LASER PHOTOSTIMULATION: An old mystery metamorphosing into a new millennium marvel

The notion that light, in the visible and near infrared ranges, can produce photochemical and photobiological changes that ameliorate pain and/or promote tissue repair was first observed in the late 1960s. At that time the prevailing notion was that lasers were uniquely photodestructive, prompting attempts to develop powerful lasers that my yield military superiority. Thus, the mood was not right and neither were medical minds ready to accept the idea that a tool that can cut, vaporize, and otherwise destroy tissue could be used for beneficial purposes. Skepticism about the therapeutic value of laser therapy continues to linger, but much has changed in the last four decades. The cold war is over, the arms race has waned, and works supporting the medical benefits of laser therapy have been on the rise.

Since this special issue of the journal presents some of the major works and accomplishments in the field, it is perhaps appropriate to use Dr. Toshio Ohshiro's summary of his 27-year experience in the field as a backdrop for a meaningful discussion of our achievements to date. About 20 years ago, Ohshiro's group demonstrated that 830 nm portable GaAlAs diode laser system attenuates pain when used in the contact mode, within dose parameters that include an average power of 60 mW. The works of Dr. Kevin Moore of the U.K., and Professor Osamu Kemmotsu of Japan, support the findings of Ohshiro et al., given that both have shown, in a series of double-blind studies, that low power laser phototherapy ameliorates pain in a wide range of conditions, particularly in patients with post-hepertic neuralgia.

Similar successes have been demonstrated in the treatment of other conditions—hypertrophic scars and keloids, failing skin grafts and flaps, hyper- and hypopigmentation, vitiligo, atopic dermatitis, atrophic skin, psoriasis vulgaris, Buerger's disease, and strawberry hemangioma in infants. The effects of laser therapy on some of these conditions have been studied by Drs. Junichiro Kubota of Japan and L. Schindl of Austria. Kubota's works on skin grafts reveal accelerated angiogenesis, better reperfusion and flap survival following laser therapy. Schindl's works elucidate the effectiveness of laser therapy in relieving the pain associated with Buerger's disease, i.e., thromboangiitis obliterans, showing that this beneficial effect is sustained for at least nine months. This carryover effect is partially explained by the work of Ohshiro et al., which indicates that laser therapy stimulates neoangiogenesis in persons with Buerger's disease.

The mechanisms involved in laser amelioration of pain continue to emerge. When pain is associated with inflammation, the evidence suggests that the mediators of inflammation are influenced by light in such a way that the overall process of inflammation proceeds faster. Works by Dr. Mary Dyson and her group have shown that mast cells are induced to release granules containing heparin and other chemical mediators of inflammation. Her group and others have also shown that certain white blood cells, e.g., macrophages are activated by light and caused to release a host of chemicals—including growth factors—that further promote the process of inflammation. Drs. G. Barberis, Vilma Campana, Fernando Soriano and their associates of Cordoba, Argentina, have demonstrated the involvement of other factors in laser amelioration of pain. They have shown that 632.8 nm light reduces the pain associated with rheumatoid arthritis by modulating the level of prostaglandin E_2 (PGE_2). A finding supported by some of the early works of Endre Mester and the recent report published by the husband and wife pair of Drs. Constantine and Laura Ailioaie of Romania.

Another mechanism via which laser therapy can modulate pain is presented in this issue of the journal by Nelson and Friedman of the U.S. Using a 1.7 mW 632.5 nm light source, they irradiated the maxillary nerve intraorally for two minutes and showed that somatosensory trigeminal evoked potentials (STEP) decreased 60% immediately after irradiation, and by as much as 72%, 20 minutes later. Given that STEP provides an objective assessment of pain, the sharp decrease in STEP amplitude observed in this study suggests a direct effect of laser treatment on the nerves that carry the sensation of pain. Their finding is supported by the work of Professor Aldo Brugnera of São Paulo, Brazil (also in this issue of the journal), which indicates rapid relieve from the sharp intense pain associated with dentinal hypersensitivity when 4 J cm^{-2} energy fluence of either 780 nm or 830 nm wavelength is used to treat this condition over a relatively short period. Other evidence supporting the idea that light affects nerve conduction can be seen in some of the works of Prof. G. David Baxter and his group of Ireland.

Since Endre Mester first published his pioneering work identifying the therapeutic value of laser therapy in wound healing, gaining a better understanding of how light energy promotes tissue repair has been a primary focus of most researchers. Important advances have been made in the areas of skin repair, muscle repair, nerve repair, tendon repair, cartilage repair, bone repair, and gum and dental tissue repair. It is now known that when healing is impaired, the aforementioned tissues respond positively to appropriate doses of light, especially light wavelengths within the 600 to 1000 nm range. The exact fluence necessary to achieve optimal healing continues to be explored for each tissue, but there is a growing consensus that accelerated healing can be accomplished with doses ranging from 1 to 6 J cm^2. As detailed in our work presented in this issue of the journal, the amount of light absorbed by each tissue differs, even when wavelength is kept constant. Therefore, the energy fluence needed to optimize healing will differ among tissues.

While it is difficult to acknowledge every important work published to date, the sustained contributions of the Schindls of Austria, Dr. Farouk Al-Watban of Saudi Arabia, Prof. Leonardo Longo of Italy, Prof. Zlatko Simunovic of Switzerland and his associates, Profs. Rachel Lubart and Uri Oron of Israel, Sandra Giavelli of Italy, S.M. Ghamsari of Japan, and Dr. Ray Lanzafame of the U.S. are noteworthy in the area of skin repair, as are the important works emerging from our laboratory and those of Drs. Harry Whelan of the U.S., and Pamela Houghton of Canada. The labs of Drs. Shimon Rochkind and Juanita Anders of Israel and the U.S. respectively, have made significant contributions revealing the positive effects of specific energy fluences of light on nerve tissue regeneration, including regeneration of the spinal cord, a part of the central nervous system once considered inert to healing.

A substantial amount of evidence has emerged supporting the use of low energy lasers to promote fracture repair since Mario Trelles of Spain published his pioneering work, which revealed the positive effects of laser therapy on bone healing. The contributors in this area include Dr. R. Giardino and coworkers of Italy, Dr. J. Chen of China and Dr. Shimon Rochkind and others detailed in his review article published in this volume. Supporting their findings are reports which demonstrate the effectiveness of laser therapy in promoting bone, oral or dental tissue repair with or without surgery. These include the works of Professor Tony Pinhiero and his group in Brazil, one of which appears in this volume. The cellular studies of Dr. Luciana Almeida Lopes in this area are noteworthy. Tendon and cartilage are two other connective tissues that respond positively to laser therapy, as evidenced by several reports on tendon repair from our group, and the works of Giardino and his associates published in a wide range of journals.

Whereas little was known about light-tissue interaction 40 years ago, the works of Professor Lubart, Professor Passarella of Italy, and others have shown that light energy is absorbed by endogenous chromophores in the mitochondria and membranes of cells. Furthermore, Drs. Tiina Karu and Kira Samoilova of Russia, Patrick Abergel of the U.S., and others have demonstrated that the energy absorbed is used to synthesize DNA, RNA, proteins and various enzymes, resulting in cell proliferation, and tissue repair. Given our understanding of the mechanisms involved in laser tissue repair and pain modulation, it is clear that this form of treatment is emerging from its obscurity of the late 60s to a technological breakthrough that is becoming a mainstay clinical armamentarium of the new millennium. More remains to be done. If the high rate of producing the objective evidence supporting the efficacy of light in treating a wide range of conditions is sustained, its widespread acceptance within the first decade of the new millennium is assured.

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