



Comparison of high-intensity and low-level laser therapy effecton combined sensory index, sensory conduction velocity and distal motoric latency: a study in moderate carpal tunnel syndrome patients

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ABSTRACT

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Carpal tunnel syndrome (CTS) is the most common neuropathy compression syndrome. The effectiveness of low-level laser therapy (LLLT) as one of the conservative therapy for CTS is still debatable. High-intensity laser therapy (HILT) is developed with higher energy and deeper tissue penetration than LLLT. This study aimed to compare the effect of HILT and LLLT on sensory and motoric electrophysiologic parameters in moderate CTS patients. This was an experimental randomized pre and post-test group study. Sixteen patients (fifteen females and one male) with moderate CTS were randomly assigned into two groups. The HILT group was given HILT with analgesic dosage 10 J/cm² and biostimulation dosage 120 J/cm². The LLLT group was given LLLT with dosage 6 J/cm². All treatments were given for ten sessions in 2 weeks. Combined sensory index (CSI), sensory nerve conduction velocity (SNCV), and distal motoric latency (DML) were recorded before and three days after the last treatment. The mean decrease of CSI was more significant in HILT group (-0.37±0.37 ms; p=0.03). There were no significant differences in the mean increase of SNCV (HILT = 3.16±3.15 m/s, LLLT= 2.74±1.42 m/s; p=0.73) and mean decrease in DML between two groups (HILT = - 0.20 ± 0.18 ms , LLLT = - 0.14 ± 0.21 ms; p=0.52). In conclusion, the HILT is more effective than LLLT in improving the CSI values in moderate CTS patients.

ABSTRAK

Sindroma terowongan karpal (CTS) adalah neuropati kompresi yang sering ditemui. Keefektifan *low level laser therapy* (LLLT) sebagai salah satu terapi konservatif untuk CTS masih diperdebatkan. *High intensity laser therapy* (HILT) dikembangkan dengan energi yang lebih tinggi dan daya penetrasi yang lebih dalam dari LLLT. Penelitian ini bertujuan untuk membandingkan efek HILT dan LLLT terhadap parameter elektrofisiologis sensorik dan motorik pada pasien CTS derajat sedang. Penelitian ini adalah studi eksperimental acak pre dan post tes. Enam belas pasien (lima belas perempuan dan satu pria) dengan CTS derajat sedang secara acak dibagi ke dalam dua grup. Grup HILT diberikan HILT dengan dosis analgesik 10 J/cm² and dosis biostimulasi 120 J/cm². Grup LLLT diberikan LLLT dengan dosis 6 J/cm². Terapi diberikan selama sepuluh sesi dalam 2 minggu. *Combined Sensory Index* (CSI), *sensory nerve conduction velocity* (SNCV) dan *distal motoric latency* (DML) dievaluasi sebelum pemberian terapi dan 3 hari pasca terapi terakhir. Perbedaan rerata penurunan CSI pada kedua grup secara signifikan lebih bermakna pada grup HILT (-0,37±0,37 ms; p=0,03). Tidak terdapat perbedaan yang bermakna dalam rerata peningkatan SNCV (HILT = 3,16 ± 3,15 m/s, LLLT=2,74±1,42 m/s; p=0,73) dan rerata penurunan DML antara kedua grup (HILT = -0,20±0,18 ms, LLLT= -0,14±0,21ms; p=0,52). HILT lebih efektif dibandingkan dengan LLLT dalam memperbaiki nilai CSI pada pasien dengan CTS derajat sedang.

Keywords:

CTS;
electrophysiologic;
HILT;
LLLT;
neuropathy;

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common neuropathy compression syndrome caused by local compression of median nerve in carpal tunnel. It is characterized by pain, tingling, numbness, and burning sensation at the palmar side of the thumb, middle finger, and radial side of the ring finger.¹ In the United States, CTS prevalence among the general population is about 3.8%, and the incidence is 276:100,000/ year.^{2,3} In Indonesia, there were several studies about CTS prevalence among worker population. Tana *et al.*⁴ and Pangestuti *et al.*⁵ reported that CTS prevalence was 20.3% among 814 garment workers in Jakarta and 87.2% among 39 grinding workers at the shipyard in Surabaya. Repetitive movement, pressure, vibration, temperature, and unergonomic working posture were allegedly related to high CTS prevalence among those workers. The loss of workdays and high treatment cost cause CTS to become a significant problem in the occupational world.⁶

