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The Effects of Nerve and Tendon Gliding Exercises Combined with Low-level Laser or Ultrasound Therapy in Carpal Tunnel Syndrome

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Abstract

Background:

Carpal tunnel syndrome (CTS) is a common medical condition that doctors and physiotherapists come across in clinical practice. There are no explicit recommendations concerning which physical therapy methods should be applied in its treatment; however, there have also been no studies on the effects of combining low-level laser therapy (LLLT) or ultrasound with nerve and tendon gliding exercises. The purpose of this study was to evaluate the therapeutic efficacy of ultrasound and LLLT combined with gliding exercises.

Materials and Methods:

A total of seventy patients with mild to moderate CTS, divided into two groups, were included in this study. Group 1 received ultrasound treatment, whereas Group 2 underwent LLLT. The treatment lasted 2 weeks (5 sessions/week). In addition, both groups were treated with nerve and tendon gliding exercises three times daily. The clinical evaluation involved an interview on subjective and objective sensory abnormalities, the intensity of pain, the measurement of grip strength, Phalen's test, Tinel's sign, and the Boston Carpal Tunnel Questionnaire. The assessment was performed before and after the treatment.

Results:

A decrease in sensory impairments, improvement in visual analog scale, hand grip strength and the Boston Questionnaire results were significant in all patients after therapy. No meaningful differences between groups were noted in any of the examined variables after treatment. No adverse effects were observed.

Conclusions:

The results of this study may suggest the clinical efficacy of LLLT or ultrasound combined with gliding exercises in patients with mild to moderate CTS.

Keywords: *Carpal tunnel syndrome*, *low-level laser therapy*, *nerve gliding exercises*, *tendon gliding exercises*, *ultrasound treatment*

Introduction

Carpal tunnel syndrome (CTS) is considered the most common entrapment neuropathy.[1,2,3] Conservative treatment is recommended in the mild and moderate stage of CTS[2,4,5] and should involve splinting, steroid injections, oral steroids, and ultrasounds.[5] However, the results of some research studies have showed the beneficial effect of photobiomodulation as well as nerve and tendon gliding exercises in nonoperative treatment.[6,7,8,9,10,11,12,13] It has been assumed that the analgesic, anti-inflammatory, and anti-edematous effects of the application of low-level laser and ultrasound might be caused by stimulation of biochemical and biophysical processes at the cellular and tissue level.[14,15] The application of gliding exercises may influence "stretching the adhesion in the carpal tunnel, broadening the longitudinal area of contact between the median nerve at the transverse carpal ligament, reducing tenosynovial edema, improving venous return from the nerve bundles, and reducing pressure inside the canal."[12]

The purpose of this study was to evaluate the therapeutic efficacy of ultrasound treatment and low-level laser therapy (LLLT) combined with nerve and tendon gliding exercises and to compare the two regimens.

Materials and Methods

The study involved seventy patients with CTS (53 women, 17 men; mean age 46.8 ± 10.8 years). All participants complained of having pain in their hand and of symptoms such as tingling, numbness in the distal distribution of the median nerve, which was particularly exacerbated at night, as well as of a reduction in grip strength and function of the affected hand. Phalen's test and Tinel's sign were also performed.

Patients were allocated to group mild (34 patients) or moderate (36 patients) according to criteria by Whitney and McDonell.[16] The participants with mild CTS were defined as "patients having the mildest symptoms, including intermittent numbness, tingling, and pain in the median nerve distribution. Symptoms commonly wake these patients at night. These patients often report that they have to shake their hand to get the "feeling" back."[16] The group with moderate CTS were characterized by: "having persistent symptoms that include hypesthesia, clumsiness, and loss of dexterity and pinch strength. These patients often complain of "burning" pain and have exacerbations of pain at night or when using their hand."[16] The mean time of symptom duration was 25 ± 27.8 months. According to current recommendations[17] on the management of mild to moderate stage of CTS, previous treatment included oral steroids and/or steroid injections, splints or another physical therapy modalities. Inclusion criteria involved a diagnosis of the mild or moderate stage of CTS (according to criteria by Whitney and McDonnell) by an orthopedist or neurologist, symptom duration for more than three months, and general good health. Exclusion criteria comprised advanced CTS, secondary CTS, any previous surgery in the upper limb, steroid injections and any physical therapy treatment within six months before the study, pregnancy, cervical radiculopathy, peripheral polyneuropathy, or other neurological conditions. Patients who underwent surgical treatment were excluded from the study. All subjects expressed written consent to participate in the study, which was conducted in concordance with the Declaration of Helsinki and with the approval of the Bioethics Committee of our University.

