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Effectiveness of Ultrasound Plus Nerve Gliding Exercise with and without Low-level Laser Therapy in Patients with Moderate Carpal Tunnel Syndrome

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ABSTRACT

Introduction: Although carpal tunnel syndrome (CTS) is an incident entrapment neuropathy disorder, there has been inadequate evidence about the effect evaluation of adding low-level laser therapy to ultrasound (US) plus median nerve glide exercises in these patients. Hence, this research investigated the trace of US plus median nerve glide exercises with and without low-level laser therapy (LLLT).

Materials and Methods: Thirty-six patients with moderate CTS in two groups of intervention were assessed. One group received 10 sessions of adding LLLT to median nerve glide exercises plus US and the other group received median nerve glide exercises plus US without LLLT. Outcome measures were hand grip strength (HGS), visual analogue scale (VAS), Boston questionnaire (BQ), and cross-sectional area (CSA) of the median nerve.

Results: Baseline analysis revealed similarities between the two groups in all parameters. Statistical analysis indicated significant improvement of HGS, VAS, BQ, and CSA of the median nerve in two groups of intervention.

Conclusion: In patients with CTS, US and median nerve glide exercises with and without LLLT significantly improved without the superiority of adding LLLT to mentioned treatment.

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1. Introduction

Carpal tunnel syndrome (CTS) is a prevalent kind of peripheral entrapment neuropathy that leads to a lack of hand function after median nerve damage and loss of hand function if the patients do not receive on-time treatment [1]. Median nerve compression occurs due to the specific position of the nerve in the tunnel and another factor is repetitive wrist movements [2]. Wrist pain at night or after hard work, weakness, paresthesia, and fingers numbness in front of the thumb, index, and middle finger, and radial half of the ring finger are some signs of CTS. In patients with severe damage, nerve grip deficiency and falling of objects were seen [3].

Management of patients with CTS is affected by disease severity. The first choice of treatment is rest and conservative therapy and in some cases, surgical decompression is recommended [4]. In mild to moderate conditions conservative treatment such as a splint, exercises, [5] low-level laser therapy (LLLT) [6-8], mobilization [9-10], ultrasound [11], and shock wave therapy [12] are recommended. Some studies have focused on LLLT application in peripheral nerve injuries due to its positive effect on nerve cell regeneration. Another study reported a significant effect of adding nerve gliding along with LLLT or US. Likewise, some reviews identified the same effect of LLLT and US on patients with CTS [13-14]. Li et al. (2016) demonstrated the positive effect of LLLT on the reduction of pain, hand grip, and sensory nerve action potential. To the best of our knowledge, no study has been done on the US plus nerve gliding exercises with LLLT, and in clinics, the combination of modalities or exercises is very common and was done for achieving the best results. We purposed that using US plus median nerve gliding exercises associated with LLLT may positively affect symptoms and hand function in CTS.

Therefore, we decided to compare US and median nerve gliding with and without LLLT for the detection of superimposing effects of LLLT to the effects of US and nerve gliding in patients with moderate CTS.

On the other hand, some evidence recommended ultrasonography for helping the detection of median nerve CSA and diagnosis of CTS severity besides clinical symptoms and electrodiagnostic studies [15]. Therefore, the second aim of this study was to assess changes in CSA of the median nerve after treatment.

2. Materials and Methods

A total of 36 subjects participated in this double-blind randomized clinical trial, aged between 35 to 65 both female and male, with positive clinical “Phalen’s test, Tinel’s test” and neurophysiological diagnosis of moderate CTS without considering time over of CTS. Patients with upper limb injuries due to orthopedic, neurologic, or rheumatologic disorders or NSAIDS injections in the past 6 months, diabetic and pregnant females were excluded from the study [16]. All patients were referred by a neurological specialist and conducted at the faculty of rehabilitation of Tehran University of Medical Sciences. Subjects who met inclusion criteria through a computer-generated list were randomized into two groups. In total, 36 subjects (18 in each group: group A and group B) were determined according to the G*Power software, version 3.1.7 for statistical power of 80%, confidence interval of 95%, and medium effect size. Due to human subjects, this study was approved by the Ethics Committee of Tehran University of Medical Sciences (IR.TUMS.FNM.REC.1399.107). All subjects were informed about the study and written informed consent was taken.