The severity of CTS can be classified into mild, moderate, and severe based on nerve conduction study. Prolonged distal sensory latency and a decrease of sensory nerve conduction velocity can be found in mild CTS. Moderate CTS is diagnosed when there is a decrease of sensory amplitude and prolonged distal motoric latency at abductor pollicis brevis muscle <6.5 ms. When the sensory nerve amplitude is absent, the CTS is classified as severe.⁷ Mild and moderate CTS usually are conservatively treated. While the severe CTS will need decompression surgery.⁸

Laser is one of the conservative therapy for CTS. Laser can stimulate nerve regeneration, decrease the inflammation process, repair the nerve membrane permeability, and the intraneural vascular structure.^{9,10} The laser therapeutic effects are determined

by its power, wavelength, and therapy duration.¹¹ Low-level laser therapy (LLLT) is the type of laser that usually used to treat CTS. It is the class 3B laser therapy with wavelength 600-950 nm, power less than 500mW and depth of penetration 0.5–2 cm.^{12–14} However, the effectivity of LLLT for CTS still debatable. Bekhet *et al.*¹⁵ reported that LLLT improved the strength of hand grip but not the pain, hand function, and electrophysiologic parameters. On the other hand, high-intensity laser therapy (HILT) is developed with higher energy and deeper tissue penetration than LLLT. It is the 4th class laser therapy with wavelength 800-1064 nm, power 1–10 W, depth of penetration more than 10 cm and generate heat up to 43°C.^{10,16,17} This study aimed to compare the effect of HILT and LLLT on the sensory and motoric electrophysiologic parameters in moderate CTS patients.

MATERIALS AND METHODS

Subjects

This experimental randomized pre and post-test group study was conducted at the medical rehabilitation outpatient clinic of Tugurejo General Hospital, Semarang during the period of August – September 2018, and approved by the Health Research Ethics Committee of Medical Faculty of Universitas Diponegoro, Semarang and Dr. Kariadi General Hospital, Semarang with ethical clearance number 517/EC/FK-RSDK/VII/2018.

Twenty-nine patients of both sexes with clinical CTS were obtained from the medical rehabilitation outpatient clinic, and only sixteen patients (fifteen females and one male) met the inclusion and exclusion criteria. The inclusion criteria were 1) pain, paresthesia, or both in the distribution of the median nerve area; 2) age 30 – 50 years old; 3) moderate CTS based

on nerve conduction study (prolonged distal sensory latency, decrease sensory amplitude, and prolonged distal motoric latency at abductor pollicis brevis muscle < 6.5 ms).⁷ The exclusion criteria were the presence of 1) secondary etiologies of CTS (wrist fracture history, diabetes mellitus, thyroid disease, hand infection, gout, rheumatoid arthritis, tumor and congenital deformity of wrist, pregnancy, using oral contraception and anticoagulant); 2) proximal neuropathy at the same extremity; 3) having other conservative treatments (physical modalities, orthosis, tendon-nerve gliding, anti-inflammatory, and corticosteroid medication, vitamin B₆ and B₁₂) and decompression surgery at the wrist; 4) contraindication to laser treatment (fever, seizure, sensory disturbance, using photosensitive medication). Informed consent was obtained from the participants.^{18,19} Thirteen patients were not included in this study because they had mild or severe CTS based on nerve conduction study, secondary etiologies of CTS (diabetes mellitus), cervical syndrome, and some of them had already received conservative treatments.

Protocol of study

Subjects were randomly assigned to 2 groups with simple random sampling. Each subject took an envelope containing information about the number of the group. Group 1 (HILT group) consisted of eight subjects and was treated with HILT (BTL-6000, power 12W, wavelength 1064 nm) with analgesic dosage 10 J/cm² and biostimulation dosage 120 J/cm² for ten sessions in 2 weeks (HILT dosage was reduced 10–40% for patients with Fitzpatrick skin scale IV-VI).²⁰ Group 2 (LLLT group) also consisted of eight subjects and was treated with LLLT (Endolaser 422, power 25 mW, wavelength 905 nm) with dosage 6 J/cm² for ten sessions in 2 weeks.^{21,22}

The treatment was delivered by the physiotherapist and the subjects knew the intervention that was given. The neurophysiological parameters were evaluated by another person who did not know about the group and the intervention.

