

# Photobiomodulation in Management of Periodontitis and Periimplantitis - A Review

Mikkili Rajya Lakshmi<sup>1</sup>, NVS Sruthima G<sup>2</sup>, Gautami S Penmetsa<sup>3</sup>, Ramesh KSV<sup>4</sup>, Mohan Kumar P<sup>5</sup>, Vivek Bypalli<sup>6</sup>.

<sup>1</sup>Post Graduate, Department of Periodontics, Vishnu Dental College

<sup>2</sup>Professor, Department of Periodontics, Vishnu Dental College

<sup>3</sup>Professor and Head, Department of Periodontics, Vishnu Dental College

<sup>4</sup>Associate Professor, Department of periodontics, Vishnu Dental College

<sup>5</sup>Reader, Department of Periodontics, Vishnu Dental College

<sup>6</sup>Senior lecturer, Department of Periodontics, Vishnu Dental College.

## ABSTRACT

*Photobiomodulation (PBM) also known as low-level laser (or light) (LLLT). Photobiomodulation (PBM) therapy has attracted special attention and its applications in dentistry and medicine are continuously growing. Parameters of photobiomodulation, Molecular mechanisms and management of periodontitis and peri-implantitis which includes the healing responses, osseointegration, implant stability were summarized in this review.*

**Keywords:** *Aggressive periodontitis, Chronic periodontitis, Photobomodulation, Osseointegration*

## INTRODUCTION:

Periodontal microbiology is a complex multifactorial condition due to its sophisticated biodynamics of virulent pathogenic biofilm; once formed, it is difficult to eradicate. Periodontic infections with systemic health issues combined with many pathogens resistance to antibiotics make it increasingly evident that new approaches to intervention and care are required[1].

Due to its excellent aesthetics, functional characteristics, and high success rates, implantology is increasingly popular among patients with dental defects[2]. However, there is still a risk of failure due to many complex factors, with lack of osseointegration being the main reason[3]. Osseointegration is considered one of the most crucial determinants of implant stability[4]. It is an essential factor that determines the implant's success. However, several factors can influence osseointegration[5].

Low-level photobiomodulation or light therapy, is "a type of non-invasive, non-thermal therapy based on non-ionizing light sources, including lasers, light-emitting diodes (LEDs) and broadband light, in the visible and infrared spectrum. Therefore, increased attention has been paid to physical, chemical, and biological attempts to promote osseointegration, one of

which is photobiomodulation therapy (PBMT)[6]. LLLT was discovered by Endre Mester at Semmelweis Medical University in 1967 at Hungary[7,8].

PBM of tissue can lead to either positive healing responses or sometimes inhibitory biological effects. These are all possible as a result of non-thermal photochemical and biological interactions. Light-emitting diodes (LEDs), broad light sources, and lasers may be used for this purpose. Clinically many different advantages, such as relief and reduction of pain and inflammation and promotion[7,9].

### PARAMETERS OF PHOTOBIMODULATION

The most important parameters regarding the light source and light doses[10] are described below in Table 1

Low-level light therapy refers to the use of light in the red or near-infrared (NIR) region, with wavelengths typically between 600-700nm and 780-1100nm, and laser or LEDs are generally having radiation or a power density between 5 m Wcm<sup>-2</sup> and 5Wcm<sup>-2</sup>. This type of irradiation can be a continuous wave or a pulsed light consisting of a beam of relatively low density (0, 04 to 50 J cm<sup>-2</sup>), but the output power can vary widely from 1 mW to 500 mW in order not to allow thermal effects[11].

Table 1: Parameters of light sources and light doses

Irradiation Parameter	Measurement unit	Description
Wavelength	nm	Light is an electromagnetic form of energy with a wave-like behavior. Measured in nanometers (nm) and it is visible within the 400–700 nm range
Irradiance	W cm <sup>-2</sup>	Also called as Power Density or Intensity and corresponds to the Power (in W) divided by the area (in cm <sup>-2</sup> )
Pulse Structure	Peak Power (W) Pulse frequency (Hz) Pulse width (s) Duty cycle (%)	If beam is pulsed, the Power should be called Average Power, which is calculated as follows: Average Power (W) = Peak Power (W) x pulse width (s) x pulse frequency (Hz)
Coherence	Coherence length depends on the spectral width	Coherent light produces laser speckle which play an important role in photobiomodulation interaction with cells and organelles
Polarization	Linear polarized or	Polarized light is known to lose its polarity in highly scattering media such as biological tissues; therefore, this

	circular polarized	property is not considered very often on the effects of PBM
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## MOLECULAR MECHANISMS OF PBM

