LASER IN PERIODONTOLOGY: A REVIEW OF THE FIELDS OF APPLICABILITY AND THERAPEUTIC EFFECTS

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Abstract:
Lasers have multiple applications in periodontology, such as periodontal surgery and biostimulation adjuvant therapy for tissues affected by periodontal disease. Both high-power lasers such as Nd:YAG, Er:YAG, Er,Cr:YSGG or CO2, as well as low-power lasers like diode lasers, have demonstrated their applicability in the periodontal field over time, in surgeries with or without flaps, periodontal pocket decontamination or bone grafting interventions. In the treatment of peri-mucositis and peri-implantitis, the Er:YAG laser as well as the low-power diode laser produce beneficial effects for decontamination of implant surfaces without affecting the implant or soft tissue surrounding it. The property of stimulating cellular components and their modulation by the light source, led to the development of the photobiomodulation therapy concept, with anti-inflammatory, anti-allergic healing, and stimulation effects of cell growth factors. Emerging trends in this field are the use of laser in multiple periodontal surgery procedures, regeneration of soft and hard oral tissues, but also in stimulating the orthodontic tooth movement with anti-inflammatory and analgesic effects. The purpose of this article is to review the techniques of laser therapy used in the periodontal field and its effects on the soft and hard tissues.

Keywords: periodontology, laser, peri-implantitis, periodontitis, photobiostimulation, orthodontic tooth movement

1. Introduction
LASER is the acronym for “light stimulated by radiation emission” and was first introduced into Periodontology in the 1990s as a method of diagnosis and surgical treatment [1-3]. This device emits light in a small and non-divergent intense beam, with enough energy to cut through both hard and soft tissues. A review of current literature was commenced in order to debate the effects of laser therapy and its current usage in Periodontology. PubMed online research was conducted in order to identify articles regarding this subject using the keywords “laser”, “periodontology” and “periodontal disease”. Manual searches of published articles and related reviews were performed.
as well for completing the research necessary in writing this paper. The laser effect depends on both the energy absorption capacity of the target tissue and the energy emitted. This energy is absorbed, reflected, dispersed, and transmitted into the tissues by heating, coagulating, or vaporizing them according to the intensity of the energy. [1] [4]. The laser has multiple applications in periodontology and oral implantology both surgically and as an adjuvant periodontal or biostimulation therapy [1, 5-8]. in gingivectomy surgeries and dental crown lengthening [1, 9,10], as well as in the decontamination of dental implants in peri-implantitis [1, 5,11].

The use of laser devices has widely and constantly spread in the field of oral surgery as laser devices have evolved technologically. This stems from the fact that recently emerged lasers with wide range wavelengths, offer multiple possibilities of transmitting the laser beam to the tissues, resulting in reducing trauma, postoperative complications, and bleeding [12].

Rocca JP (2008) and more recently Meleti et al (2015) divided lasers used in the oral surgery field into two categories according to the degree of wavelength absorption in soft and hard tissues [10-12]:

- Lasers that can be used in soft tissues with good absorption in hemoglobin, oxyhemoglobin and melanin with wavelengths ranging from 532nm-1064nm:
  1. KTP laser
  2. Diode laser with wavelength between 864 nm – 1064 nm
  3. Nd:YAG laser with wavelength of 10654 nm
- Lasers that can be used in hard tissues with good water and hydroxyapatite absorption having wavelengths between 2780 nm-10600 nm:
  1. Er:YAG laser with wavelength of 2780 nm
  2. Er,Cr:YSGG laser with wavelength of 2940 nm
  3. CO2 laser with wavelength of 9300 nm, 10600 nm

2. Laser therapy in periodontal disease

Periodontal disease is an inflammatory condition caused by opportunistic bacteria that live in the oral cavity, and which under certain conditions affect the marginal periodontium. Current periodontal therapy is no longer limited to stopping the progression of the disease but increasingly on the regeneration of lost tissues, using multiple methods of treatment [7]. Root planning and scaling, as a non-surgical treatment procedure, remains the main treatment method in periodontal disease [7, 15]. This clinical intervention involves removal of the affected tissues from the dental root using various manual and ultrasonic instruments in order to facilitate the reattachment of periodontal ligament fibers and the gingival junctional epithelium to a healthy tissue [16, 17]. In addition to these large-scale procedures, other surgical or non-surgical methods such as gingival curettage, gingivectomy, various types of flaps such as apical or modified Widman repositioning flaps are used to reduce the depth of periodontal pockets and increase the level of clinical gingival attachment [7, 18-20]. Other treatment options that aimed to recover lost tissues as a result of periodontal disease are guided tissue regeneration or the application of growth factors, with varying degrees of success and predictability, but
regardless of the surgical method chosen, they are expressed with pain and discomfort [7].

