

Effectiveness of Low Level Laser in the Treatment of Carpal Tunnel Syndrome

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Summary:

Background: Carpal tunnel syndrome (CTS) is one of common peripheral nerve disorder which involves an entrapment neuropathy of the median nerve at the wrist which occurs either due to primary idiopathic cause or secondary to systemic causes. The diagnosis of CTS is clinical and supported by neurophysiological analysis. Surgical intervention is the main treatment modality.

Objective: The aim of the present study is to evaluate the effectiveness of low level laser therapy (LLLT) to treat mild – moderate CTS cases.

Pateients and methods: The study involves 60 symptomatic patients complaining of CTS were divided into two groups. Group A was subjected to real LLLT by Gallium – Arsenide (Ga-As) laser (904 nm), whereas group B was subjected to sham laser. Thirty asymptomatic normal individuals as group C were subjected to real LLLT in the same protocol as that applied to CTS cases. The individuals were evaluated clinically and by nerve conduction studies (NCSs) at early time as baseline reading and immediately after the treatment and later on after two weeks from stopping the treatment sessions.

Results: LLLT showed significant pain reduction (70.9%) and improved latency and amplitude studies for sensory (16.7% and 29%, respectively) and motor (18% and 26%, respectively) median nerve fibers in patients group who were exposed to real laser therapy in comparison to sham group but normal individuals showed significant increment in motor amplitude (12%) after completing therapy sessions. Conduction velocity and minimal F wave latency studies did not show significant changes in all study groups.

Conclusion: LLLT is proved to be an effective, easy, handy, relatively safe, and noninvasive treatment modality for idiopathic CTS of mild – moderate severity. Broadening the spectrum of wavelengths and changing the power density and energy doses and enrolment of cases which has already been treated surgically still a hopeful view of using LLLT in CTS treatment for further investigations.

Keywords: Carpal Tunnel Syndrome, Low Level Laser Therapy, Nerve Conduction Study, Visual Analogue Scale, Boston questionnaire.

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Introduction:

According to mechanical compression theory, compression of a peripheral nerve induces marked changes in intraneural microcirculation and nerve fiber structure, impairment of axonal transport, and alterations in vascular permeability, with edema formation and deterioration of nerve function 1. The most important target of hypoxia involves mitochondrial oxidative phosphorylation and adenosine tri-phosphate (ATP) production 2. In early or mild CTS, the median nerve has no morphological changes, and neurologic symptoms are intermittent. Prolonged increased pressure on the nerve results in segmental demyelination. The focal demyelination causes short segment conduction delay or conduction block across the site of entrapment. The prevalence has been estimated to 50 - 160 cases per 1000 subjects in the general population 3 and up to 500 cases per 1000 subjects in certain high risk groups 4. Patients typically complain of pain, tingling, and numbness

in the dominant hand affecting first three and a half digits in particular, and awakening them from sleep. Sensory findings on examination are typically limited to the distribution of the median nerve. Motor examination often reveals slight weakness of thumb abduction. Thenar muscle atrophy indicates axonal nerve injury in more advanced CTS. Symptom replication tests in Tinle's and Phalen's signs may assist in the clinical diagnosis of CTS by exacerbating or reproducing the symptoms reported by the patient. Mild symptoms of short duration are thought to be self-limiting and will often resolve with conservative measures otherwise operative treatment would be the last resort. Low level laser therapy (LLLT) is a kind of conservative modality and its effect is considered to be photobiologic rather than photothermal through increased proton electrochemical potential, more ATP synthesis, increased RNA and protein synthesis, an increase in oxygen consumption, membrane potential, and enhanced synthesis of reduced form of nicotineamide adenine dinucleotide (NADH) and ATP. This study is conducted to assess the therapeutic effect of low level laser therapy on carpal tunnel syndrome assessed by nerve conduction study of median nerve.

