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Photobiomodulation Therapy Promotes Expansion of Epithelial Colony Forming Units

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Abstract

Objective: This preliminary study examines the effects of low-dose light therapy, also called Photobiomodulation (PBM) therapy, on epithelial colony forming units (eCFUs) in epithelial cells from skin and mucosa to assess their potential to contribute to tissue regeneration. Also, preliminary comparison of basic PBM parameters such as wavelengths, light sources, and dose were evaluated in promoting eCFUs. ***Background Data:*** Regenerative medicine is at the brink of exploiting the tremendous potential offered by advances in stem cell biology. The two distinct aspects for utilization of stem cells, either resident (endogenous) or transplanted (exogenous), rely on cells amenable to expansion and being directed toward mature, functional tissues. Despite major progress in fundamental understanding of stem cell pluripotency, there remain fundamental challenges in applying these insights into clinical practice. ***Methods:*** PBM treatments with various devices, wavelengths, and doses were used on two epithelial cell lines and colony forming assays were performed. ***Results:*** This study noted a dose-dependent effect of 810 nm laser on increasing eCFUs, either in terms of size or numbers. Comparisons of different wavelengths and light sources noted better efficacy of collimated and coherent lasers compared to LEDs and broad-band light. ***Conclusions:*** PBM therapy promotes expansion of eCFUs that represent progenitors and stem cell populations capable of contributing to tissue repair and regeneration. Further exploration of the precise mechanisms would allow optimization of PBM clinical protocols to harness the regenerative potential of stem cells for wound healing and other clinical regenerative applications.

Keywords: colony forming units, laser, photobiomodulation, stem cells

Introduction

The ability of organisms to repair and regenerate tissues after injury is dependent on an evolutionary conserved trait involving endogenous, resident (non-embryonic) stem cells. The characteristics of stem cells to self-renew and differentiate into specialized functional tissues have profound clinical implications.[1] A major limitation in using stem cells is their naturally low numbers limiting their clinical use. The regenerative potential of stem cells is being harnessed through several modalities such as transplanting exogenous stem cells (auto- or xenotransplantation) and administration of small molecules and biomolecules to mobilize and/or differentiate these cells. The use of low-dose light has been shown to stimulate wound healing and tissue regeneration. This process has been called low level light/laser therapy or, more appropriately, Photobiomodulation (PBM) therapy.[2]

Mechanisms of PBM therapy have been attributed to absorption of photons by specific chromophores within (intracellular) and outside (extracellular) the cell that results in generation of reactive oxygen species (ROS). Cytochrome C oxidase in the mitochondria is among the most well-studied intracellular PBM targets that result in modulation of the electron transport chain, increased adenosine triphosphate formation, and release of nitric oxide along with generation of other ROS. This leads to activation of diverse downstream signaling pathways that activate potent biological processes such as cell proliferation, migration, and differentiation.[3–6] More recently, we demonstrated an extracellular pathway involving low-dose laser-generated ROS, which acts on a ubiquitous, multifaceted latent growth factor complex, TGF-β1.[7] This distinct PBM growth factor mechanism was noted to be capable of directing differentiation of dental and mesenchymal stem cells.[7,8] The therapeutic benefits of PBM therapy on adipose-derived stem cells and bone marrow mesenchymal stem cells have been documented previously.[9,10] Moreover, mouse embryonic fibroblasts and human skin fibroblasts have been shown to respond to PBM therapy with clonal expansion

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