Effects of Low-Level Laser Therapy and Transcutaneous Electrical Nerve Stimulation on Pain and Hand Function Following Carpal Tunnel Syndrome

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Abstract

Introduction: This study aimed to compare the short-term effects of Low-Level Laser Therapy (LLLT) and Transcutaneous Electrical Nerve Stimulation (TENS) on hand pain and function in patients with low or moderate levels of Carpal Tunnel Syndrome (CTS). **Materials and Methods:** Twenty-four patients with confirmed mild to moderate CTS were recruited for this study. The eligible patients were randomly divided into two groups: LLLT and TENS. Patients in the LLLT group were exposed to GaAlAs diode laser, 808 nm with 6.5 J/cm^2 for two points perpendicularly over the carpal area. Patients in the TENS group were treated daily by conventional TENS with 80 µs duration for a period of 30 minutes per day. All patients were treated daily, five days per week for a period of two weeks. The researchers performed clinical assessment using visual analogue scale and McGill Pain questionnaire for pain rating and Disabilities of the Arm, Shoulder and Hand questionnaire for functional scales. For statistical analysis, paired t-test was used in each group, and analysis of variance was used for comparison between groups. **Results:** All outcome measures in the LLLT group were substantially improved while the TENS group provided better pain sensation. **Conclusion:** This study documented that LLLT might be effective in reducing pain and improving function in patients with mild to moderate CTS. Electrical stimulation might have been effective (short term) in controlling pain in these patients.

Keywords: Carpal Tunnel Syndrome; Function; Low-level Lasers; Pain; TENS

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Introduction

Carpal tunnel syndrome (CTS), the most frequently encountered peripheral neuropathy, occurs when the median nerve at the wrist in the carpal canal is compressed (1). Its symptoms include numbness, tingling, paresthesia, pain, weakness (especially in the first three fingers) and loss of hand dexterity and function (2-3). The symptoms are more severe at night and often keep the patients awake. The frequently prescribed treatments for CTS include exercises, wrist splinting, ultrasound (US), low-level laser therapy (LLLT) and transcutaneous electrical nerve stimulation (TENS) (4-7). However, it should be noted that the best way to manage CTS is debatable (8). The effects of LLLT are considered to be photo biologic rather than photo thermal through increased proton electrochemical potential, more adenosine triphosphate (ATP) synthesis of reduced form of nicotine amide adenine dinucleotide and ATP (9). Conventional TENS is the usual clinical protocol applied for pain relief based on the gate control theory (10). The aim of this study was to compare the short-term efficacy of LLLT and TENS on pain and hand function in patients with CTS.

Many trials have compared LLLT with different treatment methods. For example, Yagci *et al.* compared the LLLT with splinting and found no differences in relief of symptoms and small differences in electroneurophysiologic parameters (11). Dincer *et al.* compared US and splinting versus LLLT and splinting and splinting alone. The LLLT and splinting method showed better symptom relief compared to splinting alone, but it

Table 1. Demographic data (age and BMI) in TENS and laser groups

Variable	Groups mean(SD)		Minimum		Maximum	
	TENS	Laser	TENS	Laser	TENS	Laser
Age, y	50.14 (8.53)	50.9 (9.17)	36	26	72	63
BMI, kg/m^2	28.84 (8.42)	28.42 (4.18)	21.80	22.15	39.56	35.25

Table 2. Mean difference and significant levels of Variables [McGill (McGill pain questionnaire), VAS (visual analogue scale), DASH (Disabilities of the Arm, Shoulder and Hand)]

Group	Variable Scores	Mean difference	Sig.
TENS	McGill	-3.52	0.037
	VAS	-0.3	0.271
	Pain intensity	-0.33	0.049
	DASH	-7.58	0.058
Laser	McGill	-6.43	0.006
	VAS	-0.65	0.006
	Pain intensity	-0.38	0.042
	DASH	-10.53	0.001

Table 3. T-test analysis for identified outcome measures between the TENS and laser groups

Variable Scores	df	*P*-value
McGill	22	0.407
VAS	22	0.870
Pain intensity	22	0.152
DASH	22	0.075

was not superior to US and splinting (12). Bakhtiary *et al.* found that US was superior to the LLLT method in terms of improved level in Visual Analogue Scale (VAS), pinch strength, and electro-neurophysiologic results, but the symptoms relief and functional improvement were not evaluated (13). Based on the above findings, it is unclear whether the expensive laser therapy is more efficient than the regular TENS in terms of pain relief and improved function following CTS. Therefore, this study aimed to compare the effects of LLLT irradiation and TENS application in the treatment of CTS patients.

