Original Article

Comparison of the Effectiveness of Low Level Laser Therapy Plus Exercises and Phonophoresis Plus Exercises in Treatment of Idiopathic Carpal Tunnel Syndrome

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ABSTRACT

Aim: Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment due to median nerve compression in the carpal tunnel of the wrist. We aimed in this study to compare the effect of low level laser therapy (LLLT) plus tendons and nerve gliding exercise versus phonophoresis plus tendons and nerve gliding exercises on median nerve conduction studies, pain intensity, symptoms severity, function status, hand grip strength, and key pinch strength in patients with mild and moderate CTS. Material and Method: Forty patients were assigned in two different groups; LLLT plus tendons and nerve gliding exercises (n=20) and phonophoresis plus tendons and nerve gliding exercises (n=20). Pre-treatment (W0) and post-treatment follow-ups at four (W4) weeks were carried out using Electromyography (EMG) devise, Visual Analogue Scale (VAS), Symptoms severity scale (SSS), function status scale (FSS), Hydraulic hand dynamometer, and pinch dynamometer. Results: There was no statistically significant difference ($p > 0.05$) between two groups concerning age, sex, hand, and duration symptoms. There was a significant ($p = 0.0001$) improvement in all the tested parameters between pre-and post-treatment within each group. There was no significant difference ($p > 0.05$) between two groups concerning median nerve conduction studies, and grip strength. While, there was significant difference ($p < 0.05$) for phonophoresis plus tendons and nerve gliding exercises group in post Vas, SSS, FSS, and key pinch values between the two groups. Discussion: Our study results showed that LLLT plus tendons and nerve gliding exercises and phonophoresis plus tendons and nerve gliding exercises were effective during 4weeks follow-up in patients with mild and moderate CTS with statistical signifi¬cance superiority to phonophoresis with tendon and nerve gliding exercises for improving pain level, symptoms severity, function status, and key pinch strength.

Keywords: Carpal tunnel syndrome, phonophoresis, low level laser therapy, tendons and nerve gliding exercises.

Introduction

Carpal Tunnel syndrome (CTS) is entrapment of the median nerve due to transverse carpal ligament inflammation and swelling as it passes under it, beside with flexor tendons of the hand [1]. The main reason for this condition is unidentified [2]. The general prevalence of CTS is about %1[3]. Women are affected more than men, and it occurs with high prevalence rates in persons who perform certain repetitive movements in the wrist [4]. Manifestation of CTS include tingling in the lateral three and half fingers, awakening at night because of pain, and hand weakness [5]. Treatments include conservative and surgical to remove the median nerve compression [6]. The selection of the treatment type either conservative or surgical is based on the degree of symptoms and the physical limitations of the patient [7]. Conservative treatments are anti-inflammatory drugs, splint, ultrasound, and carpal tunnel steroid injections [8,9]. Low level laser therapy (LLLT) is an effective method of

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conservative action CTS [10-13]. Several human studies have showed beneficial effect of phonophoresis on patients with CTS [14-17]. Tendons and nerve gliding exercises are used in the treatment of CTS [15,16]. We wanted to know the difference between the effect of LLLT plus tendons and nerve gliding exercises versus phonophoresis plus tendon and nerve gliding exercise on median nerve conduction studies, pain intensity, symptoms severity, function status, strength of hand grip, and strength of key pinch in patients with mild and moderate CTS.

Material and Method

Patient Selection

40 patients were referred from a neurologist and diagnosed as mild and moderate CTS to the physical therapy outpatient clinic of Alsahel teaching hospital in Cairo participated in this study between November 2016 and September 2017. All the patients agreed to participate in the research before beginning. Inclusion Criteria were: cases with idiopathic mild and moderate CTS for more than 3 months ago, aged between 25-50 years, had pain and tingling in the lateral 3 and half fingers, and Patients had nerve conduction study with median nerve prolonged motor distal latency more than 4.3 ms or prolonged sensory distal latency more than 3.5 ms. Exclusion criteria were: open wound, cellulites, or recent surgery at the affected forearm, hypothyroidism, rheumatoid arthritis, infective diseases, history of carpal bone fracture or radius or ulnar fracture, previous surgical decompression or local injection of the carpal tunnel, diabetes mellitus, cervical disc prolapse or thoracic outlet syndrome, tumor disease, pregnancy, and peripheral polyneuropathy.

The present study examined 40 patients. They were assigned in 2 different groups: Group 1: LLLT plus tendons and nerve gliding exercise (n=20) and Group 2: phonophoresis plus tendons and nerve gliding exercises (n=20). Pre-treatment (W0) and post-treatment follow-ups at four weeks (W4) were carried out using Electromyography (EMG) devise, Visual Analogue Scale (VAS), Boston Carpal Tunnel Questionnaire (BCTQ), Hydraulic hand dynamometer, and pinch dynamometer

Treatment Protocol

Before starting the treatment, complete explanation was given to each patient about what is going to be done for the two groups.

