Review Article

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ADVANCEMENTS IN LASERS: A REVOLUTIONARY TOOL IN PERIODONTICS

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ABSTRACT

Lasers have revolutionised the dentistry as with introduction of laser in the field of dentistry for last several years, it has emerged and witnessed several wonderful experiences by clinicians and the patients. They allow the dentist to reach sites where the conventional mechanical instrumentation fails. Since its first experiment for dental application in the 1960s, the use of laser has increased rapidly in the last decades. Because of their many advantages different types of lasers are available for clinical and specific use. They are activated at different power setting modes, and pulse for soft and hard tissues. This review discusses recent advancements in lasers and the applications in periodontics.

KEYWORDS: Laser therapy; periodontal disease; waterlase; periowave

INTRODUCTION

Dentistry has revolutionised over the past decade to the benefit of both the clinician and the patient. One technology that has become increasingly utilized in clinical research is that of the laser.[1] The word laser stands for Light Amplification by Stimulated Emission of Radiation.[1,2] A laser is a device that transforms light of various frequencies into a chromatic radiation in the visible, infrared and ultraviolet regions with all the waves in phase capable of mobilizing immense heat and power when focused at close range.[3] Stern and Sognnaes and Goldman *et al*., in 1964 were the pioneers of the application of a laser to dental tissue describing the effects of ruby laser on enamel and dentine.[2] The principle effect of laser energy is photothermal; this effect on tissue depends on the degree of temperature rise and corresponding reaction of the interstitial and intracellular water.[4] Clinical lasers are of two types: "soft" and "hard" lasers. Soft lasers are claimed to aid healing and to reduce inflammation and pain. However, few rigorous studies are available to support their use. Surgical hard lasers can cut both hard and soft tissues, and newer varieties can transmit their energy via flexible fiberoptic cables. Many procedures can be performed without local analgesia, and because lasers sterilize as they cut.[5] In hard tissue application, the laser is used for caries prevention, bleaching, restorative removal and curing, cavity preparation, dentinal hypersensitivity, growth modulation and for diagnostic purposes, whereas soft tissue application includes wound healing, removal of hyperplastic tissue to uncovering of impacted or partially erupted tooth, photodynamic therapy for malignancies, photostimulation of herpetic lesion. Use of the laser proved to be an effective tool to increase efficiency, specificity, ease, and cost and comfort of the dental treatment.[6]

Lasers commonly used in dentistry are[1,2]

- Carbon dioxide (CO_2) laser
- Neodymium:Yttrium- aluminium- garnet (Nd:YAG) laser
- Erbium:yttriumaluminum-garnet (Er:YAG) laser
- Erbium,Chromium: yttrium -selenium gallium-garnet (Er,Cr;YSGG) laser
- Argon (Ar) laser
- Indium-Gallium-Arsenide-Phosphide (InGaAsP) Gallium-Aluminium-Arsenide (GaAlAs) Gallium-Arsenide(GaAs) laser
- Holmium:yttriumaluminum-garnet (Ho:YAG)

Lasers are named according to the active element(s) that is induced to undergo the stimulated quantum transitions that, in turn, creates the energy beam. Thus, lasers commonly used in dentistry consist of a variety of wavelengths delivered as either a continuous,

pulsed (gated), or running pulse waveform.[7] CO_2 lasers have been used extensively in medical field and the first laser to be approved by FDA for dental application was Nd:YAG (Neodymium-Yttrium-Aluminum-Garnet) in 1990s. Since then many types of lasers including CO2, Er:YAG (Erbium-Yttrium-Aluminum-Garnet), Diode, Er Cr:YSGG (Erbium-Chromium-Yttrium-Scallium-Gallium-Garnet) have been approved for dental use. FDA approved Er:YAG for dental hard tissue in 1997 and has approved other types of lasers for soft and hard tissue procedures in many area of dentistry.[8]

The working principle of lasers

Laser is a type of electromagnetic wave generator. Lasers are heat producing devices converting electromagnetic energy into thermal energy. The emitted laser has three characteristic features.

