Review Article

The Role of Low-Level Laser in Periodontal Surgeries

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Abstract:

Treatment protocols with low-level Laser (also called 'soft laser therapy) have been used in health care systems for more than three decades. 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 have played crucial and colorful roles in performing periodontal surgeries. Their anti-inflammatory and painless effects have been variously reported in in-vitro studies. In this present review article, searches have been made in Pub Med, Google Scholar, and Science Direct, focusing on the studies which included low-level lasers, flap-periodontal surgeries, gingivectomy, and periodontal graft. The present study has sought to review the cellular impacts of low-level lasers and its role on reducing pain and inflammation following soft tissue surgical treatments.
Keywords: LLLT; periodontal diseases; laser

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Introduction

Literarily speaking, the term 'LASER' means light amplification by stimulated and excited emission, or empowerment of excited light distribution. Photon radiation is excited by atoms, which then results in the release of the next photons, and finally ends up in the generation of a strip of homologous, mono-color, and parallel light, which is named 'LASER'.

The basic theory of laser was first explained in an article by Albert Einstein[1]; however, it took relatively a long time till industry and technology could provide the grounds for manufacturing the first laser tool. Based on the theories put forth by Einstein, the first instrument for producing laser beams was invented by Maiman[2]. In the mid 1960s, laser was used for its coagulating effects in retina. In fact, the ophthalmologists were the pioneers in utilizing laser. Since then, much improvement was observed in laser use. In 1964, and for the first time, Goldman used laser in dentistry for the treatment of dental caries. The advantages of laser utilization in repair treatments included reduction of patient's physical and mental stresses due to a decrease in noise and vibration, increasing efficiency, as well as betterment in the results because of decontamination, homeostatic and ablative effects[3,4]. Dental lasers classification have been shown according to output, type of active medium and oscillating mode in Table 1.

Low-Level Laser

Low-level laser treatment, also called 'Soft Laser Therapy' has been used for more than three decades in the health system. It was first introduced by Mester and his colleagues. They pointed out that laser application with 1j/cm^4 would result in lesion repair in mice [5]. Low-level laser is a red light or infrared light whose wave length has a low absorption power in water and is capable of penetrating into soft and hard tissues in a depth of 3mm-15mm. Low-level laser application mechanism is complex; however, the most important absorption parameter of red light or infrared light is in the sub-cellular

Table 1. Laser classification according to output power, active mediator and mode of oscillating.

Standard	Type	Example
Output Energy	Low-output, soft, or therapeutic	Low-output diodes, Helium-Neon
	High-output, hard, or surgical	High-output, hard, or surgical Diodes, CO_2, Nd:YAG, Er:YAG, Er,Cr:YSGG
Mediator	Solid	Nd:YAG, Er:YAG, Er,Cr:YSGG, KTP
	Gas	Gas HeNe, Argon, CO_2
	Excimer	Excimer F_2, ArF, KrCl, XeCl
	Diode	Diode GaAlAs, InGaAs
Oscillating Model	Continuous	Depending on the utilization method
	Pulse	Depending on the utilization method

photo-receptors, especially the electron transfer in the respiratory chain of the mitochondria membrane. Light absorption by respiratory chain components results in its short time activation and NADH oxidation. This oxidative phosphorylation causes a change in the mitochondrial and cellular cytoplasm revival. The electron transfer chain through enhancement of ATP, increase in electrical potential of mitochondrial membrane, activation of the nucleus and its synthesis result into an increase in the driving force to the cells.

Generally speaking, the impacts of low-level laser is through its non-heating effects [6] which result into the stimulation of fibroblast reproduction; and in in-vivo and in-vitro experiments, it has been shown that low-level laser is capable of speeding up the repair process [7,8]. On the other hand, low-level laser has been suggested as a method for post-op pain reduction; the involved probable mechanisms in pain reduction include stability of nerve cell membrane, enhancing cell revival systems, ATP production increase, etc.

