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Impact of high intensity laser therapy on post burn cubital tunnel syndrome

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Burns in upper extremity results in edema formation resulting in neural compression disorders such as Cubital tunnel. PURPOSE: The purpose of this study was to investigate the effect of high intensity laser therapy (HILT) on post burn cubital tunnel syndrome. Thirty patients with cubital tunnel syndrome were randomly assigned to a HILT group and placebo HILT group. The study was designed as a randomized clinical trial. Each participant in the two groups received 20 treatment sessions of HILT or placebo HILT therapy over a period of four consecutive weeks. Outcome measures were the visual analogue Scale (VAS) and nerve conduction study (NCS) measured pre and post treatment program. The present study revealed a statistically significant improvement ($P<0.05$) in nerve conduction velocity and pain level in Group A compared to Group High intensity laser yield improvement in ulnar nerve conduction velocity and pain relief in post burn patients suffering from cubital tunnel nutritional.

Keywords: Cubital tunnel syndrome, High intensity laser treatment, Visual analogue scale, Nerve conduction study.

INTRODUCTION

Significant morbidity in burn patients occurs frequently because of Post burn nerve entrapment syndromes. Nerve entrapment arises due to direct compression because of edema; they may also present due to scar tissue formation and/or heterotopic ossification. Mono neuropathies and entrapment syndromes have been observed following thermal injury and most often affect nerves under the area of the burn, and they are usually seen in patient with burn greater than 20% of total body surface area (TBSA) (Tamam et al., 2013 and Tu et al., 2017)

Burns of the forearm and elbow are associated with swelling, redness and pain. In second to third-degree burns, the eschar forms a tight band constricting the circulation distally and forms edema that leads to compression neuropathy of ulnar nerve. Also the hyper metabolic response of the burned patients, has been suggested as a cause of the peripheral neuropathies, as the basal metabolic rate (B.M.R) of the burned patients increase in excess of 2 to 2.5 times normal (Normal B.M.R. equals 40 ± 10 % C/m2/hr), which contributed to the excess of the circulating catecholamines, that increase the sympathetic tone in burned patients, leading to increased systemic vascular resistance, decreased cutaneous, muscular and endoneurial blood flow (Nerve blood flow) resulting in nerve function alterations (Vemula et al., 2004 and Lioyd et al., 2012).

Cubital tunnel syndrome (CUTS) is entrapment of ulnar nerve in the cubital tunnel. It is the second most common entrapment neuropathy of the upper extremity, after carpal tunnel syndrome. Incidence of cubital tunnel syndrome in the general population has been reported at 24.7 per 100,000. Populations at risk for cubital tunnel syndrome include patients with diabetes, obesity, as well as occupations involving repetitive elbow flexion and extension, holding tools in constant positions and using vibrating tools (Dawson, 1993, Idler, 1996 and Bartels, 2005).

Patients present with intermittent parasthesias, numbness and tingling in the small finger and ulnar half of the ring finger. As the disease progresses, the symptoms become constant and patients may complain of elbow pain around cubital tunnel, non-specific complaints of hand clumsiness or weakness and atrophy of the intrinsic hand muscles innervated by the ulnar nerve (Palmer and Hughes, 2010).

The diagnosis of nerve entrapment syndromes is mainly based on clinical findings combined with electrodiagnostic tests. Nerve conduction velocity shortly known as “NCV” tests are used to determine the velocity of the electrical signals moving along a specific peripheral nerve. The use of NCV tests permit physicians to distinguish between an injury that aroused in the myelin sheaths and an injury in the nerve axons (Hjermstad et al., 2011).

Visual Analogue Scale (VAS) measures acute and chronic pain and has been validated in several studies. A VAS comprises of a 10 cm line, with start and end points of no pain and the worst pain. A VAS may also have specific labels with intensity denoted by numbers or adjectives and these are referred to as Graphic Rating Scales (GRS) (Hjermstad et al., 2011).

High Intensity Laser Therapy (HILT) is a recent rehabilitation therapy successfully used in orthopedic diseases and sports medicine, due to its fast efficacy, with rapid and permanent relief of pain and the resulting reduction of the recovery time. The most important physiological effects of HILT are increase in the activity of many intracellular enzymes, specifically in the Krebs cycle, increase of oxygen transportation and also, of glucose utilization, stimulation of DNA synthesis, activation of the Na/K membrane pumps, increase of fibroblast activity, increase of phagocytosis activation, activation of metabolic cellular processes, local changes in some important inflammation mediators (such as histamine and prostaglandins) and in endorphin levels. The most important clinical effects are analgesia and biostimulation (Fortuna et al., 2002, Dhavalikar et al., 2009 and Junior et al., 2009).