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Methods

Ninety individuals were enrolled in this study; 60 patients were diagnosed and referred with idiopathic carpal tunnel syndrome by specialists from Neurology clinic in Baghdad Teaching Hospital. The patients were subdivided randomly into two equal groups; first group was subjected to real laser therapy sessions and second group was subjected to sham laser (unreal laser) sessions where the laser machine probe applied over the same area for the same duration but the machine was switched off without patient's knowledge. Thirty normal individuals were selected according to similar inclusion criteria from normal people act as a control group (third group). They receive real laser therapy at the same region in the dominant hand in the same dose as the patients group and they were subjected to the same regime. The treatments regime consisted exposure to low level laser sessions for two successive weeks. Laser therapy session was given once a day, five days a week for two consecutive weeks. The assessment include clinical examination, visual analogue pain scale, symptom severity scale, functional status scale, and nerve conduction study were made prior to treatment, immediately after completing the tenth treatment session, and two weeks after the last session. Laser device Gallium – Arsenide semiconductor LLL instrument (Beam 904; Cosmogamma by emildue, Cento, Italy) emitted one light beam via laser diode probe placed directly along median nerve path over the transverse carpal ligament above 1 cm² grid divided into 15 points in direct skin contact. The operational wavelength was 904 nm in pulsed mode and of 200 nsec duration. Its output frequency was set to be 5000 Hz and the maximum output power 15 mW. The treatments were conducted by physical therapist over a course of 2 weeks for 15 min/session/day for 5 days a week.

Results

Mean \pm standard deviation for age of patients group which was (45 \pm 5.6) years and for control group it was (43.7 \pm 3.7) years. Male patients constituted 45% (27 cases) and female patients constituted 55% (33 cases). The average duration of symptoms was (6.5 \pm 1.4) months. Among patients group, 43 cases (71.7%) with mild degree and 17 cases (28.3%) with moderate degree of severity. All individuals were right handed and for the patients group, right hand involvement with CTS is an inclusion criterion. Individuals involved in this study were; manual worker, commonly house wives (28.3%), nurses (18.3%), and handyman worker (16.7%) According to visual analogue scale (VAS), pain perception reduced significantly after tenth real laser session (45.5 mm, 64%) and the reduction continued for two weeks later (50.4 mm, 70.9%) but no case showed complete disappearance of pain complain. The functional status score (FSS) revealed significant reduction of disability score after real laser session (4.5, 18.6%) and the reduction continued for two weeks later (5.4, 22.3%). Also, the symptom severity score (SSS) showed significant reduction after real laser session (12, 33.7%) and the reduction continued significantly (14, 39%) after stopping the laser therapy for two weeks. The duration of holding both hands in opposed flexion

position in Phalen's sign among real laser group was increased significantly as it showed increased records by 16 seconds (56.8% increment) after tenth laser session and the increment continued further by 41 seconds (144% increment) after two weeks.

Sensory NCS: After tenth real laser session, there was no significant reduction of latency (0.1 ms, 2.4%) and significant reduction of median – ulnar latency difference (0.5 ms, 31.3%). But after two weeks later, the reduction was significant for the latency (0.7 ms, 16.7%) and median – ulnar latency difference (0.7 ms, 43.8%). No significant changes were recorded among control and sham laser groups. No significant changes of amplitude and conduction velocity were recorded in any group but two weeks later, there was a significant increment in amplitude among CTS cases exposed to real laser sessions (5.5 μ V, 29%).

Motor NCS: After tenth session, the latency reduced by (0.5 ms, 10%) and median – ulnar latency difference were reduced by (0.8 ms, 40%) which was significant reduction among CTS cases exposed to real laser sessions and the reduction continued significantly (0.9 ms, 18%; 1.1 ms, 55%, respectively) after two weeks. Among control group, median – ulnar latency difference was reduced by (0.22 ms, 33.5%) after tenth session and reduced by (0.36 ms, 55.4%) which was significant reduction after exposure to real laser. CMAP amplitude showed significant changes in the groups which are exposed to real laser sessions as there was an increment by (2.3 mV, 20%) after tenth session and increment by (1.4 mV, 12%) two weeks later among control group. Also, among CTS cases exposed to real laser, the amplitude increased by (1.7 mV, 21%) after tenth session and increased by (2.1 mV, 26%) after two weeks from stopping laser therapy. Motor nerve conduction velocity showed no significant changes in the form of reduction over study stages among control and sham laser groups and increment among real laser group. No significant changes recorded for minimal F wave latency in all groups over study period.