Intervention and procedure

Intervention for group A: Eighteen patients with (40±8) years and BMI (27±5.6) kg/m^2 received US and median nerve glide exercises with LLLT. There was no priority for modality use.

Intervention for group B: Eighteen patients with (41±9) years and BMI (28±4.3) kg/m^2 received US and median nerve glide exercise without LLLT.

All interventions were conducted by a practiced physiotherapist in the Rehabilitation Center of Tehran University of Medical Sciences of Iran. Assessor was one of the experienced colleagues who were blinded to kinds of intervention; all patients were also blinded to kinds of treatment. The patients received 10 sessions of treatments during two weeks (10 sessions in total) [17].

LLLT: A Gallium-Arsenide (860 B, Novin Company/ Iran) laser emitter used with the following parameters: 3 points on the median nerve with 7 J/point, 5 minutes for 5 days a week for two weeks. The laser was positioned at an angle of 90° to the skin on Kaplan-Cardinal- line in the distal crease, according to the contact point technique.

Ultrasound: US device was (210/ NOVIN/Iran) with the following parameters: probe 1 MHz, 1w/cm^2, pulse

(1:4). Wrist was put in semi-flexion and the US used 5 minutes for 5 days a week during two weeks on Kaplan-Cardinal- line.

Nerve glide exercise: These exercises are simple hand and finger movements to restoring of normal movement of the median nerve. These exercises are available at YouTube [18]. These neural stretches were held for 10 seconds and were repeated 10 times per session. This treatment was prescribed 5 times a week for 2 weeks. Pre and post-scores of outcome measures were taken on the first day and at the end of the second week, respectively. All patients were in a comfortable position with their hands resting on the chair.

Outcome measures

Outcome measures were measured on the first day and at the end of the second week. The subjects indicated the severity of their pain based on a visual analog scale (VAS) from 0 (no pain) to 10 (most severe pain) [19]. A hydraulic hand dynamometer was used for the assessment of grip strength (GS). Participants sit comfortably with the shoulder adducted and neutrally rotated, with the elbow flexed at 90 degrees, and the forearm and wrist in a neutral position. The indicator needle was reset to zero and then each participant squeezed with maximum strength. The needle will automatically record the highest force exerted. Minimal wrist extension (30 degrees or less) is permissible as the maximum grip is achieved. The best effort rating from both was recorded [20].

Symptom severity scale (SSS) and functional status scale (FSS) were assessed by the Boston carpal tunnel questionnaire (BCTQ) [21].

Cross section of area (CSA) of the median nerve was computed with an ultrasonography instrument (2100/ Honda/Japan, with linear transducers,7-10MHz) that was implemented the in neurosonology unit at a hospital in Tehran University of Medical Sciences by a practiced neurosonographer, who was blinded to the subjects' clinical data and kind of treatment (groups). All patients were located in the resting neutral position with the palm up and the full course of the median nerve was assessed in the carpal tunnel in the transverse plane to assess the CSA (Figure 1). The average values of 3 times recordings were used for analysis [14].

Statistical analysis

The statistical analysis was conducted by SPSS software, version 22 (Chicago, IL, USA). The Kolmogorov-Smirnov test was used to determine the normal distribution of the data ($P>0.05$). The paired t-test and independent t-test were performed to evaluate the changes in the variables before and after the intervention and between groups. The confidence interval was set at 0.95, and the statistical significance was$\leq$0.05. Cohen's d effect size was used for the analysis of the effect size. According to Cohen (1988, 1992), the effect size is small if d= 0.2, medium if d=0.5, and large if d=0.8 [22].

