LASERS – IT'S ROLE IN PERIODONTAL REGENERATION

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ABSTRACT

The use of lasers has evolved as clinical experience along with scientific investigation. The dental lasers of today have benefited from decades of laser research and have their basis in certain theories from the field of quantum mechanics. When used efficaciously and ethically, lasers are an exceptional modality of treatment for many clinical conditions that dental specialists treat on a daily basis. The concept of using lasers for the treatment of periodontal disease elicits very strong reactions from all sides of spectrum. Evidence suggests that lasers are useful as an adjunct or alternative to traditional approaches in periodontal therapy. Future direction of lasers would be towards a minimally invasive regenerative procedures along with laser assisted calculus detection systems using laser fluorescence that is optical coherence tomography and a laser system which selectively and completely removes the plaque and calculus that is under development. With recent advances and development of wide range of laser wavelengths, different instrument designs and different delivery systems, the purpose of this review is to determine the application and current concept of lasers in the regeneration of periodontal tissues.

KEYWORDS

Carbon Dioxide Laser, Solid state Laser, Laser Assisted New Attachment Procedure, Laser assisted Comprehensive Pocket Treatment, Low Level Laser Therapy.

1. BACKGROUND

Maiman, a scientist with the Hughes Aircraft Corporation, conducted a study using a ruby crystal that emits a coherent radiant light when stimulated by energy, based on the theory originally postulated by Albert Einstein and first developed LASER (Light Amplification by Stimulated Emission of Radiation).

In a study conducted by a dermatologist, Goldman, when two pulses of red light beam from ruby crystals were focused with laser for tattoo removal, it showed painless surface crazing of enamel Further experiments conducted by Stean&Sojrmaer, showed the shift of pendulum from ruby laser to CO2 &Nd:YAG lasers for better interactions with dental hard tissues.

In the nineteenth century , 1970 was considered as "a pivot of change" where the use of lasers for soft-tissue surgical procedures came forth and Lenz et al together with Frame, Pecaro& Pick were among the pioneers to report oral surgical application of CO2 laser, oral soft tissue lesions and periodontal procedures. It was Mayer's & Myer's who described the use of modified ophthalmic

DOI: 10.5121/hiij.2018.7401

Nd:YAG laser for removal of dental caries and received permission from FDA for selling of

Nd:YAG laser device in 19891.

Nd:YAG laser was eventually used in periodontal procedures and since then lasers have been used largely by researchers and clinical periodontal practitioners.

2. LASERS IN PERIODONTICS AND PERI-IMPLANT THERAPY

As a result of increase in the basic and clinical investigations related to Diode, CO2, Nd:YAG, Er:YAG&Er,Cr:YSGG lasers, application of laser for periodontal and implant therapy have gradually expanded.2-3 Adjunctive use of lasers for initial periodontal therapy, not only to debride connective tissue & epithelium within pockets, but also to inactivate bacteria that invade the periodontal tissues can be carried out with the help of these wavelengths with moderate power output. In addition, Erbium lasers have been observed to achieve ablation of calculus with efficiency that can be compared with hand/ultrasonic instruments thus preserving the underneath root cementum[4].

Precise & small procedures with minimal damage around the treated site can be performed by the practitioners with laser power delivered through a fine laser tip. Such a precise treatment modality is of great importance while performing minimally invasive periodontal treatments[2,5].

Another treatment modality has emerged, named phototherapy, which is better known as Low-Level Laser Therapy (LLLT)[6]. An important principle of phototherapy is that the power parameters are employed at lower dose than that used for surgery. LLLT was often termed as "Soft Laser Therapy" or "Cold Laser Therapy" which created some confusion. Hence, the current term "photo biomodulation", more accurately describes the intended process that is, the reduction of inflammation with stimulation of cell proliferation[6].

Another application of phototherapy is antimicrobial PDT, which aims to destroy pathogens in pocket with ROS produced by combination of a low-level visible light laser & a photosensitizer. This protocol has attracted attention as a novel, minimally invasive approach for the treatment of pockets around teeth and dental implants[7,8].

3. CHARACTERISTICS OF EACH WAVELENGTH IN PERIODONTITIS AND PERI-IMPLANT THERAPY.

3.1 LASERS FOR SOFT TISSUE ABLATION ONLY.

3.1.1 Diode &Nd:YAG Lasers

The photonic energy from Diode & Nd:YAG lasers is in the neon-infrared spectrum (approx.. 800-1100nm) and is selectively absorbed in areas of inflammation by blood components and tissue pigments. A non-contact mode may be employed when attempting any haemostasis[2].

