Original Article

# The Effects of Low Intensity Laser on Clinical and Electrophysiological Parameters of Carpal Tunnel Syndrome

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## Abstract

**Introduction:** Carpal Tunnel Syndrome (CTS) is the most common type of entrapment neuropathy. Conservative therapy is usually considered as the first step in the management of CTS. Low Level Laser Therapy (LLLT) is among the new physical modalities, which has shown therapeutic effects in CTS. The aim of the present study was to compare the effects of applying LASER and splinting together with splinting alone in patients with CTS.
**Methods:** Fifty patients with mild and moderate CTS who met inclusion criteria were included in this study. The disease was confirmed by electrodiagnostic study (EDx) and clinical findings. Patients were randomly divided into 3 groups. Group A received LLLT and splinting. Group B received sham LLLT+ splinting and group C received only splints. Group A received LLLT (50 mw and 880nm with total dose of 6 joule/$cm^2$). Clinical and EDx parameters were evaluated before and after treatment (3 weeks and 2 months later).
**Results:** Electrophysiologic parameters and clinical findings including CTS provocative tests, Symptoms severity score (SSS), Functional Severity Score (FSS) and Visual Analogue Score (VAS) were improved in all three groups at 3 weeks and 2 months after treatment. No significant changes were noticed between the three groups regarding clinical and EDX parameters.
**Conclusion:** We found no superiority in applying Low Intensity Laser accompanying splinting to traditional treatment which means splinting alone in patients with CTS. However, future studies investigating LLLT with parameters other than the one used in this study may reveal different results in favor of LLLT.
**Keywords:** laser therapy, low level; CTS; electrodiagnoses

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## Introduction

Median neuropathy at wrist or carpal tunnel syndrome (CTS) is the most common focal peripheral nerve entrapment[1-3]. While the published incidence and prevalence of CTS is variable based on the diagnostic criteria, incidence of approximately 2.7% has been reported for CTS[1]. It affects women more than men[1]. CTS represents the compression of the median nerve within the carpal tunnel formed by carpal bones on

the medial, lateral and dorsal[1,2,4]. Individuals with mild CTS usually present with intermittent symptoms that may be worse at night or with upper-extremity activity. The symptoms may improve with splinting, repositioning or shaking of the hand[3-6]. Physical examination findings in moderate cases may present with neurologic deficits, such as impaired sensation or thenar muscles weakness[1,2]. On the other hand, mild cases may only present with positive carpal tunnel provocative maneuvers (e.g., with Phalen's test and Tinel's sign) without any neurological deficit. Nerve conduction studies (NCS) are frequently used as a diagnostic tool for confirming the diagnosis of CTS[7,8]. Electrodiagnostic studies have 49-84% sensitivity and 95% specificity for diagnosing CTS[7].

Conservative treatments are the main therapeutic approaches at the first step[1-3]. Conservative treatments include anti-inflammatory medications, physical therapy (mobilization and ultrasound therapy), bracing and steroid injections in carpal tunnel[2,5]. Severe CTS and the patients who are refractory to conservative therapy are often referred for surgical decompression of carpal tunnel[6]. Among non invasive treatments, Low-level laser therapy (LLLT) has been found to be effective in the treatment of various musculoskeletal conditions including CTS, osteoarthritis and various tendinitis[9,10,11]. In previous studies, it was reported that low intensity Laser had positive effects on hand and pinch grip strengths in CTS patients[9]. Low intensity LASER may reduce pain related to inflammation by lowering levels of pain mediators such as prostaglandins, beta endorphins, interleukin 1-beta and tumor necrosis factor-alpha. Laser also enhances local microcirculation leading to better healing[8]. Remote immunomodulatory effects are also suggested for Laser[9-11].

Therapeutic effects of splinting for CTS have been shown in previous studies[5,12,13]. However, the number of studies evaluating the effects of LASER on CTS is limited and lacking adequate sample size[1,9]. The aim of the present study was to evaluate the effects of applying low intensity laser therapy compared to conventional therapies including splinting and anti-inflammatory medication on improving clinical and electrophysiologic findings, as well as hand function in patients with mild to moderate CTS.