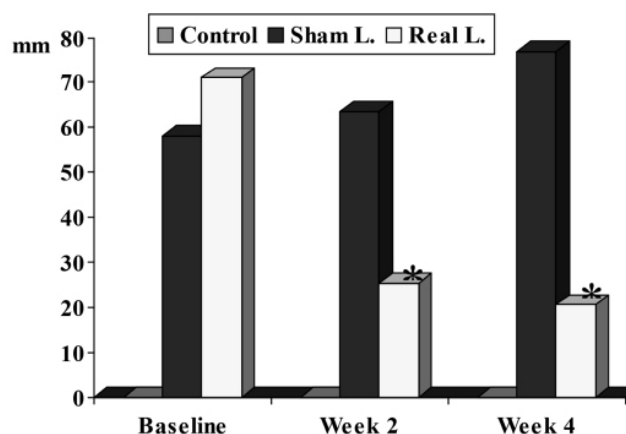


Figure 1: VAS over treatment stages among all study groups (*: significant change)

Table 1: Clinical data of study groups along study stages Minus sign (-) indicate increment reading

Variable	Study group	Baseline Mean \pm SD	Week 2 Mean \pm SD	P value 2 wk Vs. baseline	Week 4 Mean \pm SD	P value 4 wk Vs. baseline	One way ANOVA
VAS (mm)	Control (n = 30)	0	0	1	0	1	< 0.001
	Sham laser (n = 30)	58.3 \pm 6.9	63.6 \pm 4.9	0.08	77 \pm 5.3	0.05	
	Real laser (n = 30)	71 \pm 8.9	25.5 \pm 6.8 (*)	< 0.01	20.6 \pm 4.9 (*)	< 0.01	
Functional status score	Control (n = 30)	8 \pm 0	8 \pm 0	1	8 \pm 0	1	< 0.001
	Sham laser (n = 30)	27.7 \pm 3.6	27 \pm 4	0.9	28.5 \pm 3.5	0.8	
	Real laser (n = 30)	24.2 \pm 8.1	19.7 \pm 7.5 (*)	0.07	18.8 \pm 8 (*)	0.08	
Symptom Severity score	Control (n = 30)	11 \pm 0	11 \pm 0	1	11 \pm 0	1	< 0.001
	Sham laser (n = 30)	36.6 \pm 5	36.9 \pm 5	1	37.2 \pm 4.4	0.9	
	Real laser (n = 30)	35.9 \pm 5.2	23.8 \pm 3.7 (*)	< 0.01	21.8 \pm 2.8 (*)	< 0.01	
Phalen's sign time (sec.)	Control (n = 30)	120 \pm 38.9	130 \pm 33.9	0.9	125 \pm 18.5	0.9	< 0.001
	Sham laser (n = 30)	35.2 \pm 8.9	33.2 \pm 7.8	0.9	30 \pm 8.3	0.8	
	Real laser (n = 30)	28.7 \pm 12.6	45 \pm 13.8 (*)	< 0.01	70 \pm 17.8 (*)	< 0.01	

Table 2: Sensory parameters of median nerve (*: significant difference)

Variable	Study group	Baseline Mean + SD	Week 2 Mean + SD	P value 2 wk Vs. baseline	Week 4 Mean \pm SD	P value 4 wk Vs. baseline	One way ANOVA
SL (ms)	Control (n = 30)	1.8 \pm 0.25	1.7 \pm 0.13	0.6	1.6 \pm 0.16	0.3	< 0.001
	Sham laser (n = 30)	3.8 \pm 0.9	4 \pm 0.5	0.8	4.1 \pm 0.1	0.6	
	Real laser (n = 30)	4.2 \pm 0.2	4.1 \pm 0.15	0.5	3. \pm 0.13 (*)	0.01	
SNAP (uV)	Control (n = 30)	39.6 \pm 4.3	41.3 \pm 5.2	0.7	41.7 \pm 6.6	0.7	< 0.001
	Sham laser (n = 30)	17 \pm 5.5	16.1 \pm 3.8	0.8	15.7 \pm 4.2	0.8	
	Real laser (n = 30)	19 \pm 4.5	19.3 \pm 5.4	0.9	24.5 \pm 5.7 (*)	0.03	
SNCV (m/s)	Control (n = 30)	57.7 \pm 3.9	55.9 \pm 2.5	0.5	56.3 \pm 3.2	0.7	< 0.001
	Sham laser (n = 30)	40.5 \pm 0.9	39.9 \pm 1.1	0.5	39.5 \pm 0.4	0.1	
	Real laser (n = 30)	39.9 \pm 1.2	38.9 \pm 2.3	0.5	38.1 \pm 1.9	0.2	

Table 3: Median motor nerve fiber of the study groups (*: significant difference)