Interventions for group 1

They received LLLT plus tendons and nerve gliding exercises. LLLT was applied using low intensity Ga-As laser (PAGANI, Mod Digilaser, class I Type, manufactured by Italy) with wave length of 904nm with average power 27 mw. The area of treatment was cleaned with alcohol. The patient was in sitting position. The investigator and the patient used special goggles to protect their eyes from hazardous effect of laser. The probe of laser with diameter 1cm was applied with direct contact perpendicularly on 5 points over the median nerve course where it passes superficially on the wrist volar side [18]. The probe of laser was applied for 120 seconds per point with the energy density 3.2J/cm2 with total energy 16 joules per session for 10 minutes. The sessions were 3 sessions per week for 12 sessions in 4 weeks. The patients also instructions were given to the patients to do nerve and tendons gliding exercises [19]. The patients were in a sitting position. The shoulders and neck were in neutral position. The elbow was right angle. During tendon gliding exercises; the fingers were placed in 5 different positions. Each position was kept for 5 seconds. Those were straight hand, claw fist, full fist, table-top position, and straight fist. The exercise was applied as 3 sets during the session with 10 repetitions of each set, 3 sessions per week for 4 weeks. Every patient was asked to repeat these exercises at home during the non-session days. The gliding exercises were done by placing the wrist and hand in 6 different positions. Each position was kept for 5 seconds. The first position; the fingers and thumb were fully flexed, while the wrist was in a neutral position. The second position; the fingers were extended, while the thumb and the wrist were in a neutral position. The third position; the fingers and the wrist were extended, while the thumb was in a neutral position. The forth Position; the fingers, thumb and the wrist were extended. The fifth Position 5; the fingers, thumb and the wrist were extended, while the forearm was supinated. The sixth Position; the same position as the fifth one, and extra extension of the thumb was done by the other hand of the patient. Each position was kept for 5 seconds. The exercises were performed as 3 sets during the session with 10 repetitions of each set, 3 sessions per week for 4 weeks. Every patient was asked to repeat these exercises at home during the non-session days.

Interventions for group 2

They received phonophoresis plus tendons and nerve gliding exercises. Ultrasound device (PAGANI, Mod DT20, manufactured by Italy) was used for application of phonophoresis. Phonophoresis was applied using pulsed ultrasound waves with duty cycle of 1:4 with diethylamine salicylate 5% gel (reparil gel) as a Coupling medium (1 MHz, 1W/cm2) for 10min per session over the area of carpal tunnel from the crease of the wrist to the palmer area, 3 sessions per

week for 12 sessions in 4 weeks. The area of treatment was cleaned with alcohol. The patients were in sitting position. They received tendons and nerve gliding exercises as the group 1.

Outcome Measures

Outcome was measured before intervention and four weeks after the finish of intervention for all patients. Outcome measures are median nerve conduction studies, pain intensity, symptoms severity, function status, strength of hand grip, and strength of key pinch. Sensory latency, motor latency, and sensory nerve conduction velocity were measured using EMG devise for the median nerve conduction studies. The same neurophysiologist performed the conduction studies of the median nerve using a Neuropack M1 (Nihon Kohden, Tokyo, Japan) EMG devise**.** The temperature of the room was remained at 22- 24°C during all the measurements. Recording of the Median motor nerve conduction was done by using active electrode over the center of the abductor pollicis brevis muscle and reference electrode over the distal phalanx of the thumb. The bipolar stimulating electrode was placed at two different sites. The first site was above the wrist joint, between flexor carpi radialis and Palmaris longus tendons. The second site was between the biceps tendon and the medial epicondyle of the elbow joint. The distal motor latency was calculated from the beginning of the stimulating artifact to the beginning of the compound muscle action potential. Recording of the Median sensory nerve conduction was done by using active ring electrode over proximal interphalangeal joint of the index and reference electrode over the distal interphalangeal joint of the index. The stimulation delivered on median nerve above the wrist joint between the flexor digitorum Superficialis and flexor carpi radialis tendons proximal to the transverse carpal ligament activated antidromic sensory action potentials at the second digit. The distal sensory latency was calculated from the beginning of the stimulating artifact to the peak of the sensory nerve action

potential. The measurement of the median nerve sensory velocity was calculated based upon the latency and the distance between the stimulating and recording electrode.