Low-Level Laser Impact Mechanism on Inflammation

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. 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, and can justify its impact on wound repair. Lasers with wavelength of 670nm along with typical periodontal treatment result in betterment of treatment outcomes, as well as stability in treatment time [9]. Thus, the laser's anti-inflammatory effect does not originate from just one method; rather different mechanisms are involved in such a process. In brief, low-level laser affects COX_2, IL-1ß, MMP-8, PDGF, TGF-ß, bFGF, and plasminogen expressions [10-13].

Low-Level Laser Impact Mechanism on Repair

Numerous processes including inflammation, migration, reproduction, and differentiation are necessary in successful repair. Many studies have reported that low-level laser, with a specified wavelength results in fibroblast reproduction. In higher densities, no reproductive effects are observed. By moderating the inflammatory reactions, low-level lasers will start the proliferation phase sooner, and therefore it will increase collagenous fibers [14]. In many experimental and clinical studies which emphasized on speeding up the repair process, cell reproduction has been reported as the reason for laser impact.

Low-level laser may result into vasodilation, and local blood circulation, as well as relaxing the soft vascular muscles. This vascular dilation is responsible for blood perfusion, and an increase in the immunity cell migration to the tissues, these two effects can speed up repair. On the other hand, low-level laser can activate vessels by affecting the mast cells [15]. There is clear evidence proving that 820nm, 940nm, and 660nm lasers can stimulate mast cell degranulation[16] and thus the result of the release of pre-inflammatory TNF-α factor may stimulate the diffusion of leucocytes in the tissue; and on the other hand, the protease released from mast cells can change the basic membrane and facilitate leucocytes penetration into the tissue [17]. Low-level laser activates lymphocytes and speeds up their reproduction. The impacts of low-level laser on fibroblasts include fibroblast reproduction increase and maturation, fibroblast conversion into myofibroblast, reduction in reproduction of E2 prostaglandin, and an increase in fibroblast growth factor (bFGF)[18]. The very vital point here is that such impacts on the skin, buccal and gingival mucosa may be observed under low-level laser doses; while high doses result into reduction of fibroblast reproduction and growth factor release [18].

The effects of low-level laser on macrophages include the following: increase in phagocytic activity, increase in fibroblast growth factor secretion, absorption increase, and fibrin breakdown due to phagocytic activity in the first phase of speedy and early epithelialization tissue repair, increase in fibroblast activity, as well as faster diffusion of leucocytes.

Low-Level Laser Impact on Pain

Pain control following an operation is a necessary part of periodontal treatment. This pain results from tissue trauma and the release of inflammatory mediators, which reaches its highest pick following the removal of local anesthesia. Low-level laser has been suggested as a pain-control protocol, which has more advantages over oral pain relievers and anti-inflammatory non-steroidal drugs; the reason is that the treatment protocol of the anti-inflammatory effect of this kind of laser overlaps with its potential in the advancement of wound repair. The anti-pain mechanism of low-level laser is not yet clear; however, numerous studies have pointed out the physiological changes from light interference with various cells as the cause. The offered mechanisms include: stability of the lipid double membrane and its proteins, the enhancement of revival system and the increase in ATP production. Low-level laser can modify the inflammatory process in a dose-related mechanism; and thus it can reduce the inflammatory pain. In acute pains, premium outcome is reached when the low-level laser is prescribed within the first 72 hours following the operation [19].

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. Moreover, among other gingivectomy applications, one may refer to removing sick tissue for prosthetic or aesthetic purposes; or even in order to restore the normal gingival structure. 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 [20,21].

