

Practical Applications of Low Level Laser Therapy

A brief review of some of the basic concepts of low level laser therapy, clinical indications for its use, and treatment options when applying therapeutic lasers to patients in pain.

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[Editor's note: To bring the very best information on laser therapy to our readers, we called upon Dr. William Kneebone, a chiropractor with connections to the medical profession and with a thorough understanding of how a medical doctor can utilize laser therapy as a compliment to more traditional approaches. He has been in a complimentary medicine practice in the San Francisco Bay area since 1978. He is also a Fellow of the International Academy of Medical Acupuncture and a Diplomate of the International Academy of Clinical Thermology Dr. Kneebone has been using therapeutic lasers in his practice for over seven years and has been teaching laser seminars to practitioners, including many physicians, for the past four years. He is scheduled to teach 25–30 Cutting Edge Laser Seminars™ next year around the US.]

The North American Association of Laser Therapy (NAALT) adopted the term Phototherapy in 2003. This inclusive term is defined as: a therapeutic physical modality using photons (light energy) from the visible and infrared spectrum for tissue healing and pain reduction. Light photons can be produced by: low level lasers (therapeutic lasers), non-coherent narrow band light diodes, non-coherent broad band light diodes, polarized light, and photodynamic therapy.¹ This article will be discussing therapeutic lasers as well as non-coherent narrow band and broad band light diodes.

Strictly speaking, a laser is a light amplifier if the radiation produced is within the visible range or a radiation amplifier if the radiation produced is in the infrared range. All lasers must have the following parts: an energy source (power supply), lasing or amplifying medium (solid, gas or liquid), and a resonating cavity (mirrors). The first working laser was presented to the public at a press conference in late 1960's by Theodore Maiman.² He demonstrated a ruby laser. The potential for using lasers for surgery was soon explored and rapidly introduced into surgical suites in many countries throughout the world. A Hungarian physician named Endre Mester performed cancerous tumor treatment experiments on rats utilizing laser. He found that because it was underpowered for that purpose, the laser he was using didn't kill tumor cells but, instead, accelerated wound healing in the surgical sites of the experimental rats.³ He is the grandfather of photobiomodulation since he was the first to ob-

serve the healing effects of low powered lasers. To date, there have been more than 2500 published studies worldwide involving low level laser therapy with approximately 120 double blind studies published.⁴

There are several extraordinary effects that have been observed with therapeutic lasers, and phototherapy in general, that make laser therapy unique among the various healing modalities available today. Photobiomodulation produces changes in oxidation/reduction status of the mitochondria which lead to dramatic increases in ATP synthesis. Activation of the sodium/potassium pump alters the cell membrane permeability to calcium⁵ (see Figure 1).

Phototherapy has been shown to effect cellular activity in the following ways:

- stimulates cell growth
- increases cell metabolism
- improves cell regeneration
- invokes an anti-inflammatory response
- promotes edema reduction
- reduces fibrous tissue formation
- stimulates nerve function
- reduces the production of substance P
- stimulates long term production of nitric oxide
- decreases the formation of bradykinin, histamine, and acetylcholine
- stimulates the production of endorphins.⁶

These photo-biological responses are largely responsible for the pain relieving effects often observed in patients treated with phototherapy. There are three effects that commonly occur as a result of tissue exposure to light photons. They are:

Primary effects of photoreception are a result of the interaction of photons and cell mitochondria which capture, direct, and transduce photon energy to chemical energy used to regulate cellular activity.

Secondary effects occur in the same cell in which photons produced the primary effects and are induced by these primary effects. Secondary effects include cell proliferation, protein synthesis, degranulation, growth factor secretion, myofibroblast contraction and neurotransmitter modification—depending on the cell type and its sensitivity. Secondary effects can be initiated by other stimuli as well as light.

Tertiary effects are the indirect responses of distant cells to changes in other cells that have interacted directly with photons. They are the least predictable because they are dependent on both variable environmental factors and intercellular interactions. They are, however, the most clinically significant. Tertiary effects include all the systemic effects of phototherapy.⁷ Primary, secondary, and tertiary events summate to produce phototherapeutic activity.

