Role of Laser Bioactivation in Surgical Periodontal Therapy: An Update

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Abstract Low level Laser therapy (LLT) is the safest therapy which is used from past many decades. This therapy doesn't increase the temperature of the treated tissues and therefore also called as soft laser therapy. Application of LLT is commonly used in dental treatments and its application in periodontal filed are inflammatory process, wound healing, periodontal therapy, various types of grafts, periodontal flaps. The present study shows the role of LLT in periodontal aspects.

Keywords LASERS, low level laser therapy, periodontal therapy, wound healing, gingivectomy, connective tissue graft

INTRODUCTION

Low- level laser therapy (LLLT) is a light source treatment that generates light of a single wavelength. The phrase "therapeutic laser" has also been used to suggest the purpose and intent of the treatment. A more appropriate designation of the phenomenon might be "LASER PHOTOBIOMODULATION or LASER BIOACTIVATION." [1]

MECHANISM OF ACTION OF LOW LEVEL LASERS

Bio-stimulatory effect of laser irradiation represents a set of structural, biochemical and functional changes in living microorganisms. It supplies direct bio-stimulation light energy to the body cells. Cellular photoreceptors (e.g. Cytochromophores and antenna pigments) can absorb low-level laser light and pass it on to mitochondria, which promptly produce Adenosine-triphosphate (ATP). The alterations in photo-acceptor function are the primary reactions and subsequent alterations in cellular signalling, and cellular functions are secondary reactions resulting in faster cell division, proliferation rate, migration of fibroblasts and rapid matrix production.[1]

Primary reactions after light absorption

There are various theories to explain the mechanism of therapeutic lasers.[1]

1. Singlet oxygen hypothesis (1981)
2. Redox properties alteration hypothesis. (1988)
3. Nitrogen oxide hypothesis (1992)
4. Transient local heating hypothesis. (1992)
5. Superoxide anion (1993)
6. Photochemical theory (1999)

The most recognized theory to explain the effects and mechanism of therapeutic lasers is the photochemical theory. According to this theory, the light is absorbed by certain molecules, followed by a cascade of biologic events. Suggested photoreceptors are the endogenous porphyrins and molecules in the respiratory chain. (Cytochrome c-oxidase, leading to increased ATP production) In addition, the conversion of some of the incident energy into heat would suggest an increase in local micro-circulation through vasodilation. Therefore the stimulatory effects of LLLT include the following:

- Proliferation of macrophages
- Proliferation of lymphocytes
- Proliferation of fibroblasts
- Proliferation of endothelial cells
- Proliferation of kerantinocytes
- Increased cell respiration /ATP synthesis
- Release of growth factors and other cytokines
- Transformation of fibroblasts into myofibroblasts
- Increase in fibroblast growth factor (FGF)
- Collagen synthesis

The most popularly described treatment benefit of LLLT is wound healing. Mester et al (1971) did electron microscopic examination and showed evidence of accumulated collagen fibrils and electrondense vesicles intra-cytoplasmatically within the laser-stimulated fibroblasts as compared with untreated areas. The range of radiation doses at which stimulation of fibroblast proliferation has been observed is wide (0.45-60 J/cm2).

The mechanisms of action underlying the analgesic effects are unclear, despite the implicit treatment benefits. There is evidence suggesting that LLLT may have significant neuropharmacologic effects on the synthesis, release, and metabolism of a range of neurochemicals, including serotonin and acetylcholine at the central level and histamine and prostaglandin at the peripheral level. The pain influence has also been explained by the LLLT effect on enhanced synthesis of endorphin, decreased c-fiber activity, bradykinin, and altered pain threshold.[1]

