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Neurophysiology of Neuro-Rehabilitation with Laser Therapy

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ABSTRACT

Laser therapy as a kind of treatment and rehabilitation method has been used for many years. This method has great potential for reducing pain, inflammation and neuro-rehabilitation. Researchers showed that laser has an important role on cellular repair, reproduction and inhibition. Resent studies help us better comprehension of these mechanisms for neuro-rehabilitation. The results of these studies are needed to be accompanied with medicine studies which have measurable outcomes. The researches showed the improvement neural system and rehabilitations. Also Laser will help to other parts for improving condition. It can be an important method in treatment of both chronic and acute work related neural injuries. As a result, laser therapy is applicable in the treatment and rehabilitation of pain, inflammation, tissue healing and also neuro-rehabilitation programs after surgery, acute phase of injuries and chronic neural disorders.

Introduction

Flourishing Laser in medicine

Many years ago, researchers found that very low levels of laser energy causes cell changes in rats (Mester et al., 1967). The cell studies are necessary because they present basic information about the measure of laser that must be entered to the desired location. These studies indicate that in case of using the same measure of laser on the skin surface as previously influenced on the culture plate, much lower dosage of treatment is needed for the target tissue (Bjordal et al., 2009).

Laser therapy has long been used in medicine. Applications of this method such as hair removal and eyesight correction are more popular in medical field. Surgical laser is also currently used to perform procedures of surgery which were formerly done techniques. Rehabilitation and occupational therapy clinics also use lasers. Many of these studies have discussed about the very low output power of the laser systems.

Important parameters in laser therapy

When the laser hits the tissue may be absorbed, distributed, reflected or passed. Thus, many parameters are involved in laser therapy for human. These parameters include the following:

The main components of the tissue: Melanin, Oxy-hemoglobin, Deoxy-Hemoglobin and H_2O. If most of the laser lights be absorbed in the dermis, none desired result can not achieve.

The wavelength: Lights with a wavelength of 600 nm (end of the red spectrum) to 1100 nm (near the end of the red spectrum) can be entered the body. Although these wavelengths can penetrate, each of them has its own unique features. If an ordinary white light source is beamed to the palm of the hand, a bright red light can be seen on the other side of the hand. Longer wavelengths such as red penetrate deeper. The amount of red light that can be seen from the other side of the palm depends on the color of one's skin. Melanin absorbs lights strongly, so dark skins absorb more lights. Wavelengths longer than 1200 nm are strongly absorbed in water. Thus, it is difficult to penetrate deeper into tissue. These long wavelengths are commonly used in liquidator techniques like surgery and skin reconstruction. In laser therapy system, the appropriate wavelength is important in order to penetrate deeply into the tissue. Wavelengths longer than 800 nm are generally able to penetrate deep for the treatment of skeletal and muscular cases. In more superficial wounds, shorter wavelengths such as 635 nm could also be useful. This is because Penetration is of lesser importance.

The desired dosage of radiation for treatment: Certainly, there is a threshold or optimum radiation dosage for creating therapeutic effects. Many studies have been conducted in this field on organisms in which appropriate dosage was investigated for cellular responses. Since all wavelengths are probable to be distributed, absorbed or passed, the more power or photons they have at a certain time, the more penetration will take place (Hode & Turner, 2007). We get 2.5 % of the total beamed laser light (250 mW laser source) into the skin of the knee tendon. If we use a 250 mW laser source, we are only getting 6.25 at the tendon or 0.00625 J per second of exposure. Also we use 10 mW laser source in tendon is 250 mW or 0.25 J. Using a weaker laser source with longer time can potentially reach deeper tissues. In the above example, for 250 mW laser with the same amount of energy 10w per second, one minute laser is required. In fact, lower energy with an appropriate wavelength (800 nm to 1000 nm) for good penetration in a long time would have the same depth and health outcomes. However, some studies show that results were not the same by using a very low power density. It was shown that less than 10^{-5} W/cm^2 has not measurable results even when they were exposed for a long period.

Diagnosis of affected area: In many circumstances, it is extremely difficult to accurately diagnose the affected area, as other muscles involved often lead to pain. Therefore, it is important to treat the area as much as possible and more laser energy storage can be an advantage. In a short time treatment, a very large area can be treated. This influences on the treatment and rehabilitation of the affected area and pain sub-areas.

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The laser output power: When a conventional laser treatment and rehabilitation is used lower Power Laser, (250 mW), the duration is approximately 38 minutes. But, the same area with a higher power (10 W) only takes 58 seconds. Using older laser systems with less power make the treatment and rehabilitation difficult for wide areas in outpatient clinics.