## Methods

### Study design

This study was designed as single blinded controlled study and carried out at physical medicine and rehabilitation department of Shohada-ye-Tajrish hospital, Tehran, Iran during 2010-2011.

### Patients

Fifty patients of both sexes, affected by CTS were recruited.

Inclusion criteria were as follows:

1) The presence of pain /paresthesia in the distribution of the median nerve,
2) A positive clinical provocative tests for CTS (Tinel, Phalen),
3) The electrophysiological evidence of mild or moderate median nerve lesion at wrist (mild: sensory nerve latency >3.5 ms at third digit, moderate: sensory nerve latency >3.5 ms at third digit and median motor latency>4.2 ms).

Exclusion criteria were: Presence of conditions affecting nerve conduction or abnormal findings in other nerves such as the presence of polyneuropathies, as well as proximal neuropathies affecting nerve trunks, plexus or cervical roots diagnosed by physical examinations and comprehensive electrodiagnostic studies.

A written consent was signed by all patients. They were randomly assigned to one of the three treatment groups by means of the random number table.

## Therapy groups

Group one (Laser group):

The patients in this group were treated with 10 sessions of MLS (Multiwave Locked System) indium laser of M1 type with trademark of ASA, srl, a company of El.EN group, Italy, which had two laser sources: continuous waves with wavelength of 880 nm, and pulsed wave with wavelength of 905 nm, with peak power output of 1100 mw, frequency of 1000 Hz. Each session lasted 10 minutes. Each patient was treated with 880 nm, power laser in continuous mode and consisting of radiating dose delivered to five points of the skin overlying the course of the median nerve at the wrist. We intended to deliver laser at 6 J/cm$^2$.

$$\text{Energy Density (Joule/cm}^2\text{)} = \frac{\text{Laser Output Power (Watts)} \times \text{Time (Secs)}}{\text{Beam Area (cm}^2\text{)}}$$

OR: Energy Density (Joule/cm$^2$) =
Power Density (W/cm$^2$) × Time (Secs)

To calculate the treatment time for this particular dosage, we used the below formula:

$$\text{Treatment Time (Seconds)} = \frac{\text{Energy Density (Joules/cm}^2\text{)(6)}}{\text{Output Power Density (W/cm}^2\text{) (0.05)}}$$

$= 6/0.05 = 120$ seconds

So laser was delivered for 120 seconds at each point along the course of median nerve in each session in each hand (6 J/cm$^2$ for each point, totally 30 J for 5 points).This was via a fiber optic probe with a spot size of 1 cm$^2$. The probe was moved along the course of the nerve for 10 cm. This group received Laser therapy for 10 sessions in 2 weeks. Eighteen patients were allocated to this group.

**Group two (Sham Laser)**

Fifteen patients were assigned to this group and received 10 session of Sham Laser with the same device as Laser group but the device was switched off. Patients were blinded to the treatment used in Laser and Sham Laser group. The Laser probe was moved along the median nerve the same as real Laser group.

**Group three (splinting group)**

The patients in group three received only vitamin B6 and their hands were splinted.

The hands of patients in all three groups were splinted with a static wrist splint fixed in zero degree of wrist flexion. Patients were instructed to use the splint daily for 4 weeks. All patients in three groups also received vitamin B6 daily.

**Outcome measurements**

Electrophysiologic parameters:

Neurophysiological parameters were collected according to the descriptions in Dumitru textbook of electrodiagnostic medicine,[7] and included: sensory nerve action potential peak latency (SNAP), distal motor latency (DML) and motor nerve conduction velocity.

Skin temperatures were recorded with thermometer and maintained above 31°C.