For initial periodontal therapy, these lasers are used for inactivation of bacteria and removal of inflamed soft-tissue from periodontal pocket/from around the implant sulcus, for achieving

hemostasis in acutely inflamed tissue[3]. These procedures employ relatively low average power, which are usually below than that used for surgery.

In general, Nd:YAG laser must be used with caution, and attention must be given to the irradiation parameters and to the laser beam placement[5].

3.1.2 CO2 Laser:

These employ photonic energy in far - infrared spectrum (9,300-10,600). Compared to others, they have highest absorption in dental minerals such as Hydroxyapatite and Calcium phosphate. The penetration depth into soft-tissue is relatively shallow (approx.0.2mm)[2].

CO2 lasers have similar soft tissue applications for periodontal therapy as the diode and Nd:YAG wavelengths. These applications include bacterial reduction, debridement of diseased soft tissue in pockets and around implants and coagulation[2].

3.1.3 ERBIUM Laser:

Erbium lasers such as Er:YAG and Er:Cr:YSGG lasers target water/hydroxide ions (OH^-) as primary targets and minerals as secondary target and emit in the mid-infrared range at a wavelength of 2940nm for Er:YAG and 2780nm for Er:Cr:YSGG[5]. It can be used as a hard tissue laser for excisions, ablations, bony tissue exostosis & bony tissue biopsy.

The photonic energy of both the lasers can be delivered in either a contact/non-contact mode. These lasers can be used for soft-tissue debridement of periodontal and peri-implant diseased tissue, bacterial reduction and calculus removal in a non-surgical approach[8].

4. LOW LEVEL LASERS FOR BIOMODULATION

Evidence from literature has demonstrated that the photo-biomodulatory effect of laser treatment, conventionally termed as LLLT using above described wavelengths utilized to cut soft/hard tissue contribute to the beneficial effects of 'surgical' laser approaches[6].

In an in-vitro study Er:YAG lasers have shown to stimulate more osteoblasts and gingival fibroblasts (human). This low dose of laser energy delivery enhanced proliferation and earlier structural formation.

The mechanisms of enhanced proliferation accelerated wound healing with LLLT is not completely clear, but can be partially explained by biostimulation. Devices specifically designed for photo-biomodulation are available in diode lasers with emission wavelengths of 630-980nm[6].

5. MINIMALLY INVASIVE FLAPLESS PERIOPOCKET SURGERY

Laser therapy is well accepted by patients as a minimally invasive procedure that potentially reduces the necessity of subsequent periodontal flap surgery[7].

5.1 LANAP &LAPIP

LANAP was developed by two dentists in California; Robert Gregg and Del Mc Carthy 1989, who were looking for alternatives to conventional periodontal surgery, especially for periodontally hopeless teeth[5]. Through trial and error several evolutions and name changes from Laser ENAP to LPT to LANAP, the definitive LANAP protocol was established and patented[9].

LANAP is a minimally invasive surgical procedure as indicated in systematic review of the AAP workshop by Kao et al (2015) and in a recent review by Aoki et al (2015)[8]. It is still the only laser procedure to have human histologic evidence to justify the US-FDA 510 (K) marketing clearance for cementum-mediated periodontal ligament attachment in the absence of a long junctional epithelium[7,9].

The Laser Assisted Peri-Implantitis Procedure (LAPIP) protocol for treating peri-implantitis with a minimally invasive surgical approach adapts the LANAP protocol used to treat teeth for treatment of ailing dental implants[11].

5.2 LASER ASSISTED COMPREHENSIVE POCKET TREATMENT USING ERBIUM LASERS (LCPT):

Erbium lasers can safely and effectively remove granulation tissue, even from the bone defects difficult to access without harming the osseous tissue and when used in Non-Surgical Periodontal Therapy, can aid in restoring periodontal health. From these observations, Aoki et al (2015) proposed the concept of Laser Assisted Comprehensive Pocket Therapy (LCPT)[8]. Successful clinical results were obtained with this therapy, occasionally accompanied by bone regeneration in the vertical bone defects.

Hence, LCPT technique might be an effective minimally invasive approach as a flapless surgical procedure for the treatment of moderate to deep periodontal pockets with vertical bone defects and might reduce the necessity for subsequent conventional flap surgery.

