Effect of 670 Nm Laser Beam on the Action Potentials of Sural Nerve in Healthy Individuals

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Introduction: Low Level Laser (LLL) is being used in physiotherapy for pain relief in various pathologies and particularly on peripheral nerve entrapments. In the present study, the effect of LLL on the electrophysiological parameters of sural in humans was investigated. The results might be used as a basis for further clinical research in abnormal conditions. **Methods and Materials:** Thirty-eight normal men voluntarily participated in the current study and 670 nm LLL beam was applied to the left sural nerve at 5 points for 10 sessions. The electrophysiological parameters such as onset latency, peak latency, negative peak amplitude, peak to peak amplitude, and duration were measured before and after the application of LLL (0.5, 1.5 & 2.5 J/cm² energy density). **Results:** Overall, 670 nm laser beam increased the latency and reduced the nerve conduction velocity (NCV). In addition, LLL beam decreased the amplitude of action potentials. Among the various values of energy densities, application of 2.5 J/cm² had the most effective results ($P < 0.001$). **Conclusion:** These results might suggest that 670 nm laser beam could affect the latency and reduce the NCV in sural nerve of human. Probably, LLL affects the bioelectric and bioenergetic properties of the neural biomembrane. These findings might have clinical signlificance in non-surgical treatment of entrapment syndromes, such as carpal, tarsal syndromes and trigeminal entrapment in human. Further investigations are needed to elucidate the effects of LLL beam on the human peripheral nerves in pathological conditions.

Keywords: Low-Level Laser, Sural Nerve, Electrophysiology, Pain

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Introduction

Utilization of Low Level Laser (LLL) in physical therapy is considered as an effective means for pain relief and connective tissue repair (1, 2). The effect of LLL on electrophysiological parameters of sural nerve (as a superficial nerve) in human has not fully been investigated. Only, one report encompasses the effects of 830-nm laser beam on the conduction velocity of sural nerve (3, 4) and other electrophysiological parameters have not thoroughly been examined (4). However, there are some controversial evidences about the effects of different wavelengths and doses of LLL on human peripheral nerves, conducted mainly on nerves containing both sensory and motor fibres*(5). Application of LLL did not show to have any effect on the latency of sensory branch of radial and median nerves. On the contrary, application of LLL increased the latency of sensory branch of the radial nerve in normal individuals (6). In addition, no significant difference was observed between the effects of LLL on the right and left radial nerves. In addition, some researchers reported on the application of LLL leading to increase in the latency of sensory branches of median nerve (5).

Therefore, the present study examined the effects of 670 nm laser beam on the electrophysiological parameters of the sural nerve in healthy individuals. The findings might be useful for the management of carpal and tarsal tunnel syndromes, trigeminal syndrome, Bell's palsy, and other injuries.

Methods and Materials

Thirty-eight normal men voluntarily participated (20-35 yrs. old) in the study. The Ethical Committee of Tehran University of Medical Sciences approved the experimental protocols and all the participants signed the consent forms. Participants had

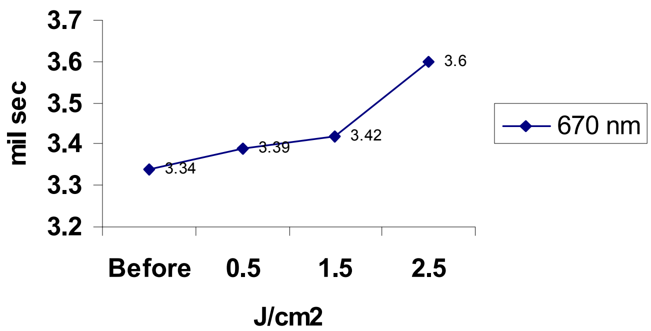

Figure1. Comparison of onset latencies (OL) before and after the irradiation of LLL at different energy intensity

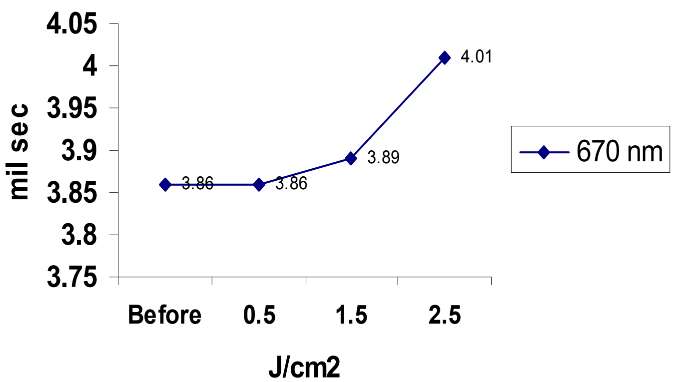

Figure 2. Comparison of peak latencies (PL) before and after the irradiation of LLL at different energy intensity

