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EFFECT OF HIGH TONE POWER THERAPY ON CARPAL TUNNEL SYNDROME PATIENTS: (RANDOMIZED CONTROLLED TRIAL)

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ABSTRACT

Background: Carpal tunnel syndrome (CTS) is a familiar entrapment neuropathy that causes pain and functional impairment of the hands. CTS occurs due to a compression of the median nerve at the carpal canal, resulting in sensory and motor symptoms in the thumb, index, and middle fingers, which worsen at night and impair patients' sleep. High tone power therapy (HTT) is a unique characteristic of electrotherapy. Its main effects are introducing energy into the body to activate cells, producing an oscillation or vibration in the cells and tissues to promote metabolism, scattering the mediators of pain and inflammation leading to pain relieve.

Results : The Visual Analogue Scale , Boston Carpal Tunnel Questionnaire (symptoms severity scale and Functional Statuses scale) are assisted pre and post treatment for the two groups. The pain and functional outcome after-intervention values for each group were considerably greater than the pre intervention values. The study group had significantly higher post-intervention values than the control group (visual analogue scale value = 0.00001; Boston carpal tunnel questionnaire symptoms severity scale p value = 0.508 ; Boston carpal tunnel questionnaire functional statuses scale p value = 0.659).

Conclusions: Treatment through high tone power therapy is effective on decreasing pain and improving function outcome in patients with CTS than selected physical therapy program only. **Keywords:** Carpal tunnel syndrome, High tone power therapy, Boston Carpal Tunnel Questionnaire, functional outcome.

I. BACKGROUND

Carpal tunnel syndrome (CTS) is a familiar entrapment neuropathy that causes pain and functional impairment of the hands [1]. CTS occurs due to a compression of the median nerve at the carpal canal, resulting in sensory and motor symptoms, particularly in the thumb, index, and middle fingers, which worsen at night and impair patients' sleep [2].

According to the American Academy of Neurology, CTS is recognized as a common syndrome that affecting ten percent of people. Mechanical injury, compression, and ischemia of the median nerve at carpal tunnel are the pathogenesis of this syndrome [3].

High tone power therapy (HTT) is a unique characteristic of electrotherapy. Its main effects are introducing energy into the body to activate cells, producing an oscillation or vibration in the cells and tissues to promote metabolism,

scattering the mediators of pain and inflammation leading to pain relieve, normalizing the cell metabolism and nerve regeneration [4].

So, HTT has positive effects on pain, inflammation, and metabolism. This study was designed to evaluate the effect of HTT on carpal tunnel entrapment to be included into treatment plan during rehabilitation of patients with CTS.

II. METHODOLOGY

This study was a randomized control trail . It was conducted in the outpatient clinic of Faculty of Physical Therapy, Cairo. The study was approved by the ethical committee of the faculty of physical therapy, Cairo University (**NO P.T.REC/012/003178**). The patients were recruited from outpatient clinic of faculty of physical therapy Cairo university, EL-Kasr EL-Ainy Hospital, the unit of neurophysiology El-Ain-Shams university and private clinics. Thirty patients of both sexes were conducted into the study. All participants signed a written consent form after receiving full information on the purpose of the study, procedure, possible benefits, privacy, and use of data.

The patient's age ranged from 30 to 55 years old [5]. Patients were referred from neurologist with nerve conduction study (NCS) revealed with moderate stage median nerve entrapment at level of carpal tunnel according to NCS according to American Academy of Orthopedic Surgeons 2020. Patients that were chosen in this study had positive clinical provocative tests (Tinel test , Phalen test and carpal compression test) [6] , Patients with painful wrist movement, pain, and paresthesia in median nerve distribution at level of carpal tunnel with symptoms persist at least 3 months. Patients must be medically stable.

Patients excluded from this study if they had history of a CTS operation neurolysis of median nerve, any disease that may affect study such as diabetes, rheumatoid arthritis, gout, renal failure , Patients with neurological disorders as MS, ALS, GBS, Patients with musculoskeletal deformities as cervical rib, claw hand or thoracic outlet syndrome, Patients with cognitive impairment or any tumor or infection affect cervical spine, burn and dermatological disorders at upper limb, Pregnant women, Any patient had corticosteroid injection in the carpal tunnel, Patients with severe stage of median nerve entrapment revealed by EMG with axonal loss and reduced CMAP in APB [7].

Patients were randomly assigned by sealed paper envelopes into two equal groups: The experimental group (n=15) received twelve sessions of HTT program and selected physical therapy program for 12 sessions three times per week for one month. The control group (n=15) received selected physical therapy program only. The pain intensity was recorded by the visual analogue scale (VAS), which was a horizontal line with 10 cm long with no pain at one end and the worst pain at the other. Boston carpal tunnel questionnaire (BCTQ) which classified into two scales: symptoms severity scale and functional statuses scale were used to assess functional outcome.