The repetitive hand and wrist movement risk during working hours was evaluated before the treatment. Repetitive hand and wrist movement was defined as repetitive hand and wrist movement more than six cycles in one minute, lifting weights more than four kilograms and vibration exposure.^{18,23} The subjects were asked if they had the risk of repetitive hand and wrist movement. Neurophysiological parameters were evaluated before and three days after treatment with electromyography machine Keypoint 4011 (Dantec, Denmark). Collected neurophysiological parameters were Combined Sensory Index (CSI), sensory nerve conduction velocity (SNCV), and distal motoric latency (DML) of the median nerve at the carpal tunnel. CSI was calculated from median-ulnar latency difference from palm to wrist (palmdiff), median-ulnar latency difference from wrist to ring finger (ringdiff), and median-radial latency difference from the wrist to the thumb (thumbdiff). The Median SNCV was measured from the wrist to the index finger. Median DML was measured from the wrist to abductor pollicis brevis muscle.²⁴

Statistical analysis

Statistical analysis was performed using IBM SPSS for Windows version 22. Shapiro Wilk normality test was used to evaluate the distributions of numeric data. The independent t-test was used for normally distributed numeric data for equality test; otherwise, the Mann Whitney test was used. A Chi-square test was used for the analysis of categorical

data. The within-group comparison was evaluated by paired t-test if the data distribution was normal or the Wilcoxon test if the data distribution was not normal. An independent t-test was used to assess the between-group comparison if the data distribution were normal or Mann Whitney test if the data distribution were not normal. Significance in this study was obtained if p values <0.05 with 95% confidence intervals.^{25,26}

RESULTS

From 29 patients with clinical CTS, sixteen patients (fifteen females and one male), who meet the inclusion and exclusion criteria, were recruited in this study. Eight subjects were assigned to each group. The subjects’ baseline characteristics can be seen in TABLE 1. The subjects’ occupation was varied

in both group, but the difference was statistically insignificant. The majority of the subjects of both groups showed that they had the risk of repetitive hand and wrist movement during the working hours. There were no significant differences in age and gender for both groups.

The neurophysiological parameters evaluation were summarized in TABLE 2. There was no difference in the neurophysiological parameters before the treatment. After the treatment, there was a significant improvement in the CSI value of the HILT group. The SNCV value increased significantly in both groups. The DML value decreased significantly in the HILT group, but the inter-group comparison was not significant. The correlation between CSI and SNCV value was significant negative with moderate strength (p=0.02; r=-0.54).

TABLE 1. Baseline characteristics of subjects

Characteristic	Group		p
	HILT (n = 8)	LLLT (n = 8)	
Age (mean ± SD)	39.38 ± 7.41	41.63 ± 5.63	0.505 [§]
Gender [n (%)]			
• Male	0 (0)	1 (12.5)	1.000 [¥]
• Female	8 (100)	7 (87.5)	
Occupation [n (%)]			
• Housewife	1 (12.5)	4 (50)	0.180 [¥]
• Cleaning service	2 (25)	0 (0)	
• Sales	0 (0)	1 (12.5)	
• Musician	0 (0)	1 (12.5)	
• Administrator	4 (50)	1 (12.5)	
• Medical doctor	1 (12.5)	1 (12.5)	
Repetitive hand and wrist movement risk [n (%)]	6 (75)	7 (87.5)	1.000 [¥]

[§] Independent t; [‡] Mann Whitney; [¥] Chi square

TABLE 2. Neurophysiological parameters comparison

Variable	Group		p
	HILT (n = 8)	LLLT (n = 8)	
CSI (ms)			
• Pre	2.93 ± 1.38	4.73 ± 2.29	0.077 [§]
• Post	2.56 ± 1.12	4.73 ± 2.10	0.026 ^{§*}
p	0.026 ^{¶*}	0.970 [¶]	
Δ	-0.37 ± 0.37	0.004 ± 0.26	0.037 ^{§*}
SNCV (m/s)			
• Pre	40.11 ± 5.17	36.75 ± 5.74	0.239 [§]
• Post	43.28 ± 4.04	39.49 ± 6.26	0.173 [§]
p	0.025 ^{¶*}	0.001 ^{¶*}	
Δ	3.16 ± 3.15	2.74 ± 1.42	0.735 [§]
DML (ms)			
• Pre	4.59 ± 0,19	5.34 ± 1.46	0.486 [‡]
• Post	4.39 ± 0,26	5.20 ± 1.48	0.288 [‡]
p	0,015 ^{¶*}	0,105 [‡]	
Δ	-0.20 ± 0,18	-0.14 ± 0.21	0.527 [§]

