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Lasers and their therapeutic applications in chiropractic

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The purpose of this paper is to review some of the applications of laser therapy and its reported effects on tissue healing, pain relief and other effects. Several musculoskeletal and low back pain studies are highlighted to show the efficacy of laser therapy and its' applicability as an adjunct to chiropractic treatment. Information is also presented which highlights the necessary information the clinician should be aware of in order to develop specific protocols for musculoskeletal pathologies. The parameters, which are now available on lasers, include power, frequency, duty cycle and cadence. When these are manipulated, different effects are achieved on tissues, which may enhance chiropractic treatment.
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KEY WORDS: laser, tissue healing, ATP, pain modulation, back pain, protocols, parameters, power, frequency, duty cycle, cadence.

Le présent article vise à passer en revue quelques applications du traitement au laser et ses effets sur la cicatrisation des tissus, le soulagement de la douleur, etc. Plusieurs études sur les douleurs musculo-squelettiques et les lombalgies montrent l'efficacité du traitement au laser et son applicabilité comme traitement d'appoint en chiropratique. On y présente également l'information nécessaire que devraient posséder les cliniciens et cliniciennes afin d'élaborer des protocoles particuliers pour le traitement des maladies musculo-squelettiques. Maintenant, les appareils au laser présentent différents paramètres, dont la puissance, la fréquence, le cycle de service et la cadence. Une fois réglés, ces paramètres permettent de produire différents effets sur les tissus, qui peuvent renforcer le traitement chiropratique.
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MOTS CLÉS : laser, cicatrisation des tissus, ATP, modulation de la douleur, douleurs au dos, protocoles, paramètres, puissance, fréquence, cycle de service, cadence.

Introduction

Low energy laser therapy was pioneered in Europe and Russia in the early 1960's. By definition low energy laser therapy takes place at irradiation intensities so low that any biological effects are due to the direct effects of the radiation and not as a result of heating.[1]

Karu,[2] suggested that irradiation of isolated mitochondria induces changes in cellular homeostasis, which entails a cascade of reactions, and proposes a number of the components of the respiratory chain (e.g., cytochromes, cytochrome oxidase and flavine dehydrogenase), which are primary photoacceptors or chromophores and thus able to absorb light at appropriate wavelengths. This causes short-term activation of the respiratory chain, leading to changes in redox status of both mitochondria and cytoplasm. In

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turn, the activation of the electron transport chain in this way results in enhanced synthesis of ATP. Furthermore, laser irradiation also affects hydrogen ion levels in the cell. This, coupled with an increase in ATP, causes activation of other membrane ion carriers such as sodium and potassium, and alters the flow of calcium between mitochondria and cytoplasm. The variation of such parameters is a necessary component in the control of proliferative activity of the cell.

Tissue healing

Recent in vivo and clinical studies suggest that lasers can induce phenomena in injured tissues, which promote acceleration of recovery after acute trauma.[3,4,5] Faster edema reduction and lymph flow enhancement was observed in laser-treated animals after surgery in mice,[6] and why clinical laser therapy can be an effective treatment for edema.[7]

Improvement of microcirculation, less cellular infiltrates, procollagen synthesis and fibroblast proliferation activation, and stronger fibrosis were observed after laser treatment in rat adjuvant arthritis.[8] Studies have found a considerable improvement in tensile strength of irradiated wounds at one and two weeks post irradiation, with collagen content significantly increased after two weeks,[9] and improvement in tensile strength due to enhanced collagen accumulation in mice, and further showed procollagen levels in irradiated pigskin were elevated.[10]

Braverman,[11] reported significant differences in the tensile strength in all laser treated wounds . Interestingly, non irradiated contralateral wounds also increased their tensile strength. On the basis of this, the investigators concluded that laser irradiation may cause the release of tissue factors into the systemic circulation which increased tensile strength of the non irradiated wounds. Similar results were found with tendon regeneration and laser stimulation. The laser stimulation increased the healing rate of the tendon.[12]

Wound healing and collagen synthesis are well researched areas in relationship to lasers. Recent studies suggest that laser therapy facilitates collagen production in a manner that enhances tendon healing,[13] and that appropriate dosimetric parameters can provide the acceleration effects of wound healing on rats. The effects were dependent on dose and frequency[14] and of laser wavelengths used.[15] This healing effect has been described to occur in both humans[16,17,18,19] and animals.[20,21]

