

# EXTRACORPOREAL SHOCKWAVE THERAPY FOR POST BURN CARPAL TUNNEL SYNDROME

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## ABSTRACT

**Background:** Carpal tunnel syndrome is considered the most common compression neuropathy of the upper extremity. It may lead to work disability and functional impairment. Burns are associated with swelling and eschar which forms a tight band constricting the circulation distally.

**Purpose:** To investigate the effect of shockwave therapy on the carpal tunnel syndrome post burn.

**Subjects:** Thirty male and female patients selected with manifestation of carpal tunnel syndrome post burn evaluated by electromyography, patients were divided randomly into two equal groups (A & B); group (A) received shockwave therapy plus traditional physical therapy, while group (B) received only traditional physical therapy (heating and stretching); Shock wave therapy protocol was two sessions per week for 12 weeks. Traditional physiotherapy was applied for both groups, 20 min for session 3times per week for 12 weeks.

**Evaluation:** Electro diagnostic evaluation was done before treatment, one and three months post treatment.

**Results:** There were improvement and significant increase in motor and sensory conduction velocities in shockwave group compared to those in the control group ( $p < 0.05$ ), also there were improvement and significant decrease in motor and sensory latencies in shockwave group compared to those in control group ( $p < 0.05$ ).

**Conclusion:** Extracorporeal shockwave therapy provided a non-invasive, satisfied treatment option for carpal tunnel syndrome post burn.

**KEY WORDS:** Shockwave therapy, Carpal tunnel Syndrome, Post Burn.

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## INTRODUCTION

Carpal tunnel syndrome (CTS) results from compression of median nerve at wrist with the carpal tunnel boundary and is considered the most common entrapment neuropathy in the upper extremity. It may lead to work disability and functional impairment for many people. The typical symptoms are often nocturnal pain, paresthesia, hypoesthesia, and loss of function [1].

The most common cause of CTS is a congenital predisposition, other contributing factors include stressful work, trauma, injury, endocrine disorders, joint deformities, fluid retention, and the development of any space occupying lesions in the tunnel [2]. In burn cases, the reported causes of CTS are increased volume of carpal tunnel content due to edema and synovitis, wrist hyperextension, tight dressing, fibrosis, and direct burn to the nerve [3].

Median nerve is more affected than the ulnar nerve among patients with wrist burn [4] The development of CTS following burns is common and usually due to thermal burns, owing to excessive edema in circumferential burns, extensive metabolic and inflammatory changes occur in response to burns [5].

The resolution of symptoms and the preservation of hand function are goals of treatment for carpal tunnel syndrome. Treatment includes conservative and surgical treatment. Conservative therapies include anti-inflammatory drugs, vitamins and physiotherapy [6]. The physiotherapeutic modalities used in CTS treatment include; exercises, wrist splints, therapeutic ultrasound, activity or ergonomic modification, laser therapy, chiropractic treatment and magnetic therapy [7].

Extracorporeal shockwaves are defined as sequence of single sound impulses characterized by a high-pressure peak (100 MPa) and quick pressure rise in a short duration (10 ms). Produced by an appropriate generator, and focused on a specific area [8]. In the last 20 years shockwave (SW) therapy had been successfully used to treat a variety of orthopedic diseases such as pseudo arthrosis, tendinopathy and muscle trauma [9].

## MATERIALS AND METHODS

**Subjects:** This study included 30 post burn patients in post hospitalization period (17 females and 13 males). They were selected from outpatient clinic of burn in Kasr Alini and Om Al Masrieen Hospitals. Study was conducted from June 2012 till July 2013.

**Inclusive criteria:** All patients had the following characteristics; their ages ranged between 20 and 35 years, they had upper limb burn with the percentage of the total body surface area ranging from 20 % to 25 % and diagnosed as a 2<sup>nd</sup> or 3<sup>rd</sup> degree burn complicated with carpal tunnel syndrome and the diagnosis was confirmed by using electroneurographic (ENG) examination as well as by using physical examination which included Tinel's test and Phalen's test. All patients were nonsmokers and were under own prescribed medications described by their physicians.

**Exclusive criteria:** Patients with a history of double crush syndrome, distal radius fracture, wrist fracture, cervical radiculopathy, fibromyalgia, diabetes mellitus, skin diseases and peripheral vascular diseases were excluded from the study. The approval for this study was obtained from the ethical committee of Faculty of Physical Therapy Cairo University; all participants signed an informed consent form prior to the study.

