal discomfort and recurrence rates after 1 year of follow-up were modest as well (Qadri et al., 2015;Schwartz et al., 2001). A comparative analysis was conducted utilizing a 980 nm diode laser and electrocautery. The study found no notable disparity in terms of the average duration of the procedure, bleeding, healing, pain, or self-restriction of the disease. Both groups experienced charring, although the likelihood of charring was higher in the laser group. A study employed Nd:YAG and Er:YAG lasers in an autofluorescence-guided surgical method, yielding remarkable results including complete mucosal healing and the alleviation of symptoms. This treatment, characterized by its great precision and little invasiveness, proved to be highly effective. Two investigations employed the Er,Cr:YSGG laser and documented reduced operative time, expedited healing, absence of bleeding or pain, and a high degree of post-surgical comfort. A different investigation employed the Er:YAG laser technique for crown lengthening, incorporating osteotomy, and documented satisfactory outcomes. Two studies conducted a comparison between the use of an Er:YAG laser and a bur for the extraction of mandibular third molars. One participant in the laser group reported a notable reduction in discomfort, edema, and trismus. Conversely, the other one did not see any noteworthy disparity in terms of pain, bleeding, swelling, healing, or problems. The duration of laser-assisted osteotomy was twice as long as the time required for cutting bone using a bur. A separate study conducted a comparative analysis of three distinct techniques, namely Er:YAG laser, piezosurgery, and rotary systems, for performing osteotomy in the mandibular bone during the extraction of third molars. There were no notable disparities observed among the groups regarding pain, trismus, edema, or postoperative healing. However, it is worth mentioning that the rotary group experienced a prolonged duration of pain. The laser group had the longest duration of operation, whereas the rotary group had the shortest duration. The researchers determined that both piezosurgery and Er:YAG laser are viable alternatives to rotary instrument systems for extracting third molars. However, neither of these techniques demonstrated clear superiority over the rotary system during the initial period of postoperative recovery (Ma et al ., 2018).

Laser-assisted frenectomy

Laser assisted frenectomy is performed on dental patients to reduce the pain and discomfort typically experienced during a standard periodontal frenectomy. A comprehensive review was conducted on a total of 21 articles in this regard. Four publications were published that utilized a 1064 nm Nd:YAG laser for laser-assisted frenectomy, in comparison to the traditional scalpel procedure. The findings demonstrated reduced intraoperative and postoperative hemorrhaging, less requirement for suturing, and fewer functional issues related to mastication and speech, along with a decrease in surgery duration. Unlike three of these trials, a comparative research found no statistically significant disparity in pain levels between laser surgery and conventional surgery. Out of the six research that utilized a 980 nm diode laser for frenectomy, three studies conducted a comparison between laser surgery and the conventional approach. Two investigations saw a notable augmentation in the width of keratinized gingiva, width of attached gingiva, and thickness of attached gingiva (Hamblin et al., 2017). However, there was no discernible distinction between the laser surgery group and the conventional group. The laser-treated group likewise reported low discomfort and functional difficulties. All six investigations documented uneventful recovery, with minimal or absent postoperative problems such as pain, edema, and bleeding, and notably improved healing results.

A comparative study was conducted to evaluate the efficacy of a 980 nm diode laser and a 10600 nm CO_2 laser for frenectomy. The utilization of the CO_2 laser resulted in accelerated wound healing, reduced gingival recession, and decreased bleeding in comparison to the diode laser. After utilizing the 980 nm diode laser, there was a notable enhancement in clinical attachment loss and a substantial reduction in periodontal pocket. However, no significant alteration in clinical attachment loss was found in the CO_2 laser group. Both techniques successfully reduced pain, however, the diode laser provided faster pain relief. A study employed an 810 nm diode laser and documented the absence of bleeding after surgery and a minimum requirement for pain-relieving medications in youngsters. In a separate investigation, the efficacy of an 810 nm diode laser was compared to that of traditional surgery. The results indicated that there were no difficulties in the healing process, no instances of recurrence, and comparable probing depth in both treatment groups. However, the group treated with the laser had much lower plaque index and gingival index scores. A separate study employed an 808 nm diode laser in comparison to standard treatment, and observed a noteworthy reduction in pain score and discomfort, along with a high level of satisfaction among the laser group. Two further investigations employed an 880 nm diode laser in conjunction with a 606 nm low-level laser for the purpose of photo-biomodification. These studies demonstrated outstanding outcomes and minimal discomfort after the surgical procedure. A comparison study was conducted using a 940 nm diode laser and an Er,Cr:YSGG laser. The study found no significant difference between the two groups, however the wound surface area was smaller in the Er,Cr:YSGG laser group after one week. Additional research employed a 2940 nm Er:YAG laser and a 2780 nm Er,Cr:YSGG laser for the purpose of performing frenectomy. The patient experienced successful surgical recovery with no recurrence and minimal pain. A comparative study examined the efficacy of 2940 nm Er:YAG laser treatment vs traditional surgery and concluded that there was no statistically significant disparity in the production of scar tissue. The laser group exhibited greatly reduced operation time and bleeding time. Immediately following the surgery, the wound size was considerably greater in the group that received laser treatment. However, no disparity was observed after a period of 5 days (Akram et al., 2019).

Conclusion

Lasers are being considered as a supplementary or alternative option to traditional treatments, like using a surgical scalpel, for both hard and soft tissue procedures in periodontology. This is because lasers can remove tissue with minimal pain, swelling, and discomfort. They also result in shorter surgical time, less need for sutures and anesthetics, improved wound healing, reduced bleeding, detoxification effects, and a clean surgical site. These advantages may not be present with traditional treatments. The utilization of this novel advancement in contemporary dentistry ought to be founded on the substantiated advantages.CO2 lasers with a wavelength of 10600 nm, Nd:YAG lasers with a wavelength of 1064 nm, Er,Cr:YSGG lasers with a wavelength of 2780 nm, and diode lasers with wavelengths of 808, 810, 940, 975, and 980 nm are highly beneficial for doing soft tissue treatments. Based on the majority of research, combining laser application with conventional periodontal therapy does not appear to offer any substantial advantages compared to conventional treatment alone. Erbium lasers exhibit the most favorable and appropriate attributes for performing treatments on both soft and hard tissues. Although lasers have yielded excellent outcomes in the field of periodontology, it is important to take into account the necessity for further education, the relatively expensive expenses, and the varying characteristics of different wavelengths when implementing a safe and beneficial technique.

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