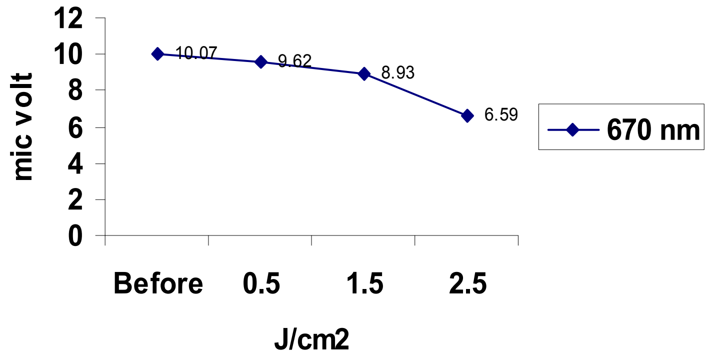

Figure 3. Comparison of negative peak amplitudes (NPA) before and after the irradiation of LLL at different energy intensity

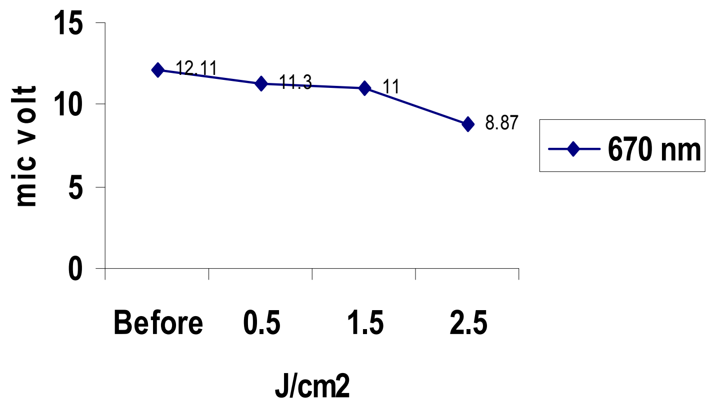

Figure 4. Comparison of peak-to-peak amplitudes (PPA) before & after the irradiation of LLL at different energy intensity

no peripheral neuropathy, diabetes mellitus or any history of trauma in the ankle/leg regions.

All the participants were in prone position and the left foot was positioned on a pillow for easy recordings of actionpotentials. Recording electrodes were placed distal and posterior to the lateral malleolus. There was 2 cm distance between the two recording electrodes. Stimulating electrodes were located 14 cm proximal to the active recording electrode. Action potentials (Disa, Dentech Inc. Denmark; Frequency, 20Hz-2kHz; Sensitivity: 20μVolt/Division; Sweep speed: 4ms/Division; Stimulus Duration: 0.2ms) of Sural nerves were recorded antidromically and electrophysiological parameters such as onset latency (OL), peak latency (PL), negative peak amplitude (NPA), peak to peak amplitude (PPA), and duration were measured and conduction velocities (CV) were also calculated (7, 8).

Six hundred seventy nm LLL was applied transcutaneously to the left sural nerve at five points (1 cm apart) distal to the recording electrodes using a laser beam generator (Chattanooga, TN, USA). Technical features of the laser beam were gallium-aluminium-arsenide, continuous beam at 3 mW delivering 0.5 J/cm^2 of energy density at each point. The irradiation time of laser beam was calculated using the following equation: Irradiation Time = E (energy) / P (out power); (9). Next, sensory nerve action potentials (SNAPs) were recorded separately before and after the application of LLL from the first, third, and fifth points (0.5, 1.5 & 2.5 J/cm^2 of energy densities). Throughout the experiment, the room mean temperature was kept at 25 °C and skin mean temperature was 34 °C (Sahar IR Company, Tehran, Iran). For statistical analysis, SPSS (Chicago, IL, USA) was used. Paired *t*-test and Friedman two-way analysis of variances were run (10).

