Laser versus Nerve and Tendon Gliding Exercise in Treating Carpal Tunnel Syndrome

Azza Mohamed Atya[*1] and Waleed Talat Mansour[2]

[1]Department of Basic Science, Faculty of Physical Therapy, Cairo University, Cairo, Egypt
[2]Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, Cairo, Egypt
[*]azzaatya73@hotmail.com

Abstract: carpal tunnel syndrome (CTS) is a highly prevalent entrapment neuropathy with a major impact on hand functions. The purpose of this study was to compare the clinical effect of low level laser (LLLT) with nerve and tendon gliding exercise as a conservative treatment for carpal tunnel syndrome. Methods: Thirty female patients with mild to moderate carpal tunnel syndrome; ranged in age from 30-45 years, participated in this study. Patients were randomly divided into two groups of equal number; patients in group (A) received low level laser, while those in group (B) received nerve and tendon gliding exercises. Treatment was conducted three times / week for two successive months for both groups. Outcomes were assessed at the baseline and at the end of the two months using visual analogue Scale, grip strength measurement and nerve conduction studies. Results: Both groups showed a statistically significant reduction in pain, improvement of the grip strength and nerve conduction in favor to the group (A), that showed significant differences in all measured variables compared with group (B). Conclusion: LLLT has to be more effective treatment option than nerve and tendon gliding exercises for treatment of mild to moderate CTS. Further studies are recommended to investigate the combined effects of both interventions for treating CTS.

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1. Introduction

Carpal tunnel syndrome (CTS) is one of the most common upper limb entrapment neuropathies particularly in the adult women. [1] The prevalence of CTS varies from 0.6% to 16% in the general population. [2]It has been estimated that CTS is one of the work related disabilities in the industrial countries that recently become a growing reason for workers' compensation claims due to work absence, induced social impact, and increased load to the health care system.[1]

The pathophysiology of CTS is thought to be a constellation of symptoms associated with localized compression of the median nerve at the wrist resulting in ischemia or mechanical injury which impaired nerve conduction velocity .[3] This condition may result from space-occupying lesions within the tunnel, such as cysts, tumors, osteophytes, fracture callus, or hypertrophic synovial tissue. It has also been tied to metabolic or systemic conditions such as thyroid disease, diabetes mellitus, rheumatoid arthritis, alcoholism, and pregnancy.[4]

In addition to compression and systematic disease, CTS has also attributed to a decrease in longitudinal excursion of the median nerve as it passes through the carpal tunnel. [5] Although most cases of CTS are idiopathic, its incidence is much higher in certain occupations involved daily high velocity and high-force manual labor and repetitive work as construction, meat-packing and assembly line trades as well as those that perform long periods of precise hand movements. [6, 7] Patients with CTS typically reported symptoms of numbness, tingling, paraesthesia and nocturnal burning pain involving the fingers innervated by the median nerve. Symptoms are worst at night and often wake the patient. The clinical signs may include a decrease in both light and discriminative touch sensation, and in advanced cases, a loss of grip and pinch strength. [8]

Early in the course of CTS, no morphologic changes are observable in the median nerve, neurological findings are reversible, and symptoms are intermittent. Prolonged or frequent episodes of elevated pressure in the carpal tunnel may result in segmental demyelination and more constant and severe symptoms, occasionally with weakness. When there is prolonged ischemia, axonal injury, and nerve dysfunction may be irreversible. [9]

The management of CTS is based on relieving the pressures from the median nerve. Several treatments are used with considerable controversy surrounding the optimal management modalities. Despite the superiority of surgical release of transverse carpal ligament in the management of patients with advanced CTS, conservative management is the treatment of choice for patients with mild to moderate CTS.[10] The currently recommended conservative treatment options are splinting, modifications in working conditions, local cortico-steroid injections, non-steroidal anti-inflammatory drugs, ultrasound therapy, and iontophoretic applications.[11,12] However, systematic reviews indicate that there is either limited evidence for the long term effects of these conservative treatment modalities [13,14] the long term effects are considered to be poor.[10]

