

The Role of Lasers in Therapeutic Treatment

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Low-energy “cold” lasers are currently used for wound healing in preoperative and postoperative settings, pain management, acute and chronic soft tissue injuries, biomodulation, and in conjunction with acupuncture or trigger point therapy (Mester, Toth, and Mester, 1982, Felton, 1994). While the clinical effects of the laser are easily demonstrated, the molecular mechanism of action is not precisely understood (Karu 1989, Basford. 1995).

Yet, during the past decade, over 2500 papers have been published documenting in vivo and in vitro success stories supporting use of cold laser light therapy to treat infected, ischemic and hypoxic wounds (Fiszerman and Rozenbom, 1995). The “magic” healing effects of the laser include enhanced wound healing with minimal scar formation in acute soft tissue wounds and enhanced remodeling and decreased pain in chronic soft tissue injuries (Sutton, 2003), diabetic and mucosal ulcers, and burns (Sumano and Cosaubon, 1987), enhanced fracture consolidation (Sutton, 2003), decreased post-traumatic nerve regeneration time (Vogel, 2002), and marked prolonged analgesia (Illeminen et AL, 1992). Suspected mechanisms of action include increased nerve conduction latency (Rochkind, 1991) endogenous cortisone release (Vogel, 2002) or through trigger point meridians (Airaksinen, 1995).

Response to injury

The body’s response to injury is predictable and well defined. While soft tissue injuries rupture cells and blood vessels, the release of cellular by-products initiates the healing process. Healing progresses in three Phases:

1. During the **Inflammatory Phase**, destruction of tissue causes production of lymph resulting in pain, swelling, and the laying down of scar tissue. Immediate control of inflammation limits tissue destruction and edema formation by the release of the inflammatory mediators. Immediate control of inflammation is the best predictor for full return of function in the future. Pain control is essential to promote patient well-being. Sepsis control is necessary to minimize scar formation and to prevent multi-systemic organ failure,
2. The **Regenerative Phase** can be delayed as long as about 5-7 days after injury without control of hemostasis, inflammation, edema, and sepsis. During this phase, production and orientation of collagen at the site of damage occurs. Treatment is designed to restore range of motion, strength, and fitness.
3. By the time the **Remodeling Phase occurs**, scar tissue contraction can decrease tissue movement resulting in limited range of motion and disfigurement. Treatment is designed to promote collagen synthesis, orientation, and reorganization, and to promote reorganization of granulation tissue in order to restore range of motion, muscular strength, power and endurance.

Light as therapy

Radiant exposure dose-dependent low-energy photon therapy induces corresponding dose-dependent cellular changes during each phase of the healing process.

1. Low-level photon therapy contains the **Inflammatory Phase** by inhibiting exuberant immune-reactivity, inducing vasodilatation, inhibiting mast cell deregulation and decreasing free radical production. This prevents the release of destructive inflammatory mediators including histamine, prostaglandins, hyaluronic acids and mucopolysaccharides, in addition to inhibiting leukocyte chemotaxis, and lipid peroxidation from free radical formation. Analgesia results from endogenous cortisol release. Cortisone levels peak at four hours and remain elevated for up to four days (Vogel, 2002). Musculoskeletal pain caused, for example by muscle spasms or disc

disease, appears relieved through a mechanism similar to trigger point therapy (Sutton, 2003).

Containing the inflammatory cascade drastically decreases recovery cycle time (Schwartz et al, 1987) and allows minimal scar formation (Pontinen, 1993). Laser beams promote rapid hemostasis, but can open up occluded arteries as well (Pontinen and Airoksinen, 1985) balancing the body's tendency towards ... hypercoagulable states (Fiszerman and Rosenbom, 1995) that can lead to disseminated intravascular hemolysis (DIC) and death.

On a cellular level, radiant exposure causes dose-dependent cellular effects on erythrocytes, leukocytes, fibroblast and keratinocytes. Increased connective cell proliferation occurs through energy absorption by the amino acids and nucleic acid bases, or by biostimulation of cellular chromophores including hemoglobin, melanin, and the cytochromes of the mitochondrial electron transport system. The result is increased collagen formation, increased production of mitochondrial ATP, enhanced RNA synthesis and DNA production, enhanced cell division and leukocytic phagocytes (Anders et. al., 1993).

Biostimulation by laser light increases both glucose and oxygen consumption in irradiated tissue. An increase in the chemiluminescences of cellular components within peripheral blood support laser induced changes in cellular oxidative metabolism (Salansky and Brill, 1994). Several cellular mechanisms appear influenced by low-energy photon therapy. In hypoxic tissue, burns and poorly healing wounds, the laser appears to alter membrane potential by rallying intracellular potassium, increased vasodilatation, and release of the local neuropathies including VIP (vasoactive intestinal peptide), or by changing neuropeptide binding affinities (Hasan et. al., 1989, Rochkind, 1992).