The vast majority of therapeutic lasers are semiconductor lasers today. There are three diode types:

1. Indium, Gallium-Aluminum-Phosphide (InGaAlP) laser
2. Gallium-Aluminum Arsenide (GaAlAs) semiconductor laser
3. Gallium-Arsenide (GaAs) semiconductor laser

Indium, Gallium-Aluminum-Phosphide (InGaAlP)

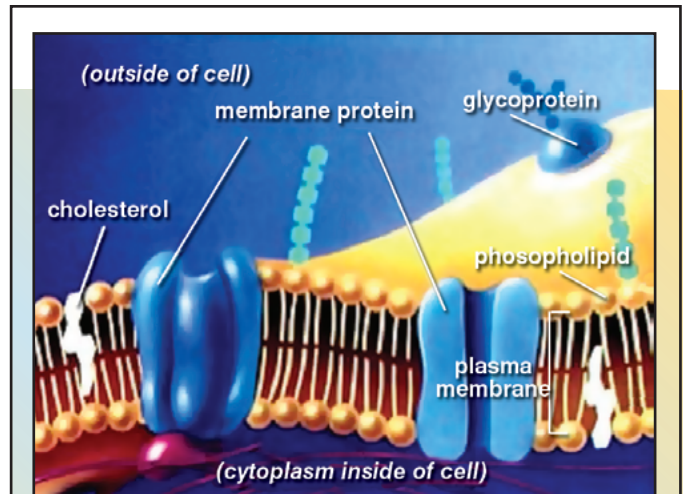
This is a visible red light laser diode that operates in the 630–700nm range. These lasers output light in a continuous manner. These lasers may also be pulsed by an electro-mechanical method (duty cycle). A duty cycle output means that the power is switched off for part of a second, and then switched back on. If it was off for ½ second and on for ½ second that would be referred to as a 50% duty cycle. This reduces the average power output by 50%. Red light lasers have the least amount of penetration of the three lasers with a range of 6–10mm. They effect the skin and superficial tissue.⁸

Gallium-Aluminum Arsenide (GaAlAs)

This is a near infrared laser, which means that the light emission is invisible to the naked eye. This laser operates in the 780–890nm range. This type of laser also has a continuous output of power and is often pulsed on a duty cycle as described above. This laser penetrates to 2–3 cm depth. These lasers are often utilized for medium to deep tissue structures such as muscles, tendons, and joints.⁹

Gallium-Arsenide (GaAs)

This laser is unique in that it is always operated in superpulsed mode. Superpulsing means that the laser produces very short pulses of high peak power. These peak power spikes are usually in the 10–100 watt range but last for only 100–200 nanoseconds while maintaining a mean power output that is relatively low. This phenomenon is similar to what happens in a camera flash. Superpulsing allows for deep penetration into body tissues without causing the unwelcome tissue effects of continuous



Photobiostimulation

- Photostimulation or photobiomodulation is the process where a chain of chemical reactions is triggered by exposure to light.
- Stimulation of the respiratory electron transport chain results in two major events.
 - The light changes the reduction/oxidation status of the mitochondria which leads to enhanced ATP synthesis (Kreb Cycle).
 - The activation of sodium/potassium pump alters the cell membranes permeability to the flow of calcium.
- The cell is provided with more energy.
- The cell is in optimum condition to play its part in a natural healing process.

FIGURE 1. Cellular effects of photobiostimulation.

Courtesy of Multi Radiance Medical

high power output such as heat production. Super pulsing allows for deeper penetration than a laser of the same wavelength that is not superpulsed but has the same average output power. Penetration is 3–5 cm or more. Superpulsing also allows for treatment times to be the shortest possible. These lasers are extremely well suited for medium and deep tissues such as tendons, ligaments and joints.¹⁰

Most phototherapy research has been historically laser centered. Several studies are now appearing in the literature utilizing light emitting diodes (LED's) and infrared emitting diodes (IRED's). LED / IRED diodes have approximately 80% of the effect on tissues as lasers.⁶ The most commonly used light diodes for phototherapy are:

- Visible Red – 630nm, 640nm, 650nm, 660nm
- IRED – 830nm, 880nm, 950nm

These are driven by power outputs up to 100mW or more and are most often used in clusters of several diodes. Some devices use clusters of a single frequency and others use a mix of LEDs and IREDS of various wavelengths.



FIGURES 2 AND 3. Treatment of lumbar paraspinous muscles. Courtesy of Multi Radiance Medical

There are a few exotic devices that use unusual wavelengths. One interesting device utilizes a cluster of various wavelengths 700nm and 2,000nm IR.

Most LED and IRED diodes are made from the following compounds:

- GaAsP — Red light – 640nm, 655nm
- AlInGaP — Blue and red light
- InGaN — Blue and red light
- AlGaIn — Blue and red light
- AlGaAs — IR – 880nm, 950nm

Red light at 640nm has been shown to effect skin so it may be effective in treating cuts, scars, trigger points and acupoints. Usual depth of penetration is less than 10mm.