The analgesic effect is produced by high-power pulsed applications, which create inside the body photomechanical waves that reach the subcutaneous pain receptors, stimulate the A fibers and close the gate for pain transition (according to the gate control theory described by Melzack). The biostimulation effect is the ability to bio stimulate cell growth and cell repair (Santamato et al., 2009, Pryor, 2011 and Prouza et al., 2013).

Considering the reported effectiveness of HILT in the treatment of pain, the aim of the current study was to investigate the effect of High intensity laser on post burn sulcus ulnaris syndrome.

MATERIALS AND METHODS

This was a randomized controlled trial Ethical approval was obtained from the institutional review board at faculty of physical therapy, Cairo University before study commencement.

Subjects

Convenient samples of thirty patients from both sexes diagnosed with unilateral cubital tunnel syndrome (moderate degree) were enrolled in this study, their age ranged from 20 to 40 years (Qing et al., 2014).

The patients were randomly divided into 2 groups of equal number; Group (A) contained 15 post burn cubital tunnel syndrome patients who received a medical treatment (Nonsteroidal anti-inflammatory drugs and Vitamin B12) in addition to HILT, while Group (B) contained 15 post burn cubital tunnel syndrome patients who received same medical treatment as Group (A) without HILT.

Participants with factors resulting in symptoms similar to cubital tunnel syndrome such as diabetes, arthritis, fluid retention in pregnancy, hyperthyroidism, traumatic changes, and prior injury to the elbow were excluded from the study.

Patients were evaluated at base line before treatment and after completion of treatment using Neuropack S1 MEB-9004 NIHON KODEN, JAPAN for measuring the motor conduction velocity of the ulnar nerve across elbow.

Visual analogue scale was used to measure pain on a 10 cm horizontal axis between a left end point of “no pain “and a right end point of “worst pain ever”. The distance was measured and pain was recorded on a zero-point scale (Hjermstad et al., 2011).

Procedures:

A brief explanation about the EMG machine and the protocol of the ulnar nerve motor conduction velocity were introduced to the patients, and then each subject signed a consent form before the beginning of the NCV measurement. Subjects were asked to remove any metallic objects to avoid any interference. Skin of the subjects at the areas of recording electrodes were positioned in a comfortable manner, then it was scratched by a disposable razor (vertical position) and secondly cleaned by alcohol, while the areas of stimulation were only cleaned using alcohol. Massage was applied to the upper limb in which the NCV measurement was done by a deep stroking (effleurage) maneuver to eliminate the temperature related variability (Landau and Campbell, 2013).

Ulnar nerve conduction velocity protocol:

The subjects were in a relaxed sitting position on a chair and the forearm supported on the plinth. Earth electrode was applied around the wrist level in motor conduction velocity. Recording motor electrode was applied, negative electrode on the center of the corresponding abductor digiti minimi muscle and the positive electrode on the tip of the little finger (Landau and Campbell, 2013).

The ulnar nerve was stimulated at four sites for each of the five angles of elbow joint: At wrist level just above the wrist joint on the ulnar border (CV1), below the elbow joint (CV2), above elbow located behind and above the medial epicondyle (CV3), at axilla (CV4) (Choi et al., 2017).

Measurement was done through the distance between distal and proximal stimulation to calculate conduction velocity of the ulnar nerve to ensure that the conduction velocity is normal. Nerve conduction velocity was calculated by the following formula: (Kim et al., 2015)

$$\text{Conduction velocity (Meter/Second)} = \frac{\text{Distance (cm)} \times 10}{\text{Proximal latency} - \text{Distal latency}}$$

Parameters:

Treatment protocol:

A standard hand piece endowed with fixed spacers was used to provide the same distance to the skin and perpendicularly to the zone to be treated with a laser beam diameter of 5 mm. Three phases of treatment were performed for every session. The total energy that was delivered to the patient during one session was 1275 J through three phases of treatment

The first phase involved fast manual scanning (100 cm2 per 30 s) around medial epicondyle and flexor muscles extending over forearm from medial epicondyle. Scanning was performed in both transverse and longitudinal directions. In this phase, a total energy dose of 625 J was administered. In the first phase, the laser fluency was set to three sub phases of 510 mJ/cm2 (208 J), 810 mJ/cm2 (208 J), and 970 mJ/cm2 (209 J), for a total of 625 J.