Neurophysiological studies were performed using the same equipment by the same operator for all patients: (Medelec Synergy T electromyography Medelec™ Synergy T-EP). Disposable surface electrodes for nerve conduction studies and concentric needle for electromyography were used. Motor nerve conduction study to obtain median DML and median Compound Muscle Action Potential (CMAP) amplitude was performed via stimulating median nerve at wrist stimuli by using a bipolar surface stimulator at a fixed distance of 8cm from recording electrodes located at mid-point of Abductor Pollicis Brevis muscle (APB). DML was measured in milliseconds (ms) at the onset of negative motor action potential.

Sensory nerve conduction study stimuli was delivered to the third finger using stimulating electrode at a fixed distance of 14 Cm. SNAP latency was measured at the peak of Sensory Action Potential.

Peak to peak amplitude (mV) and Base to peak amplitude (mV) was measured for SNAP and CMAP amplitude respectively.

**Pain scores**

Pain and disability scores were measured by Visual Analogue Score (VAS), Symptoms Severity Score (SSS) and Functional Status Scale. VAS is a valid and reliable pain score[14]. SSS questionnaire evaluated the pain severity and has 11 items. Reproducibility and responsiveness of this scale has been shown in previous studies[15]. Functional Status Scale assesses 8 items of daily activities that can be affected by pain, this is also a valid and reliable disability assessment questionnaire[16].

Clinical and neurophysiological parameters were evaluated before and after treatment by one physiatric and same instrument.

**Ethical considerations**

All patients signed the written consent.This study had the approval of the Shahid Beheshti University of Medical Sciences Committees as per the guidelines by the Declaration of Helsinki.

**Statistical analysis**

Descriptive statistics are given as mean±SD. The variables had normal distribution so parametric tests were used for data analysis. Within groups, comparisons were carried out by paired t-test and between groups, comparisons were carried out by unpaired T-test. The $\chi^2$ test was used for the analysis of the categorical variables. $P < 0.05$ was considered statistically significant.

## Results

### Patients' characteristics

Fifty hands of patients with mild to moderate CTS were evaluated. Demographic, clinical and neurophysiological characteristics of all patients at baseline were recorded. There was no significant difference between the three groups regarding age, duration of symptoms, side of involvement and clinical parameters of pain scores including VAS and SSS at baseline (Table 1).

Also, there was no statistically significant difference in neurophysiologic findings including latency and amplitude of median SNAP and CMAP.

### Laser group

Eighteen patients recruited in this group.

### Pain scores

Mean VAS scores of all patients in this group decreased from 4.2±2.9 at baseline to2.3±3.5 and 2.6±1.7 three weeks and two months after therapy respectively (Mean±sd, P=0.001).

Mean FSS scores of patients changed from 11.3±4.6 before treatment to 5±5.5 and 3.6±2.9 three weeks and two months after therapy respectively (Mean±sd, P=0.01).

Mean SSS scores of patients improved from 5.2±16.7 before treatment to 5.9±6.8 and 6.5±4.8 respectively(Mean±sd, P=0.001).

### Electrophysiological findings

Electrophysiological findings changes after Laser therapy are displayed in table 2:

Median SNAP and CMAP Latency decreased significantly 3 weeks after therapy and this decline remained significant at 2 month follow up electrodiagnostic study. The alteration in other electrophysiological parameters was not statistically significant in 3 week and 2 month follow up examinations.

**Table 2.** Electrophysiological findings changed after Laser therap

| LASER | SNAP Latency | CMAP latency | SNAP Amplitude | CMAP Amplitude |
|---|---|---|---|---|
| Before Tx | 4.6±0.7 | 4.9±0.74 | 30.±16 | 9±3.1 |
| 3 weeks after Tx | 4.4±0.8 (P=0.001) | 4.7±0.7 (P=0.03) | 29.±18 (P=0.6) | 9±2 (P=0.4) |
| Two months after Tx | 4.3±0.7 (P=0.01) | 4.6±0.7 (P=0.02) | 30±15 | 10±3 (P=0.3) |

### Provocative tests

Phalen and Tinel tests were positive in 13 (72%) and 11(61%) patients before treatment respectively. Three weeks and 2 months after treatment, phalen test was positive in 5 (27%) and 3 (16%) patients respectively (P<0.05). Three weeks and 2 months after treatment, Tinel test was positive in 5(27%) and 4(22%) patients respectively (P<0.05).

