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The effect of laser therapy on the treatment of carpal tunnel syndrome symptoms

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Abstract
The carpal tunnel syndrome (CTS) is a common type of peripheral entrapment of the median nerve that occurs in the wrist and specifically in the carpal tunnel. Laser therapy is one of the most widely used therapies available to the physiotherapist for the treatment of symptoms in the management of patients with CTS. However, its exact effects as well as the appropriate treatment parameters have not been fully elucidated. The aim of this review is to describe recent research data on the efficacy of the application of laser in improving symptoms in patients with CTS as well as to provide data on device configurations and treatment time. The following databases were searched: PEDro, PubMed and Google Scholar, with the following keywords: carpal tunnel syndrome, physiotherapy, Low-Power Laser Therapy, High-Power Laser Therapy, rehabilitation. Both clinical studies and systematic reviews were included in the review and in total 10 articles were included. The results of this review show that laser treatment seems to have a positive effect on the treatment of symptoms in patients with CTS. However, the treatment parameters need to be further investigated, as different results can be obtained with different parameters.

Keywords: Carpal tunnel syndrome, physiotherapy, low-power laser therapy, high-power laser, rehabilitation

Introduction
Carpal tunnel syndrome (CTS) is a neuropathy due to entrapment of the median nerve at the level of the wrist by the first group of the wrist bones and the transverse carpal ligament [1–4]. Symptoms of CTS are pain in the wrist, referred pain in the forearm and lower third of the arm, muscle weakness in the thenar muscles and the lumbrical muscles of the hand and weakness in the thumb opposition [4]. Pain and paresthesia are the most common symptoms and usually occur at night in 80% of patients [5]. When this happens, patients wake up at night to move their fingers in order to relieve the area [6].

CTS is the most common peripheral nerve entrapment syndrome [6]. Its incidence rates are 276 in 100000 annually, with a prevalence of up to 9.2% in women and only 6% in men [3]. The condition usually appears at the age of 35-50 years [4]. In the USA, 500000 cases are reported annually and it seems that women in the age range of 50-59 have a higher chance of being affected [7]. CTS is treated either surgically or conservatively. Conservative treatment is more recommended than surgery, although both treatments increase functioning, reduce symptoms, and improve sensory disorders. However, in the event of failure of conservative treatment then surgery is the last resort [8].

Physiotherapy is the cornerstone of conservative management of the symptoms of CTS. Various physiotherapy methods have been investigated for their efficacy in treating CTS. Treatment with Light Amplification by Stimulated Emission of Radiation (LASER) has been shown to have a strong anti-inflammatory effect [9]. Low-Power Laser Therapy (LPLT) is considered to reduce pain and local inflammation by causing perfusion in the small capillaries, blocking pain enzymes and activating endorphins. Many studies have shown that laser increases microcirculation in the tissue, promotes nerve healing, increases the growth rate of myelinated axons and causes the regeneration of the injured nerve. High-Power Laser Therapy (HPLT) is a more advanced laser and has the ability to heal larger areas of the body, is 24 times more powerful, penetrates deeper into the body (over 4cm) and is more time efficient.

The LPL has a penetration depth of half a centimeter and therefore helps in the treatment of superficial microtissues. Skin hyperemia is caused during the application of laser [10]. However, despite the benefits of HPL, there is not much research to prove its efficacy in the treatment of CTS. The purpose of this review is to describe recent research data on the efficacy of laser application in the conservative treatment of CTS in patients with mild or moderate symptoms who do not require surgical intervention, as well as to compare those two laser therapies with each other.

Method

The PEDro, PubMed and Google Scholar databases were searched with the following keywords: carpal tunnel syndrome, physiotherapy, Low-Power Laser Therapy, High-Power Laser, rehabilitation. Both clinical studies and systematic reviews were included in the review.

Results

This review included 10 articles. Below are their main findings and conclusions.