Non-parametric Friedman two-way ANOVA (Siegel 1988) was used to compare the effects of different energy densities of 670 nm LLL on the electrophysiological oparameters of the sural nerve.

Results

Various energy densities

Different energy densities of LLL beam were applied to the sural nerve. Each energy density had different effects on the electrophysiological parameters of the sural nerve. Hence, the results for each intensity are as follows:

***a) 0.5 J/cm²*:** Irradiation of 0.5 J/cm² laser beam to sural nerve increased the onset latency, OL (*P*<0.04) and decreased the peak-to-peak amplitude, PPA (*P*<0.01) (Figure 1, 4).

b) 1.5 J/cm²: Irradiation of 1.5 J/cm² laser increased the onset latency OL (*P*<0.01) and decreased negative peak amplitude, NPA and PPA (*P*<0.01) (Figure1, 3 and 4).

c) 2.5 J/cm²: Irradiation of 2.5 J/cm² laser increased the OL and peak latency, PL (*P*<0.001), and decreased NPA and PPA (*P*<0.001) (Figure 1-4).

Among the different energy intensities of 670 nm laser beam, significant difference was seen only among the mid. of OL (before and after irradiation of 0.5, 1.5, and 2.5 J/cm², respectively, *P*<0.04); however, the greatest difference was seen after the irradiation of 2.5 J/cm² LLL (Figure 1).

Discussion

In the present study, attempts were made to investigate the effects of 670 nm LLL on electrophysiological properties of a purely sensory and superficial nerve in humans. There is only one report in the literature on the effect of 830-nm laser beam on the negative peak latency of sensory nerve action potentials at 0.5, 1 and 1.5 J/cm2 of energy densities (4).

The results obtained in the present study revealed that utilization of continuous beam of gallium-arsenide laser beam (670 nm, 3mW) at an energy density of 2.5 J/cm² can significantly affect the electrophysiological parameters of the sural nerves. These findings are in accordance with the previous studies *(5). The application of LLL increased the latencies of sensory branches of median and radial nerves. However, other researchers presented evidences arguing that application of pulsed laser beam (904 & 830 nm) had no effect on the latency, amplitude, and NPL of the sensory branch of radial nerve *(5). This controversy might be because they used pulsed beam (904 & 830 nm wavelengths) instead of a continuous beam.

In the present study, the application of low-level continuous laser beam increased the OL and PL of sensory nerve action potentials (SNAPs). The laser beam can affect the Nerve Conduction Velocity (NCV). This might be due to the bioelectric and bioenergetic effects of laser on the ion transition through the cell membrane, which could cause hyperpolarisation of the biomembrane *(5).

In addition, application of LLL might have caused the presynaptic inhibition of afferent fibres responsible for the transmission of pain. The findings of the current study might have clinical application for the non-surgical management of entrapment syndromes, such as carpal, tarsal tunnel syndromes, and trigeminal entrapment. Our preliminary results, with respect to the effects of LLL beam on the electrophysiological parameters of the sural nerve, might suggest the utilization of LLL for the management of entrapment syndromes such as Carpal Tunnel Syndrome and other pathologic conditions *(5). The clinical application of LLL might have beneficial effects for various conditions (11). Further studies are needed to elucidate the effects of LLL beam on the human peripheral nerves in pathological conditions.

Conclusion

Based on the results obtained in the present study, it can be suggested that 670 nm laser beam has some effects on electrophysiological parameters such as latency and NCV in sural nerve of human. These changes might be due to the influence of LLL on the bioelectric and bioenergetic properties of the neural biomembrane. These findings might have clinical significance for the non-surgical management of entrapment syndromes, such as carpal, tarsal syndromes, and trigeminal entrapment in human. Future studies can provide explanations on probable effects of laser on peripheral nerves in pathological conditions.

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None

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Authors' contributions:
All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

References

1. Dyson M, Young S. Effect of laser therapy on wound contraction and cellularity in mice. Lasers in Medical Science. 1986;1(2):125-30.
2. Grosman Z. Effect of laser radiation on different cell structures. Sbornik vedeckych praci Lekarske fakulty Karlovy university v Hradci Kralove. 1975;19(3-4):375-88.
3. Lowe AS, Baxter GD, Walsh DM, Allen JM. Effect of low intensity laser (830 nm) irradiation on skin temperature and antidromic conduction latencies in the human median nerve: relevance of

radiant exposure. Lasers Surg Med. 1994;14(1):40-6.