Patient's clinical assessment

The clinical examination included an interview regarding the patient's symptoms (tingling, numbness, and hypoesthesia), an evaluation of any sensory disturbances and pain intensity in visual analog scale (VAS), measurement of grip strength and the application of provocative tests (Tinel's sign, Phalen's test). The Boston CTS Questionnaire was used for self-assessment of symptom severity and the hand's functional condition. All participants were evaluated before and after treatment.

Semmes-Weinstein monofilaments (2.83) were used to measure the response to touching sensation,[18] two-point discrimination was tested with a caliper within a 5-mm distance between two points.[19]

The Jamar dynamometer (Sammons Preston, Canada) was used to assess hand grip strength;[20] the mean score of three consecutive trials was accepted for each strength measurement.[21]

Patients graded the intensity of pain by using the VAS score, with 0 as “no pain” and 10 as “worst pain.”[21]

The Boston CTS Questionnaire consists of two scales: The Symptom Severity Scale (CTS SSS) and the Functional Status Scale (CTS FSS).[22] The CTS SSS comprises 11 questions concerning pain, nocturnal symptoms, numbness, tingling, and weakness; the CTS FSS consists of 8 questions concerning problems in writing, buttoning clothes, opening jars, holding a book, gripping of a telephone handle, household chores, carrying of grocery bags, bathing and dressing.[22] The severity of each symptom or difficulty in performing daily living activity was scored from 1 point (no symptom or difficulty) to 5 point (very severe symptoms or no possibility of performing the activity). The overall result for CTS SSS or CTS FSS was calculated as the mean score for all questions. The Polish version of the Boston Questionnaire was applied in this study.

Interventions

Patients were divided into two groups. Group L (35 patients) received LLLT; group US (35 patients) underwent ultrasound treatment. A total of ten therapeutic sessions were performed during a period of 2 weeks (five session times per week). All procedures were applied by the same physiotherapist. In addition, nerve and gliding exercises were administered in both groups.

The application of a GaAlAs infrared laser with a pencil probe (BTL 5000 Combi, United Kingdom; at 830 nm, 9J/cm^2 per point, the power output of 100 mW, the beam diameter of 5 mm) was performed at five points along the median nerve on the palmar side of the wrist.[7] The time of exposure was 10 min (2 min per point). Both the patient and the therapist wore protective glasses during every session.

Ultrasound treatment was administered at a frequency of 1 MHz, the intensity of 1 W/cm^2,[23] pulsed mode duty cycle of 1:4[23] and with a handheld transducer of 5 cm^2 (BTL 5000 Combi, UK). The time of application was 6 min over the area of the carpal tunnel. The aquasonic gel was used as a couplant.

Before the treatment course began, gliding exercises were presented by the physiotherapist and then performed by the patient with the supervision of the therapist. The participants also obtained a brochure with instructions and illustrations describing the exercises. Gliding exercises were performed three times a day;[12,13] two times by the patients on their own and once during the therapeutic session to check for proper performance. Each position in the tendon and nerve gliding exercises was maintained for seven seconds[12] and repeated five times.[12,24] The nerve gliding exercises involved maintaining the fingers and the hand in six consecutive positions.[24] At the beginning, (1) with the wrist in neutral and the fingers and thumb in flexion (grasp), then (2) with finger extension, (3) with the wrist and fingers extended and the thumb in neutral, (4) with the wrist, fingers, and thumb extended, (5) as the fourth position with the forearm in supination, and (6) as the fifth position and the other hand gently stretching the thumb.[24] When doing the tendon gliding exercises[25] the fingers were placed in 5 discrete positions: (1) neutral– with all finger joints in the neutral position, (2) angle– with the metacarpophalangeal (MP) joints at 90° of flexion and the interphalangeal joints in neutral position, (3) straight fist– with the MP and proximal interphalangeal joints flexed maximally and the distal interphalangeal joints in straight position, (4) hook– with the MP joints in the neutral position and the interphalangeal joints flexed maximally, and (5) fist– with all finger joints flexed maximally.

Statistical analysis

The SPSS 10 (StatSoft Inc., Tulsa, OK, USA) was used for statistical analysis. The significance level was defined as $P < 0.05$. Homogeneity of groups was verified with Cochrane's Q-test and the Friedman test. Pretreatment and posttreatment values were compared between groups and within groups using the Wilcoxon and Mann–Whitney U-test because of nonnormal distribution. The Student's *t*-test was applied for normally distributed data. Both the Pearson test (because of the normal distribution) and the Spearman test (because of nonnormal distribution) were used to verify correlations between the data.

Results

The demographic characteristics of the patients are presented in Table 1.

No significant differences were found between groups for mean age, sex, duration of symptoms, and body mass index (BMI) ($P > 0.05$) [Table 1]. The proportion of patients with mild and moderate CTS was similar in both groups [Table 1].

The comparison of subjective and objective tactile disturbances in patients with CTS before and after treatment is shown in Table 2.

