LOWER LEVEL LASER THERAPY FOR PAIN MANAGEMENT: AN INTEGRATIVE REVIEW

ABSTRACT
The purpose of this review article is to provide the current information about the safety, effectiveness and usage of Low Level Laser Therapy (LLLT) for the treatment of musculoskeletal conditions. Low Level Laser Therapy (LLLT) is also known as Low Intensity Light Therapy (LILT), cold laser, phototherapy, light therapy, low-energy laser therapy, photobiomodulation among other terms. Laser is an acronym for “Light Amplification by Stimulated Emission of Radiation”. Laser therapy, in general, is safe and can be often used where other physical modalities are contraindicated such as with pacemakers or metal implants. Laser phototherapy can be of value in the mitigation and elimination of many painful conditions. 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.
INTRODUCTION:

Pain is an unpleasant feeling often caused by intense or damaged stimuli. It is the most common reason for physician consultation[1]. It is a major symptom in many medical conditions and can significantly interfere with a person’s quality of life and general functioning. Sometimes it becomes too expensive to treat pain[2]. But now a revolutionary technique for pain management have introduced in the field of health care, which is having no surgery, no needle and no medicine known as Lower Level Laser Therapy (LLLT).

LLLT is a light source treatment that generates light of a single wavelength. LLLT emits no heat, no sounds, or no vibrations. Instead of producing a thermal effect, LLLT may act via non-thermal or photochemical reactions in the cells, also referred to as photobiology or biostimulation.

Low-power laser devices were first used as a form of therapy more than 30 years ago. Following a literature search, these findings mandate the conclusion that laser phototherapy is a highly effective therapeutic armamentarium for tissue repair and pain relief. Research shows that LLLT reduces pain immediately after treatment in acute neck pain and up to twenty two weeks after completion of treatment in patients with chronic neck pain[3]. The mechanism and effectiveness of LLLT has been compared with ultrasound therapy, and should be considered as an extension to the accepted physiotherapy modalities that currently utilize parts of the electromagnetic spectrum, such as short waves, microwaves, infrared, and ultraviolet therapy.

HISTORY:

It has been known for centuries that light has therapeutic benefits. Historically sun therapy &color therapy was being used. In 1967, a few years after the first working laser was invented, Endre Mester in Semmelweis University Budapest, Hungary wanted to find out if use of laser might cause cancer[4]. He took some mice, shaved the hair off their backs, divided them into two groups and gave a laser treatment with a low powered ruby laser to one group. They didn’t get cancer & surprisingly the hair on the treated group grew back more quickly than the untreated group. That was how laser bio stimulation was developed[5]. By the mid 1970’s laser therapy was gaining popularity in Asia, Africa and Soviet Union. Today LLLT is being offered by various chiropractic offices to treat many conditions including:

- athletic injuries
- lower back pain
- knee and foot pain
- shoulder injuries
- carpal tunnel syndrome
- arthritis and muscle spasms
- relief of muscle and joint pain
- skin infections including cold sores, warts, and verruca
- relief of stiffness, promoting muscle relaxation
- wound treatment including ulcers, pressure sores, and burns
- soft tissue injuries including sprains and strains, tendonitis, and haematoma
- joint disorders including arthritis and tenosynovitis
- chronic pain including trigeminal neuralgia as well as chronic neck and back pain

WHAT IS LLLT?

Low-level laser therapy (LLLT) is a medical and veterinary treatment that uses low-level lasers or light-emitting diodes (LED in the range of 1mW – 500mW) to alter cellular functions like tissue regeneration, reduce inflammation and relieve pain[6]. The light is typically of narrow spectral width in the red colour or near infrared. Unlike conventional light sources, a laser beam travels in only one direction and is monochromatic with its photons (little packets of energy) which are all identical in size, traveling equidistant in time.
and space. Sometimes LLLT is also known as Low Intensity Light Therapy (LILT), cold laser, phototherapy, light therapy, low-energy laser therapy, and photobiomodulation among other terms.[7]

LLLT devices include the Gallium Arsenide (GaAs), Gallium Aluminum Arsenide infrared semiconductor (GaAlAs), and Helium Neon (HeNe) lasers. The 632.8 nm wavelength HeNe laser emits visible red light and may have a shallow penetration into skin. The GaAlAs, infrared laser has a longer wavelength than red beam laser and may have deeper tissue penetration. At 904 nm wavelength of GaAs laser is most commonly used for pain and inflammation because it has the deepest tissue penetration. Earlier studies utilized low powered HeNe lasers (<=1mW) and resultant low energy densities (<=.012 J/cm2). More recent studies utilizing higher energy densities and deeper penetrating lasers have found alterations in distal nerve latency and conduction velocity by a few to many percent, and which can last for periods of 30 minutes or greater[8].