Hojjati *et al.* [10] conducted a single-blind clinical trial in 45 patients aged 30-50 years with mild to moderate symptoms of CTS to compare LPLT with HPLT regarding the level of pain, the wrist function, the strength of the pinch grip and the conduction of the median nerve. The patients were equally divided into three groups: the control group in which only a wrist splint was applied, the LPLT group in which both a wrist splint and LPLT were applied and the HPLT group in which both a wrist splint and HPLT were applied. All the above interventions had a duration of 12 weeks. The measurements were made at the beginning and immediately after the intervention while a follow-up was performed 12 weeks after. Improvements were observed in all groups compared to the initial measurement in pain, function and pinch strength. However, in the two laser intervention groups the improvements were statistically significantly larger than in the control group, without any significant differences between them. The researchers concluded that both HPLT and LPLT are equally effective in treating CTS.

Furthermore, Ezzati *et al.* [11] conducted a double-blind randomized controlled trial to compare the dose-dependent effect of Low-Level Laser Therapy (LLLT) and High-Intensity Laser Therapy (HILT) on pain and electrophysiology in patients with CTS. The study involved 98 patients with CTS, aged between 20-60 years, who were randomly assigned to five groups. All participants were given four standard exercises and one group performed only them. The remaining patients were randomly divided into groups that applied high or low energy LLLT or high or low energy HILT for more than five sessions. Pain with the Visual Analog Scale (VAS), median compound muscle action potential and sensory nerve conduction were evaluated before the intervention and three weeks after. The results showed that LLLT and HILT with energy intensities of 8-20J/cm^2 have the effect of reducing pain and improving the electrophysiological parameters of patients with CTS. HILT with 1.6W power and energy intensity 8J/cm^2 had better results in reducing pain and improving the electrophysiology of the median nerve compared to the other groups.

In another randomized trial, Mohammad *et al.* [12] attempted to compare the efficacy of High-Power Diode Laser Beam (HPDLB) with Transcutaneous Electrical Nerve Stimulation (TENS) therapy in 45 patients with CTS. The participants were divided into three groups. In the first group (15 participants), conventional TENS was applied to the pain point for 30 minutes, five times a week for two weeks. In the second group (HPDLB group, 15 participants), energy intensity of 6.5J/cm^2 was applied for two weeks, five times a week. In the third group, a combination of conventional TENS and HPDLB with an intensity 6.5J/cm^2 was applied for 30 minutes, five times a week for two weeks. Pain with relevant scales (VAS and the 5-point scale of pain severity of McGill Pain Questionnaire) and functional ability with the Disabilities of Arm, Shoulder, and Hand questionnaire were evaluated before and after the intervention. The results showed that treatment with HPDLB (808 nm, 6.5J/cm^2) alone or in combination with TENS increased blood flow and anti-inflammatory action, reduced pain, and improved hand function compared to the application of individual application of TENS in patients with CTS with mild symptoms. The researchers concluded that the application of HPDLB is more effective than TENS in combating the symptoms of CTS.

Moreover, Evcik *et al.* [13] conducted a randomized controlled trial in 81 CTS patients, who were divided into two groups. The first group consisted of 41 patients who underwent LPLT (7J for two minutes) and 40 patients were in group two, who underwent placebo laser treatment. A total of 10 treatments were applied five times a week and every night the patients used a carpal splint. Significant improvements in the VAS, pinch grip and functioning were observed in both groups ($p < .001$). LPLT did not reduce pain, but there was an improvement in hand strength, pinch grip, velocity of the sensory neurons and reduction of peripheral sensations and motor dysfunction. In the second group, only the velocity of the sensory neurons increased.

The clinical trial of Tezcan *et al.* [14] focused on the efficacy of LPLT in median nerve stiffness using strain elastography. Their study included 34 patients and 37 mild to moderate CTS were studied. In the control group (17 patients, 18 CTS) only a carpal splint was applied and, in the intervention group, the gallium-aluminum-arsenide diode laser device (Encre Intelect laser; Hixon Manufacturing and Supply Co., Fort Collins, CO) with power output of 100mW and wavelength of 670nm was used. A total of 4J were applied in each session and 60J were applied in total for the 15 sessions. The study showed that the stiffness in the cross-sectional area of the median nerve was reduced, which may be due to neuroplasticity and better perfusion.

Another study that investigated the role of LLLT in patients with CTS was that of Elgendy *et al.* [15]. It included 40 women with CTS, who were randomly divided into two groups of 20 participants each. In the first group, a real LLLT with gallium-aluminum-arsenide laser (905nm) was applied with a light sensor guide and eight diodes of 100MW each (800MW in total) and a pulse frequency of 10000Hz in two areas. The second group underwent placebo LLLT. Pain, function and electromyographic characteristics of the muscles of the hand that are innervated by the median nerve were assessed before and after the intervention. The study showed that LLLT reduced pain (due to reduced inflammation, swelling and pressure in the wrist) and the severity of symptoms and improved electrophysiology of the median nerve and hand function.

Also regarding LLLT, Burger *et al.* [16] conducted a systematic review to determine the effectiveness of LLLT in pain, autonomic hand function and grip strength compared to placebo therapy in adults with CTS. Although there are not enough studies on the effect of LLLT on CTS in adults, there has been a significant report of clinical trials on the short-term effect of LLLT on pain relief at the end of treatment. Studies using 780-860nm laser and energy intensity of 9-11J/cm^2 or 10.8J had

better results in reducing pain, severity of symptoms and improving function and grip strength at the end of treatment in the short term.

As far as other laser therapies are concerned, Juan *et al*. [17] conducted a single blind controlled trial in 84 patients with idiopathic, mild to moderate CTS in order to observe the efficacy of Laser Acupuncture (LA) treatment. The intervention group consisted of 43 patients and was compared with placebo LA treatment (41 participants). LA is Low-Level Intensity (class IIIb laser: 5-500mW, red ray or near-infrared wavelength, 600-1000nm). The intensity of the symptoms was measured with the Global symptom score before the intervention and at the two- and four-week follow-ups. The results of the LA group showed that they improved more. The researchers concluded that LA treatment was more effective than placebo LA treatment in CTS in terms of symptom intensity.

The same results were obtained by Cheung *et al*. [18], who conducted a systematic review to study the advantages and disadvantages of LLLT over placebo therapy and other conservative CTS treatments. The results showed that there was no evidence that LLLT was more effective than ultrasound or other treatments. The only difference was the reduction in pain and the improvement in pinch strength.

Lastly, Chen *et al*. (2016) [19] conducted a clinical study in 30 patients with SCS to study the efficacy of LPLT optical power for CTS. The power of the laser can be found by the reflection on the back and the diffusion of the laser by the skin of the wrist. The results showed that the efficacy of laser power differed significantly between patients, with the measured laser reflection coefficient ranging from 1.8% to 54%. The reflection coefficient for 36.7% of patients was 10-20%, but for 16.7% of patients it was higher than 40%. The researchers pointed out that when treated with laser, its application parameters must be constantly measured, as it can affect the efficacy of treatment.

Discussion

The results of this review show that the application of laser for the treatment of CTS can significantly improve the severity of symptoms of the condition. Some studies have suggested that HILT is more effective in reducing pain than LLLT [11] but other studies have reported a reduction in pain in LLLT as well [15,16,18]. This may be due to the different parameters of the laser application in the above studies, as different laser parameters can lead to different results [11, 19]. Improved hand function, pinch strength and hyperemia were observed in all laser types [10, 12, 13], While in LLLT there was also an improvement in the conduction velocity of the median nerve [13].

Conclusions

Based on the results of this review, laser treatment has been shown to undoubtedly be more effective in treating CTS than its placebo counterpart. However, its efficacy when compared with other treatment methods did not prove to be certainly superior.

More research needs to be implemented on the efficacy of laser in the treatment of CTS. Studies should investigate its various application parameters and the effects they have on the symptoms of CTS.

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