The pain level was assessed by using the VAS. It is a line of 10 cm with two ends. One end is 0 (no pain). The other end is 10 (worst pain). Instructions were given to Patients to put a spot on it, which best reflects his experience of pain and the distance was measured by a ruler. Symptoms severity and function status were assessed using BCTQ. BCTQ is a self-applied questionnaire. It includes Symptoms Severity Scale (SSS) and Function Status Scale (FSS). SSS consists of 11 items regarding to pain, tingling, numbness, weakness, and skill. FSS includes 8 items activities regarding the functional use of hand. These scales have 5 answers for each item, organized from 1 to 5[20]. Strength of hand grip was assessed using a handheld dynamometer. Strength of key pinch was assessed using pinch dynamometer. The position of the patients for measurement was sitting position. The procedure was explained to each patient. Every patient performed 3 consecutive trials. The average force of the trials was calculated in kilograms with a period of rest of 2 min between each trial.

Statistical analysis

Analyses of the collected data were performed by IBM SPSS 20.0 statistical package program (SPSS, Inc., Chicago, IL). When the study data were evaluated, the comparison of the qualitative variables was done using the Chi-square test. Shapiro-Wilk test was used to test the normal distribution of data. The comparison between pre and post-treatment was done using Paired t-test within each group. The comparison between the two groups was done using Unpaired (Independent) t-test. When a normal distribution was not found, the Wilcoxon signed rank test within group comparisons and Mann Whitney U test for comparisons between groups were used. All statistical analyses were significant at 0.05 level of probability ($p \leq 0.05$).

Results

Based on the criteria of selection, 40 cases with unilateral CTS (13 males, 27 females) were included in the trial. There was no statistically significant difference between two groups concerning age, sex, hand, and duration symptoms (Table 1).

There were significant statistical improvements in all the tested parameters in both groups after the intervention. Comparisons between the two groups showed no significant difference between two groups concerning sensory latency, motor latency, sensory nerve conduction velocity, and strength of hand grip ($p > 0.05$). While, there was a significant difference in VAS, SSS, FSS, and strength of key pinch values between two groups in favor of the group 2 as compared with group 1 ($p < 0.05$) (Table 2).

Table 1: Baseline characteristic of patients

	Group 1 (n=20)	Group 2 (n=20)	P-value
Age (years)	39.00 ±7.21	39.45 ±6.39	0.836

Duration of symptoms (months)		7.85 ±3.10	8.00 ±3.37	0.884
Gender	Male	8 (40%)	5 (25%)	0.069
	Female	12 (60%)	15 (75%)	
Affected hand	Right	13	14	0.057
	Left	7	6	

Table 2: Comparison of the parameters at baseline, and at eight weeks

		Group 1 (n=20)	Group 2 (n=20)	P-value
Sensory latency	Baseline	4.16 ±0.33	4.14 ±0.27	0.836
	Eight weeks	4.07 ±0.34	3.96 ±0.25	0.264
Motor latency	Baseline	4.93 ±0.52	4.88 ±0.61	0.806
	Eight weeks	4.75 ±0.49	4.65 ±0.52	0.538
Sensory nerve conduction velocity	Baseline	31.01 ±2.04	30.93 ±1.90	0.893
	Eight weeks	32.12 ±2.03	32.73 ±1.65	0.784
VAS	Baseline	6.13 ±1.29	6.10 ±1.21	0.940
	Eight weeks	3.56 ±1.06	2.44 ±0.70	0.002
SSS	Baseline	3.39 ±0.50	3.38 ±0.59	0.978
	Eight weeks	2.18 ±0.45	1.79 ±0.36	0.007
FSS	Baseline	3.67 ±0.77	3.50 ±0.71	0.394
	Eight weeks	2.81 ±0.84	2.17 ±0.61	0.009
Grip strength (kilograms)	Baseline	21.87 ±2.65	21.58 ±2.68	0.733
	Eight weeks	25.15 ±3.20	25.46 ±2.92	0.750
Key pinch strength (kilograms)	Baseline	6.32 ±1.39	6.73 ±1.67	0.409
	Eight weeks	7.47 ±1.50	8.39 ±1.59	0.042

VAS: Visual Analogue Scale
SSS: Symptom Severity Scale
FSS: Functional Status Scale

Discussion

In our research, we wanted to know the difference between the effect of LLLT plus exercises versus phonophoresis plus exercises on CTS, which is a common peripheral nerve entrapment. Our study results showed that LLLT plus exercises and phonophoresis plus exercises were effective during 4 weeks' follow-up with superiority to phonophoresis with exercises for improving pain level, symptoms severity, function status, and key pinch strength. To our Information, this is the first study that compares between the effect of LLLT plus exercises versus phonophoresis plus exercises.