*Significant; [§]Independent t; [‡]Mann Whitney; [¶]Paired t; [†]Wilcoxon; CSI = Combined Sensory Index; SNCV = Sensory Nerve Conduction Velocity; DML = Distal Motoric Latency

DISCUSSION

High-intensity laser therapy and LLLT have the same role in nerve regeneration but different in the amount of photon energy that can be delivered and the depth of penetration. Both treatments increase nerve cell metabolism, Schwann cell proliferation, fibroblast activity, and collagen production, angiogenesis, microvascular improvement, and inhibit the production of inflammatory cytokines.¹⁰ The remyelination process depends on the amount of the photon energy that the Schwann cells received.²⁷

In this study, HILT improved all neurophysiological parameters. This result was consistent with R Casale et al.²⁸ that reported HILT improvement on median nerve SNCV and DML. R Casale used HILT with dosage 250 J/cm² for 15 sessions in 3 weeks, while in this study, we used HILT with analgesic dosage 10 J/cm² and biostimulation dosage 120 J/cm²

for ten sessions in 2 weeks. Although the dosage and the number of the therapy session in this study were lesser than R Casale, the result was the same. Our study also evaluated CSI that consists of distal sensory latency difference of median sensory branches to radial and ulnar nerve in hand.²⁹ The decrease in CSI value indirectly represents an improvement in distal sensory latency in median nerve branches.

Low-level laser therapy in this study only significantly improved the SNCV. This result was different from Rayegani *et al.*,²¹ that reported improvement in SNCV and DML. The difference between previous study²¹ and this study was the addition of wrist splint and vitamin B₆ for four weeks. Wrist splint places the wrist in the neutral position and decreases the carpal tunnel pressure.⁸ Vitamin B₆ has a neuroprotective effect and increases nerve regeneration.³⁰ Rayegani *et al.*²¹ evaluated the

neurophysiological parameters three weeks after the last treatment. But in our study, the neurophysiological evaluation was conducted three days after the last treatment. The earlier neurophysiological assessment could only record the initial process of remyelination but not the complete results of treatment effects on nerve regeneration. The process of remyelination after nerve decompression takes weeks to months because the chronic compression change the Schwann cell's morphology and response to the myelination precursor factors.³¹⁻³⁴ Those factors might cause Rayegani *et al.*²¹ to have a better result than our study. Besides that, the sensory nerve fiber has a larger myelin sheath, and this might be the reason why sensory nerve fiber recovered earlier than the motoric nerve fiber in our LLLT group.³⁵ Both CSI and SNCV evaluated the sensory component of the median nerve, and their correlation in this study was significantly negative with moderate strength. The improvement of SNCV values was not accompanied by CSI values in the LLLT group. It might be because we only evaluated the SNCV of the median nerve branch to the index finger; meanwhile, CSI also evaluated the other median nerve branches, and the recovery of each median nerve branches did not happen at the same time.

In the inter-group comparison, HILT improved CSI values better than LLLT. The improvement in SNCV and DML parameter in the HILT group were insignificant compared to the LLLT group. This might be because of the earlier evaluation and the uncontrolled repetitive hand and wrist movement. Each occupation has its own intensity of repetitive hand and wrist movement. In this study, we only evaluated whether the subject had the risk of repetitive hand and wrist movement as the leading cause of primary CTS. We did not measure the intensity of repetitive

hand and wrist movement for each occupation nor restricted the patient's activity. Therefore we could not ensure that every occupation in both groups had the same interference effect on the treatment even though the distribution of the occupation in both groups did not significantly different. The results of treatment in this study might be affected by this factor. Nevertheless, we recommended HILT as a conservative treatment for moderate CTS.

CONCLUSION

In conclusion, HILT is more effective than LLLT in treating moderate CTS, although only improved the CSI value. The limitation of this study was the small number of samples, earlier neurophysiological evaluation, uncontrolled repetitive hand and wrist movement, and varied occupation. For the optimal results, future research will need more samples in the same occupational population, controlled repetitive hand and wrist movement, appropriate timing, and long term neurophysiological evaluation.

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