1. **Monochromatic**: in which all waves have the same frequency and energy.
2. **Coherent**: all waves are in a certain phase and are related to each other, both in speed and time.
3. **Collimated**: all the emitted waves are nearly.[1]

Amplification occurs in optical cavity present at the center of the laser device, having two parallel mirrors one at each end, and core of this cavity is comprised of chemical elements, compounds or molecules, in gaseous, crystal or solidstate semiconductor form known as active medium. Excitation source, either a flash lamp strobe device or an electrical coil surrounds the optical cavity which provides the energy into the active medium. Other mechanical components include cooling system, focusing lenses, and other controls.[9] The characteristic of a laser depends on its wave-length (WL), and wave-length affects both the clinical applications and design of laser. Different wave lengths can be classified into three:

1. The UV range (ultra-spectrum approximately 100- 400 nm).
2. The VIS range (visible spectrum approximately 400-700 nm).
3. The IR range (infra-red spectrum which is approximately 700 nm) to the microwave spectrum.[1]

TYPES OF LASERS

Carbon dioxide (CO_2) laser

CO2 laser was first time developed by Patel et al. in 1964.[10] Specific indications for use of Carbon Dioxide (CO_2) lasers in periodontal procedures are sulcular debridement, Gingival excision/incision, laser assisted new attachment procedure, Gingivectomy/gingivoplasty. Its ability to provide dry surgical field and haemostasis has been proven useful in periodontal surgical procedures. Additionally CO2 laser use has shown mixed results when used for periodontal pocket debridement in addition to mechanical debridement, pocket reduction, attachment gain, decreased microorganisms, and guided tissue regeneration cases.[8]

Neodymium:Yttrium- aluminium- garnet (Nd:YAG) laser

Nd:YAG laser was first developed by Geusic in 1964. A crystal of yttrium-aluminum garnet doped with neodymium is used and they are invisible similar to CO2 laser, have infra-red range on spectrum, with maximum power output 3W at a frequency of 1.06 micron.[10] (Nd:YAG) laser wavelength, highly absorbed by the pigmented tissue and make it very effective surgical laser for ablation (cutting) and coagulating dental soft tissue with good homeostasis. Laser ablation is defined as the mass removal by coupling laser energy to a target material.[11] Indicated for subgingival curettage and bacterial decontamination.[2] de Andrade AK *et al*.,[12] evaluated the bacterial reduction after Nd:YAG laser irradiation associated with scaling and root planning in class II furcation defects in patients with chronic periodontitis and revealed that the Nd:YAG laser associated with conventional treatment promoted significant bacterial reduction in class II furcation immediately after irradiation. Miyazaki A *et al*.,[13] carried out a study to compare the effectiveness of Nd:YAG and CO2 laser treatment to that of ultrasonic scaling used as monotherapies by examining clinical parameters, subgingival microflora, and interleukin-1 beta (IL-1beta) in gingival crevicular fluid (GCF) and suggested that Nd:YAG laser and ultrasonic scaling treatments showed significant improvements regarding the clinical parameters and subgingival microflora compared to the baseline.

Erbium: yttrium aluminum-garnet (Er:YAG) laser

Applications are soft tissue incision and ablation; subgingival curettage; scaling; root conditioning;

osteoplasty and ostectomy; degranulation and decontamination of implants, analgesia, melanin and metal pigment removal and treatment of dentine hypersensitivity.[14]

Erbium, Chromium: yttrium -selenium gallium-garnet (Er,Cr;YSGG) laser Argon (Ar) laser:

Indications for (Er,Cr;YSGG) laser are caries removal and cavity preparation, modification of enamel and dentin surfaces, intraoral general and implant soft tissue surgery, sulcular debridement (subgingival curettage in periodontitis and periimplantitis), scalingof root surfaces, osseous surgery, treatment of dentin hypersensitivity, analgesia, pulpotomy, root canal treatment and disinfection, aphthous ulcer treatment, removal of gingival melanin and metal-tattoo-pigmentation.[1] Dyer B *et al*.,[15] evaluated the effectiveness of Er,Cr:YSGG laser by measuring the clinical changes in probing depth and clinical attachment level (CAL) in pockets treated with conventional therapy with assistance of Er,Cr:YSGG laser and concluded that Er,Cr:YSGG laser with conventional therapy is an effective modality for the treatment of moderate to advanced periodontal diseases.

Diode laser: Indium-gallium-arsenidephosphide-InGaAsP (diode); Gallium-aluminumarsenide-GaAlAs (diode); Gallium-arsenide - GaAs(diode)

For dental use diode laser has been introduced for last few years after FDA safety clearance. It has wavelength range of 635 to 950 nm, utilizing flexible quartz fiber; it is absorbed by pigmentation of the soft tissue. Thereby making diode laser an excellent hemostatic agent. Diode is used for soft tissue removal in contact mode, giving tactile sensation similar to electro cautery. The power output used is generally 2 to 10 W, and can be either pulsed or continuous mode. Its effect on the tissue is similar to Nd:YAG laser, with less thermal effects on the deeper tissues. Tissue penetration is less than comparable Nd:YAG effects, with potential for heat damage to underlying bone reduction.[10]

Indium-Gallium-Arsenide-Phosphide (InGaAsP) laser:

