Photobiomodulation in Tissue Engineering-Future Trends

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DOI: *10.22037/rrr.v4i2.29800*

In December 2013, the United Nations entitled 2015 as the International Year of Light and Light-Based Technologies. This initiative was developed by a variety of scientific groups alongside UNESCO. By this course of action, the United Nations comprehended the significance of raising awareness about light and light-based technologies, and the way it can provide confirmable enhancement and delivering solutions to different worldwide challenges in various topics such as in energy, education, agriculture, and health (1). But the question is whether we have perfected our focus and practices to the point to fulfill its huge potential as so called 'light scientists? The study of chemical reactions which undergo by the absorption of light by atoms or molecules is called "Photochemistry which is a subdiscipline of chemistry. We can observe different examples of photochemistry in action such as photosynthesis, vision initiation by a photochemical reaction of rhodopsin and the formation of vitamin D with sunlight in our daily life. PBM is a mechanism in which a nonionizing optical radiation in the visible and near-infrared wave length is absorbed by endogenous chromophores to initiate photophysical and photochemical react at different level of biological scales without doing any thermal damage; and PBMT is a photon therapy which lies its fundamentals over the principals of PBM. It uses the nonionizing forms of light from different sources like lasers, light-emitting diodes (LEDs), and broadband light, in the visible and near-infrared spectrum (2).

In living or multicellular organisms, cells need to communicate between themselves in order to survive. Sending messages between them can happen via chemical messages in many different ways but usually through direct contact, secretions (Juxtracrine, Paracrine, Autocrine, Endocrine Signaling) or through the nervous system.

In conventional medical science, the nature of these messages are thought to be chemical molecular. In scientific literature, we can find different pathways of message transition in between cells with different natures so cell interact with other languages such as: low intensity pulsed ultrasound (LIPUS), electrical signal, bioresonance signal and ultra-weak photon emission (UPE) (3).

A long time ago, a Russian embryologist Alexander Gurwitsch initiated the Mitogenetic Radiation theory in which cells interact in a different way (4). He suggested that these messages had an electromagnetic wave nature and according to Maxwell, Plank and Einstein's quantum theory, these waves are made of photons so, he called them biophotons (5). Interestingly, over the years, as soon as the advanced technology of detection of these waves were discovered, scientists found out that polymorphonuclear cells and macrophages also emit photons.

Based on photon harmony I named this cell communication language the "Photon Morse". We cannot recognize the Photon Morse for cells, yet. The alphabet of these languages such as this code seems to be the physical parameters of these sources; such as photon wavelength, energy density, power density, coherence, irradiation mode (pulsed or continuous mode), etc. (3).

Due to the complexity of living organisms requires a collaboration between different groups of scientists such as bio-scientists, biochemists and biophysicists to decrypt this language specially in humans. The mystery of the code which is based on bio photonic harmony is yet to be understood (3).

At first high power lasers were designed for surgical destruction of tissues. Observations from Dr. Mester opened a new and special door in his early studies on photostimulation which was the starting point of a novel field of photobiological science that was popularly entitled low level laser/light therapy, cold lasers treatments or most recently, Photobiomodulation (PBM) therapy. A lot of various effects of PBM therapy has been

recorded such as its effects on stifling pain, inflammation and aberrant immune responses. Also, PBM therapy has had a huge effect on prompting tissue regeneration and healing. These responses happened to happen via separate photobiological targets which were located in different areas such as the mitochondria which is counted as intracellular, on the cell membrane and the extracellular milieu. Impressively, the biological responses recorded in treatments' areas were both regional and distant (e.g.; contralateral limb) as well as systemic. These bystander or episcopal effects have been happening due to paracrine signaling and secreted factors in the circulation. Interest shown in the biophysical characteristics of PBM therapy and related researches incited the scientists to examine various types of light sources from lasers and LEDs to broad band light sources. Interestingly, there has been some theories about effects of sun light being beneficial in the realm of PBM. Clinical medicine has led the adaptation of PBM therapy with clinical lasers alongside different biomedical usages (6).

