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Research Article

ROLE OF PHOTOBIOMODULATION IN MANAGEMENT OF PERIODONTAL DISEASE

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A B S T R A C T

Photobiomodulation is a therapeutic technique which can be applied in tissue regenerative surgery. It is a Low-Level Laser Therapy applies minimally invasive dentistry approach and serve as a non-cutting method of using the red to near infra-red light on body tissues. Photobiomodulation promotes cell proliferation and enable tissue restoration after diffent types of traumatic oral injuries. It is an excellent alternative to traditional therapy, simple and fast to perform, well tolerated by the patients, relief pain and reduces inflammation, promote healing and enhance tissue repair processes. Photobiomodulation can enhance stem cell differentiation and induce cell proliferation. Therefore PBM is used as adjunctive therapy to the conventional treatment of various periodontal diseases and repair of damaged soft and hard tooth structure as well as surrounding tissues. The aim of this study is to establish the fact of the applications of PBM therapy in management of periodontal diseases by understanding mechanism of action and mechanisms of repair. Furthermore, it is necessary to focus on evidence-based methodologies, types of patients are more susceptible to treatment as well as to understand the best ways of using this important and cutting-edge therapeutic option.

INTRODUCTION

The majority population of the world suffer from the most common oral disease is periodontal disease [1]. Whenever the periodontal tissue is damaged, Inflammation occur. Periodontal diseases start as gingival inflammation called as gingivitis, which can aggravate into the damage of deep periodontal tissues with alveolar bone loss termed as periodontitis. When gingivitis and periodontitis type of chronic inflammation are left untreated, it results as tooth loss [2]. Due to the sophisticated biodynamic of virulent pathogenic biofilm, periodontal microbiology is now seen to be a complex multifactorial condition. It is difficult to eradicate if once formed. It is evident that new approaches to intervention and care are required as because periodontic infections are combined with many pathogens resistance to antibiotics [3]. Implantology is increasingly popular among patients with dental defects due to its excellent aesthetics, functional characteristics, and high success rates [4]. However, still there is failure due to many complex factors with lack of osseointegration being the main reason [5]. Osseointegration is considered one of the most important factor of implant stability. It is the most essential determinant that determines the implant's success [6].

Light plays an important role in our biological systems which can be evident clearly from our sleep–wake up cycle, circadian rhythms, and absorption of vitamins from sunlight. Thus researchers are in their study found that using the high-powered light with specific wavelengths can create a new perspective for its application in healing, protect the cells from dying and tissue engineering. LASER is Light Amplification and Stimulated Emission Radiation. This is the device which produces light which have the same frequency called coherent light. Depending upon the type of laser-tissue interaction, lasers can be categorized as hard tissue lasers and soft tissue lasers. The laser-tissue interaction dependents on tissue type, incident energy, wavelength and time. Where the effect is ablative, direct and primary, such lasers are termed as ‘hard such as CO2 Laser, NdYAG Laser, and Er:YAG Laser.They have limitations as they are expensive and cause thermal injury to the tooth pulp and surrounding tissues. Alternatively, there are soft or cold lasers where tissue effects are non-direct and through secondary biostimulatory with intermediate actions. These are also termed as low-level lasers therapy (LLLT), low power laser therapy (LPLT), biostimulation laser, cold laser, bioregulation laser, photobiomodulation, medical laser, healing laser, therapeutic laser, non-thermal laser, low-reactive laser, low intensity laser [7]. The term "low-level laser therapy (LLLT)" and all other coherent and non-coherent non-monochromatic light-emitting diodes (LEDs) with comparable parameters to low-power lasers have been changed with the term "photobiomodulation" [7,8].

The term Photobiomodulation is used to describe either the process of stimulation or inhibition of biological processes. Both processes are beneficial in biological systems. Photobiomodulation is the application of specific wavelengths of light with a narrow spectrum band-width light from red to near infrared light to regulate cell metabolism, signal

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transduction, and secretion in the body tissues reduce inflamation , accelerate healing, and increase cell viability by stimulating the mitochondrial and cell membrane photoreceptors synthesis of ATP. This process can also be applicable in promoting the proliferation of osteoblasts which can stimulate bone healing. Photobiomodulation is a non-invasive and non-surgical treatment procedure by using the low level laser light therapy (LLLT). It produces low intensity energy light for pain relief by producing analgesic effect and decrease inflammation which leads to healing. It is used as an adjunct to many surgical hard and soft tissue procedures in periodontics. So it seems to be an alternative approach to improve the healing ability of tissues. The application of LLLT also stimulates various cells lymphocytes and mast cell which will produce anti-inflammatory actions causing changes in the capillary hydrostatic pressure resulting in oedema absorption and elimination of intermediary metabolites. Even it can increase collagen production, increase the mitotic activity of epithelial cells and also the fibroblast. Moreover, it can produce an analgesic effect by inhibiting nociceptive signals [9].