The second phase involved applying the hand piece with fixed spacers vertically to 90° on CFT near the medial epicondyle (trigger point inactivation phase). The second phase was carried out on CFT with a frequency of 360 mJ/cm2 (6 J), 510 mJ/cm2 (9 J), and 610 mJ/cm2 (10 J) and a time of 6 s at each time, for a total of 25 J (Table1).

Table 1: High intensity laser parameters used for Group (A) (Ibrahim Zoheiry and El Missiry, 2017).

Wave length:	**1064 nm**
Peak power	3 kW
Energy density:	360-1780 mJ/cm^2
Duration	120-150 Ms
Mean Power	10.5 w
Frequency	10-40 Hz
Duty cycle	0.1%
Probe diameter	0.5 cm
Spot size	0.2 cm^2
Total energy delivered to the patient during one session	1275 J.

The third phase involved slow manual scanning (100 cm2 per 60 s) of the same areas treated in the first phase until a total energy dose of 625 J was achieved. The application time for one session was approximately 15 min with the total energy delivered to the patient during one session of 1275 J.

The energy received in each phase and the device will calculate the total energy delivered to the patient during the treatment session. The same physiotherapist performed all laser applications. The frequency of treatment: Treatment was given five times / week for 20 sessions.

Statistical analysis:

Statistical analysis was conducted using SPSS for windows, version 20 (SPSS, Inc., Chicago, IL). Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed for nerve conduction velocity, so parametric statistical tests in the form of (paired t test) was used to compare between "pre" and "post" treatment for each group and "unpaired t test" was conducted to compare nerve conduction velocity between both groups in the “pre” and “post” treatment. While, normality test of data using Shapiro-Wilk test was used, that reflect the data was not normally distributed for pain level, so non parametric statistical tests in the form of (Wilcoxon Signed Rank tests) was used to compare between "pre" and "post" treatment for each group and "Mann-Whitney tests" was conducted to compare pain level between both groups in the “pre” and “post” treatment. The alpha level was set at 0.05.

RESULTS

Baseline and demographic data:

There were no statistically significant differences (P>0.05) between subjects in both groups concerning age and BMI (Table 2).

Regarding within group's comparison, statistical analysis using "Paired t test" revealed that there was a significant increase in nerve conduction velocity at post treatment in compare to pre-treatment at both groups with ($p < 0.05$). (Table 3) presents descriptive statistic (mean±SD) and comparison tests (within and between groups) for nerve conduction velocity. Considering the effect of the tested group (first independent variable) on nerve conduction velocity, "unpaired t test" revealed that there was significant difference between both groups at post treatment ($p<0.05$) and this significant increase in favor to group A.

Pain level:

Regarding within group's comparison, statistical analysis using Wilcoxon Signed Rank tests revealed that there was a significant reduction in pain level at post treatment in compare to pre-treatment at both groups with ($p < 0.05$). (Table 4) presents descriptive statistic (median) and comparison tests (within and between groups) for pain level. Considering the effect of the tested group (first independent variable) on pain level, "Mann-Whitney U test" revealed that there was significant difference between both groups at post treatment ($p<0.05$) and this significant reduction in favor to group A.

Table 2: Physical characteristics of patients in both groups.

Items	Group A	Group B	Comparison	
	Mean ± SD	Mean ± SD	t-value	P-value
Age (yrs.)	28.06±2.28	28.4±3.20	-0.328	0.745
BMI (Kg/m^2)	23.26±0.40	23.11±0.44	0.942	0.354

*SD: standard deviation, P: probability, S: significance, NS: non-significant.
Nerve conduction velocity:

Table 3: Mean ±SD and p values of nerve conduction velocity pre-treatment and post treatment test at both groups.

Nerve conduction velocity	Means ± SD Pre test	Means ± SD Post test	Mean difference	% of improvement	t-value	P- value
Group A	43.91±2.18	55.77±1.35	-11.86	27	-32.54	0.0001*
Group B	43.88±2.19	44.62±2.17	-0.74	1.68	-7.351	0.0001*
Mean difference	0.03	11.15				
t-value	0.038	16.879				
P- value	0.97	0.0001*				

*Significant level is set at alpha level <0.05.

Table 4: Median, U, Z, and p values of pain level pre and posttest at both groups.

Pain level	Pre- test Median	Post- test Median	Z-value	p- value
Group A	6	1	-3.501	0.0001*
Group B	6	3	-3.473	0.001*
U-value	112.5	1		
Z-value	0.000	-4.735		
p- value	1.00	0.0001*		

DISCUSSION:

The main findings in the present study were that HILT has a significant effect in decreasing pain and improving ulnar nerve conduction velocity in post burn cubital tunnel syndrome.

