

Report

Therapeutic Laser for Chronic Low Back Pain

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Abstract

Positive results in the treatment of low back pain with LLLT include decreased pain and improved function. LLLT has been in use and studied since the 1960s. To date, the research is still debating the effectiveness of LLLT to treat various pathological conditions. A few concerns arise when examining the literature on LLLT. Many studies do not publish all their treatment parameters, which makes it difficult for the findings to be translated into clinical practice.

The site of application, application method and technique, and the dosage are poorly documented. Thus, few studies meet the systemic review inclusion criteria; this limits attempts to complete meta-analyses on LLLT effectiveness. To date, very few studies have investigated the optimal wavelength, power, frequency and treatment time to obtain a therapeutic effect. Having said this, there is some evidence to suggest that LLLT decreases swelling, reduces pain and improves function. Overall the literature and research on low level laser therapy are insufficient to make conclusions on the effectiveness of laser therapy. Currently the practice of using LLLT is ahead of the evidence to support the use of the technology. This is common for most modalities used in physiotherapy and eventually the research catches up to clinical usage. Some studies may convince the therapist to use LLLT for conditions involving inflammation and for providing pain relief.

Introduction

Low back pain will affect 75-85% of all people at some point during their lifetime. Approximately 50% of them will have a recurrence within a year. Approximately 90% improve without

surgery. Approximately 7.4% of patients with low back pain account for 75% of the money spent on low back pain¹. The vast majority of acute low back pain is the result of injury such

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as sprain or strain, while the cause of chronic low back pain is multifactorial². Chronic low back pain is defined as pain of more than three months duration. It occurs in 2-8% of those who experience low back pain¹.

The effects of laser therapy are photochemical and photomechanical, not thermal - at least, not on a macro-scale. There are two primary forms of effects generated by laser irradiation of biological tissues: photon-absorption (the basis of photobiological action, and generated by all forms of light), speckle formation, which is unique to laser therapy³.

Photon-absorption effects occur when photons enter the tissue and are absorbed by photoreceptive molecules, called *chromophores*, in the mitochondria and at the cell membrane. Photonic energy is then converted to chemical energy within the cell, and is utilised in the form of ATP. A number of the effects of laser irradiation, however, are unique, and are due to the speckle field that is created when coherent laser radiation is reflected, refracted and scattered⁴. The speckle field is not simply a phenomenon created at and limited to the tissue surface, but is generated within a volume of tissue, persisting to the total extent of the depth of penetration of the laser beam. Laser speckles formed deep

in the tissue create temperature and pressure gradients across cell membranes, increasing the rate of diffusion across those membranes. Further, photons within each speckle are highly polarised, leading to an increased probability of photon absorption (one possible reason for why laser therapy has been shown to consistently out-perform other non-coherent light sources, especially for deeper tissue treatments). The five most common pain producing structures of low back pain are :

1. Posterior longitudinal ligament
2. Interspinous ligament
3. Spinal nerve root
4. Facet joints
5. Deep muscles

These structures do not fully account for the pain experienced by many chronic low back pain sufferers. The exact mechanisms of the causes of chronic low back pain continue to be a mystery. Recent scientific studies have implicated a number of chemical mediators as possible contributors to the production of chronic low back pain. These include⁵ :

- The peptide somatostatin
- Pro-inflammatory cytokines such as IL-1, IL-6, IL-10, and TNF-alpha
- PGE2
- Nitric oxide

Therapeutic Laser for Chronic Low Back Pain

Patients with chronic low back pain may also have emotional factors such as depression with a four times higher incidence of clinical depression than those without chronic low back pain. Studies have shown that 62% of the patients treated at pain clinics for low back pain have some type of depression⁶.

Low Level Laser Therapy- what is it?

Laser light is produced when an electron of an active medium undergoes a stimulated quantum jump from a higher to a lower energy state, causing an emission of photons. The emitted photons collide with other excited electrons, causing increased photon emission. This chain reaction of events is the mixture of two inert gases and is referred to as the active medium⁷. Laser light is different from other light forms because it is monochromatic, coherent and directional. Monochromatic (light is all of the same frequency), coherent (wavelengths in the same phase) and directional (light has very little divergence of the beam). These properties allow for a laser beam to focus on a very precise small target and the monochromatic light allows absorption to be targeted to a specific wavelength by photosensitive molecules called chromophores⁸.