4. Cambier D, Blom K, Witvrouw E, Ollevier G, De Muynck M, Vanderstraeten G. The influence of low intensity infrared laser irradiation on conduction characteristics of peripheral nerve: a randomised, controlled, double blind study on the sural nerve. Lasers in Medical Science. 2000;15(3):195-200.
5. Greathouse DG, Currier DP, Gilmore RL. Effects of clinical infrared laser on superficial radial nerve conduction. Physical therapy. 1985;65(8):1184-7.
6. Walsh DM, Baxter GD, Allen JM. Lack of effect of pulsed low-intensity infrared (820 nm) laser irradiation on nerve conduction in the human superficial radial nerve. Lasers in surgery and medicine. 2000;26(5):485-90.
7. Bartlett WP, Quillen WS, Gonzalez JL. Effect of gallium aluminum arsenide triple-diode laser on median nerve latency in human subjects. JSR. 2010;8(2).
8. Z S. Effects of low intensity infrared laser – irradiation upon electrophysiological parameters of the human sensory branch of radial nerve: Tehran University of Medical Sciences; 1997.
9. Snyder-Mackler L, Bork CE. Effect of helium-neon laser irradiation on peripheral sensory nerve latency. Physical therapy. 1988;68(2):223-5.
10. Basford JR, Hallman HO, Matsumoto JY, Moyer SK, Buss JM, Baxter GD. Effects of 830 nm continuous wave laser diode irradiation on median nerve function in normal subjects. Lasers Surg Med. 1993;13(6):597-604.
11. Baxter GD, Walsh DM, Allen JM, Lowe AS, Bell AJ. Effects of low intensity infrared laser irradiation upon conduction in the human median nerve in vivo. Experimental physiology. 1994;79(2):227-34.
12. Oh SJ. Clinical electromyography: nerve conduction studies: Lippincott Williams & Wilkins; 2003.
13. Kimura J. Electrodiagnosis in diseases of nerve and muscle: principles and practice: Oxford university press; 2013.
14. Kitchen SS, Partridge CJ. A review of low level laser therapy: Part I: background, physiological effects and hazards. Physiotherapy. 1991;77(3):161-8.
15. Siegel S. Nonparametric statistics for the behavioral sciences. 1956.
16. Matsushita H, Kakami K, Ito A, Kaneko M, Ishihara A, Yoshida K, et al. Effect on the action potential of the low power Nd: YAG laser as irradiated directly to the nerve. Aichi-Gakuin dental science. 1989;2:19-28.
17. Rochkind S, Rousso M, Nissan M, Villarreal M, Barr-Nea L, Rees DG. Systemic effects of low-power laser irradiation on the peripheral and central nervous system, cutaneous wounds, and burns. Lasers Surg Med. 1989;9(2):174-82.
18. Rochkind S, Vogler I, Barr-Nea L. Spinal cord response to laser treatment of injured peripheral nerve. Spine. 1990;15(1):6-10.
19. Rochkind S, Ouaknine GE. New trend in neuroscience: low-power laser effect on peripheral and central nervous system (basic science, preclinical and clinical studies). Neurological research. 1992;14(1):2-11.
20. Hadian Mr, Fakhari Z, editors. The effect of low power laser on carpal tunnel syndrome1998: Congress international federation of societies for hand therapy.
21. Moghadam B.A HMR, Bagheri H, Olyaei GR, Talebian S, editor A comparison between the Effects of ultrasound and low power laser on electrophysiological parameters of median nerve in carpal tunnel syndrome (CTS). 15th physiotherapy congress of Iran; 2004 May 12-15; Tehran.
22. Jahangard T PF, Hadian M.R, editor The Effects of Low Level LASER Therapy on Knee OA (Grade I & II) in Women (40-65 Yrs.). 16th Physiotherapy Congress of Iran; 2005 May 17-19; Tehran.
23. Otadi K, Hadian MR, Olyaei G, Jalaie S. The beneficial effects of adding low level laser to ultrasound and exercise in Iranian women with shoulder tendonitis: a randomized clinical trial. Journal of back and musculoskeletal rehabilitation. 2012;25(1):13-9.
24. Kelle B, Kozanoglu E. Low-level laser and local corticosteroid injection in the treatment of subacromial impingement syndrome: a controlled clinical trial. Clinical rehabilitation. 2014;28(8):762-71.