Occasionally, alternative modalities for treatment of CTS are carried out. These include the introduction of low level laser therapy (LLLT) [15, 16]. Many investigators demonstrated the potential effects of lease therapy in treating CTS. These include effects on acetylcholine esterase enzyme, stimulation of fibroblast proliferation, increase microcirculation, stimulation of RNA, DNA, and ATP synthesis, increase cellular oxygen consumption and increase endorphin production. [16,17,18] However the issues about optimum dose regimens, schedules, cost effectiveness and clarifying which patients will likely respond to LLLT are needed to be enlightened by future controlled trials. [19]

Recently, several narrative reviews have advocated nerve and tendon gliding exercises as a biologically plausible alternative for traditionally advocated treatment modalities in the conservative management of CTS.[19,20,21] There is evidence that median nerve excursion can be influenced by neural gliding techniques, as demonstrated in a cadaveric study.[22] nerve and tendon gliding technique based mainly and attempts to take the nerve throughout the available range of motion, potentially affecting the nerve both mechanically and physiologically.[5,22]

The beneficial effects of these exercises may include improving the actual excursion of the nerve, reducing symptoms by allowing the nerve to move freely, decreasing adhesions, direct mobilization of the nerve, facilitation of venous return, edema dispersal, This technique may also help to oxygenate the nerve, decreasing ischemic pain, decrease of pressure inside the perineurium, and decrease of carpal tunnel pressure.[23,24] Though these exercises are commonly prescribed, there has been little research performed to support their use and justify their clinical value in combined with other conservative management .[25]

So the aim of this study was comparing the clinical efficacy of low level laser versus nerve and tendon gliding exercise for treating CTS.

2. Materials and methods:

Subjects

30 female patients their age ranged from 35 to 45 years with mild to moderate CTS. The clinical and electrophysiological evidence of CTS lasted over 3 months. All patients had unilateral involvement, and they were right handed. The local ethics committee approved the study protocol. The aim and methods of the study were explained to all patients before their informed consent was given. All patients with history of pain, paresthesia or numbness in the median nerve distribution, nocturnal pain, and night waking were enrolled in the study. Inclusion criteria were: 1) positive Phalen's test, 2) positive Tinnel's test, and 3) standard electrophysiological criteria including prolongation of nerve conduction velocity (i.e., motor latency > 4 ms or sensory latency > 3.5 ms and sensory conduction velocity <39m/sec).

Patients were excluded if they had secondary entrapment neuropathies; electroneurographic and clinical signs of axonal degeneration of the median nerve, history of treatment with LLLT for CTS, or had required regular analgesic or anti-inflammatory drugs. Patients with a history of steroid injection into the carpal tunnel, thyroid disease, diabetes, pregnancy or systemic peripheral neuropathy were excluded as well. When the patients satisfied the inclusion criteria, they were randomly divided into two groups. Numbers were given to them. Group(A) consisted of the patients with odd numbers, and group (B) consisted of the patients with even numbers.

Group A: (n = 15) received low level laser therapy and group B :(n = 15) received nerve and tendon gliding exercises.

Interventions

1) For group(A):

Low-level laser therapy was administered by applying low intensity infrared laser (Enraf, Endolaser) with a wave length 830 nm and output power was 30mw. The laser probe (1 cm diameter) was applied directly and perpendicularly on five points over the course of the median nerve on the volar side at the wrist where it localized superficially.[26] The dose per tender points was (1.8 J). The total dose per treatment was (9 J) and accumulated dose for ten treatments was 72 joule. The treatment was conducted over the course of 4 weeks for 10 minutes/ day, 2times \week. To standardize the total dosage that each subject received, a thin clear plastic template with 1cm grids was placed over the wrist and palm. The template was placed at an identical location at each session. A total of 5 points across the median nerve trace were irradiated with the laser probe. [27]

2) For group (B):

The patients in group II were instructed to perform nerve and tendon gliding exercises developed by Totten and Hunter. [28] A brochure describing exercises was given to all patients in this group. During tendon gliding exercises, the fingers were placed in five discrete positions. Those were (straight, hook, fist, table top, and straight fist). Each position kept for seven seconds. During the median nerve gliding exercise, the median nerve was mobilized by putting the hand and wrist in six different positions. These exercise carried out with the patient in a sitting position that varied according to the patient's ability to relax the proximal musculature as a following:

Position 1: Exercises were begun with the wrist in a neutral position (0 degrees) and the fingers and thumb in the full flexion position. The distal median nerve was placed in a relatively relaxed position.
Position 2: With the wrist kept in the neutral position, the fingers were brought to extension with the thumb in a neutral position. Tension in the distal segment of the nerves in the digits was increased.
Position 3: With maintenance of finger extension and the neutral position of the thumb, wrist extension was added to the exercises. The area of greatest excursion was accessed as the wrist was extended.
Position 4: While keeping the wrist and fingers extended, the thumb was extended. The median nerve branch to the thumb was included in this exercise.
Position 5: With the wrist, fingers, and thumb kept in extension, the forearm was brought into supination. This added tension to the more proximal portion of the median nerve in the forearm.
Position 6: With extension of the wrist, fingers, and thumb and supination of the forearm, slight tension was applied to the thumb with the other hand.
During these exercises, the neck and the shoulder were in a neutral position, and the elbow was in supination and 90 degrees of flexion. Each position was maintained for 5 sec. The exercises were applied as 3 times a day. Each exercise was repeated 10 times the exercises program was continued for two month. [29]

Outcome Measures

Patients were assessed at the baseline and at the end of treatment sessions to compare between the effects of the two treatment protocols. The main outcomes measures include: pain assessment, grip strength measurement and nerve conduction studies (NCS).

Pain intensity was measured by means of a visual analogue scale (VAS), which is a calibrated scale on which the patients could indicate their assessment along a 10 cm line ranging from 0 ('no pain at all') to 10 ('the most severe pain that I can imagine).

Hand grip strength measured with a handheld dynamometer. The patient's positioning was standardized with his/her elbow was flexed 90° and the average force of three consecutive trials was calculated. The dynamometer was initially standard and its sensitivity was controlled regularly by standard weights.

The nerve conduction studies of the median nerve were performed with a portable electromyography (Medelec Synergy; Oxford Instruments Medical, Surrey, UK). The room temperature was maintained around 30–31°C. For the motor nerve conduction studies; a pair of surface recording electrodes placed on the abductor pollicis brevis muscle. The stimulating electrodes were placed at the wrist proximal to carpal tunnel for the distal segment stimulation, and at the elbow for the proximal segment stimulation. The distal motor latency was measured from the onset of the stimulating artifact to the onset of the compound muscle action potential. The nerve conduction velocity was also calculated to rule out any median nerve lesions such as poly-neuropathy. [30]
In the study of sensory nerve conduction, a pair of ring electrodes was placed on the index finger for recording, and the sensory nerve was stimulated anti-dromically at the same site used for distal motor stimulation. Sensory distal latency was measured from the stimulating artifact to the peak of sensory nerve action potential.[31]

The outcome measuring parameters were statically analyzed by descriptive statistics (mean and stander deviation). The paired and unpaired t-test was used to compare the pre and post– treatment values of measuring outcomes within the group and between the two groups respectively. The p value of less than 0.05 was taken as significant.

3. Results

Thirty female patients with unilateral CTS, aged from (35 to 45) years who fulfilled the inclusion criteria agreed to participate in our study and were randomly allocated to either the laser (group A) or exercise (group B) treatment groups. Demographic characteristics and clinical features of both groups before the treatment are shown in (Table 1). There was no significant difference between the two groups regarding age, weight and symptoms duration ($P>0.05$).

Table 1.Demographic Data of 30 Patients in the Two Groups

Characteristics	Group A (n=15) mean ±SD	Group B (n=15) mean ±SD	P- VALUE
Age (years)	38.07±2.25	38.47±2.29	0.418
Weight (kg)	82.6±17.23	73.47±8.45	0.075
Duration (years)	2.31±1.93	1.65±1.3	0.276

Pre-treatment and post-treatment intra-group analysis revealed that, there was a significant decrease in pain value according to VAS, significant increase in the average grip strength, and significant improvement in NCS, in favor of Laser group (Table2).