Parameters of Photobiomodulation

The most important parameters regarding the light source and light doses [10] are as hereunder;

Wave length: Light is an electromagnetic form of energy with a wavelike behaviour. Measured in nanometres (nm) and it is visible within the 400–700 nm range.

Irradiance: Also called as Power Density or Intensity and corresponds to the Power (in W) divided by the area (in cm−2)

Pulse structure: If beam is pulsed, the Power should be called Average Power, which is calculated as: Average Power (W) = Peak Power (W) x pulse width (s) x pulse frequency (Hz)

Coherence: Coherent light produces laser speckle which play an important role in photobiomodulation interaction with cells and organelles.

Polarization: Polarized light is known to lose its polarity in highly scattering media such as biological tissues; therefore, this property is not considered very often on the effects of Photobiomodulation.

Mechanisms of Action in Photobiomodulation

1. Mitochondrial Respiration and Cytochrome C Oxidase
In cellular system, mitochondria play a vital role in energy generation and metabolism. These are concerned with the mechanism of the current LLLT effects. Absorption of NIR radiation and monochromatic visible by elements of the cellular metastasis chain has been thought of because the primary mechanism of LLLT at the cellular level [11]. Cytochrome c oxidase is proposed to be the primary photo acceptor for the red near infra-red light range in mammalian cells. Absorption spectra in different oxidation states is similar to the absorption spectra acquired for biological responses to light [12]. LLLT on mitochondria increases proton electrochemical potential in ATP synthesis and also increases protein synthesis and RNA. It increases in oxygen consumption, mitochondrial membrane potential and enhances synthesis of NADH and ATP [13].

2. ROS Release and Redox Signalling Pathway
Mitochondria are an essential source of reactive oxygen species (ROS) in cells. Mitochondrial ROS can act as a modulable redox signal, reversibly affecting the activity of a range of functions in the mitochondria, cytosol, and nucleus. ROSs are tiny molecules that include oxygen ions such as peroxide, superoxide, free radicals including organic peroxides and hydroxyl radicals. ROS are very reactive with biological molecules such as proteins, nucleic acids and unsaturated lipids. ROS are also involved in signalling pathways from mitochondria to nuclei. Cells are believed to have ROS or redox sensors whose function is to detect potentially harmful ROS levels that LLLT has been reported to produce a change in the overall cellular redox potential in the direction of more large oxidation and increased ROS cell generation and redox activity have been demonstrated. These cytosolic responses may in turn induce transcriptional changes. Several transcription factors are regulated by cellular redox state changes, but nuclear factor κB (NFκB) is the most important one[14].

3. NO Release and NO Signalling

The delivery of low frequencies of red light / NIR may produce a little amount of Nitric oxide from mitochondria by dissociation from intracellular stores [14]. Like nitrosothiols, NO binds with hemoglobin or myoglobin [15]. The light-mediated increase in nitrite reductase activity of cytochrome c oxidase increases the production of NO. The light can also cause an increase in the action of a nitric oxide synthase isoform, by increasing icalcium levels intracellularly. This low concentration of NO produced by illumination is proposed to be beneficial through cell signalling pathways [16].

4. Biphasic Dose Responses in LLLT

Arndt-Schulz law states that "weak stimuli slightly accelerate vital activity, higher stimuli raise it more until a peak is reached, while stimuli even stronger suppress it until a negative response is obtained." This has been validated several times in low-level mild works [10]. This principle is followed for biphasic dose response on application of LLLT.

Application of Photobiomodulation in Periodontology and Implantology

Lasers are being used in non-surgical periodontal therapy with the purpose of improving debridement, disinfection and promoting wound healing after mechanical debridement such as scaling and root planning of deep periodontal pockets. Lasers are used more and more in the non-surgical treatment of chronic and aggressive periodontitis. Besides, lasers are also used as a part of surgical periodontal therapy like pocket reduction and regenerative procedures [17].
The various advantages of lasers over conventional periodontal surgeries are; tissue ablation, vaporization, haemostasis and pocket disinfection.