LASER CLASSIFICATION (US FDA):

Lasers are classified based on these different properties (coherence of the beam, depth of penetration, wavelength) as well as their power, duration of the “on time” when pulsed, and their effect on the eye[9].

- Class 1 lasers (for example barcode readers and some types of LED or super-luminous diode therapeutic lasers) do not affect tissues, have the lowest power rating and eye protection is not required for their use.
- Laser pointers for classroom use are usually class 2 or 3A lasers with a relatively low power rating, but can cause temporary visual disturbance when pointed at eyes.
- Some therapeutic lasers are classified class 3B and as mentioned with laser pointers, the beam could affect the eyes and protective eyewear should be worn. The class 3 infrared wavelengths A and B refer to near infrared or short wavelengths (A) and far infrared or long wavelengths (B). Class 1, 2 and 3(A and B) lasers do not harm tissue (Robertson, 2006). They are also considered the best balance of power output (less than 500mW) and safety (ChiroEco, 2005).
- Class 4 and 5 lasers at the other end of the laser spectrum are surgical lasers that cut tissue. They are very high powered and must be used under extreme precautions.

MECHANISMS OF LLLT:

Laser therapy uses a process called photobiomodulation to change the condition of damaged tissues by stimulating cellular metabolism, thereby accelerating the healing process. Several mechanisms underlying therapeutic effects with LLLT have been suggested[10-13]. Theories include:

1. Increased ATP production by the mitochondria (the cellular power plant inside every cell) and increased oxygen consumption on the cellular level, which may result in muscle relaxation.
2. Increased serotonin and increased endorphins.
3. Increased anti-inflammatory effects through reduced prostaglandin synthesis.
4. Improved blood circulation to the skin in cases like neuralgia and diabetes mellitus.
5. Decreases permeability of the membrane of the nerve cells for Na/K causing hyperpolarisation.
6. Increased lymphatic flow and decreased edema.

The photobiology law states that for low power visible light the photon must be absorbed by electronic absorption band belonging to some molecular photoreceptor or chromophores which imports some decided colors to the tissue. Examples of such chromophores are chlorophyll (for plants), hemoglobin, cytochrome c oxydase, myoglobin, flavin, flavoprotein, porphyrin & melanin. A large convex treatment head can be used to compress superficial tissues displacing excess fluid & enhancing laser penetration into the deep structures. As light pores under the tissues the photons will be scattered, reflected & absorbed. Laser, operating in the new infrared spectrum from 650nm to 1300nm, can penetrate to deep tissue structures & can be absorbed by melanin, hemoglobin, oxyhemoglobin & water. Energy from this absorption will be dissipated as heat, generating as soothing warmth in the tissue[14]. The primary target for photobiomodulation is the cytochrome c complex which is found in the inner membrane of mitochondria (Fig.-1).
Cytochrome c is the vital component of the electron transport chain that drives cellular metabolism. Stimulation of absorbed Cytochrome c leads to an increase in production of ATP, the molecule that facilitates energy transport within the cell. In addition to ATP, laser stimulation also produces free nitric oxide and reactive oxygen species. Nitric oxide is a powerful vasodilator and an important cellular signaling molecule involved in many physiological processes. Reactive oxygen species (ROS) have been shown to affect many important physiological signaling pathways including the inflammatory response. The production of these signaling molecules has been shown to induce growth factor production, to increase cell proliferation and motility to promote extracellular matrix deposition in post survival pathways. Outside the cell nitric oxide signaling drives vasodilatation which improves microcirculation in the damaged tissue delivering oxygen, vital sugar, protein and salts while removing wastes$^{[15-17]}$. The mechanisms of action have been proved by over 40 years of lab experiments using lasers of minimal power (Fig. 2).
CLINICAL APPLICATIONS:

Following are some areas in which LLLT has been using since many years (Fig.-3):

1. Physiotherapists to treat a wide variety of acute and chronic musculoskeletal aches and pain\(^{18}\).
2. Dermatologists to treat edema, indolent ulcers, burns and dermatitis\(^{19}\).
3. Rheumatologists to relieve pain and chronic inflammations and autoimmune diseases\(^{20}\).
4. Veterinary Clinics\(^{21}\).
5. Other Specialists and Practitioners\(^{22}\).
6. Sports medicine and Rehabilitation clinics\(^{23}\).