Biophysical cell communications can modulate stem cell behaviors. These effects range from stem cells' biogenetic changes to metabolic alterations to epigenetic modulations and gene expressions causing therapeutic benefits which are all induced by PBM. Specific cellular activities can be induced by using special laser and LED irradiation parameters. Cellular proliferation and viability will be induced while stimulating mitochondrial activity. This phenomenon leads to increasing adenosine triphosphate (ATP) production, synthesis of DNA and RNA, and activating cell signaling cascades. These cell signaling cascades include an increase in production of reactive oxygen species (ROS), nitric oxide (NO) release. These substances result the activating cytochrome c oxidase, and modifying intracellular organelle membrane activity, calcium flux, and expression of stress proteins (6-8).

We can deduct from the PBM's huge and impressive clinical successes in wide range of different diseases that there are common regenerative mechanisms in these diseases indication the crucial role of stem–progenitor cells at these areas. These diseases include neuropsychological diseases like traumatic brain injury (Concussions), Alzheimer's and Parkinson's diseases, multiple sclerosis, spinal cord injuries, post-traumatic stress disorders, and depression. Also, these effects have been recognized in ophthalmology (*e.g.*, dry acute macular degeneration and diabetic retinopathy), and dermatology like facial rejuvenation and hair growth (7, 8).

Regenerative medicine can revolutionize treatment of human diseases by using combined novel therapies like PBMT and stem cell therapy which not only give us prompt and complete recovery but also, lower the risk of donor organ transplantation rejection because of the autologous grafts.

In my opinion in the near future the triangle of tissue engineering which consists of 3 sides of cell, scaffold and chemical growth factors will change to a foursquare adding a side of physical signal from biophotons.

Us as the scientists interested in PBM are continuing to improve our knowledge of both basic and complex processes on a subcellular and organismal level. We are all trying to understand and quantify the mechanisms and therapeutic parameters which will change the biological processes both in clinics and laboratories. There has been a lot of progress made but there is much more to achieve.

Conflict of Interest: 'None declared'.

References

1-Abrahamse H, Photobiomodulation: An Accepted Therapeutic Modality? Photomedicine and Laser Surgery.2016. Vol 34, 9

2-Anders JJ, Arany P,Baxter D, Lanzafame J L. Light-Emitting Diode Therapy and Low-Level Light Therapy Are Photobiomodulation Therapy. Photobiomodulation, Photomedicine, and Laser Surgery. 2019.Vol 37, 2,63-65

3-Fekrazad R.Photons Harmony for Cell Communication. Photomedicine and Laser Surgery. 2018.VOL. 36, 4,177-178

4-Gurwitsch A. Die Mitogenetische Strahlung. Monographien aus dem Gesamtgebiet der Physiologie der Pflanzen und der Tiere. Berlin: Springer (1932).

5- Hellemans A, Bunch B. The timetable of Science, Simon & Schuster, New York 1988.

6- Fekrazad R, Arany P. Photobiomodulation Therapy in Clinical Dentistry, Photobiomodulation, Photomedicine, and Laser Surgery, ,2019. 37(12), 737–738

7-Arany R P, Photobiomodulation Therapy: Communicating with Stem Cells for Regeneration? Photomedicine and Laser Surgery. 2016. Vol, 34, 11.

8- Abrahamse H . Regenerative Medicine, Stem Cells, and Low-Level Laser Therapy: Future Directives. Photomedicine and Laser Surgery. 2012,Vol 30, 12. merican journal of dentistry. 2009;22(4):195-9.

7. Arany PR. Photobiomodulation therapy: communicating with stem cells for regeneration? Photomedicine and laser surgery. 2016;34(11):497-9.

8. Abrahamse H. Regenerative medicine, stem cells, and low-level laser therapy: future directives. Photomed Laser Surg. 2012;30(12):681-2.