International Journal of Research in Health and Allied Sciences

Journal home page: www.ijrhas.com

Official Publication of "Society for Scientific Research and Studies" [Regd.]

ISSN: 2455-7803

Review Article

Lasers in dentistry

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ABSTRACT:
A major diagnostic application of low power lasers is the detection of caries, using fluorescence elicited from hydroxyapatite or from bacterial by-products. Laser fluorescence is an effective method for detecting and quantifying incipient occlusal and cervical carious lesions, and with further refinement could be used in the same manner for proximal lesions. Laser technology for caries removal, cavity preparation and soft tissue surgery is at a high state of refinement, having had several decades of development up to the present time. Lasers in current form are now able to remove tissue in bulk at a similar rate to conventional methods such as bur and turbine handpiece. Some lasers may, however, provide precision cutting, which may be developed further in the future. Alternative uses of laser light are potentially more beneficial in the shorter term. The use of diode lasers as a means of activating a photosensitizer to carry out photo-activated disinfection appears to be beneficial.
Key words: Dentistry, LASERS

Received: 22 October, 2021 Accepted: 25 November, 2021

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This article may be cited as: Talwar A. Lasers in dentistry. Int J Res Health Allied Sci 2021; 7(6):44-47.

INTRODUCTION

Introduction of laser in dentistry, in the 1960s, by Miaman, led to a continuous research in the various applications of lasers in dental practice. There are two scenarios, on the one hand there are hard lasers, such as, Carbon dioxide (CO2), Neodymium Yttrium Aluminum Garnet (Nd: YAG), and Er:YAG, which offer both hard tissue and soft tissue applications, but have limitations due to high costs and a potential for thermal injury to tooth pulp, whereas, on the other hand in cold or soft lasers, based on the semiconductor diode devices, which are compact, low-cost devices used predominantly for applications, are broadly termed as low-level laser therapy (LLLT) or 'biostimulation'. On account of the ease, efficiency, specificity, comfort, and cost over the conventional modalities, lasers are indicated for a wide variety of procedures in dental practice.[1-4]

History of Lasers

"Heliotherapy" was the practice followed by our ancestors, following which the development of action therapy and photomedicine took place. The award of the Nobel Prize to Finsen in 1903 for the development of the carbon arc lamp with lenses and filters for the treatment of diseases (especially lupus vulgaris) was a major milestone in the development of lasers for medical use.[5-8]

In 1917, Albert Einstein set the foundation for the invention of the laser by explaining the photoelectric amplification, and it was introduced to the public in 1959.3 Miaman was the first person who used the laser in 1960 on the hard and soft tissue. Advancements in the application of lasers over the last two decades have extended their use in caries prevention, bleaching, cavity preparation, dentinal hyper-sensitivity, growth modulation as well as for diagnostic purposes. In the mid-1960s, enhanced methods of caries removal were reported, performed by an effective interaction of laser energy with tooth structure. Ruby lasers were very useful in vaporizing caries but they caused irreversible necrotic changes in the pulp tissue because of the high energy densities. Then, the Erbium Laser wavelengths were discovered, which did better in terms of the cavity preparation without damaging the pulpal tissue. Argon lasers were found to be effective in the photo-polymerization of dental composites and Nd:YAG (neodymium-doped yttrium aluminum garnet) lasers were effective in various endodontic therapies, prosthetic devices, gold alloys, and prosthetic devices. [5- 8]

In 1990, the Food and Drug Administration (FDA) approved the use of laser therapy in intraoral gingival and mucosal tissue surgery as it ensured a wound without suture, pain, and bleeding and increased the convenience for the dentist. The first laser designed specifically for the dentistry was introduced in the United States on May 3, 1990, by Myers. Among the various special lasers designed to be used for soft tissue procedures and for the teeth and bone, it has been seen that the erbium wavelength is very safe and effective. Lasers, either in therapeutic or photo-bimodulation, have shown effective results in healing. The first clinical results of photo-activated disinfection also showed good applications for disease control. [5- 8]

Lasers Classification

Different parameters influence lasers classification and the most important of them are power, wavelength and laser source material.