3. Results

The study was completed with 36 subjects without dropping out of the study. Demographic data are shown in Table 1. There was no statistical difference in demographic data between the 2 groups at baseline (Table 1). Paired t-test analysis revealed that there is a statistically significant improvement ($P<0.05$) (Table 2, 3, 4 and 5) for all outcomes including pain, FSS, SSS, GS, and CSA of the median nerve from pre-intervention to post-intervention. Independent t-test found that there is no statistically significant difference in outcome measures between the groups of treatment.

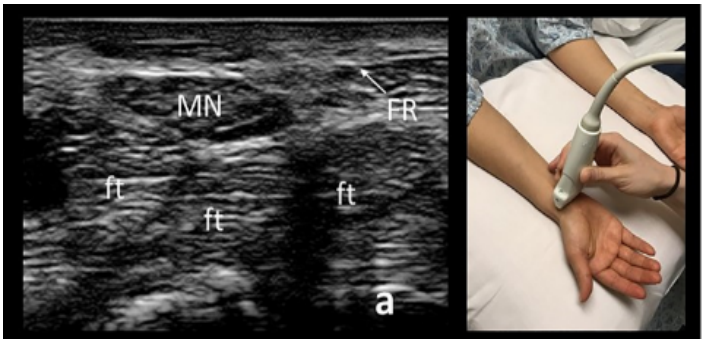

Figure 1. Hand position during median nerve sonography

Abbreviations: FT: Flexor digitron tendons; MN: Median nerve; FR: Flexor retinaculum.

Table 1. Basic characteristics of the subjects

Basic Characteristics of the subjects	No./Mean±SD		P Between-group Sig.
	Group A	Group B	
Total number of patients	18	18	
Age (y)	40±8	41±9	>0.05
Gender (male/female)	8/10	7/11	>0.05
BMI (kg/m^2)	27±5.6	28±4.3	>0.05
Duration of disease (m)	8±2.3	7.8±2.8	>0.05

JMR

Table 2. Comparative analysis of visual analogue scale (n=18 in each group)

VAS (cm)	Mean±SD		P
	Group A	Group B	
Pre	8±1.9	8.6±1.4	>0.05
Post	3.5±2.2	4.22±2.4	>0.05
P	P<0.001	P<0.001	-
Effect size	2.18	2.2	-

JMR

Table 3. Comparative analysis of grip strength score (n=18 in each group)

GS	Mean±SD		P
	Group A	Group B	
Pre	20.7±6	19.5±5.6	P>0.05
Post	26.3±5.4	23.3±5.4	P>0.05
P	P<0.001	P<0.001	-
Effect size	0.98	0.69	

GS: Grip strength

JMR

Table 4. Comparative analysis of symptom severity scale and functional status scale (n=18 in each group)

SSS/FSS		Group A	Group B	P
SSS	Pre	3.4±0.8	3.5±0.7	>0.05
	Post	1.9±0.7	2±0.9	>0.05
P		<0.001	<0.001	
Effect size		2	1.86	
FSS	Pre	3.6±0.9	3.5±0.7	>0.05
	Post	2.07±1	2.2±0.9	>0.05
P		<0.001	<0.001	
Effect size		1.6	1.6	

FSS: Functional status score; SSS: Symptom severity score.

JMR

Table 5. Comparative analysis of cross-section area (n=18 in each group)

CSA	Mean±SD		P
	Group A	Group B	
Pre	11.36±2.3	10.8±2.1	>0.05
Post	10.6±0.3	9.7±2.02	>0.05
P	<0.001	<0.001	
Effect size	0.46	0.53	

CSA: Cross-sectional area.