III. PROCEDURES

Assessment procedures:

- 1. The visual analogue scale (VAS)**, used to evaluate the pain intensity. Visual Analogue Scale measurements are both valid and reliable. In many studies, the VAS is considered the simplest to use and provides the most reliable pain severity measures. Therefore, it is usually used as the standard against other rating methods [8]. The subject was asked to make a handwritten mark on a 100 mm line (10cm). This line represents a continuum between no pain or discomfort (zero), to the worst pain (10) that the patient could feel.
- 2. Boston Carpal Tunnel Syndrome Questionnaire BCTQ** is a scale designed for monitoring the severity and functional status in patients with CTS. It includes two sections: the symptom severity section (CTQ-SSS) and the functional status section (CTQ-FS). The CTQ-SSS is an 11-item questionnaire that is used to assess the severity of symptoms in people who have CTS. Each item scored from 1 to 5 on (5 being worst). The final score is ranged from 1 (no symptoms) to 5 (severe symptoms) .It has an excellent test-retest reliability ($r = 0.82-0.95$) [9]. The CTQ-SSS was believed to be the best predictor of the success of nonsurgical treatment plan as with a baseline scores below 2.5 indicating 89 percent specific for its success. People with a score of 3 had a 72 percent chance of undergoing surgery, whereas those with a score of 3.5 had an 86 percent chance . The CTQ-FS is an eight-item questionnaire used to evaluate the functional status of CTS patients. Each item is graded from (1 to 5). 5 being the worst and 1 being the best. The total score is the average of all 8 questions. The final score is ranged from 1 (no functional deficits) to 5 (no functional deficits) (worst function possible). It has outstanding test-retest reliability ($r = 0.8530$ and 0.93162) [10]. The participants were asked to answer the BCTQ which has two scales: one for symptom severity and another for functional status. An 11-

item questionnaire was used to assess the severity of CTS symptoms. Each question is given a score ranging from 1 (zero or slight) to 5 (severe). An 8-item functioning questionnaire measures a variety of activities to determine functional status. Each task is rated on a scale of 1 to 5.

Treatment Procedures

Study group A: 15 patients were treated by a twelve sessions of high tone power therapy for 30 min. per session, 3 sessions per week for 4 weeks. The patients also received selected physical therapy program (tendon gliding exercises, stretching exercises, and graduated active or resisted strengthening exercises) for 15 minutes per session, 3 sessions per week for 4 weeks. So, the total session time was 45 minutes as followed:

- A. **High tone power therapy:** The position of electrodes were one on palmer aspect of forearm below wrist and other was on palmer aspect of forearm below elbow for each patient. According to each patient's threshold curve, the intensity of the stimulation was adjusted to a tolerable level for the patient that did not cause any pain or discomfort. The duration of HTT is thirty minutes.
- B. **The physical therapy program:** Tendon gliding exercises, strengthening exercises , wrist mobilization , stretching exercises according to American Academy of Orthopedic Surgeons 2018.
 1. **Tendon gliding exercises:** Tendon gliding exercises assist the flexor tendons to maintain their active flexibility. The exercises were done while the patient was seated in a chair. The forearm was supinated and flexed ninety degrees, and both shoulders and neck were in a neutral position.
 2. **Strengthening exercises:** The patient sat on chair with her back supported and her shoulders in the neutral position and was asked to perform the following actions against resistance: Wrist flexion, wrist extension, Finger pinching, Thumb opposition, Supination, Pronation and Gripping.
 3. **Wrist mobilization:** grade I and II to reduce pain in the form of sup. and inf. glide.
 4. **Stretching:** Stretch of wrist extensors and wrist flexors.

Control group B: 15 patients were exposed to sham treatment HTT while device was turned on. The placement of electrodes were on the same locations of treatment group but without increase in intensity at all. The patients were not informed that they were not feel any stimulation at all combined with selected physical therapy program. Patients in this group received selected physical therapy program as in study group.

I. Data Analysis

Statistical analysis was conducted using SPSS for windows, version 26 (SPSS, Inc., Chicago, IL). Prior to final analysis, data were screened for normality assumption, homogeneity of variance, and presence of extreme scores. This exploration was done as a pre-requisite for parametric calculations of the analysis of difference. Preliminary assumption checking revealed that data was not normally distributed for all measured variables, as assessed by Shapiro-Wilk test ($p < 0.05$). There was homogeneity of variances ($p > 0.05$) and covariances ($p > 0.05$), as assessed by Levene's test of homogeneity of variances. Accordingly, non-parametric statistics were used. The Mann-Whitney U test was used to compare whether there is a difference in the dependent variable for the two independent groups. While Wilcoxon test was used to compare whether there is a difference within the same group. Unpaired t-test was used to compare whether there is a difference pretreatment in the demographic characteristics for the two study groups. The alpha level was set at 0.05.

II. Results

Demographic and clinical characteristics of participants: The baseline characteristics of the participants showed that no statistically significant differences existed between both the groups ($P > 0.05$) including (age, height, weight, and BMI), as shown in Table 1. There was also, no significant difference between both groups regarding gender, site of lesion, presence of pain and provocative tests the χ^2 value was 1.36 ($P > 0.05$).

Pretreatment comparison between both the groups: No statistically significant differences were noticed regarding the pretreatment between the two groups in all measured variables ($P > 0.05$), as shown in Table 2.