In the field of periodontology, the laser used as a non-surgical adjuvant therapy has demonstrated its applicability with satisfying results on periodontal healing [7, 9, 21], and the advantages of this method, comparing them with surgical techniques, include hemostasis, sterilization of periodontal pockets, bio-stimulation, and reduction of morbidity [7]. CO2, Nd:YAG, Er:YAG and diode lasers have multiple advantages in terms of debridement of root surfaces, but the finest results appear to be those generated by Er:YAG due to its properties of removing dental calculus without overheating the adjacent tissue [22-24]. Laser systems such as CO2, diode, and Nd:YAG have been used for soft tissue surgery in gingivectomy and frenectomies [7, 12]. The CO2 laser has been successfully used for the de-epithelization of mucoperiosteal flaps as an adjuvant procedure during periodontal surgery [25]. Laser treatment used alone or in combination with mechanical treatment of gingival debridement have generated positive outcomes on gingival reattachment, decreased periodontal pockets and reduced bleeding at periodontal probing, both in generalized and localized chronic periodontitis with predictable results over a period of 5 years [7]. Furthermore, satisfying results were obtained for alveolar bone, cement, and periodontal ligament regeneration for both natural teeth and compromised dental implants when similar treatment protocols were applied [26].


Peri-implantitis can be defined as a clinical condition characterized by the appearance of an inflammatory reaction in the soft and hard tissues surrounding the osteointegrated dental implant, with existing pathological periodontal pockets and loss of the supporting bone. Although recently, implants have become the standard treatment option for replacing compromised teeth, and the success rate after 10 years is quite high, practitioners must take into account the occurrence of this type of complications [27]. The American Academy of Periodontology defines mucositis as an inflammatory condition around dental implants, without losing the supporting bone, beyond biological bone remodeling. According to recent studies, peri-implant mucositis and peri-implantitis, have a prevalence rate of 19-65% and 1-47%, with an average of 43% for mucositis and 22% for peri-implantitis [28]. The etiology of these conditions is of bacterial origin, similar to the one’s specific for periodontal disease. The main microbial components isolated are gram-negative anaerobic bacilli, fusiform bacteria, spirochetes as well as a multitude of inflammatory cells that are commonly present in periodontal pockets. [27]

As far as the treatment of peri-implant diseases are concerned, a multitude of clinical procedures have been suggested, including non-surgical therapies, surgical therapies involving raising of flaps, laser disinfection, implantoplasty, resection procedures, as well as guided tissue and bone regeneration procedures [28, 29]. The most common protocols are those that use carbon fiber and/or titanium curettes, as they are the least harmful for the surface of dental implants. Decontamination of the implant surface is mandatory for the success of the procedure. Different methods including chemical, mechanical and laser decontamination are used in order to dispose of bacterial contamination and create a favorable surface for bone regeneration and osteo-integration [27, 30].
The results obtained by Romeo et al. (2005) demonstrated the advantages of implantoplasty compared to resection surgery used without other adjuvant methods, in order to preserve the amount of bone surrounding implants affected by peri-implantitis [27,31]. Implantoplasty was subsequently compared with Er:YAG laser therapy, for decontamination of the implantation surface during resection and regenerative surgery with reasonable results in reducing bleeding at probing and increasing the clinical gingival attachment [11, 27].

4. Low-level laser therapy applications
In order to enhance the effect of nonsurgical and surgical therapy and to achieve the best possible results in the treatment of periodontal conditions, some practitioners use high-frequency lasers like Er:YAG, Nd:YAG or diode as an adjuvant treatment for their beneficial effects. These include the removal of subgingival calculus, cleansing of periodontal pockets and strong antibacterial impact. [32, 33]. In contrast with the thermal effects that high-power laser generates, low-power laser therapy is recommended for the photo-chemical anti-inflammatory, bio-stimulation and analgesic effect generated by low-power devices which use wavelengths between 600-1000 nm [34]. While high heat-release lasers can adversely alter the surface of roots during incision and ablation [35], almost no adverse effects have been reported when low-power lasers, also known as soft or therapeutic lasers, have been used. This is a consequence of the fact that when used on soft tissues, it does not produce perceptible temperature changes [36-38]. The most commonly used types of low-power lasers are He-Ne lasers and the increasingly popular diode lasers (GaAlAs, InGaAlP) [36]. Since 1960, when the low-power laser was first introduced, it has been widely used in various areas of dentistry such as: post-surgical care, bone remodeling, pain control in the oral and maxillofacial field, and more recently in the treatment of periodontal disease [34, 36, 37]. Lasers with red or infra-red wavelengths show less absorption of water and chromophores from tissues (hemoglobin and melanin) which is the reason why tissue penetration is greater than 5-10 mm [34, 39]. Low-power lasers are believed to work in the mitochondrial respiratory chain producing increased adenosine-triphosphate, subsequently leading to the proliferation of growth-releasing fibroblasts and collagen synthesis [34, 36, 37]. In vitro animal studies have shown that low-power laser suppresses inflammation in the periodontal tissues by modulating local immune response and reducing the production and release of certain pro-inflammatory cytokines such as alpha tumor growth factor, interleukin-1β and prostaglandin E2. Moreover, this type of laser improves microcirculation through angiogenesis and vasodilation, decreasing oedema and inflammation [34]. Qadri et al. reported that adjuvant low-power laser treatment reduces short-term periodontal inflammation, as demonstrated by decreased gingival index, plaque index, periodontal pocket depth, and low levels of metal-proteinase 8 matrix in the gingival crevicular fluid [34, 40]. It was subsequently shown that this therapy, in addition to stimulating cellular components, modulates them, thus the concept of photobiomodulation therapy materialized, with anti-inflammatory, anti-allergic, healing and stimulating cell growth factors effects [41]. Photobiomodulation therapy is characterized by electromagnetic energy technology with wavelengths in the spectrum of 600-1100 nm, with low-density energy in a constant light beam (0.04-60
J/cm²). Laser light sources include helium-neon (HeNe) and gallium-aluminum arsenic (GaAlAs), as these sources have a very good tissue penetrability [41, 42]. Photobiostimulation of bone tissue appears to increase healing after fractures, periodontal tissue healing, osteointegration of implants and bone reconstruction with or without the aid of biomaterials [41, 43]. It is commonly known how these conditions characterized by tooth loss, significant loss of bone tissue especially in the oral and maxillofacial field can influence the quality of life. For patients undergoing surgical interventions of bone reconstruction, the impairment is not only physical but also mental and emotional and last but not least, financially. Physiological bone remodeling is naturally coordinated, although imbalance can occur between the apposition and resorption mechanisms [44]. Thus, when extensive bone defects are present, repair and wound healing becomes a challenge, causing practitioners to embrace the use of bone grafts, dental implants, or biomaterials [41].