Classes of lasers range from 1 to 5. High intensity laser, known as Class 4 and 5 lasers, heat and destroy tissue. They are used medically for incisions and cautery during surgical procedures. Low intensity lasers known as Class 1 to 3B have less than 500mW power, 50mW/cm² power density and 40 J/cm² energy density and are referred to as low level lasers and are used as adjunct therapy in rehabilitation⁹. The passage of light into skin is necessary to achieve the physiological effects. Short-wavelength (400-700nm) lasers have visible red light such as Helium-Neon Laser (HeNe) and are highly pigment specific. Longer-wavelength (600-1200nm), invisible infrared lights such as Gallium-Arsenide (Ga-As) lasers are much less pigment-specific and penetrate deeper than the HeNe Lasers. There is consensus that the visible light (He-Ne) penetrates 1-2 mm and invisible light (Ga-As) penetrates 2-4 mm in soft tissue^{8,10,11}.

For example, the potential of low intensity infrared laser irradiation applied to the skin over the course of peripheral nerve to significantly affect conduction latencies in that nerve has been demonstrated¹². Some manufacturers claim their devices penetrate to depths of 10-13 cm (Super Pulsed Infrared Laser Radiation),

however we could find no peer reviewed publications for confirmation.

Therapeutic and Physiological Effects

Chronic low back pain is a complex clinical condition which involves many different tissue levels from subcutaneous and muscle tissues to the deeper tendons and ligaments, including the inter-vertebral disc. Laser therapy, if it is to be effective, must be applied in a way that will effectively produce significant biochemical changes in the superficial, medium, and deep tissues¹³. One may recall from the previous article that red light will affect the skin and subcutaneous tissue to an approximate

depth of 1 cm. Infrared light will effect deeper tissue structures from 1 -5 cm depth.²² Comprehensive laser/light therapy for treating chronic low back pain must therefore include the use of both red and infrared wavelengths (See Figure 1).

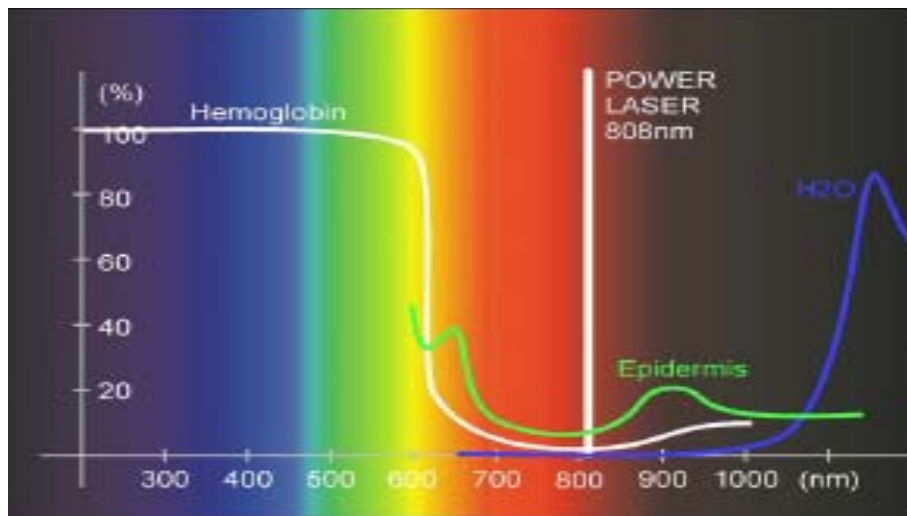


Figure 1.Therapeutic Window

Therapeutic Laser for Chronic Low Back Pain

Basically, the light from a laser, even a milliwatt LLLT system, can penetrate deep into tissue. This is due to the laser's unique properties. A laser beam travels in only one direction from its source, unlike a light bulb. A laser is monochromatic with its photons; (little light energy packets), all completely identical, and all traveling exactly equidistant in time and in space. The resulting beam therefore, has a considerably higher photon density than a monochromatic beam produced by filtering and collimating a conventional multi-wavelength light source¹². The polarization of a laser beam is also of importance in its possible applications. The end result is that the penetration of a laser beam in tissue is much greater than a conventional light source, even though the pure coherence of the beam may be lost in the first few cell layers^{11,12,14}. The photon density of the beam ensures that more photons will penetrate the tissues to reach the desired target. In-vitro studies have often pointed to no coherent-specific reaction : these ignore the simple fact that in a monosheet or ultra-thin cell medium, coherence does not make much difference as the target cells are right at the surface of the layer or medium. In in-vivo tissue targets, several layers of non-homogeneous particulate matter have to be penetrated before the beam can reach the LLLT targets, and it is the

superior photon density of coherent light, which ensures this penetration, even though actual coherence may be lost in the first few cell layers¹⁰.

