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Laser—An Emerging Tool in Surgical Periodontal Therapy: An Overview

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Abstract. The use of lasers in dentistry, particularly in periodontics and peri-implant diseases, is becoming increasingly common nowadays. Since their introduction in the late 20th century, they have revolutionized the treatment options available for the management of periodontal disease. They allow the clinician to reach inside the deeper pockets and help in reducing the bacterial load. They offer various advantages and have variations according to their clinical use. This review presents an overview of their applications in periodontics.

Keywords: Lasers, Low-Level Light Therapy, Photodynamic Therapy, Periodontal Diseases.

INTRODUCTION

Laser is an acronym, *for Light Amplification by Stimulated Emission of Radiation*. With the advancement in dentistry, Lasers are used in periodontics as a substitute for conventional scalpels in minor periodontal surgical procedures. They are also used as an adjunct in non-surgical periodontal treatment procedures. They offer various advantages, which include hemostasis, further improving the visualization of the surgical field, and improved healing with less postoperative pain and discomfort [1].

In 1960, Theodore Maiman created the first functional laser [2]. According to him, the foundation of a laser is a ruby crystal that has been pumped by a high-power flash lamp to create deep red visible light with two wavelengths. The lasers are broadly classified into two groups (according to their interaction with the tissue and wavelength) as follows: hard tissue lasers and soft tissue lasers. They can also be classified based on the lasing medium as follows: solid (e.g.: Nd:YAG and diode), liquid (e.g.: dye), and gas (e.g.: CO_2, argon, and Er:YAG) [1].

LASERS IN SURGICAL PERIODONTICS

Laser has been considered a viable alternative to conventional surgical periodontal procedures for decades. They have been actively used for various periodontal surgical procedures, including as a photo-biomodulating agent in periodontal flap surgeries, for second-stage surgery on dental implants, for low-level laser therapy that reduces periodontal pockets, de-epithelizes periodontal flaps, lightens gingival pigmentation, and removes diseased granulation tissue, and other periodontal surgical procedures [3].

Lasers offer many advantages over conventional scalpels, as lasers have better cutting, ablating, and reshaping abilities. Also, they help in achieving hemostasis during the surgery and result in less postoperative pain and discomfort to the patient. Some laser surgical procedures occasionally require no local anesthetic and can be done only under a topical anesthetic [4]. Zeredo et al. stated that laser produces less intraoperative and postoperative pain when compared with conventional scalpel surgeries. Also, in another study, it was seen that the surgical site treated with laser demonstrated little wound contraction and minimal scarring when compared to scalpel surgery [5].

The temperature effect of electrosurgery is also thought to be greater than that of laser, making it more difficult to manage and potentially damaging the periosteum and alveolar bone underneath when it comes into direct contact. This damage can lead to bone necrosis and delayed wound healing with increased postoperative pain [6].

Different wavelength lasers are used in different periodontal surgical procedures as their performance depends on their penetration depth. For example, CO_2 lasers are known to achieve greater hemostasis and provide rapid vaporization of soft tissues. Thus, providing a clean operating field requires no suturing, so they are most suitable for gingivoplasty procedures [7]. In contrast, Nd:YAG laser and diode lasers have a greater depth of penetration into the tissues making them suitable for incisional and excisional procedures, e.g., removal of gingival hyperplasia, and gingival recontouring procedures. However, these lasers have greater thermal effects; therefore, they have to be used cautiously and with a surgical technique similar to that of electrosurgery [8].

Wound Healing Post-Laser Surgery

Various studies have reported that an amplified wound healing processes postoperatively when compared to conventional scalpel surgeries. Lasers are shown to stimulate cell regeneration post-injury by modulating cellular functions. They cause an increase in ATP synthesis, thus enhancing the wound healing process that results in less postoperative pain and discomfort.

Earlier studies have also shown an increase in growth factor production and fibroblast proliferation and an increase in collagen production post-laser surgery. Also, there is an increase in the rate of epithelization on the surgical site due to improving neovascularization and an increase in keratinocyte proliferation and function [9].

However, most studies that have examined the healing of laser soft tissue wounds are conducted using CO_2, Nd:YAG, or diode laser wavelengths. Therefore, it may be said that the promises of quicker healing following laser surgery appear to be wavelength specific and extremely sensitive to energy density. Additionally, several studies showed that the initial rate of soft tissue recovery following CO_2 laser treatment was slower; however, it became equivalent to a conventional scalpel surgical procedure after 14 days [10].