Classification of lasers based on Power

Power is one of the important parameters in treatments with lasers. Any physician using lasers should be able to recognize them and to know their characteristics. Based on the power, lasers are classified in three groups, as bellow:

A-High power, warm or hard lasers:

These lasers instill their therapeutic effects by causing heat and enhancing the moving energy in tissues.These effects includes necrosis, carbonization, evaporation, coagulation and protein denaturation. As it's been mentioned in table 1, it is possible to benefit from one or more of these effects, based on controlling the resulted temperature. Power of these lasers is usually more than 0/5W. These types of lasers have applications in surgery.

B-Lasers with Moderate Powers:

These lasers have their therapeutic effect without inducing a lot of heat. Their light has a stimulating effect in tissues. Powers of these lasers are between 250 to 500mW.

C-Low Level or Cold Lasers:

These lasers have no thermal effect on tissues. Inducing a light stimulation, they result in light and gradual reactions in tissues which are called Photobiostimulation. Power of these lasers is usually less than 250mW.

The principal point in differentiating low level lasers from high power ones is induction of photochemical reactions without heat. The most important factor to achieve this light feature in these lasers is not their power, but their power density per each surface unit (i.e. cm2). A density less than 670mW/ cm2 without heat can induce the stimulating effect of low level lasers.

Classification of lasers based on wavelength

Lasers are classified in 4 categories based on their wavelengths, as follows:

- Ultraviolet range 300-400 nm
- Visible light range 400-700 nm
- Near Infrared (NIR) range 700-1200nm
- Far Infrared (FIR) range more than 1200nm

Classification of lasers based on source material

- Gas lasers such as CO2,Ne and He
- Liquid lasers such as Dye lasers
- Solid lasers such as Ruby lasers
- Semi-conductor lasers such as GaAllnP, GaALAs and GaAs[9- 13]

The Use of Lasers in Clinical Dentistry

Lasers are used in most areas of clinical dentistry and their use is steadily increasing. Their application includes caries detection, caries removal, dental cavity preparation, dentine hypersensitivity management, tooth bleaching, photodynamic therapy, excisional biopsy, aphthous ulcers management, frenectomy, vestibuloplasty, removal of irritation fibroma, removal of hyperplastic tissues, haemangioma, exposure of impacted teeth, gingivectomy and gingivoplasty, apicoectomy, an adjunct to endodontic treatment, gingival melanin hyperpigmentation removal, non-surgical periodontal treatment of untreated periodontitis and treatment of peri-implant diseases. In terms of endodontic treatment, lasers are used for post-chemomechanical preparation to reduce the remaining bacterial load either by direct irradiation of the canal walls or by laser assisted irrigation via erbium laser group. In terms of gingival melanin hyperpigmentation removal, a recent systematic review identified the use of two laser wavelength groups-near infrared diode and erbium group of mid-infrared lasers and failed to draw conclusions on the optimal laser group.[14- 18]

In untreated periodontitis patients, lasers have been studied both as monotherapy and as an adjunct to conventional non-surgical periodontal treatment (or non-surgical mechanical instrumentation). In terms of non-surgical periodontal treatment, laser use aims mainly in root surface detoxification. A recent systematic review and meta-analysis showed that in untreated periodontitis patients, laser monotherapy leads to similar clinical improvement to conventional non-surgical periodontal treatment alone, which is in agreement with earlier reviews. Systematic reviews on untreated periodontitis failed to show further clinical benefits with the addition of laser treatment to conventional non-surgical periodontal treatment. [14- 18]

Specifically, a 2015 systematic review and meta-analysis found that, when used adjunctively to conventional non-surgical periodontal treatment, neither the diode nor the Nd:YAG laser achieves additional clinical benefits beyond that achieved by conventional non-surgical periodontal treatment alone. Then, a recent systematic review showed that the adjunctive use of lasers to conventional non-surgical periodontal treatment does not lead to superior clinical improvement as compared to conventional non-surgical periodontal treatment alone. Nowadays, lasers are used as an adjunct to conventional non-surgical periodontal treatment in periodontitis. It should be stressed that the routine use of any laser for the treatment of periodontitis cannot be suggested. Decontaminating (or detoxifying) the oral biofilm-contaminated titanium surface without altering it is fundamental for the treatment of periimplantitis. [14- 18]