However, not all studies show a favorable response. We can learn from these studies regarding the dosiometric parameters that were used. Allendorf,[22] found that Helium-neon laser irradiation at power densities of 1, 2 and 4 Joules/cm2 failed to accelerate wound healing. These power densities are now shown to be too low to penetrate the tissue and place adequate amounts of photons for the initiation of the healing response. Cambier,[23] did not find any effects of low power laser and the healing of burns. This could be due to the type of laser used and also the low dosiometric parameters. Hall,[24] also did not find an effect of low level laser on wound healing. This could be due to the time of treatment and the power used.

These studies show how specific one has to be with the different parameters of the laser in treating different conditions.

Pain

In the effects of laser on painful conditions, Baxter,[25] stated: “Lasers achieved the premier overall ranking for relief of pain compared with the other listed electromodalities.” The neuropharmacological analgesic effects of lasers are most likely due to the release of serotonin and acetylcholine at the site and through higher centers.[26] There are a number of studies which have shown that high-energy densities of laser therapy applied to the small diameter unmyelinated fibers (e.g., nociceptors) produce an obvious decrease in elicited activity to standardized stimuli.[27]

Laser are also able to attenuate the effects of experimentally induced inflammation. Daily laser irradiation for less than 10 mins was sufficient to inhibit the inflammation by 20–30%.[28] Barberis[29] has also shown that laser therapy attenuates prostaglandin E2, and he concluded that PGE2 is a quantifiable parameter that could explain the pain relief in patients with rheumatoid arthritis. The mechanism may be as outlined by Tam.[30] Low-power density laser acts on the prostaglandin (PG) synthesis increasing the change of PDG2 and PGH2 into PG12. The prostaglandin 12 is the main product of arachidonic acid and is released into the endothelial cells and into the smooth muscular cells of vessel walls and has a vasodilating and anti-inflammatory action. Using 372 human subjects, Tam achieved very good results especially in cases of symptomatic osteoarthritis of the cervical vertebrae, sport-related injuries, epicondylitis, cutaneous ulcers and with osteoarthritis of the hip joints.

Other effects

Lasers with specific optical parameters (wavelength, intensity, dose) can alter cell proliferation, motility and secretion.[31] Some of these laser induced phenomena can be used in clinical practice to enhance healing in the body. Low-energy photon-laser therapy appears to be helpful for the treatment of musculoskeletal conditions generally,[32,33] and specifically shoulder tendonitis,[34] calcaneal spur,[35] rheumatic conditions,[36] rheumatoid arthritis.[37,38]

An important basis for the above phenomena vital for acute trauma healing is laser induced local microcirculation improvement. This microcirculation improvement includes relief of local spasm of arteriolar and venular vessels, intensification of blood flow in nutritional capillaries, anastomosis opening and activation of neoangiogenesis.[39,40]

This may help to explain how active myofascial trigger points, developing after acute trauma – decreased microcirculation – may contribute to muscle spasm/pain and how laser therapy,[41] showed marked statistically significant improvement in pain thresholds in comparison with a placebo treated group of patients with chronic muscle tension in the neck. The pain relief may also be related to laser induced plasma B-endorphin level increases, which was observed in a study by Laakso.[42]

Animal studies have suggested that bone fractures can heal faster in laser treated groups.[43,44,45]

Studies of laser's effect on the nervous system show very encouraging results. Success has been shown with trigeminal neuralgia,[46] and cervical radiculitis[47] and damaged peripheral nerves in both animal[48,49] and human subjects studies.[50]

Musculoskeletal and low back pain studies

The following studies will be presented in more detail so the reader obtains the full potential of lasers' effect on a variety of clinical conditions.