In recent years, there has been a great development in research of laser therapies for the dentistry field and a specialized use in the areas such as implantology[3]. Use of low-level laser therapy and certain wavelengths, specific lasers supply direct biostimulative light energy to the cells. It has been reported that low-level semiconductor diode enhances the wound healing process. The periodontal ligament is crucial for maintaining the tooth and surrounding tissues in periodontal wound healing. Low-level lasers have direct effect on periodontal ligament fibroblasts and also has stimulating effects on bone cells and can accelerate the repair process of bone[6].

In a study done by Flaminia et al (2010), evaluation of low pulse energy Nd:YAG laser irradiation was done where it showed to exert a biostimulative effect on different cells representative of oral micro-environment particularly osteoblasts[12]. Another study done by Aleksie et al in 2010, it was suggested that low-level Er:YAG laser irradiation increases osteoblast proliferation, mainly by activation of MAPK/ERK pathways suggesting that Er:YAG laser may be able to promote bone healing following periodontal and peri-implant therapy[13].

A case series study done by Brown et al in 2013, assessed the efficacy of advanced lasers in a LANAP case series, wherein the new MVP-7 laser (Periolase)[14], a free-running pulsed Nd:YAG

laser provided a reliable alternative to traditional periodontal surgery[9]. Properly applied, this laser showed lesser bleeding, swelling and discomfort. Also it was shown to specifically target identifiable pathogen.

In a study by Cochran et al in 2012, wherein the biostimulative effect of low-level laser irradiation on alveolar bone during orthodontic tooth movement along with formation of new keratinized gingiva showed that laser bio stimulation could improve the differentiation of PDL stem cells in fibroblasts and are able to promote attached gingiva around the erupted teeth[15].

A recent study done by Falaki et al in 2016 checked for the efficacy of dual-wavelength laser therapy using minimally invasive techniques for intrabony periodontal defects where it showed that use of such dual wavelength lasers showed up to 40% bone-fill which was favorably comparable with traditional surgery[7].

Dogan et al in 2016 conducted a study to compare the efficacy of GTR with GTR plus low-level laser therapy in the treatment of Grade II furcation defects. This study showed that both treatment modalities led to significant favorable clinical improvements but GTR plus LLLT showed to be more effective than GTR alone[16].

In a recent meta-analysis and systemic review done by Behdin et al in 2015 for the effectiveness of laser application in periodontal surgical therapy, showed that the evidence available is insufficient to support the effectiveness of dental laser as an adjunct to reparative/regenerative surgical periodontal therapy, due to small sample size and heterogeneity among studies[17].

To date, although clinical reports of successful laser applications for regeneration in periodontal and peri-implant diseases have been published, evidence supporting the therapeutic benefit of laser use from larger clinical trials and meta-analyses has not yet been conclusively established[17].

On the other hand, two wavelength-specific techniques like LANAP, using Nd:YAG laser and Er:YAG laser assisted comprehensive pocket treatment (Er-LCPT) using Erbium lasers have shown to be more effective and suitable over conventional surgical option of treatment[5,9].
It is evident by the data that adjunctive use and as nontherapeutic use of lasers for periodontal regeneration is better than the conventional methods alone; providing a more comprehensive method of treatment for moderate-severe cases of periodontal disease with periodontal pockets.
Hence, the studies done in past 5-6 years showed promising results especially in usage of laser for regenerative purposes along with its various other bio stimulatory effects.

The use of lasers for calculus detection using laser fluorescence that is optical coherence tomography and a laser system which can selectively and completely lead to removal of plaque and calculus is under development. This can direct the future of lasers towards a minimally invasive regenerativeprocedure. [4,7,8]
A “Photo-brushing” approach involving the application of anti-microbial photodynamic therapy for routine plaque control by patients is also under development[18].

6. CONCLUSION

Literature review of the past 5-6 years studies on lasers for periodontal regeneration were conducted on various aspects via increased rate of wound healing, analgesic effects, regenerative

effects via increased differentiation of osteogenic cell lineages from the stem cells available in the periodontium, along with the regeneration of soft tissue and it's improved qualitative and quantitative characteristics during orthodontic procedures.

Hence, along with various bio stimulatory actions of lasers (depending on wavelength, frequency, mode etc) as described in literature studies, a new feather of "regeneration" has been added to the hat of laser application in periodontology.

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