SAFETY:

LLLT is a relatively safe procedure. Due to the low level, non thermal nature of the laser, there is no tissue destruction or other hazards that you would find associated with the higher powered lasers. The FDA has classified the most commonly used low level lasers as a class III, no significant risk, and medical device for investigations use only. Because of the coherent nature of the laser beam, ocular damage is the main concern for the LLLT user. The operator should not attempt to stare directly into the beam. Suitable goggles to attenuate the wavelengths would be used by both the operator and patient. Other suggested contraindications would be to avoid exposure to sensitive tissue such as fetus, gonads and malignancy\(^{24-25}\).

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\(^{26-28}\).
Fig. 3: the flow chart represents the process initiated by the energy emitted from a lower level laser and the physical impact of that energy as well as the potential effects resulting from the application of laser energy.

**FOOD AND DRUGS ADMINISTRATION STATUS:**

Between 2002 and 2004, the Food and Drug Administration (FDA) granted 510(k) approval to several companies to market lasers that provide LLLT. The LLLT lasers are classified under “Lamp, Non-heating, for Adjunctive Use in Pain Therapy” (29-31).

MicroLight Corporation of America received approval on February 6, 2002, for the MicroLight 830. This laser is indicated for adjunctive use in the temporary relief of hand and wrist pain associated with Carpal Tunnel Syndrome. (FDA 2002)

Acculaser received approval on July 29, 2002, for Acculaser Pro Low Level Laser Therapy. Acculaser is indicated for adjunctive use in the temporary relief of hand and wrist pain associated with Carpal Tunnel Syndrome. (FDA 2002a)

Meditech International, Inc received approval on April 10, 2003 for the BioFlex Professional Therapy System, which was classified under “Infrared Lamp”. The BioFlex is indicated for “use to emit energy in the infrared spectrum to provide topical heating for the
purpose of elevating tissue temperature for temporary relief of minor muscle and joint pain, arthritis, muscle spasm, relieving stiffness and promoting relaxation of muscle tissue.” (FDA 2003)

PhotoThera Incorporated received approval on March 19, 2004 for the Acculaser Pro4. It is indicated for adjunctive use in providing temporary relief of pain associated with iliotibial band syndrome. (FDA 2004)

GRT LITE Model PRO-8A Light Therapy System, GRT Solutions, Los Angeles, received approval on February 3, 2006 for the GRT LITE, which listed the Tuco Erchonia PL3000, the Excalibur System, the Microlight 830 Laser, and the Acculaser Pro as predicate devices for indications of the GRT LITE for carpal tunnel syndrome. (FDA 2006)

Luminex LL Laser System® (Medical Laser Systems, Inc, Branford CT) received approval on October 23, 2008 for LUMINEX Laser Therapy System. It is indicated for the use in arthritis, back pain, Carpal Tunnel Syndrome, Sports Injuries and many other acute and chronic conditions. (FDA 2008)

CONCLUSION:

Low-level laser therapy is a soft therapy, without side effects for pain reduction. Laser therapy is being used as a successful treatment option for countless pain, inflammation, and illness conditions all over the world. Lasers have been used as therapeutic energy to bring about favorable biological effects in people. Laser therapy is the future of medicine and it is a modality that is rapidly growing in popularity. These advances will lead to greater acceptance of LLLT in mainstream medicine and may lead to LLLT being used for serious diseases such as stroke, heart attack and degenerative brain diseases. In the last 15 years, LLLT has been applied in treating various conditions including chronic leg ulcers, diabetic foot ulcers, venous ulceration, minor post surgical wounds, plantar fasciitis, delayed muscle soreness, lateral epicondylitis, low back pain, age related macular degeneration, pain due to diabetic polyneuropathy, pain in temporo-mandibular disorders, benign fibrotic lumps in the breast post reduction mammoplasty, recurrent herpes labialis, rheumatoid arthritis, and plantar calcaneal enthesisophysis. At present, there is no evidence of the effectiveness of LLLT in delaying the onset of muscle soreness, or in treating plantar fasciitis, lateral epicondylitis, low back pain, recurrent herpes labialis, plantar calcaneal enthesisophysis, pain due to diabetic polyneuropathy, venous ulceration, minor post surgical wounds, pain due to temporo-mandibular disorder, or rheumatoid arthritis.

REFERENCES:


