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 significance 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

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
Effect of Laser Beam on the Action Potentials of Sural Nerve

Figure 1. 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 action potentials. 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/cm² 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/cm² 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 ($P<0.01$) (Figure 1, 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.

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