Studies reported that HILT is effective in reducing the musculoskeletal pain without any adverse effects or histological risk. The high power (3KW) of HILT with a 1,064 nm wavelength is able to penetrate the deeper layer (up to 5 cm) leading to a diffusion of laser energy more than the LLLT (1–3 cm). The low frequency (30 Hz), high power emissions with very short pulse duration of HILT is postulated to have a more penetrating effect (Dundar et al., 2015, Kim et al., 2015 and Choi et al., 2017).

Neuropack S1 MEB-9004 NIHON KHODEN, Japan, had done nerve conduction velocity study. NCS is used as a standardized testing tool for diagnosis of cubital tunnel syndrome due to its objectivity in providing information on the physiological health of the ulnar nerve across the cubital tunnel. The standard diagnosis technique is comparing the motor conduction velocity of the ulnar nerve across the elbow joint (Mallik and Weir, 2005).

Pain was evaluated before and after treatment for the two groups using the visual analogue scale The VAS will be to measure pain on a 10 cm horizontal axis between a left end point of “no pain “and a right end point of “worst pain ever”. The distance is measured and pain is recorded on a zero-point scale Visual analogue scale is valid and reliable tool in evaluation of pain (Hjermstad et al., 2011).

Concerning nerve conduction velocity, group A showed improvement in conduction velocity which can be explained by increase in the activity of many intracellular enzymes, specifically in the Krebs cycle, increase of oxygen transportation and glucose utilization, stimulation of DNA synthesis, activation of the Na+/K+ membrane pumps, increase of fibroblast activity. All of these effects contribute to better transmission of nerve impulse in addition to improvement in nerve physiological properties, which reflect on nerve conduction velocity.

HILT can also affect healing and regeneration of peripheral nerves indirectly through two mechanisms, the first mechanism focuses on reducing endoneural edema through enhancement of lymphatic drainage while the second mechanism focuses on restoring normal vascular permeability, improving perineural microcirculation and improve drainage of intrafascicular space.

Our findings were supported by (Alayat et al., 2014) who investigated efficiency of HILT and

LLLT on Bell's palsy, their results showed significant difference in favor of HILT as it has more penetration and higher intensity which allow better absorption rate leading to increased mitochondrial oxidative reaction, ATP, DNA and RNA production, all of these physiological effects lead to enhanced rate of facial nerve recovery (Rochkind et al., 1990).

Further explanation was presented by (Rochkind et al., 1990) who studied influence of laser therapy on peripheral nerve injuries in rats, they reported that Laser promote proliferation of glial cells in both astrocytes and oligo denderocytes. This leads to higher neuron metabolism and better myelin production, which in turn improves nerve conduction velocity (Rochkind et al., 1990).

In the present study, group (A) showed more significant improvement than group (B) in regards to pain relief which can be explained by HILT analgesic effect produced by high power pulsed applications that create photomechanical waves and thus reach subcutaneous pain receptors, HILT can also stimulate A fibers and close pain gate resulting in pain relief. Production of endorphine and enkephaline in response to HILT helps in elevation of pain threshold. In addition, we can postulate that HILT can control inflammatory process, which leads to indirect relief of pain.

Our results were supported by (Rochkind et al., 1990) who highlighted the efficiency of High intensity laser therapy on pain gate through stimulation of A fibers. Further explanation was shown by (Dundar et al., 2015) performed a study to investigate effect of HILT on lateral epicondylitis while comparing it with brace and sham laser. They found out that HILT showed significant difference in controlling pain and inflammation as it managed to slow down pain impulses and increased production of morphine-mimetic substances in the body.

A study by (Ebid and El-Sodany, 2015) came into agreement with our results as they assessed the long-term effect of pulsed high intensity laser therapy (HILT) in the treatment of the postmastectomy pain syndrome (PMPS), after 4 weeks of HILT they reported that pain decreased significantly when compared to placebo group (Ebid and El-Sodany, 2015).

CONCLUSION

The current study concluded that High intensity laser leads to improvements in ulnar nerve conduction velocity and pain relief in post burn patients suffering from cubital tunnel which can be explained by anti-inflammatory and biostimulation properties of HILT as well as better penetration depth and absorption rate.

CONFLICT OF INTEREST

Authors declare no potential conflicts of interests.

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AUTHOR CONTRIBUTIONS

IMIZ proposed the research idea and design, performed the practical part, and helped in writing the manuscript. ES, HAH and AEK designed the experiment, performed the statistics, writing and reviewing the manuscript. All authors read and approved the final version.

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