### Study Design and Intervention

**Design:** The study design was a randomized controlled trial as patients were randomly distributed into two equal groups; study group and control group.

**Treatment:** In study group, each patient received ESWT through using ESWT device (MASTERPULS MP200, Storz Medical, Tägerwilten, Switzerland) in addition to traditional physical therapy. ESWT protocol: Patient in relaxed sitting and his forearm is placed on the table with the palm facing up, ESWT device probe was oriented perpendicular on the thenar and hypothenar area and ultrasound gel was used as a coupling agent, the protocol parameters were : 1000 shocks at a frequency of 6 Hz and energy level of 1.5 bars [8]. The protocol consisted of two sessions per week, up to 12 weeks. While received traditional physical therapy consisted of 10 minutes hot pack around wrist and forearm and 10 minutes of gentle stretching exercises for wrist joint, 3 sessions /week/12 weeks. In control group, patients received only traditional physiotherapy 3 sessions per week up to 12 weeks.

**Assessment:** Electro diagnostic assessment for median nerves in post burned hands included: assessment of; motor conduction velocity; (2 levels of stimulations at elbow and at wrist), sensory conduction velocity, distal motor latency and distal sensory latency. All assessments were done by the same evaluator. The MYTO-PRO machine, digital multifunction system EMG, (EBNeuro Company, Florence, Italy ) was used for assessment. Measurements were performed before treatment, one month and three months after treatment.

**Statistical procedure:** The parametric variables obtained from electrodiagnostic study were

analyzed using SPSS v.16 as repeated measures ANOVA test was used to compare values within group and unpaired t test was used to compare values between groups. The level of significance was  $< (0.05)$ .

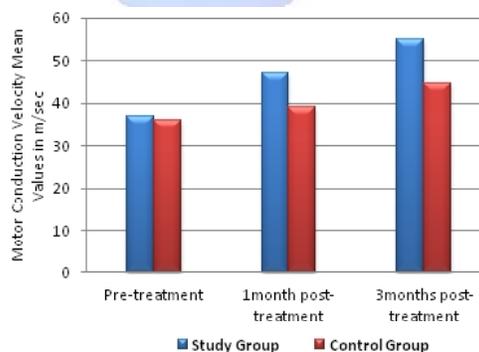
## RESULTS AND TABLES

Clinical and demographic characteristics of patients as shown in table 1 revealed that; Mean value of age for study group was  $(28.40 \pm 5.45)$  years while it was  $(28.33 \pm 5.09)$  years for control group. BMI mean value was  $(25.6 \pm 3.30)$  kg/m<sup>2</sup> for study and it was  $(29.1 \pm 6.60)$  kg/m<sup>2</sup> for control also the table showed that; CTS duration mean value was  $(2.20 \pm 0.70)$  months for study group and it was  $(1.96 \pm 0.70)$  months for control, in both groups TBSA ranged from 15% to 20% and degree of burn ranged from 2<sup>nd</sup> to 3<sup>rd</sup> degree, 80% of hands affected in study group was dominant for 73.3% in control group, while 20 % of hands affected was non dominant in study group for 26.7% in control group. The two groups did not differ significantly ( $P > 0.05$ ) at baseline regarding demographic, clinical characteristics.

**A. Results of Motor Conduction Velocity (MCV)** (meter/sec): Analysis of MCV results within both groups using repeated measures ANOVA revealed that; there was highly sequential increase in motor conduction velocity throughout assessment phases and there were a highly significant differences in the mean values of the MCV within each group as  $p = (0.00001)$  for both, and LSD test results revealed that, there were high significance differences in mean values between; (pre-treatment vs 1 month

post-treatment), (1 month vs 2 months post treatment) and (pre-treatment vs 3 months post-treatment) as  $p = (0.00001)$  for all measures in both groups. Analysis of MCV results between two groups using unpaired t-test revealed that; there was no significant difference between two groups at pre-treatment phase as the MCV mean value was  $(37.1 \pm 1.93)$  meter / sec for the study group and it was  $(36.07 \pm 2.00)$  meter/ sec for the control group and  $p = (0.161)$ , while there was a highly significant difference between two groups, one month post treatment as MCV mean value was  $(47.0 \pm 2.93)$  meter / sec for the study group and it was  $(39.26 \pm 2.13)$  meter / sec for the control group and  $p = (0.00001)$ , also there was a highly significant difference between the two groups, three months post treatment as MCV mean it was  $(55.0 \pm 2.4)$  meter / sec for study group and it was  $(44.53 \pm 1.8)$  m/ sec for control group and  $p = (0.00001)$ , these results are shown in table 2 and figures 1&2.