Neurophysiology of laser therapy

The photochemical effects will occur when laser light is absorbed and identified by chromophore which is because of biochemical changes. Photobiomodulation is a photochemical process in which photon is in relation with cells by a laser resource that leads to biochemical stimulation or alterations. Recently there are verities of studies in relation to exact mechanisms. The most proved mechanism is the mechanism of mitochondrial cytochrome C, which is found in the cell membrane and acts as a photoreceptor. Cytochrome C absorbs the light of 500 nm – 1100 nm because of the specific features of the big cells (Karu, 2008). When the light is absorbed cytochrome C is stimulated can easily be band with oxygen and transformed to cytochrome C oxidase which is crucial in ATP construction. ATP is vital for energy production in cells and leads to biological responses or secondary mechanisms. These mechanisms lead to pain reduction, inflammation and tissue repairs.

Role of Laser in Pain rehabilitation

Vast studies have been done in relation to different mechanisms resulting in photobiomodulation and pain reduction (Hode & Turner 2007). After laser interaction with cells, different processes occur. Serotonin level (5-HT) will increase; serotonin is a chemical messenger that transmits nerve signals between nerve cells. The serotonin level affects the mood. It also increases the Beta Endorphins, which reduces pain sensation. These increases can cause pain reduction in receptor site. Nitric oxide is crucial for natural potential action for impulse transmission in nerve cells that was enhanced after laser stimulation (Mrowiec, 1997; Cramond et al., 1994; Cassone et al., 1993).

It also has an effect on vasodilatation that increases oxygenation. Bradykinin becomes more in damaged tissues and causes pain sensation with stimulation of nociceptive afferents. Studies showed that laser therapy will help pain reduction by decreasing this peptide. Laser therapy also showed the following positive effects:

Normalization of Ion Channels, Ca++, Na++, K+ proven to reduce pain levels, Blocked Depolarization of C-Fiber Afferent Nerves: Therapeutic lasers can suppress the excitation of these fibers, especially in low velocity neural pathways from nociceptors (Alvarez-Leefmans et al., 2005; Wakabayashi, 1993; Kawatani et al., 1993)

Increased potential performance of neurons: Injury or wound will cause resting potential of nerve cells which leads to low level pain threshold, studies show that laser therapy causes increase of resting potential to norm ~70 mV.

Increased release of Acetylcholine: Acetylcholine helps the normalization of transform of nerve signals on autonomic and somatic ways.

Axonal sprouting and regeneration of nerve cells: various studies showed that laser had positive effects on reconstruction of nerve that can have extensive effect on reduction of pain (El-Ani et al., 2009; Blom et al., 2000; Lupyr & Sergienko 1986).

All of these proved cell responses help the pain attenuation by laser therapy. This mechanism along with advantages of anti inflammation and tissue healing introduces laser therapy as a useful method of treatment and rehabilitation.

Laser therapy for rehabilitation of inflammation

Researches show that laser therapy leads to reduction of inflammation. The following proves processes reduce edema. Enriching ATP ,stimulating vasodilatation , reduction of interkeukin , stabilization of cell membranes, acceleration of leukocytic activity , increase of prostaglandin, Enriching lymphocyte response, increase of angiogenesis , temperature modulation, enriching superoxide dismutase SOD levels (Gladwin & Shiva, 2009; Eichler et a1., 2005; Albertini et al., 2005; Harada et al., 2004)

Neural Repair and healing injury by laser therapy

The results of the studies of tissue repair mechanisms are also important because in many similar mechanisms tissue repairment is needed for improvement. A crucial physiological change of laser therapy in repairing includes: increase of growth factors, acceleration of epithelializatio , enrichment of leukocyte infiltration, keratinocyte proliferation, increase of the activity of macrophages, enhance of fibroblast proliferation, enhance of neovascularization , greater wound tensile strength, keratinocyte proliferation, neural system repair (Gladwin & Shiva, 2009; Abrahamse et a1., 2008; Benayahu et al., 2005)

The combined effect of relieving pain, reducing edema and promote tissue repair makes laser therapy a valuable tool. The treatment can be performed immediately after the injury and the treatment can also help reduction of pain.

Principles of the rehabilitation in Laser therapy

Laser therapy can have an important role in neuro-rehabilitation plans for treating patients when muscles should be cured. Treatment of associated trigger points with the laser is also a very effective way to increase the results of the treatment and rehabilitation. Laser therapy has the following positive effects:

Output power: When using laser with out put power greater than 4 W, whenever the patient feel warmth the scanning method should be used. During the treatment the patient should just feel pleasant warmth. If the temperature is unpleasant, the output power should be decreased. The higher power of the laser makes broader and faster treatment possible. Scanning of the area with the laser should be done in a grid type pattern to ensure comprehensive coverage of the affected area. Some laser systems make it possible that the handpiece be in contact with the patient's tissue. In this case some manual manipulation or massage can be done while using laser therapy. This method can be useful for treating deep tissues like muscles, tendon tear or trains. In last minutes of the treatment if possible, some movement should be applied. Many of the therapists combine soft tissue work and laser therapy (Karu et al., 2005).

