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Low level laser role in the regeneration of injured periodontal tissue

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Abstract

As medical science has advanced over the last decades, laser has become a great pioneer and ally of treatment procedures, since it has a great effectiveness in most treatments it is used including regeneration of injured tissues. Its major advantages is that, the patient's own body can be activated by the laser to produce certain substances that can often replace the drugs and no need to take medicine.

This study aimed to demonstrate the low level laser performance in the regeneration of damaged periodontal tissues. It is required to outline the device properties, kinds of radiation, the interaction of this radiation with molecular and cellular structures of the human body and the physiological effects in such tissues, so that it will be understood how laser works and performs in injured tissues. Many clinical papers have provided very important information regarding the subject, in which results of experimental studies have demonstrated numerous benefits in using low level laser in injured tissues, favoring a major breakthrough in clinical practice in several areas including periodontal treatments. If the ideal means to use laser as required wavelength, waveform, intensity, polarity, coherence and the choice of the correct laser type, duration and number of sessions, then features of the tissue to be irradiated and a faster tissue regeneration can be obtained by accelerating the collagen synthesis and cellular metabolism. Thus facilitating the clinical process. The fact is that when laser is introduced in a therapeutic treatment, wonderful favorable results are achieved.

Keywords: Low Level Laser Therapy (LLLT), Diode Laser, Soft tissue regeneration

Introduction

Laser is 'Light Amplification by Stimulated Emission of Radiation'. It consists of a coherent beam of light that focuses on a small well-defined area. There is virtually no dispersion and scattering in this beam. Any substance within that ray evaporates instantly.

In dentistry, laser is being used for two different treatments: laser surgery and laser therapy. Low level laser therapy (LLLT) is used for improving tissue healing and regeneration, also known as photobiomodulation. LLLT is a treatment in which low-level lasers or light-emitting diodes (LEDs) are used to change cellular functions and is a clinical tool in regenerative medicine and dentistry to improve healing processes and management of functional disorders [1]. Laser therapy gives a better inflammatory response by reducing edema and pain [2]. It has been found that Low-level lasers exert bio-stimulatory effects on various cell types, including osteogenic cells and bone tissue [3,4]. Some injections and medicines have the problems of systemic side effects, whereas LLLT has the advantage of not having much impacts on the health conditions of the patients [5].

Types of Laser

Each kind of Laser therapy has its own wavelength, power density, and energy density, type of exposure and treatment duration [6]. Although diode lasers are being used frequently for different dental treatments, other types of lasers; Helium-Neon (He-Ne), Argon etc. are being used successfully for various cell activation.

Diode &Nd-YAG : Lasers are the photonic energy from Diode & Nd. YAG which has the neon-infrared spectrum (approx.. 800-1100nm) and is selectively absorbed in areas of inflammation by blood components and tissue pigments. They are the soft tissue LASERS. A non-contact mode may be employed while attempting any hemostasis. For initial periodontal therapy, these lasers are used for inactivation of bacteria and removal of inflamed soft-tissue from periodontal pocket or from around the implant sulcus. These procedures employ relatively low average power, which are usually below than that used for surgery. Nd-YAG laser must be used with caution, and attention must be given to the irradiation parameters and to the laser beam placement while in action.

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). 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.

ERBIUM Laser: Erbium lasers such as Er-YAG and Er:Cr:YSGG lasers target water or 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:YSGG5 . It can be used as a hard tissue laser for excisions, ablations, bony tissue exostosis and bony tissue biopsy. The photonic energy of both the lasers can be delivered in either a contact or 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.

Effect of LLLT

The positive effects of LLLT on tissues have been demonstrated by many in vivo and in vitro studies. LLLT increases the survival of Adipose-derived mesenchymal stem cells (ASCs) and also stimulates the secretion of growth factors in the wound bed [7]. Application of LLLT has shown a better tissue organization at the site of the injury, with the presence of granulation tissue and new bone formation [8]. Improved opening of the mid-palatal suture and accelerated bone regeneration are other clinical effects of low-level lasers in rapid maxillary expansion process [9]. LLLT also stimulates repair process of the radiation-related damages in alveolar bones [10] and can enhance mineralization in sockets [11].

The effects of level laser radiation are divided into two major parts: biochemical and bioelectric. The biochemical effects of laser radiation include release of preformed substances as a result of the incorporation of laser radiation; histamine, serotonin and bradykinin, and change in enzymatic relations; provides stimulatory or inhibitory changes in normal enzymatic reactions with production of ATP (adenosine triphosphate) and prostaglandins synthesis. The biochemical effect of laser radiation has got advantages in therapeutic effects [13] [14] [15] [16]. The bioelectric effect occurs as the interior of cells is electrically negative as compared to the cell exterior. This difference in potential is due to the presence of different concentrations of positive or negative ions inside or outside the cell [13] [14]. Considering this electrical and concentration gradient, there is a natural tendency to neutralization by diffusion. Therefore, the bioelectric effect of laser radiation comes down to the maintenance of membrane potential [6]. The maintenance of membrane potential is favored by laser radiation from the direct interference onion mobility [12] [13].