Specific indications are caries and calculus detection,[16] subgingival curettage and bacterial elimination.[9]

Gallium-Aluminium-Arsenide (GaAlAs) and Gallium-Arsenide(GaAs) laser:

Soft tissue incision and ablation; subgingival curettage; bacterial elimination, pulpotomy, root canal disinfection, sulcular debridement, caries removal, aphtus ulcer treatment, analgesia, melanin pigment removal, treatment of dentine hypersensitivity.[14] Kreisler M *et al*.,[17] carried out an in vitro study to evaluate a potential stimulatory effect of low-level laser irradiation on the proliferation of human periodontal ligament fibroblasts (PDLF) and found that the irradiated cells revealed a considerably higher proliferation activity than the controls. Similarly Eun-Jeong Choi *et al*.,[18] carried out a similar study in which human PDLFs were cultured and irradiated with a gallium – aluminum - arsenate (GaAlAs) semiconductor diode laser and revealed that the GaAlAs semiconductor diode laser promoted proliferation and differentiation of human PDLFs. Schwarz F *et al*.,[19] also concluded that laser therapy using GaAIAs radiation within milliwatt range positively influences prolferation of gingival or periodontal ligamnet fibroblasts and thus plays role in periodontal and peri-implant wound healing.

Helium-neon (He-N) at 632.8 nm (red, visible). Soft tissue laser Holmium:yttriumaluminum-garnet (Ho:YAG):

Applications are in intraoral general and implant soft tissue surgery, sulcular debridement, scaling of root surfaces, osseous surgery, treatment of dentin hypersensitivity, analgesia and apthous ulcer treatment.[16]

RECENT ADVANCEMENTS

PeriowaveTM

Periowave™ is a photodynamic disinfection system that utilises nontoxic dye (photosensitizer) in combination with a low-intensity lasers enabling singlet oxygen molecules to destroy bacteria.[9,20] It inactivate the bacteria and toxins left behind after scaling and root planning by using a photodisinfection reaction. A small quantity of blue-coloured photosensitizer solution is topically applied to the gums at the treatment site where it attaches to microbes and toxins associated with gingival or periodontal disease[21] followed by a low-intensity laser which is directed on the area treated with the drug resulting in phototoxic reactions[9] destroying bacteria beneath the gingival line. Each treatment

site requires only 60 seconds of laser activation, making it a quick and painless procedure.[21]

Periodontal Waterlase MD™

Target Applications of Periodontal Waterlase MD™ are restorative and multi-disciplinary dentistry procedures, cosmetic procedures, oral surgery, endo disinfection, implants and periodontal treatment. Kelbauskiene S *et al*.,[22] carried a study and concluded that the Waterlase MD laser utilizes Er,Cr:YSGG minimally invasive surgical periodontal laser therapy that results in significant improvements in bleeding on probing, probing depth, and appears to be advantageous when compared to scaling and root planning alone, due to more efficient attachment level restoration.

Waterlase C100

Target Applications of Waterlase C100 are restorative procedures, extraction and early periodontal treatment.[23]

Indications in periodontal therapy

- Full, partial and split thickness flaps
- Laser soft tissue curettage
- Laser removal of diseased, infected, inflamed and necrosed soft tissue within the periodontal pocket
- Removal of highly inflamed edematous tissue affected by bacterial penetration of the pocket lining and junctional epithelium
- Removal of granulation tissue from bony defects
- Sulcular debridement to improve clinical indices including gingival and gingival bleeding indices, probe depth, attachment loss and tooth mobility
- Osteoplasty and osseous recontouring (removal of bone to correct osseous defects and create physiologic osseous contours)
- Ostectomy (resection of bone to restore bony architecture, resection of bone for grafting, etc.)
- Osseous crown lengthening[23]

CONCLUSION

Laser treatment is serves as an adjunctive to conventional mechanical periodontal treatment. Unlike antibiotics, lasers deliver their bactericidal properties without common side effects such as drug interactions, bacterial resistance or any gastrointestinal complications. Currently, among the different types of lasers available, Er:YAG and Er,Cr:YSGG laser possess characteristics suitable for dental treatment, due to its dual ability to ablate soft and hard tissues with minimal damage. In addition, its bactericidal effect with elimination of lipopolysaccharide, ability to remove bacterial plaque and calculus, irradiation effect limited to an ultra-thin layer of tissue, faster bone and soft tissue repair, make it a promising tool for periodontal treatment including scaling and root surface debridement.[1]Further evidenced based clinical studies are required to further evaluate the beneficial effect in periodontal therapy.

CONFLICT OF INTEREST & SOURCE OF FUNDING

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