

Low Level Laser Therapy –A Review

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Abstract: Low level laser therapy is defined to supply direct biostimulative light energy to the cells. It has been reported that low-level semiconductor diode lasers could enhance the wound healing process. The periodontal ligament is crucial for maintaining the tooth and surrounding tissues in periodontal wound healing. Low-level semiconductor diode lasers have been used in low-level laser therapy, there have been few reports on their effects on periodontal ligament fibroblasts (PDLFs). Low intensity laser therapy also has stimulating effects on bone cells and can accelerate the repair process of the bone. However still further research needs to be done in laser efficacy for periodontal treatment.

Key Words: Biostimulation, Low-level laser therapy, Periodontics, Wound healing.

I. Introduction

The principle of using low level laser therapy (LLLT) is to supply direct biostimulative light energy to body cells. Absorbed laser energy causes stimulation of molecules and atoms of cells. Using low-intensity laser radiation on the tissues does not cause rapid and significant increase in tissue temperature.[1] Among various lasers used for periodontal purposes, semiconductor diode lasers are mainly applied in subgingival curettage and periodontal pocket disinfection.[2,3] So far, a concerted effort has been made in the field of root conditioning to improve the outcome of regenerative periodontal therapies by favoring the attachment of the regenerated periodontal structures.

II. Mechanism Of Action

The mechanisms of low level laser therapy are complex, but essentially rely upon the absorption of particular visible red and near infrared wave lengths in photoreceptors within sub-cellular components, particularly the electron transport chain within the membranes of mitochondria. [4,5]

Low level laser therapy (LLLT) is also known as laser phototherapy (LPT), biostimulative therapy (BT), Low-intensity laser therapy (LILT).

III. Low Level Laser Therapy In The Periodontal Inflammatory Process

The chronic periodontal inflammatory process leads to the destruction of the periodontal ligament, and subsequently, to loss of alveolar bone [3]. It has been reported that LPT is able to reduce gingival inflammation and metalloproteinase 8 expression when applied after scaling and root planning.[6,7,8] Ozawa et al. [9] showed that LLLT significantly inhibits the increase in plasminogen activity induced in human periodontal ligament cells in response to mechanical tensile force. Plasminogen activity is capable of activating latent collagenase, the enzyme responsible for cleaving collagen fibres. LLLT also effectively inhibits PGE2 synthesis.[10] LLLT can modulate the periodontal inflammatory process, especially through reducing PGE2 release [11].

IV. 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 (laser Periodontal therapy) has also been shown to cause vaso-dilation, with increased local blood flow. This vasoactive effect is of relevance to the treatment of joint inflammation. 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. [12,13]

Several invitro studies have shown that LLLT at certain wavelengths may stimulate fibroblast proliferation when certain combinations of exposure parameters and power densities are used [14-23]. The range of radiation doses at which stimulation of fibroblast proliferation has been observed is wide (0.45-60 J/cm²). Of note high dose LPT suppresses both fibroblast proliferation and autocrine production of basic fibroblast growth factor. [24]

LLLT effects on macrophages include increased ability to act as phagocytes, and greater secretion of basic fibroblast growth factor. Macrophages resorb fibrin as part of the demolition phase of wound healing more

quickly with LLLT, because of their enhanced phagocytic activity during the initial phases of the repair response (for example, 6 hours after trauma). More rapid demolition of the wound establishes conditions necessary for the proliferative phase of the healing response to begin.

Wound healing consists of several distinct phases, all of which can be affected at the cellular level by LLLT. The initial, pro-inflammatory and vaso-active phases of inflammation include clotting of any cut blood vessels and deposition of a platelet plug, after which the site is infiltrated by neutrophils and macrophages.[25] The second phase of wound healing involves proliferation, with the formation of granulation tissue as a result of new blood vessel growth. Direct evidence for enhanced collagen gene expression both in skin fibroblast cultures in vitro, as well as in animal models of wound healing in vivo, has been presented.[26]

A final aspect of the effect of LLLT on cells relates to the effects of laser light on the cytoskeleton. Several studies have suggested that LLLT can modulate cell behavior by causing re-arrangements of the cytoskeleton.[27,28]

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 [29,30]. These findings have been confirmed in oral mucosal wound healing in clinical studies in humans.[31]

V. Effects Of Low Level Laser Therapy On Bone Cells

In the laboratory setting, LLLT using a HeNe laser exerts pronounced effects on proliferation, differentiation and calcification of cultured osteoblastic cells, although there is a specific therapeutic window for these effects. Cell proliferation and DNA synthesis are increased by LLLT only when the cells are in a phase of active growth. LLLT causes increased accumulation of calcium and accelerates calcification in vitro. If the in vivo parallel holds true, LLLT of healing sites within bone would be expected to increase bone deposition and promote bone regeneration.