Table 2: Statistical analysis of treatment outcomes between two groups

Variables	Group A		t-value	p-value	Group B		t-value	p-value
	Pre-treatment Mean ± SD	Post treatment Mean ± SD			Pre-treatment Mean ± SD	Post treatment Mean ± SD		
VAS	7.13 ± 1.3	2.86±1.30	8.49	0.0001*	7.533±1.5	5.2±1.52	5.25	0.0001*
Grip strength	9.40±2.13	16.20±2.27	16.3	0.0001*	9.73±2.12	11.6±2.92	6.08	0.0001*
MDL	4.53±0.35	3.54±0.35	10.88	0.0001	4.86±0.3	4.36±0.61	3.93	0.0015*
SDL	4.44±0.49	3.43±0.25	6.55	0.0001*	4.01±0.22	3.76±0.32	4.67	0.0001*
SCV	34.81±1.64	40.81±1.67	16.63	0.0001*	35.51±0.85	39.07±1.52	11.43	0.0002*

VAS . Visual analogue scale MDL. motor distal latency
SCV. Sensory conduction velocity SDL. sensory distal latency

Comparing the difference between post-treatment outcome measurements related to pain , grip strength and nerve conduction studies (MDL,SDL AND SCV) between two groups revealed that there was a statistically significant reduction in VAS score, increasing grip strength and improvement of NCS in laser group compared with exercise group ($p<0.05$).(fig.1,2,3).

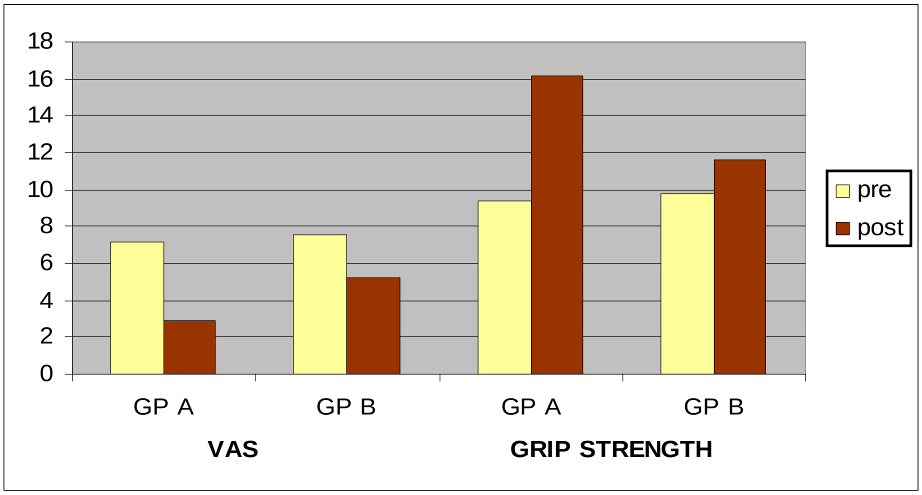

Fig1. Mean values of VAS and Grip strength of the two groups pre and post treatment

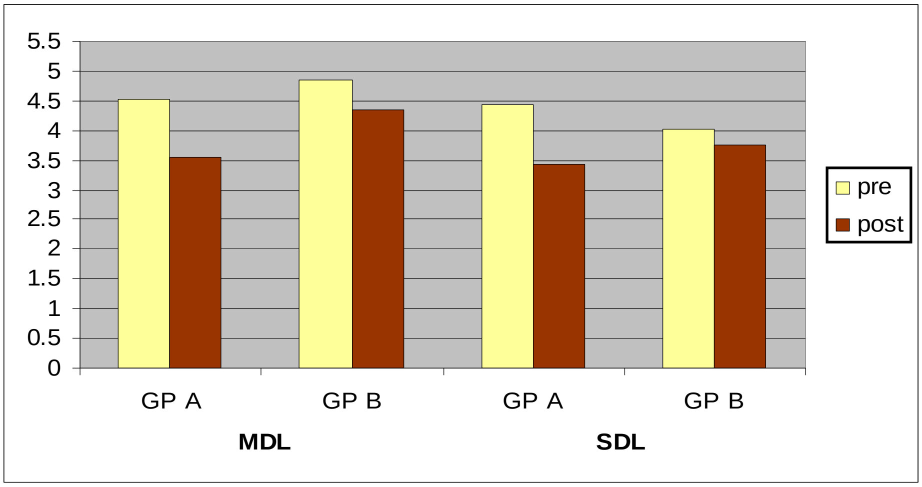

Fig2. Mean values of Motor and Sensory distal latencies for the two groups pre and post treatment

