Quantum Biology of Laser Photostimulation

Most human beings feel excited by sunshine and depressed by prolonged sunlight deprivation. This familiar observation highlights the importance of light in supporting human and other forms of life. However, to many clinicians and scientists, the idea that a few Joules of low intensity laser beam (so low in energy density that some have compared it to the average amount of sunlight received per square centimeter of the human skin on a given day) can promote metabolic processes that result in tissue repair, pain relief, and other health benefits, seems so preposterous that some consider such claims as nothing but “snake oil”, or at best hype or hokum. Yet, reports from every region of the world indicate that low intensity lasers – often described as lasers with ≤ 500 mW average power – promote the repair processes of skin, ligaments, tendons, bone, and cartilage, in experimental animals as well as wounds and ulcers of various etiologies in humans. Reports that suggest the contrary, i.e., that low intensity lasers are not effective in these situations, complicate the matter, creating the present scenario in which laser therapy is viewed with skepticism.

In this issue of the journal, Houghton et al. of Ontario, Canada, using organ cultures of fetal mouse limbs as an experimental model, examined the influence of various energy densities of 904nm Ga-As laser on wound closure and collagen synthesis in surgically induced wounds. Their results indicate that energy densities of 0.23 and 1.37 J/cm², speed the rate of wound closure, and that certain doses (0.23, 2.75, and 3.66 J/cm²) accelerate collagen deposition in bone and dermis. A slightly higher dose (4.58 J/cm²) does not produce the same effect; rather, it was shown to be detrimental, underscoring the importance of delivering the appropriate quanta of light energy if good results are to be obtained.

The clinical study of Lichtenstein & Morag of Tel Aviv, Israel (also in this issue of the journal) demonstrates that light promotes tissue repair processes, and that human ulcers respond in the same manner as laboratory cultures of fetal mouse limbs. Human ulcers respond in the same manner. They achieved 92% satisfactory healing of human ulcers – originating from chronic venous insufficiency – when any of two wavelengths of laser light, 632.8 nm and 830nm, were used to treat the patients. That the ulcers were not responding favorably to other forms of therapy before the lasers were used is worthy of note.

The work reported here by Ohshiro et al. of Japan Medical Laser Laboratory, and Keio University School of Medicine in Tokyo, Japan, suggests that the stimulating effects of laser therapy may be more extensive than previously thought, i.e., it may have an overall whole body effect. Their study indicates that 14 of 73 female patients (19%) being treated for infertility either by artificial insemination or by other assisted reproduction treatments, became pregnant in response to treatment with two wavelengths of laser; 632.8nm He-Ne laser, and 830nm diode laser. Although these patients had been treated for an average of 9 years before laser treatment was initiated, only an average of 21 laser treatments were used to achieve the 19% success.

The report of Ailioaie and Ailioaie of the University Department of Medical Physics, Iassy, Romania, further supports the notion that laser therapy can induce whole body responses. Their clinical study indicates that, in patients with rheumatoid arthritis, early intervention with 830 nm Ga-Al-As infra red laser treatment can reduce the type of pain and morning stiffness associated with this condition.

Many of these findings are not entirely new, however, the precise mechanisms involved remain unclear, making the contributions of the international group of Sattayut, Hughes and Bradley from Khon Kean University, Thailand, and the Royal London School of Medicine and Dentistry, in the U.K., timely and relevant. Sattayut *et al.* report that 820 nm Ga-Al-As laser, when applied at higher energy levels (19 J/cm² versus 4 J/cm²), can reduce the level of prostaglandin E₂ (PG E₂) synthesis stimulated by Interleukin 1 (IL-1) in an experimental model of differentiated muscle cells. They suggest that this mechanism underlies some of the analgesic effects attributed to low intensity lasers in cases of musculoskeletal pain. Whereas this study sheds some light on one possible mechanism of laser induced metabolic changes, neither this nor other published works fully clarify the issue.

We may have to step back in time in order to begin to understand the mechanisms involved. That low energy light particles can produce significant, and at times, life-supporting changes in various organisms, is not at all new. Our primordial ancestor, the purple bacteria, provides a vivid example. Found in abstemious habitats below that of most plant life – e.g., the bottom of ponds and topsoil, depending on the species – the purple bacteria inevitably lives on a meager amount of light. Only the remainder of light unharvested by plants penetrate to those depths. But with the carotenoids in its light-harvesting complexes absorbing light at 500nm wavelength, and its bacteriochlorophyll absorbing at 800-850 nm, this life form is able to carry out complex life-supporting metabolic processes with relatively minimal light energy.

To date, more than three hundred photochemically reactive proteins, capable of harvesting low light energy, have been identified in both prokaryotic and eukaryotic organisms. Many more are being discovered yearly. In humans, the most commonly known photochemically active receptor proteins are rod and cone pigments in the eye. However, other human photoreceptors have been discovered in recent times. Examples are encephalopsins in the brain, and pinopsin in the pineal gland. Given the discovery of photoreceptor proteins in the pineal gland, the hypothalamus, and other tissues of lower vertebrates, it is only a matter of time that it will become clear that other human tissues have photoreactive proteins as well.

Thus, the idea that laser photons can trigger beneficial clinical effects cannot be that preposterous; it is consistent with the familiar fact that plants and some lower organisms can survive on minuscule amounts of light. Moreover, there are clearly defined human ocular and extraocular metabolic processes that depend on small packets of light harvested by known chromophores. The challenges faced by researchers in this field are to clearly identify those chromophores that are triggered by low power laser, to determine the photochemistry of the chromophores, and to demonstrate how their responses to laser light produce beneficial clinical changes. In this regard, reports which indicate that chromophores in human mitochondria can be activated by laser light to initiate photochemical processes that elevate ATP and protein synthesis, are encouraging. They are consistent with the photochemical reactions of other chromophores, and should be replicated to elucidate how such light-induced quantum changes produce clinical benefits.

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