**Fig. 1:** Mean values of motor conduction velocity (m/sec) of median nerve between groups.



Characteristic	Study group	Control group	P value
Age (mean± SD)	28.40 ± 5.45	28.33 ± 5.09	>(0.05)
( kg/cm <sup>2</sup> )BMI	25.6 ± 3.30	29.1 ± 6.60	>(0.05)
Female/Male	8/7	9/6	
CTS duration (M) (month)	2.20±0.70	1.96±0.70	>(0.05)
TBSA	15%-20%	15%-20%	
Degree of burn	2 <sup>nd</sup> -3 <sup>rd</sup>	2 <sup>nd</sup> -3 <sup>rd</sup>	
Dominant hand	12 (80%)	11 (73.3%)	>(0.05)
Non-Dominant hand	3 (20%)	4 (26.7%)	

**Table 1:** Clinical characteristics of burned patients with carpal tunnel syndrome.

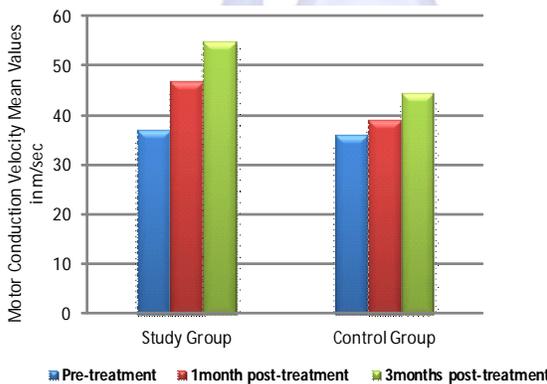
BMI: body mass index, CTS: Carpal Tunnel Syndrome, M: month, TBSA: Total Body Surface Area.

Group	Study group	Control group	P value between groups
Pre-treatment	37.1±1.93	36.07 ± 2.0	0.161
1 month post-treatment	47.0± 2.93	39.26 ±2.13	0.00001
3 months post-treatment	55.0±2.40	44.53 ± 1.8	0.00001
P value within group	0.00001	0.00001	
LSD test	(0.00001) <sup>(1,2)(2,3)(1,3)</sup>	(0.00001) <sup>(1,2)(2,3)(1,3)</sup>	

**Table 2:** Comparison of MCV mean values between groups as well as within each group.

(1): Pre-treatment, (2):1 month post-treatment, (3): 3 months post-treatment, LSD: Least Significant Difference, (1,2): (1) vs.(2), (2,3):(2) vs.(3), (1,3):(1) vs.(3).

**Fig. 2:** Mean values of motor conduction velocity (m/sec) of median nerve within groups.



**B. Results of Sensory Conduction Velocity (SCV) (meter/sec):** Analysis of SCV results revealed that; there was highly sequential increase in sensory conduction velocity (SCV) throughout assessment phases and there was a highly significant difference in the mean values of the SCV within study group as p=(0.00001) and there was a significant difference in the mean values of the SCV within control group as p=(0.027), and LSD test results revealed that; there were high significance differences in mean values between; (pre-treat

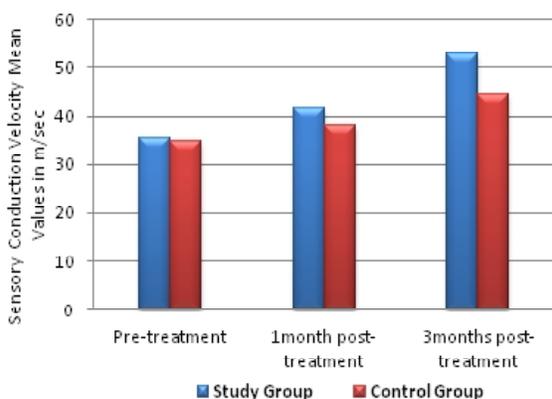
ment vs 1 month post-treatment), (1 month vs 2 months post-treatment) and (pre-treatment vs 3 months post-treatment) as p =(0.003), (0.00001), (0.00001) respectively in control group and it was (0.00001) for all measures in study group. Also results revealed that; there was no significant difference between the two groups at pre-treatment phase as the SCV mean value was (35.57±3.93) meter/sec for the study group and it was (34.74±4.12) meter/sec for the control group and p=(0.604),while there was a highly significant difference between the two groups, one month post treatment as the SCV mean value was (41.46 ±3.53) meter/sec for the study group and it was (38.23±1.64) meter/sec for the control group and p=(0.006), also there was a highly significant difference between the two groups, three months post treatment as the SCV mean was (52.7±5.75) meter/sec for the study group and it was (44.46±2.3) meter/sec for the control group and p=(0.00001), these results are shown in table 3 and figures 3&4.