### Sham Laser group

Fifteen patients were allocated to this group.

### Pain scores

Mean VAS scores of all patients decreased from 3.7±2.5 at baseline to 1.7±1.7 and 1.4±2.1 three weeks and two months after therapy respectively (Mean±sd, P=0.01).

Mean SSS scores of all patients changed from 10.1±5.7 before treatment to 6±3.9 and 3±4.6 three weeks and two months after therapy respectively (Mean±sd, P=0.02).

Mean FSS scores of all patients also improved from 10.1±5.7 before treatment to 4.4±4 and 4.4±3.1 respectively (Mean±sd, P=0.001).

**Table 1.** Patients' characteristics at baseline.

| Treatment group | Laser | Splinting | SHAM Laser | P value |
|---|---|---|---|---|
| Age | 52±12 | 47.±7. | 49±11. | 0.44 |
| Duration of symptoms | 13±9 | 13±8 | 13±9 | 0.99 |
| Side of involvement (right/left) | 8(53.3%) / 7(46.7%) | 7(46.7%) / 8(53.3%) | 9(60%) / 6(40%) | 0.76 |
| VAS | 4.2±2.9 | 2.8±2.2 | 3.7±2.5 | 0.25 |
| SSS | 16.7±5.2 | 17.8±6.4 | 16.7±6.1 | 0.8 |
| FSS | 11.3±4.6 | 9.7±3.7 | 10.1±5.7 | 0.58 |

Electrophysiological parameters changed after Laser therapy are displayed in table 3-6.

### Provocative tests

Phalen and Tinel tests were positive in 11(73%) and 8 (53%) patients before treatment respectively. Three weeks and 2 months after treatment, phalen test was positive in 4(26%) patients (P=0.03).

Three weeks and 2 months after treatment, Tinel test was positive in 2(13%) patients respectively (P=0.01).

### Splinting group

Seventeen patients were allocated to this group of therapy.

### Pain scores

The change in pain scores after splinting is displayed in table 3.

All three pain scales decreased significantly following splinting.

Electrophysiological parameters at baseline and in 3 week and 2 month follow up examinations after splinting are shown in table 4-6. Median SNAP and CMAP latency decreased significantly 3 weeks after splinting and this decline remained significant at 2 month follow up studies.

### Provocative tests

Phalen and tinel tests were positive in 8 (47%) and 10 (59%) patients before treatment respectively. Three weeks after splinting, phalen test was positive in 3 (17%) (P=0.1) but it was positive in no patients 2 months after splinting respectively (P=0.008).

Three weeks after treatment, Tinel test was positive in 2(27%) patients (p=0.001). Two months after splinting, no patients had positive Tinel sign (P=0.002).

### Comparison between groups

Pain scores (VAS, SSS and FSS) improved in three groups but there was no significant difference in pain and disability decrease between three groups according to above scales in three week and 2 month follow up (P>0.05).

Electrophysiological changes 3 weeks and 2 months after initiating therapy in and between three groups are depicted in table 4-7.

As it can be read from the tables, median SNAP and CMAP latency decreased significantly in 3 weeks and 2 months follow up. There was no significant difference between three groups regarding electrophysiological improvement after therapy.