Rheumatic conditions

The effect of a 940–980 nm wavelength laser radiation in rheumatic degenerative diseases was studied in 136 patients unresponsive to or with contraindications for anti-inflammatory non-steroid therapy. The response was clinically estimated using four parameters; pain, muscular contracture, local edema and the impairment of the articular mobility. All patients experienced beneficial response, which appeared gradually during the treatment. The patients with osteoarthritis of the knee, ankle and shoulder had a less beneficial response to laser treatment when compared to those with painful backs. The thoracic spine pain responded the best. No adverse reactions to laser treatment were observed during this study.[51]

The objectives of the following study were to treat the cases of fibromyositic rheumatisms unresponsive to other therapies. Over a 15 year period, 846 patients with different types of fibromyositic rheumatisms were submitted to laser therapy. Criteria for selection included age, sex, and standard pathological pain points. Control groups consisted of patients matched for age, sex and standard pathological pain points, were used to compare results with those of NSAIDS and steroid injections. Light diodes and CO2 lasers were employed, to exploit the photothermic and photochemical effects of the laser radiations to the fullest extent.

The results obtained (approximately ⅔ of the patients benefited from the treatment) indicate that there are greater advantages in use of laser over other presently available methods, such as NSAID and steroid injections. Standardization of treatment protocols deserves further studies.[52]

Osteoarthritis

Laser light absorption through the skin causes tissue changes, targeting the nervous, the lymphatic, the circulatory and the immune systems with an analgesic, anti-inflammatory and anti-edemic effect, stimulating tissue repair.[53] The authors analyzed the therapeutic effects of different wavelengths and intensities in various laser treatment schedules. In particular, the protocol was designed to test such physical parameters as laser type, doses and treatment schedule in different pathologic conditions, one being osteoarthritis. Three groups of patients affected with knee arthrosis (149), lumbar arthrosis (117), and muscle pain (140) were treated with laser therapy. The authors concluded that Low level laser therapy can be used to treat osteoarticular pain in geriatric patients. The authors further stated that to optimize the results, the diagnostic picture must be correct and a treatment program defining the physical parameters used (wavelength, dose and irradiation technique) must also be designed.[53]

Using a program called "Laser 3-D Pain Management Program", which was developed with 10 years of clinical testing, 19 patients with osteoarthritis of the cervical spine, thoracic, low back and knees, were treated 20 times. Seventeen had significant improvement of over 90% and two good at 70-75% as measured by the VAS pain scale.[54]

Low back

In one study, 524 patients with a variety of lumbar diseases received laser therapy.[55] One week after the final treatment, 81.6% reported excellent results. No side effects were reported. The authors concluded that low level laser therapy affords an easily applied, noninvasive, effective and safe therapeutic method for the treatment of painful back conditions.[55]

In a double blind trial involving two groups of elderly people suffering from chronic low back pain, the experimental group received laser, with a dose of 4J per acupuncture point and the control group received sham irradiation. The treatment was applied over ten consecutive, daily sessions. Pain was evaluated with a VAS scale at the beginning and at the end of the treatment period. Treatment was effective in 71% of the patients in the laser group and 36% of the patients in the sham group. The pain disappeared completely in 45% of the patients in the laser group and in 15% of the sham group. During the follow up, 35% of the patients in the laser group who had relieved their pain by more than 60% relapsed, compared to 70% in the control group. There were no side effects.[56] This study shows that because there was a relapse of 60% in the laser treated group, it maybe necessary for a specific rehabilitation exercise program in conjunction with laser therapy to obtain long term results.

To add validity to the above statement, a study,[54] was conducted on 180 consecutive chronic low back conditions using the "Laser 3-D Pain Management Program". Ages ranged from 25 to 83 years and 101 of the patients were male. Patients included in the study had chronic mechanical back conditions, degenerative discs and joints and osteoarthritic conditions. All patients had laser with specific settings, traction on the Leader Dynamic Table and a graded rehabilitation program. Patients were treated 20–24 times over 8 weeks. While 164 (91%) patients completed the eight weeks of therapy, 144 (87.81%), were pain free as per the VAS and subjective responses.

Follow up at three to six months found that 127 or (88%) of the 144, were still pain free. This would point to the fact that laser, plus a comprehensive rehabilitation program may be more beneficial for the patients suffering with chronic back conditions.