880nm IR phototherapy has been shown to effect deeper structures such as bone, tendons, deep muscles or other tissues up to 30-40mm. This performance is achieved by LED/IRED therapy utilizing large arrays of 40-60 diodes having a high power output.

Advantages include no tissue damage and broad coverage due to the non-coherent light used.

One disadvantage is the possible thermal effects in devices that cover large areas and have several watts of power output.

Historically, most laser manufacturers produced therapy devices that were of one wavelength only. This necessitated the clinician to have several probes or emitters, each of a different wavelength in order to ensure adequate coverage of various tissues. Today phototherapy devices are increasingly available that have combinations of laser diodes, LED's, and IRED's. Several companies are using blue and red LED's together with IRED's in one pad. They have observed sedation effects in the blue and stimulation effects in the red. Essentially all LED/IRED devices are pulsed on a 50% duty cycle. This allows for deep penetration by the laser and more superficial and broader irradiation by the LED's and IRED's. There are also companies that manufacture devices that have cluster or arrays of several laser diodes.¹¹

Adequate clinical assessment is important in determining whether or not a patient is a good candidate for laser therapy. Laser therapy can be used alone or in combination with other modalities. Eastern European studies have shown phototherapy to be an effective adjunct in over 200 conditions.¹² FDA clearances have been granted to several phototherapy manufactur-

ers that distribute their products in the US. The on label uses for the devices are primarily for pain management. There have been a considerable number of clinical studies of the responses to laser therapy in a broad number of conditions. The following painful conditions have been shown to be quite responsive to phototherapy: carpal tunnel syndrome, muscle strains, tendonitis, neck and low back pain, fibromyalgia, joint sprains, tennis/golfer's elbow, and soft tissue injuries.¹³ Phototherapy applications are safe and usually require only a few minutes to perform. Established protocols and tissue dosages have been developed that make clinical application relatively simple. Many phototherapy instruments have preset programs that take all of the guesswork out of the process.

There are several application techniques for utilizing low level laser therapy on patients. The first is tissue saturation of the involved area. This may be performed by pressing the emitter or probe on the skin and holding there for a period of time then moving it to an adjacent area, in a grid pattern until the entire area is covered. Scanning or back and forth movement for the duration of the treatment time may also be employed for saturating the tissues. (See Figures 2 and 3.)

Laser tissue penetration is enhanced by maintaining firm pressure on the skin surface with the emitter or probe. This helps displace capillary blood flow in the superficial tissues and decrease blood flow to the treatment area. This is desirable because photon penetration into the tissue is inversely proportionate to the amount of water content in the tissues. Blood has high water content so it will tend to absorb more of the photon energy. This will result in less penetration into the deeper tissues.¹⁴

Phototherapy devices that utilize a combination of laser and LED/IRED combinations should be used in direct contact with the skin for the additional reason that these non laser light sources are non-coherent and lose their focus as they are distanced from direct contact with the skin.

The second treatment approach is to treat trigger points.¹⁵ This is accomplished by using a stationary contact on the trigger point as described above. The use of an algometer is beneficial to obtain a comparison of pain level prior to treatment and post treatment (see Figure 4).

The third treatment approach is acupuncture point stimulation or laserpuncture. There have been considerable numbers



FIGURES 4. Treatment of occipital trigger point.
Courtesy of Multi Radiance Medical.



FIGURES 5. Acupoint stimulation of LI4 with special acupoint probe.
Courtesy of Multi Radiance Medical.

of studies performed on laser stimulation of acupoints.¹⁶ The emitter or probe can be placed over the acupoint or a special acupoint probe may be used, if available (see Figure 5). Clinical experience has shown that the more of these three techniques are combined together during treatment sessions, the faster and more long lasting are the results.

Contraindications

The North American Association for Laser Therapy (NAALT) has compiled the following list of contraindications: pregnancy (over the pregnant uterus), cancers (over the tumor site), where treatment would be over the thyroid gland, where treatment would be over pediatric joint epiphysis, transplant patients, or other immuno-suppressed patients, and photosensitive patients. Caution should be used when considering the use of laser phototherapy on patients that have recently under gone steroid or Botox treatment.

Conclusion

Laser therapy, in general, is safe and can be often used where other physical modalities are contraindicated such as with pacemakers or metal implants.¹⁷ Laser phototherapy can be of value in the mitigation and elimination of many painful conditions.¹⁸ Laser phototherapy is easily applied to patients and has relatively short treatment times, depending on the power output of the device, the wavelengths used and the size of the area to be treated. There are no known permanent or serious side effects from laser therapy.¹⁹ ■

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