In a study of wound healing after tooth extraction in a rat model, LLLT delivered on a daily basis for one week using a gallium-aluminium-arsenide (Ga Al As) laser, both increased fibroblast proliferation and accelerated formation of bone matrix were found.[32] However, studies of the influence of LLLT on bone and connective tissue regeneration in the palate in a canine animal model failed to find an effect. While at first glance this would suggest major species variations in the response of bone cells to LLLT, in the case in point irradiation levels were low and LLLT treatments were administered every second day rather than daily. Whether LLLT exerts positive results on bone regeneration following tooth extractions in humans remains controversial, although there are reports that the formation of granulation tissue during post-extraction healing is accelerated.[33]

For the treatment of intrabony defects, the use of barrier membranes and different types of grafting materials are usually indicated. In the study of effect of LLLT on the healing of bone defects associated with autologous bone grafts, bone remodelling was both quantitatively and qualitatively more evident in irradiated animals than in non irradiated animals[34]. The association of matrix protein derivative with the LLLT irradiation has shown a reduction in post operative pain, which suggests that LLLT may improve the effects of matrix protein derivative by reducing post operative complications [35]. LLLT biostimulation of bone tissue attachment to implant surfaces has also been reported. It has been shown that LLLT influences the expression of osteoprotegerin, receptor activator of nuclear factor K β ligand and receptor activator of nuclear factor K β , and results in the expansion of bone cells metabolic activity.[36,37]

VI. Low Level Laser Therapy And Analgesia

The ability of LLLT to exert analgesic effects has historically been a major clinical application of the technique. In vivo studies of the analgesic effect of LLLT on nerves supplying the oral cavity have demonstrated that LLLT decreases the firing frequency of nociceptors, with a threshold effect long-standing post-surgical IDN injury were assessed.[38,39] LLLT involved treatment along the distribution of the nerve for a total of 20 treatments. Control subjects received placebo LLLT. The degree of mechanoreceptor impairment and thermal sensitivity disability was comparable in test and control groups before treatment. Following LLLT, the test group showed a significant improvement in mechanoreceptor sensory testing, as well as a subjective improvement in sensory function, indicating that LLLT can improve mechanoreceptor perception in long-standing sensory aberrations in the IDN. However, there was no significant improvement in thermal responses in either group.

VII. Antimicrobial Photodynamic Therapy

Differently from high-power lasers, low-power lasers do not increase tissue temperature.[40] Thus, when used alone, the same antimicrobial effect as that of high-power lasers in periodontitis active sites cannot be expected.[41] The antimicrobial effect of low-power lasers is achieved by association with extrinsic photosensitizers, which results in the production of highly reactive oxygen species[42] that cause damage to membranes, mitochondria and DNA, culminating in the death of the microorganisms.[43-45] This is the process of aPDT, and its use is being increasingly studied with the aim of complementing the microbial reduction achieved by conventional mechanical periodontal therapy.

VIII. Laser Curettage

Both the Nd: YAG and gallium-arsenide (or diode) lasers are promoted for curettage.

IX. Low Level Laser Therapy And Neural Tissue

LLLT has also been proven to reduce pain in patients suffering from post-herpetic neuralgia, from cervical dentinal hypersensitivity [46], or from periodontal pain during orthodontic tooth movement [47]. LLLT may also be of benefit in treating TMJ disorders.

X. Low Level Laser Therapy Equipment

Semiconductor diode lasers are compact and have high conversion efficiency from electrical energy to laser energy. Unlike He-Ne lasers, semiconductor laser diodes do not require a high voltage supply, and so can be used in portable, battery-operated devices. It is also possible to pulse the light at various frequencies using simple external circuitry. Laser diodes have a typical life-expectancy of between 1,00,000 and 6,00,000 hours.[48] Semiconductor diode lasers are generally variants of either Aluminium:Gallium:Arsenide (AlGaAs) which emit in the near infrared spectrum (wavelength 700-940nm), or

Indium: Gallium: Arsenide: Phosphorous (InGaAs) devices which emit in the red portion of the visible spectrum range (wavelength 600-680nm). The Beam Profile from a typical diode laser is rectangular, with a high divergence on the long axis and low divergence on short axis. Laser units used for LLLT are generally classified as Class 3 and 3b in terms of the optical hazards which they pose to staff and patients. A monochromator will readily distinguish between a true laser diode and a LED.

XI. Conclusion

Based on results of reviewed articles, low intensity laser therapy can accelerate bone healing in extraction sites, bone fracture defects and distraction osteogenesis in animal models. The mechanism of action might be through stimulation of cellular proliferation and differentiation and acceleration of the healing process. Further trials of new LLLT applications in dentistry should make use of standardized, validated outcomes, and should explore how the effectiveness of the LLLT protocol used may be influenced by wavelength, treatment duration, dosage, and the site of application.

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