Group	Study group	Control group	P value between groups
treatment	35.57± 3.93	34.74±4.12	0.604
1 month post-treatment	41.46±3.53	38.23±1.64	0.006
3 months post-treatment	52.7±5.75	44.46±2.3	0.00001
P value within group	0.00001	0.027	
LSD test	(0.00001) <sup>(1,2),(2,3)(1,3)</sup>	(0.003) <sup>(1,2)</sup> ,(0.00001) <sup>(2,3)(1,3)</sup>	

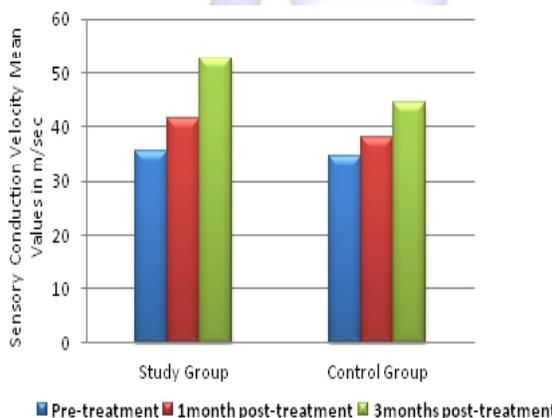
**Table 3:** Comparison of SCV mean values between groups as well as within each group.

(1):Pre-treatment, (2):1 month post-treatment, (3): 3 months post-treatment, LSD: Least Significant Difference, (1,2): (1) vs.(2), (2,3):(2) vs.(3), (1,3):(1) vs.(3).

**Fig. 3:** Mean values of sensory conduction velocity (m/sec) of median nerve between groups.



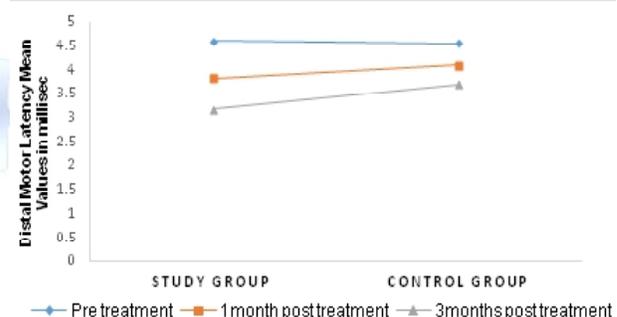
**Fig. 4:** Mean values of sensory conduction velocity (m/sec) of median nerve within groups.



**C. Results of Distal Motor Latency (DML) (millisecond):** Analysis of DML results revealed that; there was highly sequential decrease in distal motor latency throughout assessment phases and there was a highly significant difference in the mean values of the DML within groups as  $p=(0.00001)$ , and LSD test results revealed that , there were high significance differences in mean values between; (pre-treatment vs 1 month post-treatment), (1 month vs 2 months post-treatment ) and (pre-treatment vs 3 months post-treatment) as  $p =0.00001$  for all

measures in both groups. There was no significant difference between the two groups at pre-treatment phase as the DML mean value was  $(4.61\pm1.86)$  millisecond for the study group and it was  $(4.56\pm0.24)$  millisecond for the control group and  $p=(0.53)$ , while there was a highly significant difference between the two groups after one month of treatment as the DML mean value was  $(3.83\pm0.16)$  millisecond for the study and it was  $(4.1\pm0.3)$  millisecond for the control group and  $p=(0.008)$ , also there was a highly significant difference between the two groups after three months of treatment as DML mean value was  $(3.18\pm1.77)$  millisecond for study group and it was  $(3.7\pm0.21)$  millisecond for control group and  $p=(0.00001)$ , these results are shown in in table 4 and figure 5.