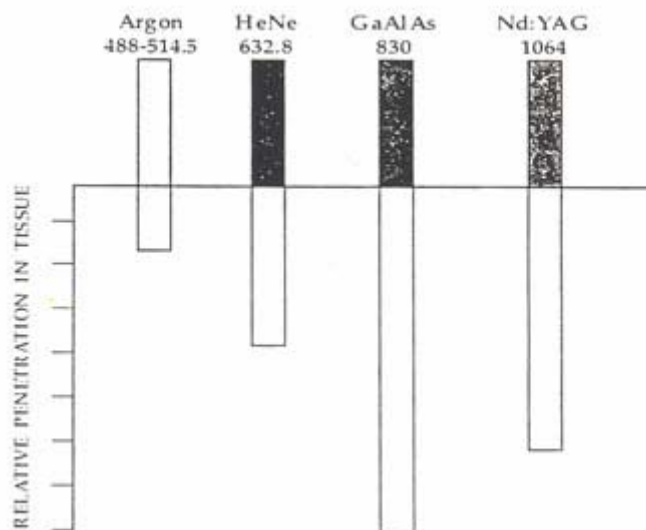
The main factor which can affect the actual depth to which a laser beam; penetrates is the wavelength of the beam: the output power is of some secondary importance. But the physical properties of the target tissue will limit the penetration of particular wavelengths, no matter how much power is behind them. Naturally in surgical lasers, the higher the power, the bigger the hole, but that must not be confused with penetration. Actually lasers which are well absorbed in surface tissues do not penetrate deeply, and so make better surgical lasers, with better depth control. In photodestructive surgery, this is of great importance^{3,4,10}.

Surgical lasers rely mainly on an instantaneous radiant heat effect with a secondary conducted heat effect: thus high peak power with a short irradiation time gives the best radiant heat effect, limiting the secondary thermal tissue damage wave from conducted heat. When this radiant heat effect is coupled with the absorption characteristics of the target tissue, cellular- or subcellular-selective treatment can be achieved. High density CO₂ laser energy is absorbed preferentially in water, thus limiting its penetration depth. Red and

black biological pigments, blood and melanin, absorb blue and green light well, peaking at the yellow waveband: thus the argon, KTP-532, argon-pumped dye, flashlamp-dye, copper-vapor, and krypton lasers are all finding good applications where this absorption is important.

The HeNe on the other hand is red, the color of blood, so it tends to penetrate much deeper than those previously mentioned. The YAG is not really pigment-preferentially absorbed, and is instead absorbed in protein. However, the YAG beam does have a recognizable water absorption component^{3,13,14}. That is where the 820-840 nm penetration window comes into play, and why the GaAIAs diode laser at 830 nm offers the clinician a penetrative tool of great efficiency. From data obtained with the use of infrared and visible-light sensitive charge-coupled device-based cameras (CCO) to assess actual depth and volume penetration in in-vivo soft tissues, the penetration rates of the various wavelengths can be summarized as in Figure 2.

A GaAs superpulsed infrared laser, or high output GaAIAs infrared laser, is necessary to obtain the deep tissue penetration needed to effectively treat the deeper structures of the back. Gruszka, using a GaAs superpulsed laser, found that **9 Joules/cm²** of energy applied to appropriate points were effective at ameliorating pain in patients with herniated lumbar discs and radiculopathy¹⁵. Most modern diode lasers utilize pre-programmed treatment



settings that help insure adequate

Figure 2. Comparative Transmission Of Laser Wavelengths In Tissue

numbers of Joules of light energy will be irradiated into the patient's tissues.

Tasaki found that relief was obtained in low back pain patients using a GaAIAs laser in the 30–80 mW output range¹⁶. Reductions in the size of lumbar disc herniations have been demonstrated by

Gruzka¹⁷, Tatsuhide¹⁸, and others. Tertiary effects by treating acupuncture points have been shown to be effective at decreasing low back pain. Nikolic found that treating acupoints with a 630 nm red laser was most effective¹⁹.

The results from the application of laser therapy will be maximized by combining several laser techniques together. Clinicians have found that tissue saturation of the effected area of the low back to be the best place to begin. Stimulation of acupoints and/or reflex points is also valuable. The irradiation of lymphatic structures is beneficial, especially when edema is present. Pulse frequency is of some importance, especially when using a GaAs superpulsed laser.[28] Pain relief is best achieved in the frequency range of 1-100 Hz. Inflammation responded well to the 3000-5000 Hz range. Edema responds well to 1000 Hz (see Figure 3).