Variable	Study group	Baseline Mean + SD	Week 2 Mean + SD	P value 2 wk Vs. baseline	Week 4 Mean + SD	P value 4 wk Vs. baseline	One way ANOVA
DML (ms)	Control (n = 30)	2.5 \pm 0.3	2.1 \pm 0.2	0.1	2.2 \pm 0.1	0.2	< 0.001
	Sham laser (n = 30)	4.9 \pm 0.5	5.7 \pm 1.1	0.3	5.09 \pm 0.9	0.7	
	Real laser (n = 30)	5 \pm 0.8	4.5 \pm 0.4 (*)	0.02	4.1 \pm 0.1 (*)	0.01	

CMAP (mV)	Control (n = 30)	11.5 ± 2.2	13.8 ± 2.1 (*)	0.01	12.9 ± 1.9 (*)	0.02	< 0.001
	Sham laser (n = 30)	8.3 ± 1.5	7.9 ± 0.9	0.7	8 ± 0.7	0.8	
	Real laser (n = 30)	8 ± 0.6	9.7 ± 1.1 (*)	0.03	10.1 ± 0.6 (*)	0.01	
MNCV (m/s)	Control (n = 30)	58.4 ± 3.2	53 ± 3.2	0.1	55 ± 2.1	0.2	< 0.001
	Sham laser (n = 30)	41 ± 3.3	39.1 ± 2.2	0.4	40.5 ± 2.1	0.8	
	Real laser (n = 30)	47 ± 2.5	45 ± 3.2	0.4	44 ± 2.4	0.2	
Minimal F wave latency (ms)	Control (n = 30)	26.4 ± 2.5	25.9 ± 1.9	0.8	26 ± 1.7	0.8	< 0.01
	Sham laser (n = 30)	27.9 ± 1.6	28.7 ± 1.2	0.5	28.5 ± 1.9	0.7	
	Real laser (n = 30)	28.9 ± 0.9	29.1 ± 1.2	0.8	28 ± 1.6	0.4	

Discussion:

The present study showed significant improvement in subjective parameters represented by pain sensation and Boston questionnaire outcome improvement immediately after tenth session of real laser therapy and in contrast to that, those follow up parameters continued to deteriorate further among sham laser group despite the changes were not significant except that for pain sensation which showed increment to 32% after 4 weeks. The analgesic effect obtained in this study agreed with other studies 5 - 14. Regarding objective parameters, the present study showed that real laser therapy causes significant reduction in sensory latency (16.7%) and motor latency (18%) of median nerve after 4 weeks along with reduced median – ulnar nerve latency difference for sensory (43.8%) and motor (55%) studies. The improved NCS obtained in this study is consistent with other studies 8 – 10, 14 - 18 but Naeser (2002) reported no significant changes in NCS 16. The improvement in amplitude was consistent with studies 19. Control group who exposed to real laser sessions also showed significant reduction of median – ulnar motor latency difference (55.4%) and also there was significant increment of amplitude (12%) and all these changes were recorded immediately after tenth session and continued two weeks later and this will rule out placebo effect as explanation of subjective parameters. In contrast, patients exposed to sham laser continue to show further prolongation of latency records and further reduction in amplitude for sensory (5%) and motor studies (3.9%) despite they were not significant. For patients exposed to real laser, conduction velocity records showed no significant changes in the form of reduction for sensory (0.5%) and for motor (6.8%) studies. This is not consistent study by Yamany and Sayed (2011) 19 which showed significant improvement in conduction velocity of sensory and motor studies. Minimal

F wave latency study did not show any significant changes in any of the study groups.

Neurological effect: Low level laser modulates the inflammatory effects in injured tissue through altering the distribution of inflammatory cells, reduction of edema hemorrhage, and necrosis 13, 20, 21. Edema reduction would accelerate resolution of

inflammatory process. Low level laser promotes neural regeneration 22 even after crush injury or transaction 23. It prevents motor cell degeneration, induces Schwann cell proliferation and higher neural metabolism, with increasing myelination and axonal regeneration 24. Nerve recovery after irradiated with 904 nm LLLT increases the total number of large diameter axons 25 and enhances the regenerative processes of peripheral nerves 26.

Conclusions:

Low level laser therapy is effective therapeutic modality for mild – moderate cases of idiopathic carpal tunnel syndrome on clinical and neurophysiological backgrounds. It is feasible, handy, safe, and relatively cheap way of conservative treatment.

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