### 1. Mitochondrial Respiration and Cytochrome c oxidase

Mitochondria play a vital role in energy generation, and metabolism and 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[12] Cytochrome c oxidase is proposed to be the primary photo acceptor for the red-Near infrared light range in mammalian cells. Absorption spectra of Cco in different oxidation states is similar to the absorption spectra acquired for biological responses to light[13]. LLLT on mitochondria increased proton electrochemical potential, ATP synthesis), increased protein synthesis and RNA (Greco et al. 1989) and increases in oxygen consumption, mitochondrial membrane potential, and enhanced synthesis of NADH and ATP[14].

### 2. ROS release and Redox signaling pathway

Mitochondria are an essential source of reactive oxygen species (ROS) in most mammalian 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 hydrogen peroxide, superoxide, free radicals such as 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 signaling 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  $\kappa$ B (NF- $\kappa$ B) is the most important one[15].

### 3. NO release and NO signaling

The delivery of low fluences of red light / NIR may produce a little amount of Nitric oxide from mitochondria by dissociation from intracellular stores[15], like nitrosothiols (Borutaite et al. 2000), NO bound to hemoglobin or myoglobin[16], or by dissociation of NO from Cco. The second mechanism given by Lane in 2006, the production of NO, is the light-mediated increase in nitrite reductase activity of cytochrome c oxidase. Poyton and Ball 2011 offer a third possibility that light can cause an increase in the action of a nitric oxide synthase isoform, by increasing icalcium levels intracelluarly. This low concentration of NO produced by illumination is proposed to be beneficial through cell signaling pathways[17].

### 4. Biphasic dose responses in LLLT

This biphasic response follows the "Arndt-Schulz law" (which 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), and has been validated several times in low-level mild works[10].

## **PBM IN PERIODONTOLOGY**

Lasers have been used in non-surgical periodontal therapy with the aim of improving disinfection / debridement and promoting wound healing after mechanical debridement (eg, scaling and root planing) of deep periodontal pockets ( $\geq 5$  mm) . Lasers are increasingly used in the non-surgical treatment of chronic and aggressive periodontitis. Additionally, lasers are increasingly used as part of surgical periodontal therapy (e.g., pocket reduction and regenerative procedures)[18].

SRP is gold standard treatment of periodontitis, still considered to be mechanical debridement of the periodontal pockets. In non-surgical treatment, lasers have used high-power lasers as adjuncts for debridement and their antiseptic and bactericidal effects. Low-level light energy was used to activate photosensitive dyes to produce an antibacterial effect, commonly referred to as photodynamic therapy.[19].

The advantages of lasers over conventional periodontal surgeries include

1. Tissue ablation
2. Vaporization, hemostasis
3. Pocket disinfection.

### **Role of PBM in reducing inflammation**

Reduction of gingival inflammation is observed after effective nonsurgical and surgical periodontal treatments; however, it is proposed that adjunctive application of low levels of light can also be beneficial in this process.[19].

### **Non-surgical treatment of Aggressive periodontitis**

Studies have shown that SRP + laser therapies, compared to SRP alone, promoted more significant reductions in the levels and proportions of periodontal pathogens of the red and orange complexes (e.g., *Porphyromonas gingivalis*[20,21], *Prevotella intermedia*[20], *Tannerella forsythia*[21] and *Treponema denticola* and *Aggregatibacter actinomycetemcomitans* [21] three at six months.

### **Nonsurgical treatment of chronic periodontitis**

Nonsurgical CP treatment has identified additional clinical gains in moderate-deep pockets with SRP + lasers or Laser alone compared with manual and ultrasonic or sonic debridement (SRP). concerning the use of lasers plus SRP, Crespi et al[22] and Eltas and Orbak[23]showed that Er:YAG, and Nd:YAG lasers, respectively, were superior to SRP at 3 to 6 months, 9 to 12 months, and 24 months, evaluations; however, the excellent outcomes seemed more evident at deep periodontal pockets ( $\geq 7$  mm)[22,23].

### **Non-regenerative surgical treatment of chronic periodontitis – open flap debridement modalities**

Gaspirc & Skaleric reported significantly 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 reevaluation. The study also found that the two treatments clinical results could be maintained over 5 years; however, no difference in clinical outcome between treatment groups was observed after 36 months[24].