Pretreatment and post-treatment comparison in each group: There was a significant improvement in all measured variables (VAS, CTQ-SSS, and CTQ-FS) ($P < 0.05$) in the study group, and also the control group showed significant improvement in VAS, CTQ-SSS, and CTQ-FS Table 2.

Post-treatment comparison between both the groups : There was statistically significant improvement in all measured variables between both groups ($P > 0.05$) in favor to study group as shown in Table 2.

Table1. General characteristics of participants in both groups

	Control group	Study group	P- value
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	
Age (Years)	37.93 ± 3.86	37.0 ± 5.07	0.575
Height (cm)	170.46 ± 10.34	170.93 ± 6.45	0.883
Weight (kg)	87.6 ± 15.02	94.93 ± 13.4	0.169
BMI (kg/m²)	28.0 ± 0.86	27.95 ± 0.48	0.866
Duration of illness (months)	4.35 ± 1.44	4.6 ± 1.29	0.600
Gender			0.624
Male	3 (20 %)	2 (13.33 %)	
Female	12 (80 %)	13 (86.66 %)	
Site of lesion			
Right hand	8 (53.33 %)	7 (46.66 %)	0.715
Left hand	7 (46.66%)	8 (53.33%)	

P-value: probability value; *Significant at $P < 0.05$

Table 2. Comparison between both groups in all measured variables.

Variable	Time	Control group $\bar{x} \pm SD$	Study group $\bar{x} \pm SD$	P- Value
VAS (score)	Before	8.8 ± 1.01	8.53 ± 0.99	0.424
	After	7.06 ± 1.33	1.33 ± 0.48	0.0001*
	P Value	0.002*	0.00001*	
CTQ-SSS (score)	Before	4.46 ± 0.63	4.2 ± 0.94	0.508
	After	2.8 ± 1.01	1.4 ± 0.63	0.0001*
	P Value	0.001*	0.00001*	
CTQ-FS (score)	Before	4.13 ± 0.91	4.0 ± 0.92	0.659
	After	3.13 ± 0.91	1.46 ± 0.74	0.0001*
	P Value	0.005*	0.000001*	

\bar{x} : Mean; SD: Standard deviation P-value: probability value; *Significant at $P < 0.05$

IV. DISCUSSION

The aim of the conducted study was to investigate the efficacy of high tone power therapy (Hi Top) on pain, and functional outcome in carpal tunnel syndrome patients. Thirty patients of both sexes were referred from neurologist who had a nerve conduction study (NCS) that revealed moderate stage median nerve entrapment at the carpal tunnel. The current study is the first one in Egypt to investigate treatment effect of high tone power therapy on pain and function outcome in patients with CTS.

The current study found that after HiTop intervention, there was a clinically and statistically significant improvement in function outcome and quality of life, which is consistent with earlier studies. Treatment with high-tone power therapy was found to have a greater great potential to enhance function than TENS (transcutaneous electric nerve stimulation), which reflects an improvement in function outcome and quality of life, patients (n=100, mean ± SD age=57±14 years, sex=42% male) were randomly assigned into two groups treated with either HiTop

or TENS with the other group. Each treatment was administered for a period of 45 min per day, 5 times within seven days [11].

It was concluded that high-tone power therapy has a significant role in the prevention and management of pain, muscle dysfunction, and function independence, which is consistent with the findings of the present study. [12].

Treatment with high-tone power therapy improved functional outcomes in a statistically and clinically significant way. High-tone power therapy was found to be very effective for the treatment of neuropathic pain, improving quality of life and function performance [13].

The results of present study revealed that there was a statistically and clinically significant improvement of pain and ADL in group (I) received High tone power therapy in addition to selected physical therapy post treatment more than in group (II) treated with selected physical therapy program only. And this can be explained by the fact that high-tone power therapy improves cell metabolism, neuronal regeneration, and endogenous hormone release. [14]. It also improves microcirculation and endoneural blood flow by increasing vasodilation (increasing nitric oxide bioavailability) (locally and systemically). In addition, it is thought that inhibiting sympathetic afferent activity reduces pain transmission to the brain. Another essential assumption is that HTT can increase the quantity and size mitochondria, accelerate the diffusion rate, accelerate wound healing, nerve regeneration, accelerate ossification (bone healing) and many more [12].

Through the results of current study which concluded that treatment through high tone power therapy is effective on improving function outcome and alleviating pain in patients with CTS than selected physical therapy program only, the teamwork of present study suggests that the treatment using High tone power therapy is a useful, effective and non-invasive approach for treatment of patients with CTS. In the future, the teamwork of current study hopes all physical therapy programs for patients with CTS include High tone power therapy because it is more effective in those patients.

Limitations

Corona crisis affected the size of the sample because of the governmental decisions of curfew. Changes of patient's lifestyle and educational level. Motivations difference between all patients. Some of patients didn't complete the protocol of treatment due to different causes and they already got excluded from the study.

Conclusions

Treatment through high tone power therapy is effective on decreasing pain and improving function outcome in patients with CTS than selected physical therapy program only.

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