**Table 3.** Pain scores improvement after splinting

| Splint | VAS (Mean±Sd) | FSS (Mean±Sd) | SSS (Mean±Sd) |
|---|---|---|---|
| Before Tx | 2.8±2.2 | 9.7±3.7 | 17.8±6.4 |
| 3 weeks after Tx | 1.6±1.8 (P=0.013) | 5.4±4.7 (P=0.0001) | 6.9±7.6 (P=0.0001) |
| Two months after Tx | 1.6±0.7 (P=0.001) | 2.3±4.3 (P=0.0001) | 8.6±2.8 (p=0.0001) |

**Table 4.** Median SNAP latency compared in and between groups before and after therapy

| SNAP Latency(ms) | Laser | Splinting | Sham Laser | P value |
|---|---|---|---|---|
| Before treatment | 4.6±0.7 | 4.2±0.8 | 4.6±0.8 | 0.3 |
| 3 weeks post treatment | 4.4±0.8 (0.001) | 3.8±0.4 (0.001) | 4.3±0.8 (0.01) | 0.09 |
| 2 months post treatment | 4.3±0.74 (0.01) | 3.6±0.3 (0.002) | 4.1±0.8 (0.01) | 0.4 |

**Table 5.** Median CMAP latency compared in and between groups before and after therapy

| CMAP latency(ms) | Laser | Splinting | Sham Laser | P value |
|---|---|---|---|---|
| Before treatment | 4.9±0.74 | 4.4±0.57 | 4.6±0.84 | 0.069 |
| 3 weeks post treatment | 4.7±0.7 (P=0.03) | 4.1±0.6 (P=0.01) | 4.4±0.83 (P=0.04) | 0.07 |
| 2 months post treatment | 4.6±0.7 (P=0.02) | 3.9±0.46 (P=0.03) | 4.3±0.64 (P=0.01) | 0.09 |

**Table 6.** Median SNAP amplitude compared in and between groups before and after therapy

| SNAP Amplitude(mv) | Laser | Splinting | Sham Laser | P value |
|---|---|---|---|---|
| Before treatment | 30±16 | 33±17 | 29±13 | 0.12 |
| 3 weeks post treatment | 29±18 (P=0.6) | 39±15 (P=0.07) | 31.5±14 (P=0.2) | 0.2 |
| 2 months post treatment | 30±15 | 40±16 | 32±17 | 0.5 |

**Table 7.** Median CMAP amplitude compared in and between groups before and after therapy

| CMAP amplitude(mv) | LASER | Splinting | Sham Laser | P value |
|---|---|---|---|---|
| Before treatment | 9±3 | 9.4±2 | 9.5±2 | 0.7 |
| 3 weeks post treatment | 9±2 (P=0.4) | 10.6±3 (P=0.08) | 9±3 (P=0.1) | 0.06 |
| 2 months post treatment | 10±3 (P=0.3) | 11±3 | 10.4±3 | 0.08 |

## Discussion

In our study, significant clinical response was observed in all treatment groups. Laser therapy didn't lead to better improvement in CTS symptoms and signs compared to splinting. Furthermore, pain and disability improved in three groups similarly and without any significant difference.

Several studies have suggested that low-level laser therapy (LLLT) is effective in patients with CTS.

In line with the results of our study, Tascioglu F and his colleagues evaluated sixty patients with CTS in a placebo-controlled and double-blind study and randomly assigned them to three treatment groups: active laser with a dosage of 1.2 J/per painful point, active laser with a dosage of 0.6 J/per painful point, and placebo groups Clinical assessments included pain intensity, grip strength, symptom severity score (SSS), functional status score (FSS), nerve conduction studies improved significantly in all groups. There was no significant difference in any of the outcome measures among the groups[17].

On the contrary to findings of our study, in a review published by Naeser MA the efficacy of Laser on CTS symptoms was investigated[18]. In that review, five studies were evaluated that observed real laser to have a better effect than sham laser, to treat CTS; but two studies did not observe real laser to have a better effect than a control condition, to treat CTS. In the five studies that observed beneficial effect from real laser, higher laser dosages (9 Joules, 12-30 Joules, 32 J/cm$^2$, 225 J/cm$^2$) were used than dosages in the two studies where real laser was not observed to have a better effect than a control condition (1.8 Joules or 6 J/cm(2)). The average success rate across the first five studies was 84% (SD, 8.9; total hands = 171). Photoradiation was suggested as a promising new, conservative treatment for mild/moderate CTS cases (motor latency < 7 msec; needle EMG, normal). It was considered cost-effective compared to current treatments[18].