Low Level Laser Therapy in The Periodontal Inflammatory Process

Low-level laser is capable of reducing inflammation and appearance of MMP8 (Matrix Metallopeptidase8) following scaling. It can also prevent plasminogen increased activity, and prostaglandin synthesis. Plasminogen activity is capable of activating latent collagenase, the enzyme responsible for cleaving collagen fibres. Studies have shown that low-level laser may lower IL-1ß; and this effect depends on radiation duration. In the meantime, it can reduce IFN-γ, while having stimulating effect in the production of PDGF and TGF-ß. All these changes would result in anti-inflammatory effect of low-level laser. In brief, low-level laser affects COX2, IL-1ß, MMP-8, PDGF, TGF-ß, bFGF, and plasminogen expressions.[2]

Low Level Laser Therapy in Wound Healing

Periodontal wound healing is necessary when periodontitis and gingivitis, or trauma, have affected the composition and integrity of the periodontal structures. LLLT has been shown to cause vasodilation, with increased local blood flow. LLLT causes the relaxation of smooth muscle associated with endothelium. This vasodilation brings in oxygen and also allows for greater traffic of immune cells into tissue. These two effects contribute to accelerated healing**.**[2]

Wound healing consists of several distinct phases, all of which can be affected at the cellular level by LLLT. Faster wound closure is of great importance in compromised patients, such as diabetics, and patients undergoing treatment for malignancies. Because LLLT can enhance the release of growth factors from fibroblasts, and can stimulate cell proliferation, it is able to improve wound healing in such compromised patients. Histological studies have demonstrated that laser irradiation improves wound epithelialization, cellular content, granulation tissue formation, and collagen deposition in laser-treated wounds, compared to untreated sites .These findings have been confirmed in oral mucosal wound healing in clinical studies in humans.(Marie et al.1997)[3]

LLLT benefits can be performed with various wavelengths and units with different outputs. Usually, the therapeutic window for sub-thermal tissue interaction is 1 to 500 mW, but surgical lasers can be defocused and used as a low level laser. The most popular lasers are relatively inexpensive diode units that were developed in the 1980s. The GaAs (gallium-arsenide; 904 nm) diode laser was developed in the early 1980s and was typically 1 to 4 mW. Pulse-train modulated GaAs lasers entered the market in the late 1980s.[1]

Application of low laser therapy in periodontal therapy

Bearing in mind the suitable sub-cellular absorption and the cellular-vascular impacts, low-level laser may be a treatment of choice for soft tissues. Low-level lasers is recommended in surgical periodontal therapy or as an adjunct to nonsurgical periodontal therapy for its pain –reducing, wound healing promoter and anti-inflammatory effects[1]

Qadri et al. 2005[4] conducted a split-mouth, double-blind controlled clinical trial to study the effects of low-level lasers as an adjunctive treatment of inflamed gingival tissue. In seventeen patients with moderate periodontitis, samples of Gingival Crevicular Fluid (GCF) and subgingival plaque were taken one week after SRP. The laser therapy was started 1 week later and continued once a week for 6 weeks. One side of the upper jaw was treated with active laser and the other with a placebo. The test side was treated with two low-level lasers having wavelengths of 635 and 830 nm. The GCF samples obtained were analysed for elastase activity,IL-1β and MMP-8. The results showed that, the probing pocket depth, plaque and gingival indices were reduced more on the laser side than on the placebo one. The decrease in GCF volume was also greater on the laser side. Elastase activity, IL-1beta concentration and the microbiological analyses showed no significant differences between the laser and placebo sides while there was decrease in MMP-8 on the laser side.

Pejcic A et al. 2010[5] analyzed the effects of low level laser irradiation treatment and conservative treatment on gingival inflammation. All patients in the study underwent conservative treatment. After conservative therapy, the patients from the experimental group were subjected to 10 low level laser treatment sessions. The results of this study showed that the with laser therapy values of indexes decreased steadily, whereas with conservative therapy they increased up to a certain point, but did not reach the pre-therapy values.