**Fig. 4b:** Mean values of DML (msec) of median nerve between groups and within each group.



**D. Results of Distal Sensory Latency (DSL) (millisecond):** Analysis of DSL results revealed that; there was sequential decrease in distal sensory latency throughout assessment phases and there was a highly significant difference in the mean values of the DSL as  $p=(0.00001)$  within the study group while p value within the control group was  $(0.003)$ , and LSD test results revealed that ,there were significant differences in mean

Group	Study group	Control group	P value between groups
Pre-treatment	4.61±1.86	4.56±0.24	0.53
1 month post-treatment	3.83 ±0.16	4.1± 0.3	0.008
3 months post-treatment	3.18±1.77	3.7±0.21	0.00001
P value within group	0.00001	0.00001	
LSD test	(0.00001) <sup>(1,2)(2,3)(1,3)</sup>	(0.00001) <sup>(1,2)(2,3)(1,3)</sup>	

**Table 4:** Comparison of DML mean values between groups as well as within each group.

(1):Pre-treatment, (2):1 month post-treatment, (3): 3 months post-treatment, LSD: Least Significant Difference, (1,2): (1) vs.(2), (2,3):(2) vs.(3), (1,3):(1) vs.(3).

values between; (pre-treatment vs 1 month post-treatment), (1 month vs 2 months post treatment) and (pre-treatment vs 3 months post-treatment) as  $p = (0.049), (0.003), (0.00001)$  respectively in control group, while it was  $(0.00001)$  for all measures in study group. Analysis of DSL results between the two groups revealed that; there was no significant difference between the two groups at pre-treatment phase as the DSL mean value was  $(4.7 \pm 0.66)$  millisecond for the study group and it was  $(4.8 \pm 0.58)$  millisecond for the control group and  $p = (0.9)$ , while there was a highly significant difference between the two groups after one month of treatment as the DSL mean value was  $(4.01 \pm 0.4)$  millisecond for the study group and it was  $(4.47 \pm 0.65)$  millisecond for the control group and  $p = (0.041)$ , also there was a highly significant difference between two groups after three months of treatment as the DSL mean value was  $(3.12 \pm 0.3)$  millisecond for the study group and it was  $(3.7 \pm 0.53)$  millisecond for the control group and  $p = (0.002)$ , these results are shown in table 5 and figure 5.

## DISCUSSION

Pre-treatment EMG evaluation in this study revealed that there were slow nerve conduction and long latencies in all patients and this consistency with the following: systemic reaction to cutaneous burn involves a shift in the distribution of fluids and electrolytes that affect peripheral nerve conduction velocity<sup>(10,11)</sup>. The release of large molecules from damaged cells increases interstitial oncotic pressure and stimulates fluid loss, leading to edema formation [12,13]. Cytokines have been shown to increase vascular permeability and/or the production of nitric oxide, which contribute to burn induced neuropathy [14,15].

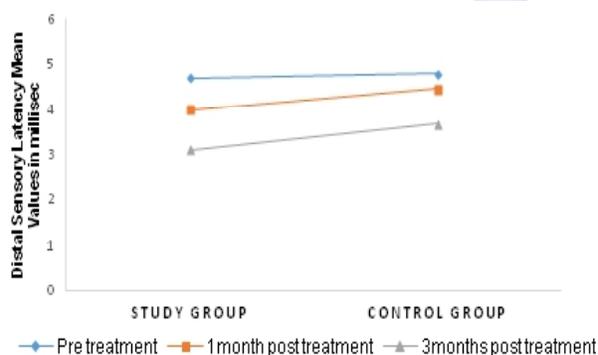
The pathophysiology in entrapment neuropathies is focal (Segmental) demyelination with secondary axonal degeneration as severity of compression increases [16]. According to studies with experimental animal models of burn, electro diagnostic studies showed that motor and sensory conduction velocities were significantly reduced after the burn and morpho-

Group	Study group	Control group	P value between groups
Pretreatment	4.7± 0.66	4.8±0.58	0.9
1 month post treatment	4.01±0.4	4.47±0.65	0.041
3 months post treatment	3.12±0.3	3.7±0.53	0.002
P value within group	0.00001	0.003	
LSD test	$(0.00001)^{(1,2),(2,3)}$	$(0.049)^{(1,2)}, (0.003)^{(2,3)}$ $(0.00001)^{(1,3)}$	

**Table 5:** Comparison of DSL mean values between groups as well as within each group.

(1):Pre-treatment, (2):1 month post-treatment, (3): 3 months post-treatment, LSD: Least Significant Difference, (1,2): (1) vs.(2), (2,3):(2) vs.(3), (1,3):(1) vs.(3).