There was a considerable improvement in sensory disturbances such as tingling sensation, numbness, or touching sensation after treatment in both groups ($P < 0.05$) [Table 2].

The analysis of clinical and functional parameters measured in patients with CTS before and after treatment is presented in Table 3.

Significant differences were found in hand grip strength and VAS in both groups before and after treatment ($P < 0.05$) [Table 3]. The significant difference in Phalen's test was found only in the US group ($P < 0.05$) [Table 3]. There were no meaningful differences in Tinel's sign in both groups ($P > 0.05$) [Table 3]. Considerable differences were found in CTS SSS and CTS FSS between results obtained before and after treatment in both groups ($P > 0.05$) [Table 3]. Improvement in the CTS SSS was expressed by a decrease in pain at night and daytime, in the duration and frequency of pain and in the reduction of the number of awakenings at night. Despite the significant improvement in CTS FSS in both groups, patients still had problems with buttoning their clothes, opening jars, and carrying grocery bags.

No significant differences were detected between groups in the results for grip strength, VAS, CTS SSS and CTS FSS before and after treatment ($P > 0.05$).

There was no correlation between age, sex, duration of symptoms, BMI, and effectiveness of the therapies. A positive moderate correlation was revealed between the stage of CTS (mild or moderate) and the results of VAS ($P = 0.00$, $r = 0.63$), CTS SSS ($P = 0.00$, $r = 0.53$), and CTS FSS ($P = 0.00$, $r = 0.57$).

No side effects were reported in the course of treatment.

Discussion

The recommendations of the American Association of Orthopaedic Surgeons have only dealt with ultrasound for a wide variety of physical therapy modalities in the treatment of mild and moderate CTS (recommendation 4b; Grade C, Level II)[5] so far. Similarly, in the European Handguide Study methods such as ultrasound and gliding exercises might be added to conservative management in CTS.[4] Nonetheless, according to the Cochrane Database Systemic Review on the application of ultrasound in CTS, the evidence is of poor quality and from limited data suggesting the prevalence of ultrasound over placebo in patients with CTS.[26] Furthermore, there have been no recommendations regarding the parameters of ultrasound applied in CTS.[26]

The effectiveness of ultrasound treatment as a monotherapy in mild and moderate CTS was noticed by Ebenbichler *et al*.[23] Ultrasounds were administered for 20 sessions; with a frequency of 1 MHz, low intensity of 1.0 W/cm^2, pulsed mode 1:4 and time of insonation of 15 min/session.[23] Real ultrasound applications were administered in the area of one symptomatic wrist and the sham therapy was administered to the other wrist in each of 34 patients.[21] After 2 weeks of treatment, significant improvement in VAS, hand grip strength and NCS was only found for wrists with active applications.[23]

However, the findings of the investigation by Oztas *et al*. may suggest that the effectiveness of ultrasound therapy is equal to placebo.[27] The authors compared physiotherapeutic interventions involving ultrasound with various intensities (W = 1.5 W/cm^2, W = 0.8W/cm^2) to sham treatment among thirty women with CTS.[27] The ultrasound was applied with a frequency of 3 MHz for 5 min, for 10 sessions, 5 times/week. After treatment, the meaningful improvement was detected in VAS, in a decrease in nocturnal pain and paraesthesia and in a reduction in the number of awakenings at night both in groups with active and placebo applications.

The majority of prior research concerning laser therapy compared the effectiveness of active application of LLLT to placebo.[8,9,10,28] The results of several investigations suggest the positive effect of LLLT in patients with CTS.[8,9,10,28] The studies were performed in groups of 36–80 patients with the application of a wide range of LLLT (GaAlAs)[10,28] parameters (wavelength of 780–830 nm, power output of 30–400 mW, and dose of energy 0.6–11 J/cm^2) and with various duration of treatment (10–15 sessions within 2–3 weeks). Significant improvement after treatment was observed in VAS,[8,9,10] grip strength,[8,9] Boston Questionnaire,[9] and electrodiagnostic tests[8,10,28] only in groups with active applications.

To the best of our knowledge, there has been only one study comparing the therapeutic effectiveness of LLLT and ultrasound in mild to moderate CTS so far.[21] The results showed the superiority of insonation over laser therapy.[21] Meaningful differences existed between groups in VAS, finger pinch strength, and the electrodiagnostic examination.

Nerve and tendon gliding exercises may be used for neural mobilization of the median nerve and to improve the condition of the upper limb muscle tendons in CTS.[12,24,25,29] Numerous studies have showed the effectiveness of gliding exercises as a part of conservative management of CTS, usually as an addition to splinting.[11,12,13,29,30,31]

To date, there has been one study by Baysal *et al*. on the effectiveness of treatment comprising ultrasound, gliding exercises, and splinting in nonoperative treatment.[11] The meaningful improvement was showed in Phalen's test, Tinel's sign, VAS, CTS SSS and FSS, two-point discrimination and grip strength in all groups.