Makhlouf et al. 2012[6] conducted a split-mouth, double blinded, short-term, controlled clinical trial to study the effect of low-level laser therapy (LLLT) as an adjunct to scaling and root planing (SRP) for treatment of chronic periodontitis. Sixteen patients with a probing pocket depth (PPD) of 4–6 mm involving at least three teeth in each quadrant were recruited for the study. Afterwards, SRP quadrants were randomly assigned for 10 sessions of LLLT. The results showed that SRP+LLLT (10 sessions, 830 nm, 100 mW, 3 J per point, 3 J/cm2) exhibited greater reductions in PPD at 5 weeks and 3 months but not at 6 months. Further, SRP+LLLT-treated sites had a statistically significant increase in mean radiographic bone density when comparing 6- and 12-month data and overall from baseline to 12 months. There was also reduction in interleukin (IL)-1β but the difference between control and laser sites was not statistically significant.

Obradovic R et al. 2012[7] conducted a study to evaluate the effects of low-level laser therapy (LLLT) by exfoliative cytology in patients with Diabetes mellitus (DM) and gingival inflammation. Three hundred patients were divided in three equal groups: Group 1 consisted of patients with periodontitis and type 1 DM, Group 2 of patients with periodontitis and type 2 DM, and Group 3 of patients with periodontitis (control group). After oral examination, smears were taken from gingival tissue. Full-mouth scaling and root planning was done. A split-mouth design was applied; on the right side of jaws GaAlAs LLLT (670 nm, 5 mW, 14 min/day) was applied for five consecutive days. After the therapy was completed, smears from both sides of jaws were taken. The results showed that the investigated parameters were significantly low after therapy compared with values before therapy. Therefore it was concluded that LLLT as an adjunct in periodontal therapy reduces gingival inflammation in patients with DM and periodontitis.

Low-Level Laser and Gingivectomy

Gingivectomy is used to remove the supra-bony periodontal pockets, or the pockets not extending from the Muco-gingival junction. Following gingivectomy, an open wound is formed whose repair may take more than five weeks; the period in which the patient may experience pain due to the open wound and secondary repair. Therefore, there have been studies through which drugs, antibiotics, and amino acids are used to reduce pain and speed up repair. Recently studies were conducted to evaluate the effect of LLLT on healing and reduction of pain after gingivectomy procedure.[1]

Amorim JF et al. 2006[8] conducted a study to investigate gingival healing after gingivectomy and adjunctive use of low-level laser therapy (LLLT). Twenty patients with periodontal disease were selected. After surgery; one side was submitted to LLLT using a 685-nm wavelength, output power of 50 mW, and energy density of 4 J/cm2. The other side was used as the control and did not receive laser irradiation. Healing was evaluated, clinically and biometrically, immediately post-surgery and at days 3, 7, 14, 21, 28, and 35. The results showed significant improvement in healing for the laser group at 21 and 28 days.

Ozcelik O et al. 2008[9] conducted a split-mouth controlled clinical trial to assess the effects of LLLT on healing of gingiva after gingivectomy and gingivoplasty. Twenty patients with inflammatory gingival hyperplasia on their symmetrical teeth were included in this study. After gingivectomy and gingivoplasty, a diode laser (588 nm) was randomly applied to one side of the operation area for 7 days. The surgical areas were disclosed by a solution (Mira-2-tones) to visualize the areas in which the epithelium is absent. The results showed that LLLT-applied sites had significantly lower stained areas compared with the controls on the post-operative third, seventh and 15th day.

Martu S et al .2012[10] evaluated the efficiency of laser therapy in healing, regeneration and repair processes located in the superficial periodontium after gingivectomy procedures. The study group consisted of 38 patients without any systemic diseases presenting with gingival hypertrophy developed exclusively within the clinical context of gingivitis and/or periodontitis. 17 patients were treated only through gingivectomy procedures. For 21 patients, gingivectomy was associated with laser therapy, applied every day for seven days. Gingival mucosa fragments were taken on day 1 and on day 21, and routinely processed for the microscopic exam. This study showed morphological differences at the gingival epithelium level and subjacent lamina propria in laser group i.e there was decrease in the inflammatory infiltrate located in the lamina propria and diminished number of lymphocytes and macrophages which determine a lower production of chemical mediators interfering with the sequences of the healing process.