Mechanism of LLLT

The precise mechanism of LLLT has not been completely explained yet, though several in vitro studies have shown that LLLT has stimulating effects on osteoblast-like cells and accelerates the repair process of the bone [3,11]. Some other studies reported about delayed fracture healing or no effects after low level laser irradiation [5]. Bloise et al. used diode laser (659 nm) on human osteoblast-like cell line (Saos-2), which resulted in enhanced proliferation and differentiation [17]. Same type of results was shown in the study carried out by Stein et al. using a helium-neon (He-Ne) laser (632 nm) on human osteoblast cell line which also promoted cell proliferation and maturation of human osteoblasts [4]. However, Bouvet-Gerbettaz et al. used a diode Laser (808 nm) to assess bone cell proliferation as well as osteoblastic and osteoclastic differentiation on murine bone marrow cells and found no significant change between the control (non-radiated) and LLLT groups [18]. On the other hand, in another study, a single exposure of 830 nm Diode on osteoblastic (MC3T3) cell line resulted in a reduction in cell growth compared to non-irradiated controls [5].

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 as well as hard tissue contribute to the beneficial effects of 'surgical' laser approaches. 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 bio-stimulation. Laser therapy has been well accepted by patients as a minimally invasive procedure that potentially reduces the necessity of subsequent periodontal flap surgery.

Robert Gregg and Del Mc Carthy 1989, developed Laser-assisted new attachment procedure (LANAP) while looking for alternatives to conventional periodontal surgery, especially for periodontally hopeless teeth. 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)[19]. 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. 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.

Aoki et al (2015) proposed the concept of Laser Assisted Comprehensive Pocket Therapy (LCPT) in which Erbium lasers can safely and effectively be used to remove granulation tissue, even from the bone defects difficult to access without harming the osseous tissue [19]. When it is used in non-Surgical Periodontal Therapy, can aid in restoring periodontal health. Successful clinical results have been obtained with this therapy. Thus 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 of implantology. Use of low-level laser therapy and certain wavelengths, specific lasers enhances biostimulation in the cells. It has been found 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 [20]. In a study done by Flaminia (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[21]. Another study done by Aleksie et al in 2010, it was suggested that low-level Er-YAG may be able to promote bone healing following periodontal and peri-implant therapy[22]. Properly applied, LLLT 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[24]. A recent study done by Falaki et al in 2016 checked for the efficacy of dual-wavelength laser therapy using minimally invasive techniques for intra-bony 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[23] . 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[25]

To date, although many 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[26]. 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[27,28]. 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 which provides 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 regenerative procedure.

Discussion

It is well accepted that low level laser therapy (LLLT) is a clinical tool in regenerative dentistry and medicine which improves healing process and management of soft tissue regeneration [1]. Directing bio stimulative light energy to the cells is the main aim of low level laser therapy. Without having no significant increase in tissue temperature, LLLT stimulates the molecules of cells.

Low-level laser therapy (LLLT) as a simple and noninvasive technique which is highly effective in different branches of regenerative dentistry and medicine. It shows favorable results on a variety of pathological conditions; pain and inflammation reduction, Chondral and fibroblast proliferation, collagen synthesis and nerve regeneration, and such other effects of LLLT.

Wave lengths used in LLLT irradiation varies between 600 to 1000 nm with an energy density of 0.04–60J/cm^2. Different laser light sources, like helium-neon and gallium-aluminium-arsenide (GaAlAs), are being frequently used in clinical studies such as: surgical treatments of oral lesions, recovery of implants, bacteria reduction in root canals, bacteria reduction in periodontal pockets and dentine hypersensitivity reduction. Diode lasers are known to have a high penetration depth compared to other types of laser.

As the exact mechanism of LLLT action is still unclear, we may not be aware of the effects of laser therapy on other parts of the body.

Conclusion

Considering the variety of lasers, exposure of cells and less study on the subject, exact effects of LLLT seems to be unclear. Although almost all the studies agreed on getting positive effects from LLLT, still it is not clear that it has no effect on other parts of the body. With low-energy density range, low level lasers appear to create a biostimulatory effect on tissue and cells, thereby enhance osteoblastic proliferation and differentiation on cell lines. Thus it may be a useful tool for regeneration therapy.

Despite the fact that many researches have been done on the applications and effects of LLLT on different cell lines, without knowing the precise mechanism and effects, no one able to offer a clinical treatment protocol. The paper may help further progress in study and extend practical use of LLLT in future.

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