In another study, 15 patients with one or more protruded lumbar disc herniations and radicular symptoms, received treatment on 20 to 25 points on the lumbar spine 3 to 5 times a week during 4 months, with a Gallium/Arsenide diode laser (GaAs), with a wavelength of 904 nm and a power of 9J/cm squared, on each point. Pain was relieved in 100%, gait and neurological signs improved in all patients, EMGs improved and CAT scans showed less protrusion of the herniated discs.[57]

Sixty-three ambulatory men and women between the ages of 18 and 70 years with symptomatic nonradiating low back pain of more than 30 days duration and normal neurologic examination were included in a study to assess the effectiveness of low-intensity laser therapy in the treatment of musculoskeletal low back pain.[58] Treatment was three times per week for four weeks. Main outcome measures were : subject's perception of benefit, level of function as assessed by the Oswestry Disability Questionnaire and lumbar mobility. Results showed a moderate reduction in pain and improvement in function in patients with musculoskeletal low back pain. Benefits however, were limited and decreased with time. This study shows the limitation of laser therapy especially in the treatment of low back pain. The study also points to the fact that because low back pain is a complex condition, a more comprehensive approach of structural balancing and specific exercises should also be incorporated in conjunction with the laser.

Information for developing laser protocols

Photodynamic therapy such as laser therapy and light dosimetry should be considered as treatment approaches in certain clinical situations. The propagation of light in tissues is influenced by fundamental or microscopic optical properties, namely absorption, scattering coefficients and refractive index.[59]

The Arndt-Schultz Law states that the activity of biological systems is stimulated by weak stimuli, supported by moderately strong ones, arrested by strong ones, and retarded by very strong stimuli.[60] Laser parameters can be used to affect any and all of the above, but first we need to appreciate some of the interactions.

The gallium aluminum arsenide (GaAlAs) diode laser is emerging as one of the most efficient lasers in low reactive-level laser therapy (LLLT) for a variety of applications including pain attenuation, enhanced bone knitting and wound healing, treatment of soft tissue trauma and normalization of abnormal metabolic states.[61] Various studies have been designed to show some possible mechanisms by which this as yet not fully understood therapeutic modality works at both cellular, subcellular and systemic levels.[61] One of the immediate, delayed and long-term effects of LLLT appears to be increased macrophage activity in injured or affected areas, with quicker resolution of haematomata, faster resorption of edema and enhanced autoimmunologic reaction in areas of infection. The neutrophil is the most numerous of the white blood cells and is responsible mainly for the phagocytosis of foreign bodies.

An in vitro study was devised to measure the macrophagocytic activity of LLLT-irradiated human neutrophils.[61] Blood samples were drawn from healthy adult males and the neutrophils were isolated, and divided into four samples. Three of these were assigned to an experimental group to be irradiated by one of three GaAlAs diode laser systems. A: 830 nm. 60 mW continuous wave (CW); B: 830 nm 100 mW. CW; C: 904 nm 10W peak power pulsed wave (1024 Hz). Following exposure times of 30, 60, 90 and 120 seconds , the degree of production of reactivated oxygen (superoxide) during phagocytosis was measured by the intensity of luminescence (MLI). The maximum intensity in both the control and experimental specimens was measured as an indication of macrophage activity, along with the time to reach maximum activity (MLT). System A (830 nm. 60 mW. CW) produced a significantly higher MLI and shorter MLT, therefore eliciting the greatest stimulation of macrophage activity. This was followed by system C.[61]

Kubota,[62] designed an investigation using three groups of rats with skin flap lesions as the test sites to access the efficacy of whether equivalent energy doses of light were the same. Group 1 and 3 were experimental. Group 1 received radiation from gallium aluminum arsenide (GaAlAs) diode laser, wavelength 830 nm., power of 20 mW. and Energy Density 10 J/cm2, and group 3 received non coherent radiation from a light-emitting (LED) with a narrow spectral band with in the wavelength region 840 nm, power of 15 mW, but with an equal incident energy density of 10 J/cm2.

Group 1, which received the diode laser-irradiation, the rats' skin flaps showed greater perfusion, a greater number of larger blood vessels, a significantly enhanced flow rate and a higher rate of survival than the LED- irradiated and control groups.

It appears that tissues are sensitive to the width of light projected on them. The width of light affects the penetration and the absorption of photons. As early as 1956, Hardy,[63] identified a tissue window with high penetration between 700–1200 nm. Recent work by Karu,[64] has confirmed this and narrowed down the window to 820–840 nm.