Figure 3.
(Courtesy Doug Johnson, Atc, Cls)

| Pulse Frequency Settings ³⁶ | |
|--|-----------------|
| Diagnosis | Frequency Range |
| Pain, neuralgia | 1-100 Hz |
| General stimulation | 700 Hz |
| Edema, swelling | 1,000 Hz |
| General stimulation | 2,500 Hz |
| Inflammation | 5,000 Hz |
| Infection | 10,000Hz |

The amount of time it takes to adequately treat an area of involvement (therapeutic levels of Joules of photon energy) in the low back depends on the size of the area and the power output of the laser/light therapy device. This is known as photon or power density . You can use Figure 4 as a general guide for average duration of treatment at different penetration depths versus laser power output²⁰.

| Depth | 10mW | 25mW | 50mW | 100mW | 200mW |
|-------|---------|-------|--------|---------|--------|
| .5 cm | 2.5 min | 1 min | 30 sec | 15 sec | 10 sec |
| 1 cm | 5 min | 2 min | 1 min | 30 sec | 15 sec |
| 2 cm | 10 min | 4 min | 2 min | 1 min | 30 sec |
| 3 cm | 15 min | 6 min | 3 min | 1.5 min | 45 sec |
| 4 cm | 20 min | 8 min | 4 min | 2 min | 1 min |

The output powers are average powers. Treatment should be done with skin contact.

Figure 4. Note: A Surface Area Of 50 Cm² Is Roughly Equivalent The Surface Area Of An Average Sized Apple Sliced In Half Horizontally.(Courtesy Doug Johnson, Atc Cls)

Treatment Modality

A typical treatment approach for a patient with chronic low back pain would involve the following:

1. History of condition, physical examination of the low back paying particular attention to the level of abnormal muscle, nerve and joint function, as well as pain level. This would include lumbar and pelvic range of motion, lumbar and pelvic orthopedic tests, lower extremity deep tendon reflexes.
2. The initial treatment aim is to saturate the primary area of involvement. A good choice would be to use 3000-5000 Hz for 5-10 minutes with a GaAs laser in order to help reduce inflammation. A scanning

contact is utilized for this technique in order to maximize the tertiary or systemic effects (see Figure 6). Note that treating the lymph nodes proximal to the area of involvement with 3000 Hz laser emitter utilizing a pumping action -prior to treating the area of involvement—will enhance the reduction of edema (see Figure 5).

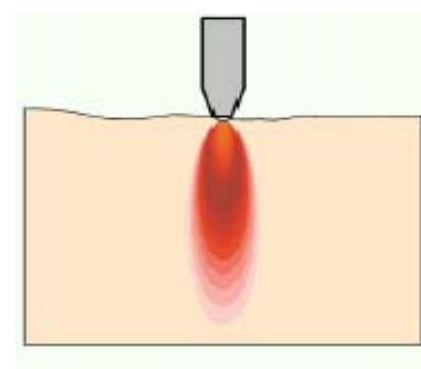


Figure 5. “Method Of Treating

Therapeutic Laser for Chronic Low Back Pain

3. The secondary treatment aim is to reduce pain and stimulate healing in the deeper tissue of the Right low back. A GaAs superpulsed laser at 5-50 Hz for 5-10 minutes is the best choice in order to get the deepest penetration.³⁰ This is performed with a stationary contact with the emitter. Note that patients with chronic low back pain can become exacerbated after the initiation of laser therapy so it is advisable to use one half of the above dose during the first treatment, until the individual Laser therapy treatment times are usually 10–20 minutes per session. Chronic low back pain patients will usually respond best to 3-4 treatments per week. Maximum effect is often reached in 3-4 weeks but several months of care may be necessary in extremely complex cases. It is important to allow for delayed effects and cumulative effects which commonly occur in patients receiving laser therapy. Treating a patient too frequently can actually slow down the recovery process and increase symptoms.³¹ While laser therapies can often produce results as a stand alone therapy, they also work very well adjunctively with other therapies such as: physical therapy, manipulation, exercise and stretching.

patient's response can be



determined on the first follow-up visit (see Figure 6). **Figure 6.** *Stationary Contact To The Left L4area.*

Contraindications and Adverse Effects

LLLT is a safe and non-thermal modality. There are no published reports of serious adverse effects, however, a few patients do report feelings of tingling, mild erythema, burning sensation, numbness or skin rash in¹¹. Irradiation to the eyes is the main contraindication to LLLT, thus, both the therapist and patient must wear protective goggles to block the emission. Other contraindications include avoiding LLLT four to six months after radiotherapy, hemorrhaging regions and endocrine glands. Caution is advised when applying LLLT to patients with epilepsy, fever, malignancy, abdomen

area during pregnancy, epiphyseal plates of children and infected tissue¹¹.

Conclusion

Therapeutic lasers and other phototherapy devices offer a safe, often effective, easily utilized primary or adjunctive therapy that is relatively cost effective to both the clinician and

patient. Laser therapy can be a viable part of the multi-faceted approach often needed to bring relief to the millions of chronic low back pain sufferers that present in offices, clinics, and hospitals. The future is promising as research continues to increase understanding of this new healing modality.

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