In our study, significant differences were observed in VAS, sensory disturbances, hand grip strength and CTS SSS and FSS between results before and after treatment in both groups. No significance was found between groups.

The major limitation of our study is a lack of long term followup. The short-term evaluation of therapeutic effects was caused by a considerable drop-out after the treatment course. However, no participation in followup appointment may indicate on the effectiveness of therapy.

To the best of our knowledge, this was thefirst study on the efficacy and comparison of the above-mentioned therapeutic combinations. Thus, a discussion in the literature is limited.

The undisputed advantage of these methods is the fact that no adverse effects have been reported yet.[9,14,15,23,26,28,30,32] Nonetheless, it should be emphasized that the application of LLLT, ultrasound, and gliding exercises is limited to mild and moderate CTS.

Conclusions

Considerable improvement in both groups was observed after treatment as a decline in sensory disturbances and pain, an increase in hand grip strength, and in improvement in CTS SSS and CTS FSS. No significant differences were found between the therapeutic regimens in any of the analyzed aspects. Conservative treatment comprising ultrasound or LLLT with a combination of gliding exercises is effective in nonoperative management in patients with a mild and moderate stage of CTS.

Patient declaration statement

“The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.”

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Figures and Tables

Table 1

Baseline characteristics of the patients

Variable	L group	US group
Mean age±SD (years)	47.4±11.1	46.9±10.8
Sex female/male, *n**	25/10	28/7
Mean duration of symptoms±SD (months)	23.5±25.2	24.3±22.2
Mean BMI±SD	25.4±3.1	23.1±3.5
Mild CTS, *n** (%)	18 (51.4)	16 (45.7)
Moderate CTS, *n** (%)	17 (48.6)	19 (54.3)
Right hand affected, *n** (%)	24 (68.6)	24 (68.6)
Left hand affected, *n** (%)	5 (14.3)	5 (14.3)
Both hands affected, *n** (%)	6 (17.1)	6 (17.1)
Dominant hand affected, *n** (%)	31 (88.6)	30 (85.7)

*Number of wrists, BMI=Body mass index, CTS=Carpal tunnel syndrome, SD=Standard deviation

Table 2

Comparison of subjective and objective tactile symptoms status; before and after treatment in both groups

Variable	Time of observation	L group	US group
Subjective tactile symptoms			
Tingling, *n** (%)	Baseline	28 (80.0)	31 (88.6)
	Posttreatment	19 (54.3)	22 (57.1)
	P	0.02†	0.01†
Numbness, *n** (%)	Baseline	29 (82.9)	24 (68.6)
	Posttreatment	20 (57.1)	14 (40.0)
	P	0.02†	0.01†
Hypoeshtesia, *n** (%)	Baseline	16 (45.7)	17 (48.6)
	Posttreatment	9 (25.7)	7 (20.0)
	P	0.08	0.01†
Objective tactile signs			
Disturbances in touching sensation, *n** (%)	Baseline	28 (80.0)	26 (74.3)
	Posttreatment	17 (48.6)	16 (45.7)
	P	0.01†	0.02†
Disturbances in two-point discrimination, *n** (%)	Baseline	5 (14.3)	8 (22.9)
	Posttreatment	2 (5.7)	4 (11.4)
	P	0.26	0.18

*Number of wrists, †$P<0.05$ - statistically significant difference

Table 3

Results of the clinical and functional assessment of patients; baseline versus posttreatment

Variable	Time of observation	L group	US group
Hand grip strength (kg), mean value±SD	Baseline	23.0±3.9	22.8±3.6
	Posttreatment	24.9±3.3	24.7±2.8
	P	0.03†	0.01†
VAS (mean±SD)	Baseline	5.9±1.4	6.0±1.3
	Posttreatment	3.6±2.1	3.4±1.7
	P	0.01†	0.01†
Positive phalen's test, *n* (%)*	Baseline	26 (74.3)	27 (77.1)
	Posttreatment	19 (54.3)	18 (51.4)
	P	0.08	0.03†
Positive tinel's sign, *n* (%)*	Baseline	18 (51.4)	21 (56.7)
	Posttreatment	12 (34.3)	15 (42.9)
	P	0.15	0.28
CTS SSS (mean±SD)	Baseline	3.0±0.7	3.2±0.6
	Posttreatment	2.2±0.7	2.3±0.6
	P	0.01†	0.01†
CTS FSS (mean±SD)	Baseline	3.0±0.8	3.1±0.7
	Posttreatment	2.3±0.8	2.2±0.7
	P	0.01†	0.01†

*Number of wrists, †$P<0.05$ - statistically significant difference. SD=Standard deviation, CTS=Carpal tunnel syndrome, SSS=Symptom severity scale, FSS=Functional status scale, VAS=Visual analog scale