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Photobiomodulation: The Forth Side of Tissue Engineering Foursquare

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2015 was named the International Year of Light and Light-based Technologies by the United Nations, initiated by different scientific societies in collaboration with UNESCO. This initiative shed light on the importance of light and light-based technologies and their positive effects on solving various challenges in such topics as agriculture, energy, education, and health.[1] However, as "light scientists," we have perfected our focus and practices to fulfill their potential. Photochemistry is a subspecialty of chemistry focusing on the chemical reactions which occur by the atoms' light absorption. Different examples of photochemistry are vitamin D production with sunlight, photosynthesis, and vision initiation by rhodopsin. Photobiomodulation (PBM) is a mechanism in which a nonionizing visible or near-infrared light form is absorbed by endogenous chromophores causing photochemical and photophysical reactions on different levels of biological scales without causing any thermal damage. PBM therapy is a photon-based therapy based on the fundamentals of PBM. Various light sources such as lasers, broadband light, and light-emitting diodes (LEDs) in the near-infrared and visible spectrum can be used for this matter.[2]

Living organisms' cells need to communicate with each other to thrive. Different pathways are used through direct contact, the nervous system, and secretions (paracrine, autocrine, juxtracrine, and endocrine signaling).

The nature of these messages is considered chemical or molecular by conventional medical scientists. We can find different pathways of message transition between cells, such as electrical signaling, bio-resonance signals, low-intensity pulsed ultrasound, and ultra-weak photon emission.[3]

Alexander Gruwitsch, a Russian embryologist, proposed a theory in which he stated that cells interact in different ways, and he called it the mitogenetic radiation therapy.[4] He explained that these messages are based on electromagnetic nature and called them biophotons due to the quantum physics theory developed by Maxwell, Planck, and Einstein.[5] Remarkably, with the rise of advanced technologies in detecting these waves over time, scientists discovered that polymorphonuclear cells and macrophages also emit photons.

We have named this cell communication language "Photon Morse" according to photon harmony. Cellular Photon Morse has yet to be recognized. While cells need the energy to function properly, this type of energy transition and communication is also vital for cells to serve as a whole. Physical parameters such as photon wavelength, power density, energy density, coherence, irradiation mode, and linear and non-linear effects of irradiation seem to be the alphabet of this language. To understand this language, various groups of scientists, such as biochemists, biophysicists, and biologists, are required to work together due to the complexity of living organisms.[3] There are so many questions that have yet to be answered, but the one that drives the most attention to itself is, 'can we affect cells by using the same energy that they use to communicate with each other from outside?'

Lasers were initially used as high-power destructive energy sources for surgical purposes. Dr. Mester's studies led to the discovery of a unique horizon in the field of photostimulation, which was popularly entitled low-level laser therapy, cold laser therapy, and most recently, PBM therapy. A variety of effects of PBM therapy have been discovered, such as inflammation reduction, stifling of pain, downregulation of aberrant immune responses, and diverse metabolic effects. On the other hand, the impact of PBM therapy on tissue regeneration and healing process improvement has been proven. This

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diversity of cellular responses resulted from activating different photobiological targets such as mitochondria (intracellular), cell membrane, and extracellular milieu.

Interestingly, biological responses were regional, distant (e.g., contralateral limb), and systemic. These bystander and episcopal effects happen via circulatory paracrine signaling and secreted factors. Various types of laser sources, such as lasers, LEDs, or broadband light sources, have been studied by scientists. Interestingly, even the sun has been included in some theories as a light source in the realm of PBM. PBM therapy and its adaptation to clinical lasers, together with different biomedical applications, have been used in the clinical medicine.[6]

Stem cells can serve as a chief target for PBM. Various types of stem cells, especially pluripotent stem cells, can be modulated by biophysical cell communications. Stem cells can be affected on different levels, such as biogenetic alterations, epigenetic modulations, metabolic changes, and gene expressions, leading to therapeutic effects induced by PBM. Special laser and LED irradiation parameters can stimulate more exclusive cellular modulations. Mitochondrial stimulation causes cellular proliferation, which leads to adenosine triphosphate production enhancement, DNA and RNA synthesis, and cellular signaling cascade activation. Cell signaling cascades include reactive oxygen species production and nitric oxide release, which lead to cytochrome c oxidase activation, calcium flux, expression of stress proteins, and modification of intracellular organelle membrane activity.[6,7]

The colossal clinical benefits of PBM in a variety of diseases emphasize the vital role of stem-progenitor cells in common regenerative mechanisms. PBM has also been proven to be beneficial in neuropsychological diseases such as Alzheimer's and Parkinson's diseases, multiple sclerosis, spinal cord injury, depression, and post-traumatic stress disorder. Furthermore, these effects have been seen in ophthalmologic and dermatologic conditions such as diabetic retinopathy and hair growth, respectively[7]

Regenerative medicine has revolutionary potential by combining novel therapies such as PBMT and stem cell therapy, resulting in prompt and complete recovery and decreasing the risk of organ transplantation rejection due to autologous grafts.

From our point of view, the triangle of tissue engineering consisting of a cell, scaffold, and chemical growth factors will change to foursquare, adding a side of physical signals from biophotons shortly.

As scientists interested in PBM, we should continue to enhance our understanding of basic and complex mechanisms on subcellular and organismal levels. We are all trying to apprehend and quantify these mechanisms and the Photon Morse to personalize clinical therapies based on genetic mapping for personalized PBM therapy. Much has been done, but there is a lot left to achieve.

Conflict of Interests

The authors declare that they have no conflict of interest.

Ethical Considerations

Not applicable.

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