Review on Optimal Laser Parameter for LLLT Treatment

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Introduction

Low-level laser therapy, often abbreviated as LLLT, encompasses various therapeutic approaches utilizing photobiomodulation. This method induces biological changes in organisms through the interaction of photons with atoms or molecules. The most usual LLLT procedures are carried out by irradiation of low-level or low-powered lasers to sites of injury in order to speed up cellular processes leading to better healing and decrease of inflammation and pain. Almost all LLLT treatments are conducted with red or near-infrared (NIR) light (390–1100 nm), with an output power of 1–1000 mW in a non-heating energy density (0.1–100 J/cm2)[1]

This review delves into the varied physical properties of lasers and aims to present a thorough analysis of existing literature, exploring their potential effects on cellular and molecular levels across different mammalian models. Additionally, it seeks to highlight the importance of selecting optimal laser characteristics tailored to specific biological targets for maximum effectiveness at the cellular and molecular levels.

Methodology

The first step toward being able to predict light's interactions within any clinical (or experimental) environment is gathering the optical characteristics of all relevant tissue types involved. Here we outline a few methods to do so. Beer's law can be used to calculate the absorption for a transparent sample in a conventional spectrophotometer. **In Integrating Sphere** Technique Diffuse reflectance and transmittance can be measured with an integrating sphere: a spherical light collector that couples to an optical detector. A single sphere can be used in which case the sample is placed first in front of the sphere to collect the transmitted light and then behind the sphere to collect the reflected light (Fig.1).

Discussion

Monte Carlo simulation is referred to as an "exact method" because it involves the individual microscopic interactions of photons with absorbing and scattering particles. The microscopic interactions are based on the laws of optics, including the law of **reflection, Fresnel's equations for reflection and refraction, and Snell's law for changes in refractive index.[1].** Figure 2 Monte Carlo simulation of a fiber held at three distances from the surface of a tissue phantom: 0, 2.5, and 7.0 mm, left toThe top row in Fig.2 looks down on the tissue and shows where light that entered the fiber emerged. The second row shows a cross section of the tissue, showing where detected light traveled, and the bottom row shows the actual illuminated volume. **[1]**

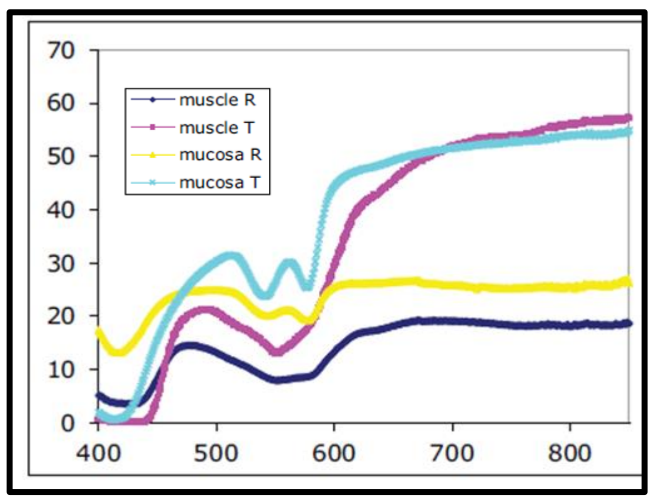

Figure:1 Diffuse reflectance and transmittance spectra collected with a single integrating sphere system for pig esophagus mucosa and muscle samples **[1]**

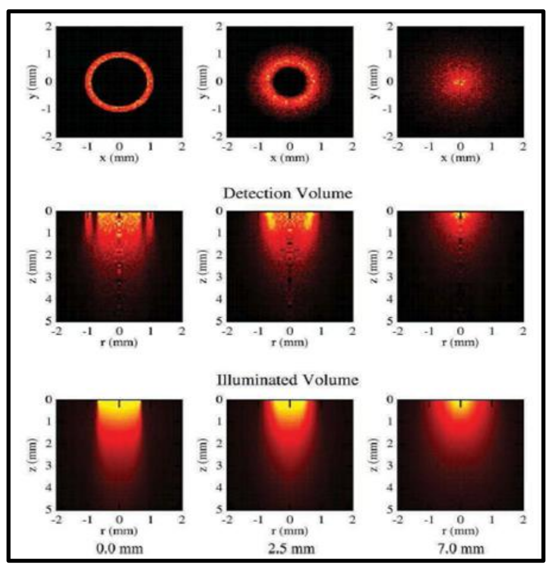

Figure:2 Monte Carlo simulation of a fiber held at three distances from the surface of a tissue phantom

In recent years, numerous studies have been conducted on PBM therapy using infrared (IR) wavelengths, particularly ranging from 700nm to the near infrared (NIR) spectrum [2], [3], [4].These investigations have demonstrated that IR wavelengths can yield more favorable outcomes than red light in various medical conditions. These include neural stimulation, achieved by directly activating neural tissue[4], combating photoaging (where IR radiation exhibits a biphasic effect), exerting anti-tumor effects (by inhibiting cancer cell proliferation and enhancing chemotherapy efficacy), providing neuroprotection for the brain (in treatments for stroke, traumatic brain injury (TBI) in vivo models) [4]and addressing neurodegenerative disorders such as Alzheimer's and Parkinson's diseases. These findings have been summarized in Table 1 [5].

Study NO	Types of laser	Wavelength (nm)	Power (mW)	Energy density (J/cm2)	Power density (mW/cm2)	Emission model CW/Pulse	Types of diseases
1	Diode laser	810	10 W	3 and 30	5 and 50	CW	Zymosan-induced arthritis [4]
2	He-Ne	632.8	10	3, 5, 10, 20, 25and 50	64.6	CW	Neurodegenerative[5]
3	He-Ne	632.8	10	0.5, 1, 2 and 4		CW	Alzheimer's disease[6]
4	Nd:YAG	1064	1.25 W			CW	Dental/Tooth extraction[7]
5	GaAs	904	10	5.4	20	CW	Musculoskeletal diseases[8]
6	Diode laser	830	30	1.1		Pulse	Painful stomatitis control[9]
7	Diode laser	810	30	0.9	30	CW	Diabetic wounds[10]
8	Diode laser	808			110	CW	Hearing loss[11]
9	GaAs	980	10 80 W	2–4		CW Pulse	Chronic low back pain[12]

Table 1: Review of published studies using LLLT to treat different diseases.[5]

Therapeutically, these super-pulsed GaAs and In-Ga-As lasers offer deep penetration capabilities without the adverse effects associated with continuous wave lasers (CW), such as thermal damage, and also enable shorter treatment durations. Pulsed lasers hold promise due to their pulse OFF times (pulse quench intervals) following the pulse ON times, allowing for reduced tissue heating.

Conclusion

The outcomes of this review revealed that light-emitting diodes (LEDs) have demonstrated efficacy in treating surface-level tissues, as exemplified in wound therapy. However, when it comes to treating deeper tissues, lasers have been found to be more effective in comparative studies. Furthermore, Shorter wavelengths are considered most suitable for addressing superficial target tissues. These shorter wavelengths have been recommended specifically for the treatment of skin wounds as well as LLLT devices equipped with longer wavelengths and higher power (mW) are most effective for treating deeper muscle, tendons, and ligaments.

On the other hand Effective utilization of these techniques and further improvement in their performance requires a good understanding of light propagation in Tissue for example Choose LLLT device that has sufficient power level and energy density is important to deliver treatments efficiently.

References

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