Photomedicine and Laser Surgery
Volume XX, Number XX, 2017

Pp. 1–10
DOI: 10.1089/pho.2017.4275

Review

Effect of Low-Level Laser Therapy on Bone Regeneration During Osseointegration and Bone Graft

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Abstract

Background: The effect of low-level laser therapy (LLLT) on bone regeneration during osseointegration and bone graft is very controversial. Despite many positive reports of *in vitro* and *in vivo* studies and more than 50 randomized clinical trials claiming a positive effect of photobiomodulation (PBM), many reports found no significant effect of lasers. ***Objective:*** The aim of this study was to evaluate studies correlating PBM and bone regeneration and to assesses parameters that produce positive results based on dose and output power used. ***Materials and methods:*** Four electronic databases were used: PubMed, Springer, Google Scholar, and Cochrane. ***Results:*** The research yielded 230 articles. The full texts of all articles were evaluated and scored using eligibility criteria adapted from Cericato et al. After evaluation, only 19 articles met the inclusion criteria. ***Conclusions:*** A positive effect of low-level laser energy on bone regeneration within a certain relationship between dose and output power was found. LLLT stimulates cellular metabolism, increasing protein synthesis and subsequent bone regeneration. A high dose combined with low power or a low dose combined with high power appears to produce a positive effect.

Keywords: low-level laser therapy, low-level laser therapy and osseointegration, low-level laser therapy and bone graft, low-level laser therapy and cells

Introduction

PHOTOTHERAPY IS THE use of light to influence tissue, and it can be accomplished through two distinct techniques: Combining light with a photosensitizing dye in a procedure called photodynamic therapy or use of the light alone in a procedure called low-level laser therapy (LLLT).[1] In recent years, the term photobiomodulation (PBM) is preferred since it suggests influence on cellular metabolism as a result of applied photonic energy.

De Freitas and Hamblin[2] state that LLLT refers to the use of light in the red or near-infrared region (NIR) with wavelength usually in the range from 600 to 700 nm and from 780 to 1100 nm. A wavelength range between 700 and 780 nm has been found to be ineffective as it coincides with a trough in the absorption spectrum of cytochrome c oxidase.[3] Moreover, red/NIR wavelengths are chosen because the penetration through tissue is maximal in this range, due to lower scattering and absorption by tissue chromophores.

The laser or light emitting diode (LED) used for this application typically has an irradiance or power density between 5 and 50 mW/cm^2. Continuous wave or gated energy has been used at a relatively low energy density (0.04 – 50 J/cm^2), and output power can vary widely from 1 to 500 mW.[2]

In PBM, energy density or irradiance is lower than in other laser uses such as ablation and thermal coagulation.[4]

Application of incorrect parameters of fluence (J/cm^2), irradiance (mW/cm^2), and delivery time or repetition rate can lead to ineffective treatment. A biphasic dose response or hormesis phenomenon follows the Arndt-Schultz Law, which states that weak stimuli slightly accelerate vital activity; stronger stimuli raise it further until a peak is reached; and even stronger stimuli suppress it until a negative response is achieved.[5] Studies suggest that the biological effects of laser energy and LED energy are the same when the wavelength is properly chosen.[6]

Phototherapy at the cellular level can be classified into primary, secondary, and tertiary light-induced effects.[7,8]

-A primary effect is restricted to photon absorption. Photons emitted from the laser reach the mitochondria of cells, are absorbed by chromophores (cytochrome, porphyrins, and flavoproteins), and are finally converted into chemical energy in the cells. A cascade of signals between mitochondria, nucleus, and oxidative metabolism leads to an increase in adenosine triphosphate (ATP) production, causing pain relief and wound healing.[9]

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