Low-Level Laser and Periodontal Flaps

Gingival recession is a ubiquitous finding in periodontal visits, which can lead to root sensitivity, aesthetic problems, and caries. There are numerous ways for the treatment of gingival recession, one of which is Coronally Advanced Flap (CAF). Numerous models have been suggested to increase the CAF potential as a treatment protocol, one of which is the low-level laser.

Ozturan, et al. 2011[11] conducted a study on coronally advanced flap adjunct with low intensity laser therapy. In this split mouth study, after CAF, and before suturing, laser was radiated to the targeted area. The laser parameters used included a wavelength of 588nm, with a power of 120mW, continuous mode, and 5 minutes radiation duration. Following suturing, the targeted area was radiated with laser. No dressing was used. The patients underwent laser therapy everyday for 5 minutes for 7 days. In the control group, following CAF surgery, laser (in switched off form) was used. Significant differences were found for the width, and depth of the gingival recession, keratinized gingival thickness, and finally clinical attachment level and complete root coating in the test group was more than that of the control group.

Javier et al. 2013[12] conducted a single-masked pilot clinical study to compare the tissue response and postoperative pain after the use of a diode laser (810 nm) (DL) as an adjunct to modified Widman flap (MWF) surgery to that of MWF alone. Statistically significant differences were seen for tissue edema and pain scale assessment. The study concluded that the use of an 810-nm diode laser provided additional benefits to MWF surgery in terms of less edema and postoperative pain.

Doshi et al. 2014[13]conducted a randomized controlled double-blinded split mouth study to compare the levels of dentinal hypersensitivity (DH) and pain after 660 nm laser irradiation in test and control sites following periodontal flap surgery. There was statistically significant decrease in both DH and pain in the laser-irradiated site on the 7th day following periodontal flap surgery, as compared with the control site.

Jayachandran et al. 2015[14] analyzed the pre and post–operative results obtained between conventional periodontal flap surgery and diode laser assisted periodontal flap surgery. According to this study clinically significant improvement in probing pocket depth and clinical attachment levels were observed in both the surgical sites. Patient acceptance and comfort were more in laser treated sites compared to conventional surgical sites.

Low-Level Laser and Free Gingival Graft

Moslemi et al. 2014[15] conducted a randomized controlled clinical trial to evaluate the effect of 660nm low power laser on pain and healing in palatal donor site. In the test group, following the free gingival graft ops, the Diode laser with 660 nm and a power of 200 mW was applied to the targeted site for 32 seconds, which was repeated on days 1, 2, 4, and 7 post-op .On day 14, the palatal wound in the laser-applied group was significantly better healed than the control group regarding clinical repair and epithelialization; and in day 21, the epithelialization amount was significantly much better in the laser-applied group than the control group. The authors concluded that low-level laser may heal the wound in the palatal graft site.

Lasers and Connective Tissue Graft

Stephanie et al. 2014[16] evaluated the treatment of gingival recession with a connective tissue graft (CTG) alone or in combination with low-level laser therapy. The test group presented more complete root coverage than the control group Dentine sensitivity decreased significantly after 6 months in both groups. Therefore the authors concluded that Low-level laser therapy may increase the percentage of complete root coverage when associated with CTG.

SUMMARY

The use of LLLT helps to control the symptoms and condition of periodontitis. The anti-inflammatory effect slows or stops the deterioration of periodontal tissues and reduces the swelling to facilitate the hygiene in conjunction with other scaling, root planning, curettage, or surgical treatment. As a result, there is an accelerated healing and less post-op discomfort. It is non-invasive, non-pharmaceutical, and economical. These benefits may help generate interest among more clinicians, researchers, and manufacturers to study and gain more knowledge on how best to use this phenomenon. Developing the equipment and treatment protocols and training the general educators and health practitioners is essential for improving health services and treatment outcomes.[1]

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