In the present study, splinting alone without Laser therapy leaded to improvement in both clinical and electrophysiological findings in patients with CTS. Splinting used to be a traditional treatment for CTS with the aim of reducing repetitive wrist motion to promote healing of irritated nerve[5,12].

Laser therapy leads to better significant improvements on both clinical and electrophysiological findings in a RCT with similar design to our study. Yagci I and his colleagues investigated the short-term efficacy of splinting and splinting plus low-level laser therapy in mild or moderate CTS. The patients in Laser group received ten sessions of laser therapy and splinting while splinting group was given only splints. The patients were evaluated at the baseline and after 3 months of the treatment. In the third-month control, Laser group had significant improvements on both clinical and NCS parameters (median motor nerve distal latency, median sensory nerve conduction velocities) while splinting group had only symptomatic healing. The grip strength of splinting group was decreased significantly. Additionally, applied laser therapy provided better outcomes on NCS but not in clinical parameters in patients with CTS[19].

The efficacy of Laser on treating inflammatory response in achille tendinitis[20], reducing pain in fibromyalgia, muscle spasm and knee osteoarthritis[10], also entrapment neuroapathis such as carpal tunnel syndrome[21] were previously investigated.

In another study, the effects of laser compared to ultrasound in treatment of shoulder myofascial pain syndrome were investigated. Laser resulted in more pain and disability decrease, also better algometric assessment comparing to ultrasound[22,23].

Irvine conducted a double blinded RCT to evaluate the effect of Laser on CTS. The patients in the treatment group received 860 nm galium/aluminum/arsenide laser at a dosage of 6 J/cm$^2$ over the carpal tunnel, whereas those in the control group were treated with sham laser. The same as our study, there was a significant symptomatic improvement in both the control and treatment groups. However, there was no significant difference in any of the outcome measures between the two groups. Thus, they concluded that LLLT was no more effective in the reduction of symptoms of CTS than is sham treatment[1].

In our study, all patients in the three groups showed significant improvement regarding clinical symptoms (VAS, FSS, SSS) and Tinel and Phalen tests; however, comparison of the three groups in terms of clinical symptoms (VAS, FSS, SSS), Tinel and phalen tests two months after the start of treatment was not significantly different. Most of the therapeutic effects of laser on clinical symptoms were noticed immediately after therapy. Electrophysiologic parameters improvement happened 3 weeks after treatment and this improvement remained significant at follow up.

In agreement with our results, 81 patients were evaluated in randomized placebo-controlled trial

aimed to investigate the efficacy of laser therapy in the treatment of CTS. In that study, using low energy laser, there was no difference relative to pain relief and functional capacity during the follow-up in CTS patients; but there were positive effects on hand and pinch grip strengths in laser compared to sham laser group[9].

In a similar study 80 patients were randomly assigned into two groups: Laser and sham Laser. In that study, Laser therapy was effective in treating CTS paresthesia and numbness and improves the subjects' power of hand grip and electrophysiological parameters[21]. However, we did not evaluate pinch grip strength in our study.

There are theories regarding the effect of Laser in pain and inflammation control. The effect of low energy laser is not thermal, rather, it is believed to stimulate microcirculation and endorphin secretion, also block the enzymes that block pain enzymes leading to reduce pain and inflammation[21-25].

In conclusion, splinting was effective in the present study to reduce pain and disability associated with mild to moderate CTS. Splinting also improved electrophysiological findings. Low intensity Laser therapy with the parameters defined in this study didn't lead to more improvement. However, further researches with larger sample size and longer follow up periods should be conducted to obtain more conclusive results.

In order to define the exact efficacy of Laser in treating CTS, it is suggested to apply low intensity laser with different parameters including power, intensity and wavelength than what used on our study.

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