Laser treatment has been proved to be effective in the decontamination of oral biofilm-contaminated titanium surfaces. Several types of lasers have been studied for this purpose. Among them, Er:YAG seems to be the best for titanium surface decontamination without damaging the titanium surface. Specifically, Er:YAG laser and Er, Cr:YSGG laser treatment have been found to be effective methods for the detoxification of oral biofilm-contaminated titanium surfaces without surface alterations. In terms of clinical benefit, a systematic review and meta-analysis showed that laser treatment resulted in similar clinical improvement as compared to conventional implant surface decontamination methods. Another systematic review and meta-analysis showed that the use of lasers is not superior to conventional therapeutic approaches for the treatment of peri-implantitis. An American Academy of Periodontology systematic review showed that lasers as an adjunct to surgical/non-surgical treatment of peri-implant mucositis and peri-implantitis offer minimal clinical benefit. It seems that laser treatment is promising for the management of peri-implantitis, though further research is required to draw safe conclusions. [14- 18]

Soft Tissue

The interaction of laser radiation with various soft tissues of the human body has been reported in innumerable articles. Across a fairly broad spectrum of soft tissues, one can generalize the laser-tissue interactions. The general dentists, periodontists, endodontists, and oral and maxillofacial surgeons who were the pioneers in the use of lasers in dentistry faced a unique problem: there are teeth that pass through the soft tissue being treated. The ability of teeth to recover from traumatic injury is limited. Thus, during laser-based treatment of the soft tissue in the oral cavity, a practitioner must protect the teeth.[18- 20]

The soft tissue applications have been restricted mostly to incising and excising masses from the mucosa and gingiva in the oral cavity. Only recently have reports suggested that the COz laser may have a unique ability in periodontal surgery to impede the postoperative growth of oral epithelium. A major problem that occurs after surgery around teeth is that the epithelium grows faster then the healing connective tissues. The swiftly growing epithelium will progress down along the root surface of the tooth, causing a deep pocket to form next to the tooth. This pocket is a site for accumulation of bacteria and debris. The bacteria and debris are not cleansable in these deep pockets and can lead to a poor prognosis after periodontal surgery. Rossmann and Israel have reported on a technique where the COz laser was used to remove the epithelium from the connective tissue around the tooth. They have shown inhibition of epithelial in growth around the tooth. More research needs to be performed in this area, but it seems as if the CO, laser may have the unique characteristic of being able to remove a thin layer of epithelium cleanly, unlike anything now available in dentistry. [18-20]

Hard Tissue Applications

The argon laser produces high intensity visible blue light (488 nm), which is able to initiate photopolymerization of light-cured dental restorative materials, which use camphoroquinone as the photoinitiator. Argon laser radiation is also able to alter the surface chemistry of both enamel and root surface dentine, which reduces the probability of recurrent caries. The bleaching effect relies on the specific absorption of a narrow spectral range of green light (510-540 nm) into the chelate compounds formed between the apatites, porphyrins, and tetracycline compounds. Argon and Potassium Titanyl Phosphate (KTiOPO4, KTP) lasers can achieve a positive result in cases that are completely unresponsive to conventional photothermal ‘power’ bleaching.[21- 25]

Enamel demineralization with white spot formation on the buccal surfaces of the teeth is a relatively common side effect from orthodontic treatment with fixed appliances. There is evidence, however, which suggests that such small areas of superficial enamel demineralization may re-mineralize. Various studies depict the use of Er: YAG, since 1988, for removing caries in the enamel and dentine by ablation, without the detrimental effect of rise in temperature on the pulp, even without water-cooling, with low ‘fluences’ laser (LLLT), similar to air-rotor devices, except that the floor of the cavity is not as smooth. The Er: YAG laser is capable of removing cement, composite resin, and glass ionomer. Laser etching has been evaluated as an alternative to acid etching of enamel and dentine. Enamel and dentine surfaces etched with (Er, Cr: YSGG) lasers show micro-irregularities and no smear layer. Adhesion to dental hard tissues after Er: YAG laser etching is inferior to that obtained after conventional acid etching. Dentinal hypersensitivity is one of the most common complaints in clinical dental practice. Comparison of the desensitizing effects of an Er: YAG laser with those of a conventional desensitizing system on cervically exposed hypersensitive dentine showed that desensitizing of hypersensitive dentine with an Er: YAG laser is effective, and maintenance of a positive result is more prolonged than with other agents.[21- 25]

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