Acute or chronic situations: whether it is acute, it is usually recommended that the laser therapy be done every other day for 3 weeks for a total 6-9 treatment and rehabilitation. In proper time, laser therapy can be done daily. If patients are in a place that the treatment can be applied daily; therefore, the laser therapy will be recommended to be treated on a daily basis. Acute situations will respond to laser therapy quickly, and after primary treatments significant result will be shown. Typically 6 sessions are needed for full improvement. Chronic situations may need 3 sessions of treatment and rehabilitation and for many conditions 12 sessions of treatment and rehabilitation is needed to see significant results (Mrowiec, 1997).

Less Contradictions: Laser therapy has less contradictions and most of these contradictions are for pregnant patients and those who use photosensitive medicines, patients suffer from cancer, open growth plates, eyes, testicles, active hemorrhaging. Eye safety is the biggest precaution in using laser therapy.

Appropriate eye wear should be worn by the physician and the patient when treating by laser. The eyes should never be treated and when treating conditions around the face. Specific eye wear, like metal eye shields must be used. These are the most important contradictions which were mentioned for laser therapy. Even at these high powers and large dosages there have been very few side effects among millions of patients. Performing laser therapy is very easy and depending on the power of the laser, treatment and rehabilitation times take less than 10 minutes for peripheral conditions and less than 15 minutes for large area like the back or hip. In a clinic the laser integrate into rehabilitation protocols easily and without requiring a high level of technical skill will be performed identically. Patients enjoy treatment and rehabilitations, and mostly will respond very quickly which leads to faster more effective outcomes.

Low level laser therapy (LLLT) for Neuro-rehabilitation

Laser therapy is a type of medical treatment that implements low level laser for changing the functions of neural cells. While high level laser is used for removing tissues, low level laser stimulates and improve the function of cells including neural cells. It was shown that the dose, wave length, time, pulsing, and duration of LLLT have influential effects on nerves, joints and muscles (Roelandts, 2002) .The reason of naming this method, low level is that its dose is lower than optimal level (an optimal dose is for each specific application) and it is in cases that the dose much more than the desired level which has fewer outcomes for treatment and rehabilitation or high doses of light that leads to negative results.

The first law of photobiology indicates that in order to low level laser can have effects on an available biological system, photons should be absorbed by electronic abortion bands that are in contact with chronophers and cellular photoreceptor (Sutherland, 2002). One of the methods of finding the identity of the chronopher is to apply action spectra. This graph shows biological photo response as a function of wavelength, wave number, frequency, of energy of photons and should resemble the absorption spectrum of the photoreceptor molecule. The existence of a structured action spectrum is strong evidence of the fact that the phenomenon under study is a photobiological one.

The absorption and scattering of light in tissue depends on the wavelength and the original texture of chromospheres (hemoglobin and melanin) which has high absorption level in wave length shorter than 600 nm. Water starts the considerable absorption in wavelength larger than 1150 nm. For this reason the “optical window” is used in tissue covering the red and near-infrared wavelengths, as the effective tissue penetration of light is maximized. Since however, the blue, green, and yellow light might have considerable effects on cells growing in optically transparent culture medium, but the use of LLLT in animals and patients almost inclusively includes red and near-infrared (600-950 nm).The absorbtion of photons by molecules leads to electronic stimulation and therefore causes the acceleration of the reactions of electron transfers (Yu, Naim & McGowan,1997).These mechanisms help us for repair especially neural repair. So we can use this method for rehabilitation of neural system.

Conclusion

The future of laser therapy is vague. Cellular studies help us better comprehension of mechanisms of laser therapy for neuro-rehabilitation. The results of these studies are needed to be accompanied with clinical studies which have measurable outcomes. The studies showed promising results of the treatments and rehabilitations. Laser will help to other parts for improving condition. Laser therapy can be an important method in treatment of both chronic and acute work related injuries (Hode & Turner 2007). As time passes and science improves, the specifications of machines and protocols will change in order to have appropriate tools for treating specific conditions .Multidisciplinary cooperation will accelerate exploration, innovation for better therapeutic tools and novel methods of neuro-rehabilitation. Patients need to appropriate tools for the best results. A variety of treatment conditions should be considered for them. Laser can be an inseparable tool for the treatment and rehabilitation of many disabilities such neurological disorders. This tool, like many others, should be used appropriately in the rehabilitation procedure in order to reach maximum final results. So we suggest to future research on the role of laser therapy in neural system rehabilitation.

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