- **Role of PBM in reducing inflammation**
  Application of LLLT can be beneficial in reduction of gingival inflammation. It can be used as a adjunct procedure in place of nonsurgical and surgical periodontal treatments [18].
- **Non-surgical treatment of Aggressive periodontitis**

- Researchers have shown that SRP followed by laser therapies promote more significant reductions in the levels of periodontal pathogens compared to SRP alone. The Porphyromonas gingivalis[19,20], Prevotella intermedia[19], Tannerralla forsythia[20], Treponema denticola and Aggregatibacter actinomycetecomitans [20] shown to be reduced significantly by application of PBM found in different studies.
- **Nonsurgical treatment of chronic periodontitis**
  Nonsurgical treatment of chronic periodontitis with LLLT or with both SRP and laser has shown significant result of clinical advantages in healing of moderate-deep pockets and deep periodontal pockets. Crespi et al and Eltas and Orbak showed that Er:YAG, and Nd:YAG lasers respectively are superior to SRP at 3 to 6 months, 9 to 12 months, and 24 months evaluation with the use of lasers plus SRP [21,22].
- **Non-regenerative surgical treatment of chronic periodontitis – open flap debridement modalities**
  Gaspirc & Skaleric reported that there is more significant improvements in PD and CAL after flap access and Er: YAG laser debridement, compared to conventional open flap debridement, at 6, 12, 24 and 36 months evaluation. However it was observed that there was no difference in clinical outcome between treatment groups after 36 months [23].
- **Nonsurgical treatment of chronic periodontitis in patients with systemic conditions/disease known to impact disease progression – smoking and diabetes**
  Pamuk et al. recommended LLLT as an adjunctive treatment of periodontitis in smokers [24]. Koçak et al. identified modestly greater improvements in CAL and PD in people with diabetes treated with SRP plus high power laser when compared with those treated with SRP alone[25].
- **PBM and bone regeneration as an adjunct to periodontal regenerative surgeries**
  Dogan et al. conducted guided tissue regeneration (GTR) surgery alone and GTR plus low level laser therapy to treat Grade II furcation defects. It was reported that there is more improvement in the horizontal probing depth of the defects with adjunctive LLLT compared with GTR alone[26]. Bhardwaj et al. also had found significant results with 4 mm of CAL gain and 37% bone fill with minimal amount of recession after adjunctive low-level laser in treatment of a periodontal intra-bony defect [27].
- **PBM as an adjunct to soft tissue wound healing**
  After a daily LED irradiation, Wang et al. observed a better wound closure, re-epithelialization, more amount of sequestrum formation, reduction of inflammatory cell, and decrease of TNF-a significantly[28].
- **ole of PBM in bone formation around implants**
  In vitro studies have shown biostimulatory effects for low-intensity light laser therapy on cells and their osteogenic differentiation on Ti surfaces by measuring different bone formation markers' changes. It was found that for effective treatment procedure in terms of promoting bone formation around Ti implants, a procedure of applying energy densities of around 10-20 J / cm2 every other day for 2 weeks can be considered [29].
- **Influence of PBM on Implant stability**
- Low level light therapy may influence osteoblastic cells and the process of osseointegration. It seems possible that it also be effective in increasing the stability of Ti implants [29]. Implant stability values (IQS measurements) were shown to be increased in low-level laser therapy (LLLT) groups.

Conclusion

Application of Photobiomodulation is very promising adjunctive treatment procedure in periodontal and peri-implant inflammation therapy, temporomandibular joint problems, orthodontic treatment, surgical exposure of impacted teeth, with oral medicine lesions, paediatric dentistry, dentin hypersensitivity, crown cementation, gingivectomy and gingivoplasty. Photobiomodulation is also recommended as an alternative treatment for failed standard therapy. It is safe and potentially effective on its own thus facilitates easy use. LLLT is simple, easy, shorter chair time required, with mostly accepted technic by patients. Moreover it helps to reduce the intensity of pain, stimulate the healing with better coagulation. There is no need for suturing, hence accepted by patients more. It is a helping device to adjunct conventional therapy. In short, Photobiomodulation in a form of LLLT is an adjunctive therapy to surgical and non-surgical periodontal treatment which improves periodontal healing and significantly reduce post-operative pain. However, there are few limitations including the knowledge and practice of the dental practitioners as well as the higher cost of the device.

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