### **Nonsurgical treatment of chronic periodontitis in patients with systemic**

	Level of certainty	Benefit
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### **conditions/disease known to impact disease progression – smoking and diabetes**

Pamuk et al. did not observe any significant differences between the clinical parameters in LLLT and sham groups of either the smokers or nonsmokers. Overall, they recommended LLLT as an adjunctive treatment of periodontitis in smokers[25].

Koçak et al. identified modestly greater improvements in CAL and PD at moderate sites (PD = 5–6 mm) in people with diabetes treated with SRP plus high power laser (diode) when compared with those treated with SRP alone[26].

### **PBM and bone regeneration as an adjunct to periodontal regenerative surgeries**

Dogan et al. compared guided tissue regeneration (GTR) surgery alone with GTR plus low-level laser therapy to treat Grade II furcation defects and reported more improvement in the horizontal probing depth of the defects alkaline phosphatase levels of GCF with adjunctive LLLT compared with GTR alone[27].

Ozcelik et al. showed that adjunctive application of 4 J/cm<sup>2</sup> of diode laser used together with enamel matrix derivatives (EMD) in the treatment of intrabony defects can improve the effect of EMD[28].

Bhardwaj et al. also had successful results with 4 mm of CAL gain and 37% bone fill and minimal amount of recession after adjunctive low-level laser in treatment of a periodontal intrabony defect[29].

### **PBM as an adjunct to soft tissue wound healing**

Wang et al. after a daily 10 J/cm<sup>2</sup> LED irradiation observed better wound closure, re-epithelialization, and collagen, and the amount of sequestrum formation, infiltration of inflammatory cell, and TNF- $\alpha$  decrease significantly[30].

Table 2: Comparison of Laser with NSPT in Chronic and Aggressive periodontitis

SRP plus infrared diode laser or infrared diode laser alone versus SRP for the nonsurgical treatment of AgP	Low	SRP + infrared diode laser promoted modest additional clinical benefits over those achieved by SRP alone
Infrared laser alone versus SRP or SRP plus infrared laser in the nonsurgical treatment of CP	Moderate	Modest
SRP plus infrared diode laser or Er:YAG alone versus SRP for the nonregenerative surgical treatment of sites with residual PD $\geq$ 5 mm in patients with CP	Low	No Additional benefits when compared to SRP alone

### Role of PBM in bone formation around implants

Many in vitro studies have shown biostimulatory effects for low-intensity light therapy on cells and their osteogenic differentiation on Ti surfaces by measuring different bone formation markers' changes[31].

Lopes et al. have also shown positive effects for adjunct phototherapy. In their study, the absorption of calcium-hydroxyapatite and the integration of the implants were considerably increased by the application of LLL irradiation[32].

Pereira et al. have irradiated Titanium implants inserted in rabbits' tibia with low-intensity laser with a 48-h interval for 14 days. they reported that there is increase in BIC T 3- 6 weeks with laser therapy. However, it doesn't show any effect on the area of bone formed within the threads[33].

Another animal study by Kim et al., the expression of osteoprotegerin (OPG), activator of the kappa-B nuclear factor ligand receptor (RANK L), and RANK were shown to be influenced by low-level laser irradiation, increased bone metabolic activity and bone tissue cellular activity have been observed[34].

Overall, it appears that energy densities of around 10-20 J / cm<sup>2</sup> performed every other day for 2 weeks can be considered an effective treatment procedure in terms of promoting bone formation around Ti implants[31].

### **Influence of PBM on Implant stability**

Decreasing the duration of osseointegration has been a topic of interest in laser implant research for many years. Since it is proposed that low-level light therapy may influence osteoblastic cells and the process of osseointegration, it seems possible that it may also be effective in increasing the stability of Ti implants[31].

Torkzaban et al. reported that no significant effect of low 940 nm adjuvant laser therapy on implant stability[35]. Garcia-Morales (2012) reported that LLL could not significantly increase implant stability when assessed by resonance frequency analysis (RFA)[36]. Implant stability values (IQS measurements) were shown to be increased in low-level laser therapy (LLLT) groups.

### **CONCLUSION:**

PBMT reduces the inflammation and could facilitate hard and soft tissue regeneration, promote osseointegration, and improve implant stability.

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