Materials and Methods

Twenty-four patients with mild to moderate CTS in their dominant hand were recruited for this study from Naft Grand Hospital in Ahvaz-Iran. The inclusion criteria were as follows: age between 26 and 72 years, confirmed CTS diagnosis by clinical examination using the *Tinel's* sign and *Phalen's test*, and also low to moderate points in electromyography (14). The exclusion criteria were acute trauma, history of metabolic disease, arthritis, fracture, cervical radiculopathy, brachial plexopathy, previous hand surgery, and pregnancy. Patients were asked to refrain from using analgesic medications during the study period. The patients were randomly assigned to two groups: TENS and LLLT (14 patients in each group), by using numbered envelopes with the help of an assistant. At the beginning and final session of treatment, the patients were assessed with the McGill Pain Questionnaire (MPQ), VAS to identify the level of pain and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire to assess hand functional level. MPQ is a high reliable and valid tool developed by Melzack and Torgerson. It measures pain experience with respect to multiple dimensions such as sensory (pain location, intensity, quality, and pattern), affective (fear, depression, and anxiety related to pain), cognitive (overall pain appraisal), and behavioral (aggravating and alleviating actions) (15). VAS is a common measurement tool for pain assessment on a 10-cm line that includes points ranging from 0 for no pain and 10 for most intense pain imaginable (16) (Figures 1 & 2).

Treatment Procedure

In the LLLT group, the GaALAS diode laser device (Lumix 3 Plus) with 808 nm wavelength, power output of 400 mW, and dosage of 6.5 J/cm^2 were used over the carpal tunnel area for the LLLT group. The identified dosages were calculated based on suggested previous research (17). The laser probe (2 cm^2 surface) was applied directly and perpendicularly on wrist skin from two points (1 cm^2 for each one). The continuous mode of laser was used for 32 seconds on each point. In the TENS group, a calibrated electrical stimulator (ITO ES-520) was used for a period of 30 minutes that produced a TENS current with pulse duration of 80 μm and frequency of 100 Hz. The electrodes were located on proximal and distal part of carpal crease (electrodes distance from center to center

Figure 1. Patient under low level laser irradiation

Figure 2. Patient under TENS application

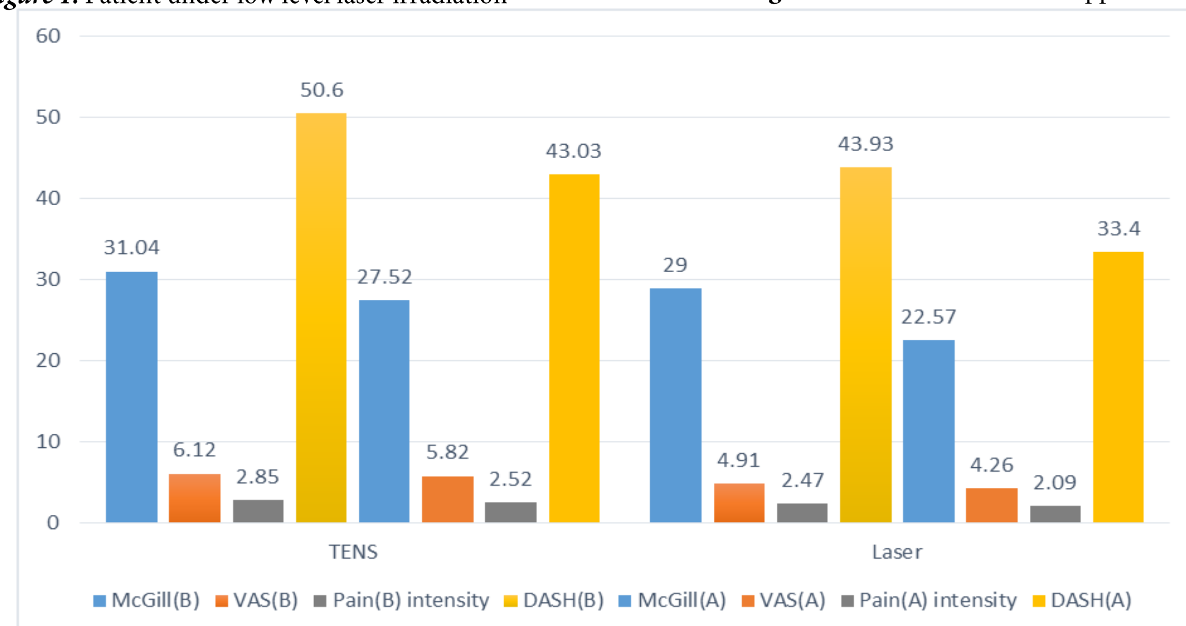

Figure 3. Mean value parameters before and after intervention in laser and TENS group