In a split mouth randomized clinical trial, “Clinical Study of the Gingiva Healing after Gingivectomy and Low-Level Laser therapy”, Amorim et al.[22] studied 20 patients. The patients had two-sided increased gingival volume on premolar teeth. Soon after gingivectomy was performed in the test group, low-level laser was used for 80 seconds onto the target area; 24 hours later, and also three and seven days post-op, low-level laser was used again. The parameters used in the study included Diode laser with a wavelength of 685nm, and a power of 50mW in continuous mode. Following all surgeries, periodontal dressings were used; the dressings were renewed 24 hours, three and seven days post-op. Photographic images were taken 3, 7, 14, 21, and 45 days following surgeries. The photographs were reviewed by three skillful periodontists based on the tissue color and contour, as well as the clinical condition of the wound repair. Moreover, in order to have biometrical assessment, a reference composite was inserted at the medial section of the buccal plane, and its distance with gingival margin and the pocket depth, as well as the keratinized gingival distance were calculated. After the third day post-op, the clinical visits showed better wound repair in the laser group; furthermore, the biometric assessments revealed more improvements in the laser group on days 21 and 28. In general, it was concluded that the application of low-level laser along with gingivectomy would result in improved conditions and faster repair [22]. Ozcelik, et al.[23] conducted a pilot study on wound healing by low-level laser irradiation after gingivectomy operations. In this split mouth randomized controlled clinical trial, 20 patients with an increased two-sided gingival volume in at least six teeth participated. Following surgery and homeostasis in the test group, low-level laser was radiated to the target points for five minutes, and then every day for one week. A specifically designed cast was made for each patient for preventing laser radiation diffusion onto the adjacent tissues. The applied laser parameters were a wavelength of 588nm and a power of 120mW in continuous mode. Dressing was not used following periodontal operation. All operations were performed by the same periodontist. The patients were prescribed to take Sodium Naproxen for pain relief. After each laser application, Mira-2-tone detector solution was used to determine the presence, or absence of epithelium, and lack of keratinization. The comparison of test and laser application was performed using Image Analysis Software. Soon after the surgery, no significant difference was found between the two groups for color; however, after 3, 7, and 15 days, the laser-applied group had fewer colored areas ($p<0.001$). Finally, it was concluded that the application of low-level laser would result into an increased epithelialization and healing in wound repair following gingivectomy and gingivoplasty [23]. In 2014, Sobouti et al showed faster and painless wound healing by Diode low-level laser after gingivectomy in patients with fixed orthodontics for aesthetic purposes in comparison with those for whom surgical knife was used[24].

Low-Level Laser and Periodontal Flaps

Gingival recession is a ubiquitous finding in periodontal visits. Anytime such a recession ends up in root sensitivity, aesthetic problems, and caries, a treatment protocol has to be followed. There are numerous ways for the treatment of gingival recession, one of which is Coronally Advanced Flap (CAF) [25]. 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. [26] conducted a study on Coronally advanced flap adjunct with low intensity laser therapy. In this split mouth study, 10 patients with 74 symmetrical gingival recession of Miller's Classes I and II were recruited. The patients had at least two buccal gingival recessions of Miller's Classes I and II which had been adjacent to each other and had occurred due to traumatic brushing. The clinical parameters which were calculated included the depth and width of the gingival recesion, probe depth, keratinized gingival thickness, and joint commissure, prior to surgery and 12 months post-op. 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 swicthed off form) was used to blind the patients' mind. Significant differences were found for the width, and depth of the gingival recession, keratinized gingival thickness, and finally clinical attachment level (p=0.018, p=0.009, p= 0.015, and p= 0.014, respectively); and complete root coating in the test group (n=7.70%) was more than that of the control group (n=3.30 %). Considering the study limitations, including low sample volume, lack of study of aesthetical aspects, and lack of potential for daily laser radiation protocols, the authors suggested that laser application following CAF may enhance treatment prognoses [26]. Periodontal disease is not a painful process, but the studies have shown that 30% of the patients suffer pain, especially following the first week of periodontal post-op[27,28].

Sanz-Moliner, et al.[29] performed a study on the effect of a 810 nm Diode Laser on postoperative pain and tissue response following modified Widman Flap (MWF) Surgery in Humans. In this split mouth radomized controlled clinical trial, 13 patients were studied. In the test group, following performance of modified Widman flap (MWF), Aluminum-Galium-Zinc-Arsenide Diode laser with 810 nm, and a power of 1W was continuously radiated; the radiation was done for 10 seconds, and after that it was stopped for 30 seconds. Following the termination of radiation, again the laser was radiated, but this time with a power of 0,1W. In the control group, after MWF performance, the switched-off laser was radiated to the targeted area to make patients believe it was working.