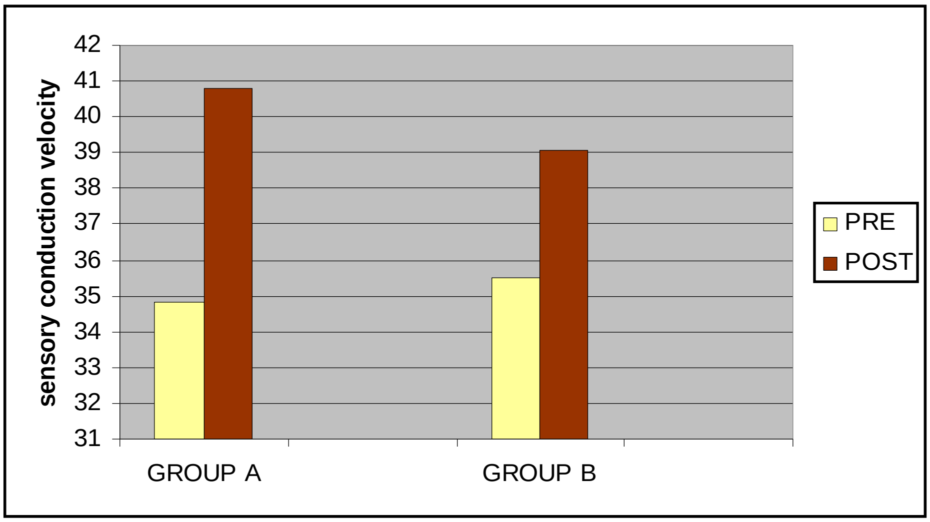

Fig3. Mean values of Sensory Conductive Velocity for the two groups pre and post treatment

4. Discussion

The current study was conducted to compare the clinical efficacy of LLLT versus nerve and tendon gliding exercises in treating CTS. In the era of CTS researches, various studies advocate the conservative management for mild to moderate cases of CTS.(19,32) There may be possible reasons for choosing conservative methods that including: recurrent symptoms of CTS in 10 % to 19% of patients following surgical release, with up to 12% requiring re-exploration ; there is probability of the spontaneous recovery in some patients with CTS related to pregnancy, in addition to potential complication of surgery compared with safety , non invasive and cost effect of the non surgical management.(33,34) Kaplan et al. tried to define more accurately those patients likely to respond to non-surgical treatments by identifying five risk factors: patient age greater than 50 years, the presence of symptoms for 10 months or more, constant paresthesias, presence of associated trigger fingers and/or positive results of phalen's test after 30s. These five factors help in predicting the outcome of conservative management of CTS. (35)

Regarding these risk factors, our patients mean age was under 50 years, and the duration of symptoms was less than 10 months and none of them had trigger fingers. The other possible reason for the favorable results obtained in our study could be the absence of thenar atrophy in those patients. There is no consensus with regard to the choice of initial treatment for CTS. The American Academy of Neurology advises non-invasive treatment first, i.e. wrist splints, modification of activities, NSAIDs or diuretics and using invasive steroid injections or open carpal tunnel release only if noninvasive treatment have turned out to be ineffective.[36]

LLLT has gained a considerable attention as a trial of alternative modalities for CTS. There are many methodological differences among the studies regarding the laser type, dose regimens, and outcome measures for treating CTS. Naeser et al. Investigated the effects of real or sham LLLT plus microamperes transcutaneous electric nerve stimulation with helium neon laser to acupuncture points on the finger and hands. A significant decrease was observed in pain, sensory latency, and Phalen’s and Tinel’s signs after real laser treatment. [37]

Based on the finding of our study, there was a significant difference in the mean value of pain, grip strength and NCS between groups after treatment. Therefore, the dosage and treatment time with the 830-nm laser used in our study may be sufficient to provide continuous energy to accelerate repair, and to decrease the inflammatory response. These results are consistent with the findings of Chang et al who investigated the therapeutic effects of the 830- nm diode laser in a placebo-controlled study, the results revealed that pain scores of laser group had reduced significantly after 2 wk of treatment, and after 2 wk of follow-up, there were significant differences in hand and finger grip strength testing in favor of laser group. [30] Irvine et al. used different laser dosage over the carpal tunnel, whereas the control group was treated with sham laser. It was found a significant symptomatic improvement in both the control and laser groups and no significant difference was detected in any of the outcome measures between the two groups. [38]