were 8 cm). All interventions, either for laser or TENS groups, were performed and repeated five sessions per week for a period of two weeks. At the end of the final treatment session, all patients completed the MPQ, VAS, and DASH questionnaires. All patients were treated by the same therapist. Four patients (two in each group) could not complete the treatment sessions because of personal reasons.

Statistical Analysis

Statistical analysis was performed with SPSS (version 18). Differences between scores before and after treatment were analyzed by paired t test in each group. The researchers also performed t test (Student t test) to identify differences between the groups (LLLT and TENS). Significant level was set as $P<0.05$.

Results

The demographic data for both groups are shown in table 1. The patients' demographic results showed that the mean age (SD) and mean BMI (SD) were approximately similar in both groups. As a result, the groups were considered homogeny and any differences might happen because of the identified interventions. There was also equal number of 12 patients (3 men and 9 women) for each group.

The mean difference and significant level of all paradigms (McGill, VAS, pain intensity and DASH scores) were shown in table 2. The mean difference analysis identified that much of pain outcome measures had improvement following interventions, while just laser irradiation helped the patients to get better function (*P*=0.001). Further analysis pointed out that mean changes for DASH score were better in laser group, but it was not statistically different from mean changes for DASH scores in TENS group. There were also no considerable differences in pain related outcome measures between the groups after interventions accomplishment (Tables 2 & 3) (Figure 3).

Discussion

In recent years, LLLT has been increasingly used to treat mild to moderate CTS. Previous studies (18-23, 25) that aimed to prove the efficiency of the LLLT had controversial outcomes. Comparatively, TENS is one of the usual treatment protocols clinically used for CTS treatment (18). Our results implied that pain parameters such as VAS, MPQ, and pain intensity decreased in both groups. Based on the analysis of the DASH scores, the hand functional level significantly (*P*=0.001) increased in the LLLT group while the TENS group showed no functional changes before and after the intervention. Some of the previous researchers reported different results. Irvin and his colleagues compared effects of Ga Al As laser with 60 mW output and 6 J/cm2 dosage with sham laser application on people with the CTS. These researchers reported degrees of improvement at both groups while there were no difference between laser and sham groups. These researchers did not obtain the LLLT effectiveness since they had not chosen the appropriate design. In brief, three reasons may have led to the different results of Irvin and his colleagues: number of patients (seven volunteers in each group), low power of laser irradiation (60 mW) and diameter of the laser probe (0.1 cm diameter) (19). Yagci and his colleagues also found no difference in clinical parameters when they used low power (30 mW) and lower treatment dosage 2.7 J/cm^2 (11). Barbosa et al. also showed no difference between laser and splint plus patient education; this might be because of the low power (30 mW), small treatment surface of 0.36 cm^2 and unusual 660 nm wavelength laser they had used (20). Tascigolu and colleagues also did not find any difference between laser and placebo methods as they used diode laser with small probe with 1 mm diameter and low treatment dosage 1.2 J (21). It has been shown that phototherapy increases local and systemic microcirculation, thereby, reducing swelling and pain (22).

The literature suggests that the therapeutic effects of the LLLT may be due to the following mechanisms: stimulated cellular ATP production by mitochondria (23), facilitated cellular oxygen consumption, anti-inflammatory effects (24), and improved blood circulation in the area of laser treatment (25). Former researchers identified that laser irradiation may stimulate nerve regeneration and also improve nerve conduction velocity following specific dosage application. These results support the idea that the LLLT may felicitate nerve recovery in compression syndromes such as the CTS (26). These effects will lead to greater acceptance of LLLT in the treatment of musculoskeletal disorders (27).

A few research works have discussed the optimal dosage and or other characteristics of laser (i.e., intensity, frequency, wavelength, and peak pulse) for various pathologic conditions (26). Further research with follow-up periods and comparisons with other treatment approaches are required to confirm the findings and to determine the most effective parameters or protocols for LLLT on CTS.

Conclusion

TENS application has low effect on pain reduction in low to moderate CTS, but the LLLT application may substantially decrease the level of pain and improve wrist function in these patients.

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Authors' contributions:
All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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