Both systems used in the above study fall within that window, thus assuring maximum penetration. However, the coherent beam of the diode laser proved to be significantly more efficient at increasing flap survival than the non coherent LED, even though similar doses were given. This would tend to repute the arguments of those who claim that wavelength is more important than coherence.[65] Perhaps the photon density of the coherent laser beam ensures its greater and more efficient penetration, even though that coherence may be lost in the first few cell layers.

In extensive research with macrophages, Dyson,[66] showed that their response is dose dependent, frequency specific for calcium uptake,[67] and to a mix of varying power and energy densities.[68] Furthermore, as shown by Zheng,[69] dose dependency has an influence on the immune system.

As specificity using the laser evolved, new insights were recognized, such as non-linearity. Non-linearity in photo-biostimulation is described as a process where linear optical absorption produces active chemicals such as cytoplasmic Hydrogen (H+) and Calcium (Ca+) ions, which participate in chemical reactions whose reaction rates depend on non-linearly on the concentration of these photo-produced active chemicals, thus allowing very sensitive light control of non-linear biological reactions. Important contributions to neural excitability and growth include photo-stimulation of ATP production which fuels the action potential and fills the synaptic ATP vesicles. As was recently shown, the synaptic ATP plays an important role of an extracellular neurotramsmitter.[70] The importance of this systemic effect of laser therapy on nervous disorders by photostimulation of ATP release by migrating macrophages is outlined.[70]

Friedmann study,[70] could be the basis for introducing nutrition into your treatment approaches. The reasoning would be that if the necessary substrates for the biological system were provided, the laser therapy would enhanced the tissue/system, by the stimulation of more ATP.

Other studies have shown that ATP production was time dependent,[71,72] and that the ATP content of different tissues can affects the absorption of laser light.[73] Studies have also shown that cell,[74] and DNA,[75] replication are affected by specific laser parameters. When specific parameters are applied to injured nerve tissue, the nerve tissue will regenerate.[76]

When one begin to compare wavelengths, studies are beginning to show that the 904 nm wavelength cause a significant increase of the substrate uptake rate of the sodium pump in the brainstem tissue, while the 660 nm wavelength result in the "competitive inhibition" of the sodium pump.[77] Interestingly, an earlier study alluded to the effectiveness of continuous wave, but new data shows when continuous wave is compared to pulsed laser radiation, the peaks coincided for both models.[78]

Using the above information and that secured via personal communication with researchers, the author began the process of experimenting with parameters on lasers that were available. These include continuous wave, dosage, and time, because all units had set frequencies of either 100 or 150 Hz. Because of the inability of the continuous wave with the super luminous diodes to penetrate deep areas, new technology helped to develop a true laser that was pulsed.[78] In addition, a duty cycle was added for controlling the amount of photons per treatment time, of five minutes. This was the real challenge, because in a clinical setting, standardization of time and optomization of results are critical.[54] The next feature added was a cadence frequency which could ride above the already set frequency. This provided us with the added ability to concurrently tap into the endocrine systems, for the release of cortisol.[79]

Summary

Due to the worldwide interest in lasers and their documented effects on pain and their ability to heal tissues, it is important that chiropractors have the most current information. Chiropractors should view lasers as a modality which could be used in tandem with chiropractic care to provide better patient care and broaden the scope of neuromusculoskeletal conditions treated.

As an example, to improve the chiropractor's efficacy when treating painful conditions, the use of frequencies between 80 Hz. and 120 Hz. would help to calm the pain afferents. If you would like to treat deep levels of the body such as the capsule around the facet joints at L5 – Sacral 1, higher Hz. frequencies are necessary to penetrate the tissues over-lying the area, along with a low duty cycle. This will get the photons to the specified area without causing flaring of the over-lying tissue.

Post surgical conditions such as carpal tunnel syndrome, which develop scar tissue in the area, and begin to reproduce the symptoms, are easily corrected with the laser by manipulating the parameters of power, duty cycle and frequencies.

From the above, one should begin to appreciate the elegance of lasers. One is able to manipulate the parameters to achieve any desired effects. It is hoped that this paper will help chiropractors to embrace the modality laser and see it as a specific adjunct to not only improve their results, but to broaden the scope of conditions they are able to treat such as degenerative conditions and osteoarthritis.

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