Also, in another study by Rouanos et al., the wound healing following irradiation by the Nd:YAG and CO_2 lasers was compared, and it was found that CO_2 laser-induced wounds in oral, oropharyngeal, and laryngeal mucosa healed significantly earlier in comparison to Nd:YAG laser. However, in both cases, wound healing was delayed than the conventional scalpel-induced wound. Whereas, in another study, it was found that at lower power settings, i.e., 1.75 W and 20 Hz frequency laser, wound healing was comparable or equivalent to scalpel-induced wound healing [11].

Laser De-Epithelialization

Successful periodontal regeneration requires the regeneration of periodontal tissues and new attachment of the periodontal ligament fibers to the root surface consisting of newly formed cementum. However, the proliferation of epithelium into that area interferes with this process [12].

Various techniques have been suggested to regress the down growth of this epithelium into the regenerating site. Various studies are conducted testing the placement of various materials at the surgical site to decrease epithelial migration and prevent the formation of a long junctional epithelial attachment. However, there are various difficulties in the application of these techniques, i.e., various studies used collagen membrane as a barrier; however, these membranes resorbed rapidly in the oral environment or nonresorbable membranes can be used. The problem with them was as they do not resorb so they require a second surgery for their removal [13].

Therefore, the use of lasers for the de-epithelization of the surgical site is suggested to promote periodontal regeneration. The CO_2 laser may stop epithelium from growing downward without harming the supporting connective tissue, as shown in several animals and human studies [14].

Additionally, the root surface is smooth, without a char layer, and the collagen matrix is revealed when the Er:YAG laser is used on periodontal surgery sites. After that, a laser is used to de-epithelialize the flap. This process enables the connective tissue to create a new connection to the smooth root surface, demonstrating amazing possibilities for periodontal regenerative surgery [15].

Laser-Induced Root Surface Modifications

Various studies have been conducted demonstrating the effect of laser root surface modification on dentin and cementum of tooth roots. The variety of laser wavelengths used for the aforementioned purpose includes primarily CO_2, Nd:YAG, Er:YAG, and diode laser. Root conditioning *via* lasers results in the decontamination of the root surfaces by removal of the smear layer, which causes increased attachment gain in the treated sites. The primary risks associated with this technique include heat injury to the pulp and unintended removal of the root surfaces. Therefore, choosing a wavelength with a shallower penetration depth into mineralized tissue is crucial.

According to Aoki et al.'s claim, the Er:YAG laser has the benefit of minimally penetrating calcified tissue while simultaneously being successful in removing calculus, root conditioning, and producing a surface that is biocompatible for reattaching cells or tissues [16]. The lipopolysaccharide on the root surface is reduced by 83.1% by the Erbium laser, according to an in vitro investigation. A stable blood clot and increased fibroblast attachment to the periodontal ligament have been seen on surfaces treated with lasers, according to several additional investigations [17].

Effect of Lasers on Bone Healing

Interactions between a laser and biological tissue are photothermal processes that rely on wavelength. Studies show that most dental lasers have a negative impact on bone, the two Er:YAG and Er,Cr:YSGG wavelengths being the exceptions.

Deep periodontal pockets have been reported to respond well to therapy with the ErCr:YSGG laser. This laser is FDA-approved for use on both soft and hard tissues, including bone. It may also be used to remove calculus from root surfaces and to obtain new attachments.

When considering intra-pocket therapy for periodontal disease treatment, Er:YAG lasers, another member of the Erbium laser family, have also the capacity to remove soft tissue, calculus, and bone. Since they penetrate just superficially, they reduce the possibility of profound heat damage and necrosis from excessive exposure to more penetrating wavelengths such as Nd:YAG and diode lasers, which have deeper penetration [18]. Nevertheless, it is important to keep in mind while utilizing lasers because bone healing after ostectomy, osteoplasty, or implant site preparation is complicated and includes a variety of local and systemic reactions, cell types, enzymes, growth factors, cytokines, and other types of signal proteins. A further increase in temperature, i.e., $>60°C$, results in tissue necrosis when heating bone to temperatures over 47°C, according to research (Erickson et al. 1983) [19].

CONCLUSION

As a result of technological advancements, lasers are now used in a variety of periodontal and peri-implant therapies as an auxiliary or alternative method. They offer various advantages including decontamination of the surgical site, hemostasis, and less postoperative pain and discomfort. Soft tissue surgeries including gingivoplasty and gingivectomy procedures are the major indications of lasers.

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