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Photobiomodulation: Implications for Anesthesia and Pain Relief

Roberta T. Chow, MB, BS (Hons), FRACGP, PhD,[1] and Patricia J. Armati, PhD[2]

Abstract

Objective: This review examines the evidence of neural inhibition as a mechanism underlying pain relief and anesthetic effect of photobiomodulation (PBM). ***Background:*** PBM for pain relief has also been used for more than 30 years; however, the mechanism of its effectiveness has not been well understood. ***Methods:*** We review electrophysiological studies in humans and animal models and cell culture studies to examine neural responses to PBM. ***Results:*** Evidence shows that PBM can inhibit nerve function *in vivo*, *in situ*, *ex vivo*, and in culture. Animal studies using noxious stimuli indicate nociceptor-specific inhibition with other studies providing direct evidence of local conduction block, leading to inhibited translation of pain centrally. Evidence of PBM-disrupted neuronal physiology affecting axonal flow, cytoskeleton organization, and decreased ATP is also presented. PBM changes are reversible with no side effects or nerve damage. ***Conclusions:*** This review provides strong evidence in neuroscience identifying inhibition of neural function as a mechanism for the clinical application of PBM in pain and anesthesia

Keywords: PBM, low-level laser therapy, LLLT, pain, nerve, neuralgia

Introduction

ALTHOUGH IT IS UNIVERSALLY accepted that we live by the starlight of the sun and that this light drives living processes such as retinal function and the production of vitamin D, the concept that light can modulate many medical conditions, especially pain, remains controversial, although there are now more than 3000 experimental studies on the effects of monochromatic light on biological processes. However, from a translational perspective, there is now evidence from randomized controlled trials that photobiomodulation (PBM) delivered clinically can have definable effectiveness on a number of painful conditions and can achieve local anesthesia. Although the biopsychosocial model of pain gives recognition to the complexity of the pain experience, this review sets out the case for a neuroscience basis by which PBM modulates nociception at the neuronal level. Although the studies discussed hereunder relate to the central, autonomic, and peripheral components of the nervous system, this distinction is one of convenience, whereas the reality is that the nervous system responses are functionally integrated and focal to the experience of pain.

To this end, we present two clinical trials, one related to pain relief and the other where PBM was clinically effective in providing dental anesthesia, followed by discussion of the evidence that a neural basis underlies PBM effectiveness.

Clinical trial evidence

In a clinical trial of PBM for chronic neck pain, Chow et al. demonstrated that 830 nm PBM at 300 mW, 9 J/point, ED: 20 J/cm^2, provided statistically significant and lasting pain relief.[1] The trial of 90 patients was randomized, placebo-controlled, and double blind. There were no side effects and specifically no adverse effects on sensation.

The second clinical trial examined the effectiveness of PBM for dental anesthesia in people requiring tooth extraction before orthodontic procedures.[2] Again the trial was randomized, double-blind, and placebo-controlled, and PBM was delivered by pulsed Nd:YAG at 0.2 W,15 Hz, 60–87 mJ energy pulse; PD: 0.3–0.45 J/cm^2; energy density, 73–107 J/cm^2; total energy, 211–312 J. PBM effectiveness was compared with the topical anesthetic cream EMLA and was statistically significant in providing more effective pulpal anesthesia than EMLA. There was also a concurrent but significant decrease in pulpal sensitivity after PBM as measured by subjective electric pulp testing. A follow-on morphological and histological study of all extracted teeth showed that there was no PBM-related damage and no significant temperature increase.[3] The anesthetic effect of PBM was reversible and as in the Chow et al. trial, there were neither side effects nor evidence tissue/nerve damage. In both trials, PBM was delivered transdermally to the ectoderm or gingiva both characterized

[1]Honorary Research Associate, Brain & Mind Centre, The University of Sydney, Camperdown, New South Wales.
[2]Neuroinflammation Group, Brain & Mind Centre, The University of Sydney, Camperdown, New South Wales, Australia.