**Fig. 5:** Mean values of DSL (m sec) of median nerve between groups and within each group.



-logical evaluation identified that the mean caliber of large axons was significantly decreased [17,18]. Functional and morphological deficits were produced in peripheral nerve axons after burn [19]. In this study, analysis of EMG results within study group using repeated measures ANOVA revealed that; there was highly significant increase in motor conduction velocity mean value (MCV) as well as in sensory conduction velocity mean value (SCV) after treatment as  $p = (0.00001)$  for both measures, also there were highly significant decrease in distal motor latency mean value (DML) as well

as in distal sensory latency mean value (DSL) after treatment as  $p = (0.00001)$  for both measures. Analysis of EMG results within control group using repeated measures ANOVA revealed that; there was highly significant increase in motor conduction velocity mean value (MCV) as well as there was a significant increase in sensory conduction velocity mean value (SCV) after treatment as  $p$  value was  $(0.00001)$  &  $(0.027)$  respectively also there were highly significant decrease in distal motor latency mean value (DML) as well as in distal sensory latency mean value (DSL) after treatment as  $p$  value was  $(0.00001)$  &  $(0.003)$  respectively. Analysis of EMG results between the study group and the control group revealed that; there were no significant differences between both groups in mean values of MCV, SCV, DML, and DSL before treatment as  $p < (0.05)$  for all measures. One month post treatment, MCV mean value and SCV mean value in the study group were increased in comparison to MCV mean value and SCV mean value in the control group respectively and there were a highly significant difference in MCV mean value as well as in SCV mean value between both groups as  $p = (0.00001)$  &  $(0.006)$  respectively, also DML mean value and DSL mean value in the study group were decreased in comparison to DML mean value and DSL mean value in the control group respectively and there were a significant difference in DML mean value as well as in DSL mean value between both groups as  $p = (0.008)$  &  $(0.041)$  respectively.

After three months of treatment, MCV mean value and SCV mean value in study group were more increased in comparison to MCV value and SCV value in control group respectively and there were highly significant differences between both group in MCV mean value as well as in SCV mean value as  $p = (0.00001)$  for all measures, also DML mean value and DSL mean value in study group were more decreased in comparison to DML mean value and DSL mean value in control group respectively and there were highly significant differences in DML mean value as well as in DSL mean value between both group as  $p = (0.00001)$  &  $p = (0.002)$  respectively. The results of this study are consistent with many authors who reported that; ESWT has recently

been proposed as another nonsurgical treatment alternative for treatment of musculoskeletal Disorders such as lateral epicondylitis, Achilles tendonitis, and plantar fasciitis. Shockwaves have been shown to be an effective method of treating both acute and chronic soft tissue painful inflammations [21]. Although the mechanism of shockwave therapy is not understood, the most important physical parameters of shockwave therapy for the treatment of orthopedic disorders include the pressure distribution, energy flux density and the total acoustic energy [22].

There are two basic effects of shockwave. The primary effect is the direct mechanical forces that result in the maximal beneficial pulse energy concentrated at the target point where treatment is provided; and the secondary effect is the indirect mechanical forces by cavitation (23). In animal models, ESWT stimulates soft-tissue healing primarily by inhibiting afferent pain-receptor function and by enhancing angiogenesis. Studies showed that ESWT may increase blood flow to the treated site and induce an inflammatory-mediated healing process [24]. ESWT induces a cascade of biological responses and molecular changes including the growth of neovascularization and up-regulation of angiogenetic growth factors leading to the improvement in blood supply and tissue regeneration [25]. In certain the study, ESWT was applied in patient after CTS surgery and evaluated pillar pain and scar tissue. Their results show that in all of the treated patients, there was a marked improvement and redness and swelling of the surgical scar had also decreased significantly [26].

ESWT treatment is able to bring about immediate pain relief because of desensitization of the local nociceptive fibers and the release of substance P [27]. Studies and reports in the literature have described a short-term anti-inflammatory effect and a long-term tissue regeneration effect for shockwave therapy, both of which are mediated by nitric oxide (NO) induction [28]. ESWT was applied after carpal tunnel release and it has shown that there was an improvement means visual analogue score [29]. Shockwave therapy triggers a neuro-bio-chemical regulatory cascade resulting in the resolution of the associated neuro-physical

pathology and cognitive response in the subjects of this case series; Increases cellular permeability & neuronal signaling [30]. ESWT stimulates angiogenesis and regulates chemical & immune mediators of the inflammatory response [31].

## CONCLUSION

Extracorporeal shockwave therapy provides a non-invasive, satisfied treatment for carpal tunnel syndrome post burn.

**Conflicts of interest:** None

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