Phonophoresis by ultrasound has numerous benefits. It has a low possibility of burning the skin, short treatment time, and deep penetration up to 5 cm. Also, it allows introducing the drugs through the ultrasound. The biological changes made by the thermal and mechanical effects of ultrasound include increasing in the power of regeneration in the tissues, increasing in the permeability of the cell membranes, increasing in the circulation of tissues, increasing of conduction velocity of the peripheral nerves, and muscle relaxation of pain [21].

Regarding phonnophoresis, few studies evaluated the effect of phonophoresis on CTS. In a study by Bakhtiary et al., they compared between iontophoresis and phonophoresis of dexamethasone for ten sessions on 35 cases. Iontophoresis was applied using 0.4% dexamethasone fluid with direct current and intensity 0, 2 mA for 20 min. Phonophoresis was applied using of 0.4% steroidal ant-inflammatory dexamethasone gel with pulsed ultrasound 1 MHz, and 1 W/cm2 for 5 min. They found that phonophoresis is better in decreasing pain, improving the median nerve conduction studies, hand grip strength and key pinch strength than the iontophoresis method [22]. Karatay et al. compared phonophoresis, local steroid injection and iontophoresis on 45 patients with CTS. The phonophoresis group received 15 sessions of phonophoresis of 0.1% steroidal ant-inflammatory dexamethasone sodium phosphate with pulsed ultrasound 1 MHz, and 1 W/cm2 for 10 minutes. The

local steroid injection group received 4 mg dexamethasone. The Iontophoresis group received 15 sessions of iontophoresis of 0.4% dexamethasone solution with direct current and intensity 1 to 4 mA for 10 minutes. They found that both phonophoresis and local steroid injection were more effective than iontophoresis in improving median nerve conduction studies, pain intensity, symptoms severity and function status [23]. The results of these studies are also in line with the results achieved in our research; however, in our study, we used non-steroidal diethylamine salicylate gel as a coupling media for phonophoresis with tendons and nerve gliding exercises.

The beneficial effects of tendons and nerve gliding exercises are improving the actual nerve excursion, decreasing symptoms by allowing free movement of the nerve, reducing adhesions, increasing mobility of the nerve, assistance of venous return. These exercises may also help better oxygenation of the nerve, and decreasing the carpal tunnel pressure [24, 25]

Regarding these exercises, Pinar et al. evaluated their effect with splinting on patients with CTS. They detected improved function status, distal latency, pinch strength and grip strength [26]. Akalin et al. obtained the same results [27].

Baysal et al. detected enhancement in latency with nerve conduction studies after these exercises. This improvement continued four to eight weeks after management [28]. In contrast, some studies found similar results with no differences when comparing with other conservative methods. Brininger et al. compared using wrist splint and these exercises. After treatment, there was similarity in the patients regarding pain level, and function status. However, the patients in this study had severe symptoms which might limit the benefit from nerve gliding exercises [29].

Several studies investigated the efficacy of LLLT as alternative for treating CTS. The studies showed differences regarding type of laser, dose and outcome measures.

Experimental studies revealed that LLLT prevents transmission of pain signals, and decrease the inflammation in the peripheral nerves [30-32]. LLLT may improve the cutaneous blood flow of the skin, endorphins release, and lymphatic drainage. It may also increase the production of ATP and consumption of the cellular oxygen within the muscles of the hand. This may clarify the improvement of hand grip strength [33,34]. These findings were in the same line with the research by Lazovic et al. who observed and documented statistically significant effect of GaAlAs 780 nm LLLT with the exercises used in our research over 6 weeks in Double-blinded, randomized, placebo-controlled research with energy density 3.4 J/cm2 per point for 90 seconds per point over 4 point for 20 sessions. The There was a significant reduction in pain, as well as sensory and motor latency of LLLT [35]. In the study by Elwakil et al. He-Ne laser with average power 12mw and energy density 3 J/cm2 for 12 sessions over 2 weeks was used versus surgical management. They found that laser can be used instead of surgery for early cases [36]. In the study by Ekima et al., they randomized 191 patients who had rheumatoid arthritis (RA) with CTS into real low-level 780 nm laser group with energy density 7, 5 J/cm2 for 10 sessions over 2 weeks versus sham laser group. The real laser displayed statistically significant differences in improvement after 3 months compared to the sham group regarding pain intensity using the VAS and the functional status. On the other hand, there was no significant improvement regarding median nerve conduction studies or the symptoms severity. This may be because the patients had (RA) [37].

Limitation

The relatively small number of cases participated in the research was the chief limitation.

Conclusion

In conclusion, our study results showed that LLLT plus tendons and nerve gliding exercises and phonophoresis plus tendons and nerve gliding exercises were effective during 4weeks follow-up in patients with mild and moderate CTS with statistical significance superiority to phonophoresis with exercises for improving pain level, symptoms severity, function status, and key pinch strength.

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