The edema-reducing effects of the low-power laser results from increased microvascularization (Rozenbom, 1995), accelerated lymphatic flow (Pontinen, 1998), and enhanced tissue oxygen uptake. The number of nail bed and mesenteric capillaries increase after laser stimulation. Laser irradiation enhance blood flow to edematous, ischemic or hypoxic tissues in general. The most marked increase in capillary density laser irradiation occurs at the dermal-epidermal junctions. Electron microscope studies demonstrate intense vascularization evidenced by an increase in the number of reactive nucleoli in and increase in the cell wall polysaccharides within the vascular endothelium (Benedicenti, 1983, Lievens, 1986, and Miro, 1984).

2. During the **Regenerative Phase**, laser irradiation enhances collagen synthesis characterized by enhanced glycine and proline content in collagen fibrils (Rochkind, 1992). This allows for more organized tissue, decreases adhesions, minimal keloid formation, and lighter colored scars (Pontinen, 1998). Zaragoza and Iturrate (1985) demonstrated the effects of focal laser irradiation spread outside the treatment site in wounds, burns, and ulcers. The mechanism of action is probably humoral mediated. Limited focal irradiation of poorly healing wounds and diabetic ulcers produces systemic effects, as well as effects on the contra-lateral extremity (Dyson and Young, 1986, Rodigo, Zaragoza, and Iturrate, 1985).

Reperfusion injury is minimized by increased oxygen tension in compromised tissue (Fiszerman and Rosenbom, 1995) while muscle and peripheral nerve regeneration is enhanced after laser therapy after crush injuries by scavenging free-radicals thus preventing lipid per oxidation of cell membranes (Karu 1988, 1989)

3. By the time the **Remodeling Phase** occurs, if excessive scar tissue has formed, wound contracture disfigurement, scarring, and decreases in tissue movement and individual

function occur. Low-level photon therapy promotes collagen reorganization regardless of the time since the initial wound occurred. This happens through the synthesis and re-orientation of the collagen fibrils, incorporation of proline and glycine amino acids into the fibrils and an increase in the number of complex mucopolysaccharides present in the connective tissue cell membranes (Rothkind, 1992). An increased amount of proline and glycine in collagen fibrils and mucopolysaccharides in the interstitial promotes the fluid motion between in damaged tissue (Sumano, 1987).

As a result, keloid formation decreases and healing accelerates. Laser treatments fight sepsis effectively by inhibiting viral and bacterial growth *in vivo* (Lee, Kim, and Kim, 1993). In addition, while lasers decrease keloid formation to begin with, continued treatment can reorganize previously healed but disorganized wounds.

Application of LEFT prior to surgery, peri-operatively, and immediately post-operatively decreased the frequency and intensity of pain reported by surgical patients. In acute phases, pain decreases because of the irradiation-induced decrease in inflammation, edema, infection, and the increase in local circulation. Continuous nociceptive discharge of active trigger points incorporated into scar tissue contributes to reports of chronic pain. Chronic pain sufferers, including cancer patients, amputees (phantom limb pain), and patients suffering with fibromyalgia, or reflex sympathetic dystrophy (RSD), report remarkable and prolonged pain relief and a general sense of well being or euphoria after a single laser treatment (Zaleskiy 1984, 1987, Vogel, 2002).

Application of light therapy to battlefield medicine

Time to treatment often determines the outcome in traumatic wound scenarios. Every freshman medical student is familiar with clinical adages including, "...fractures have a two hour "golden period for sepsis..,"¹¹ or, "...never let them die without the benefits of steroids..." and , "...DIC means death is coming..."

In today's increasing Special Forces scenarios, immediate, simple, self-contained and administered first aid is a must! LEPT is an ideal first response treatment modality because it provides analgesia, reduces swelling and insures that a thorough physical exam can be completed by permitting manual manipulation of otherwise painful wounds. Conventional care includes cleansing, surgical debridement, topical and systemic antibiotics. Immediate use of lasers can eliminate these painful procedures, accelerate healing, and decrease the time to return to function.

The *LazR MicropulsR* is ideally suited to treat the traumatic, penetrating soft tissue wounds, burns, and shattered bones and psyches encountered on the battlefield. The unique engineering (cordless), ergonomic design (hand held, balanced), easy-to-use (species specific laminated trigger point cards), durability (ability to use in numerous different environments; waterproof case; water resistant module), size (handheld; concealable), and programmability (preprogrammed treatment protocols) lends itself to field application. Except for a caution against direct eye exposure, which is easily managed with disposal ophthalmologic dark glasses, laser therapy is extremely safe. No eye injuries have been report in the literature to date from a low-energy photon therapy device.