In addition to Evcik et al. who compared placebo laser with a randomized trial, adding hand splint for both groups. The results revealed that statistically significant improvements were found in sensory nerve velocity and sensory and motor distal latencies in the laser group compared with the other group. [39] As well as Shooshtari et al. who evaluated the effects of laser therapy (9–11 J/cm2) with a sham-controlled study and were found a significant improvement in clinical symptoms, NCV findings, and hand grip in laser group while there were no significant changes in sham laser except changes in clinical symptoms.[40]

Also these findings were in agreement with Dincer et al. who compared splinting, splinting plus ultrasound, and splinting with ultrasound plus low level laser therapy. It was seen that the combinations of the ultrasound and low-level laser therapy with splinting seems more effective than only splinting in the CTS treatment. [41].

With the progressive achievement in the field of LLLT, the healing effect of damaged tissue was confirmed in this study by reliving of pain, increasing of grip strength and NCS compared with the exercise group. Previous studies have shown that laser energy may induce athermal photochemical reaction that alters the pain threshold of nociceptors. Evidence abounds that phototherapy modulate inflammation by reducing prostaglandin concentration, inhibiting cyclo-oxygenase in vitro, reducing tumor necrosis factor, increase production of adenosine triphosphate, which increases cell metabolism, and increases the production of serotonin and endorphins (the body's endogenous pain relievers). [42, 43]

The exact mechanisms by which laser energy reducing pain and inflammation continue to be evolve. It has been shown that phototherapy increases local and systemic microcirculation thereby reducing swelling and pain. Others have suggested that LLLT could relief pain by modulating the key mediators of inflammation similar to the effect of non steroidal anti-inflamatory drugs and steroids. There are many possibilities could explain why there were increased grip strength in the laser group than the exercises group, on possible explanation may be the consistently linear relationship between the repair of the nerve and the subsidence of inflammation and swilling of the carpal ligament. [25]

Identifying the specific pathogenesis of CTS may be important in determining the true efficacy of nerve and tendon gliding exercises. Though the most current and available evidence suggested that patients with CTS due to mechanical compression of the median nerve whose are likely to benefit from this type of exercise .The following etiologies are suggested to elicit a compression of the neurovascular system as it passes through the carpal tunnel: ischemia, decrease in longitudinal excursion of the median nerve, and mechanical compression or injury to involved carpal structures. [44] Nerve and tendon gliding exercises may relieve ischemic pain by contributing to the delivery of oxygenated blood to the median nerve at its distal site within the wrist and hand. Therefore, gliding exercises are recommended as an important mainstay in the conservative management of CTS of mechanical nature. [45, 46]

In light of these research findings, nerve and tendon gliding exercises applied in the present study, resulted in significant reduction of pain increase in grip strength, and median nerve conduction; however, the significant difference between both laser an exercises group does not provide sufficient reason to recommend these exercises as the best available conservative treatment of CTS, but might play an important role in enhancing the effectiveness of conservative treatments.

5. Conclusion

The current study addressed the superiority of LLLT as a non invasive treatment option for mild to moderate CTS. Incorporation of nerve and tendon gliding exercises as a cost-effective intervention in treating CTS might play an important role in enhancing the effectiveness of the conservative treatments and delay the need for surgery. Further researches are required to investigate the long-term efficacy of LLLT versus exercises using different laser parameters, and whether the combination of these two treatments is superior to either treatment alone.

Future recommendations for more research include well-controlled randomized clinical trails, follow-up periods, and combination with other physical therapy modalities. While the efficacy of neural gliding techniques for the treatment of CTS is not clear, trends toward pain and symptom reduction, improved sensation, and improved function and strength, combined with the low monetary and temporal cost of the treatment, make this treatment a reasonable option for clinicians in treating individuals with CTS.

Corresponding author:
Azza Mohamed Attya
Department of Basic Science, Faculty of Physical Therapy, Cairo University, Cairo, Egypt
azzaatya73@hotmail.com

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