The time span between two surgeries was 3 weeks, and all surgeries were performed by the same person. After the operations, the patients were prescribed Ibuprofen (200mg) every 8 hrs for pain relief. They were asked to document their pain level every night for a week based on the 'Modified Visual Analogue Scale' (from 0-10) and write down the number of sedative tablets taken. Tissue response was also documented in physical examination as a secondary variable, considering color and tissue edema. Significant differences were found between the two groups for tissue edema ($p=0.041$), the dose of sedative drug taken ($p<0.001$), and post-op pain ($p<0.001$); however, no significant difference was found for the tissue color ($p=0.98$). Moreover, the patients reported more pain after the second surgery. The authors finally concluded that the application of Diode laser 810nm along with MWF would result into pain reduction and post-op edema, so that the laser application can be useful as a complement to surgery [29].

Low-Level Laser and Free Gingival Graft

Free gingival graft is one of the most prevalent treatments of gingival augmentation. The treatment has got various applications, including increasing keratinized gingival width[30,31]; increasing the vestibule depth[32]; reducing gingival erosion[33]; and replacement of pigmented gingival [34]. Graft includes epithelium and a thin layer of connective tissue, which would result into an open wound being healed between 2-4 weeks[35]. This condition may cause discomfort and tissue damage during and after operation[36,37].

In 2009, Almeida et al. conducted the folowing study: "Utilization of low-intensity laser during healing of free gingival grafts". In this "split mouth" randomized clinical trial, 10 patients who needed double-sided gingival graft in the mandible underwent surgery by the same surgeon in one month. In the test group, following grafting, Diode Aluminum-Galium-Arsenide laser with a wavelength of 780nm (infrared) for anti-pain effect, and a wavelength of 660nm (red) for fast repair effect was used. The laser parameters used included a power of 40mW, with an energy dose of 10 j/cm² which was continously emmited onto each side. Laser was used twice, immediately after surgery and 48 hrs post-op. In the control group, following the free gingival graft, a switched-off laser was used to make them believe it was working. Photographic images were produced at 7, 15, 30, and 60 days post-op. All photographs were studied by 5 skillful periodontists for their morphology, texture, and shade. The patients were asked to record their pain on a scale from 0-10 on the Visual Analogue Scale 3 hrs, 24 hrs, and 7 days post-op. No significant differences were found between the two groups, and it was concluded that low-level laser would not be useful in pain reduction and wound healing[38]. Moslemi, et al.[39] in their "split mouth" randomized clinical trial "Evaluation of the effect of 660nm low power laser on pain and healing in palatal donor site: a randomized controlled clinical trial", benefited from the participation of 12 patients; so that 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. In the same way, in the control group, the switched-off laser was used. In order to evaluate the amount of epithelialization, H_2O_2, and for clinical repair observations, photographic images were used. The amount of the sedative drugs taken were recorded to assess the pain scale. In 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. However, the two groups showed no significant differences for the sedative drug used and bleeding. The authors concluded that low-level laser may heal the wound in the palatal graft site [39].

In a systematic, review article, Bjordal et al.[40] mentioned that low-level laser may be able to relieve pain through reducing biochemical markers, oxidative stress, and edema; such a relation is dose-related (the active dose ranging from 0.3 to 19 j/cm² with an average dose of 7.5 j/cm². The authors concluded that anti-pain efect of low-level laser with a high radiation density in the first 72 hours post-op may be more effective, and the lower laser doses have to be continued for faster pain relief [40]. The previous studies have revealed that laser in low densities would result into faster relief, while higher doses would reduce fibroblast reproduction and growth factor release reduction[18]. Bearing in mind that low-level laser radiation depends on various parameters such wavelength used, power, energy density, radiation duration, radiation model, and the distance from the site under radiation, the differences in research results may be attributed to such parameters. It seems that numerous future studies with adequate samples and various parameters have to be conducted, so more comprehensive conclusions of the low-level laser effect following periodontal surgery would be obtained.

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