Regardless of their origin, whether they are autografts (grafting materials from the same individual), allografts (grafting materials from different individuals belonging to the same species), alloplastic (laboratory grafting materials) or xenografts (grafting materials from individuals belonging to a different species), bone grafting materials must have biological, physical, and chemical properties necessary for the process of bone repair. These materials must exhibit osteointegration, osteoconduction, osteoinduction and osteogenetic properties. The only materials that exhibit such properties are autologous ones. When extensive bone defect exists, a bone graft is required, and in most cases autologous grafts are the first choice. These have a rather complex surgical technique with difficulties linked to the potential morbidity of the donor site as well as related to the fact that these grafts tend to resorb before the osteointegration process is complete. The simultaneous conditions that these bone reconstructive materials must have, are osteoconductive properties, inductive characteristics, and the presence of bone-forming cells [41]. Materials of bovine origin are a good alternative for rebuilding bone defects due to biocompatibility [45]. Physical methods such as photobiomodulation therapy have the potential to improve the bone reconstruction process, used either alone or in combination with bone grafts [41].

5. Laser therapy and orthodontic tooth movement

Orthodontic tooth movement is a complex, adaptive biological process in response to interference in the physiological balance of dental and oral structures following the application of an external force. As a result of the reorganization of periodontal tissue following the application of orthodontic force, bone remodeling during tooth movement, is a biological mechanism involving an acute inflammatory response, reported by patients through pain [46].

In recent years the use of low-level laser therapy during orthodontic movement has been shown to be useful in inducing the process of remodeling soft and hard oral tissue aiding the healing process due to the photobiostimulation effect it generates [47]. It has also been shown that the use of low-power laser during orthodontic tooth movement is useful in reducing pain caused by applied forces and in accelerating tooth movement, as well as in inhibiting the release of mediators associated with analgesia [48]. Bio-stimulation of oral tissues induced by low-level lasers is also related to the absorption of light by cells in the targeted tissue which leads to activation of intracellular cascade signals, resulting in
increased cellular metabolism and anti-inflammatory changes in hard and soft oral tissues [47]. In the long term, this process has demonstrated better tooth movement and an increase in the rate of osteoclast formation from the compression area of the teeth, decreasing the treatment time [46, 48, 49].

Other studies, such as that of Kawasaki and Shimizu in live rats, have shown that low-power laser therapy stimulates the orthodontic movement of teeth and the formation of osteoclasts in the compression area [50]. Others have shown that the acceleration of orthodontic movement is due to the activation of kappa B nuclear factor receptors (RANK), RANK ligand (RANKL) and macrophage colony stimulation factors alongside their receptors. [46, 48]

6. Conclusion
Laser therapies have been slowly integrating into clinical dentistry for the last few years, but there is still unclear information for some practitioners who hesitate to incorporate them in their day-to-day practice. Thus, this review’s purpose is to highlight the current diagnostic and treatment planning strategies. Recent studies have shown the effectiveness of laser therapies in periodontology, their beneficial effects, and the improvement in the quality of periodontal treatments, resection, and regenerative surgery. It also explains the benefit of its usage in procedures of guided bone and tissue regeneration, in the adjuvant treatment of photobiostimulation from the periodontal field as well as the anti-inflammatory and analgesic effects generated when used in orthodontic treatments.

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