Immediate application to superficial wounds promotes rapid healing and prevents infection. Lasers contribute to positive outcomes in catastrophic wounds and burns. Laser irradiation helps promote immediate homeostasis without coagulopathy (D1C), combats immunoreactivity, contains the destructive inflammatory process, provides prolonged pain relief, inhibits sepsis, and controls recurrent, mixed flora (iatrogenic) superficial skin and mucosal infections. The immediate application of laser irradiation promotes healing by increasing, blood flow to injured, ischemic, hypoxic tissue. During the recovery and rehabilitation phases, the laser continues to modulate pain and smooth scar formation, decreasing postoperative recovery time and rehabilitation.

References

- Airaksinen O:** Effects of infra-red laser irradiation on the treated and non-treated trigger points. *Acupuncture Electrotherapy Res* 14:9,1989.
- Basford JR:** Low intensity Laser therapy: still not an established clinical tool. *Laser Surg Med* 16:33, 1995.
- Benedicenti A:** a valutazione dell'effetto della luce laser 940 nm nella circolazione ematica *in vivo*, *Periodontal e Stomatol Nuova* 1:109,1983.
- Dyson M. Young S:** Effect of laser therapy on wound contraction and cellularity in mice. *Laser Med Sci* 1:125, 1986.
- Felten RP:** FDA status of dissimulation lasers. **Abstracts of ASLMS** fourteenth meeting, **Toronto, Canada, April 8-10, 1994.**
- Fiszerman R, Rozenbom CY:** Low energy therapy effect in low extremity transcutaneous oxygen partial pressure. **Abstracts ASLMS fourteenth annual meeting, San Diego, California, April 20-24, 1995.**
- Hasan P et. al.:** The possible application of low reactive level laser therapy (LLLT) in the treatment of male infertility, *Laser Ther* 1 (1):49, 1989.
- Helminen HJ:** Kuornituksen vaikutus nivelrustoon, *Duodecím* 108:1097 1992.
- Karu TI:** Molecular mechanism of the therapeutic effect of low-intensity laser irradiation, *Laser Life Sci* 2:53, 1988.
- Karu TI et. al:** Helium-neon laser-induced respiratory burst of phagocytic cells, *Laser Surg Med* 9:585, 1989.
- Lee P, Kim K, Kim K:** Effects of low levels of infrared laser irradiation on healing of infected open skin wounds in rats, *Laser Ther* 5:59, 1993.
- Lievens P:** The influence of laser irradiation on the motility of lymphatic system and on the wound healing process. *Proceedings of the International Congress of Laser in Medicine and Surgery*, Monduzzi, Ed, Bologna, 1986.
- Miro L et. al.:** Estudio capilarescópico de la acción de un láser AsGa sobre la microcirculación, *Investigacion y Clinica Laser* 1(2):9, 1984.
- Pontin PJ:** Evaluation and measurement of response to acupuncture and laser therapy. *Proceedings of the nineteenth annual International Conference on Veterinary Acupuncture*, Tromso, June 24-27. 1993.
- Pontinen PJ, Airaksinen O:** The effect of low power infrared laser on latent myofascial trigger points, *First International Symposium on Myofascial Pain and Fibromyalgia*, Minneapolis, May -10,1989.
- Pontinen P, Airaksinen O:** Evaluation of myofascial pain and dysfunction syndromes and their response to low level laser therapy, *J Musculoskel Pain* 3(2): 149,1995.
- Rodrigo, P, Zaragosa JR, Iturrate C:** Un caso de osteomielitis tratado el tiroides con laserterapia. *Investigacion y Clinica Laser* 2:94, 1985.
- Rocking et. al.:** Intraoperative clinical use of LLLT following, surgical treatment of the tethered spinal cord. *Laser Ther* 3:113, 1991.
- Rocking S et. al.:** Central nervous system transplantation benefited by low-power laser irradiation, *Lasers Med Sci* 7:143, 1992.
- Sumano HL, Casaubon T:** Evaluation of electroacupuncture effects on wound- and burn-healing, *Scand J Acup Electrother* 2:159, 1987.
- Sutton A:** The injured Horse. Hands on methods for managing and treating injuries. **David and Charles. Cincinnati, Ohio, 2003.**
- Schwartz et. al.:** Effects of low-energy He-Ne laser irradiation on posttraumatic degeneration of adult rabbit optic nerve, *Laser Surg Med* 7:51, 1987.
- Vogel C:** The Horse Health Bible. The quick-reference guide to the diagnosis of common veterinary problems, **David and Charles, Cincinnati, Ohio, 2002.**