JMR

4. Discussion

This study examined the results of US and median nerve glide exercises with and without LLLT in patients with moderate CTS. A total of 36 subjects were included in this study with the following treatment: group A was given US and median nerve glide exercises with LLLT and group B was given US and median nerve mobilization without LLLT.

The results demonstrated positive effects of US and median nerve glide exercises with and without using LLLT in reducing pain, increasing GS, improving FSS, SSS, and changing of CSA of the median nerve in patients with moderate CTS. A comparison of US plus median nerve glide exercises with and without LLLT did not confirm any advantage. Experimental effects in both groups in most of the parameters demonstrated a large effect size except for changing of CSA of the median-1nerve. Regarding the effect size, GS revealed a higher effect size in group A may be due to the positive effects of LLLT on cells and nerve tissue. However, CSA revealed higher changes in group B may be due to the better condition of patients at baseline in group B (10.8± 2.1 in group B and 11.36± 2.3 in group A). There was no difference in other outcome measures regarding effect size. It seems that adding LLLT to the US plus median nerve glide exercises for the CTS patients had no additional effect on the VAS, GS, FSS, SSS, and CSA.

Rayegani et al. (2019) demonstrated US had a better effect on the reduction of pain, GS, and function improvement, in comparison with LLLT, but this difference was not statistically significant. US had an anti-inflammatory effect that could reduce symptoms of CTS [14]. Also, LLLT could induce the reduction of pain and inflammation with a positive effect on nerve regeneration. These interventions may have effects on soft tissue inflammation around the median nerve, which leads to pressure reduction, and then improvement of median nerve CSA was seen. A meta-analysis found that a cross-sectional area of 9 mm2 or more is 87.3% sensitive and 83.3% specific for CTS [23]. Therefore, based on the study results, the patients had already been involved with CTS. Likewise, Li et al. (2016) concluded that LLLT a had significant effect on the reduction of pain and increasing GS [24]. Lim et al. (2017) confirmed a very small to large effect of median nerve mobilization in their systematic review of pain, strength, and function [25]. Vikranth et al. (2015) confirmed the positive effects of median nerve glide exercises on improving pain, functional status, and symptom severity in the treatment of patients presenting with CTS [26]. But, due to a varying methodology, we cannot compare our study results with previous study results since we add LLLT to the US plus median nerve glide exercises. Therefore, this combination of treatments may confuse the main effect of each modality and this was one of the limitations.

Cheung et al. (2020) suggested that there was no need to add LLLT to splinting for pain reduction, reduction of symptom severity, or improved functional status. Despite helping LLLT to relieve pain, reduction of inflammation, stimulate nerve regeneration, and healing of damaged tissue, there is no superiority of adding LLLT to splinting [27]. Therefore, based on previous study results, due to different methodologies regarding kinds of modality, sample size, session of treatment, a combination of modalities, or exercise for confirming our study, we should only mention that there was not enough evidence for a combination of interventions. On the other hand, despite the widespread use of LLLT and US as the most popular and commonly used modalities, there is few evidence about adding these modalities to another modality or exercise therapy. Our results detected that US plus median nerve glide exercises with LLLT did not provide preference in outcome measure changing in comparison to the US plus median nerve glide exercise without LLLT. Likewise, there was heterogeneity in research for confirming LLLT effects.

Limitations

The combination of modality and treatment was one of the important limitations due to the inability in the assessment of single intervention effect. The small sample size and assessment of short-term effect was another limitation.

5. Conclusions

The results of this study confirmed that US plus median nerve glide exercises with and without LLLT had a significant effect on pain reduction, increasing GS, FSS, SSS, and decreasing of CSA of the median nerve without the superiority of adding LLLT to the US plus median nerve glide exercises. Therefore, it seems that adding LLLT to the US and exercise program for the CTS patients had no additional effect on the outcome measures of pain reduction, GS, FSS, SSS, and CSA.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Tehran University of Medical Sciences (Code IR.TUMS.FNM.REC.1399.107).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declare no conflict of interest.

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