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Effect of Extracorporeal Shock Wave Therapy on Post Burn Scars

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Abstract: *Introduction:* Hypertrophic scarring is a difficult problem for burn patients, and scar management is an essential aspect of outpatient burn therapy. Post burn pathologic scars involve functional and aesthetic limitations that have a dramatic influence on the patient's quality of life. *The purpose* was to investigate the effect of extracorporeal shock wave therapy (ESWT) on post burn scars. *Experimental:* forty patients with post burn scars were assigned randomly into two equal groups; their ages ranged from 20 to 45 years. The study group received ESWT and traditional physical therapy program (deep friction massage and stretching exercises). Control group received traditional physical therapy program (deep friction massage and stretching exercises). All groups received two sessions per week for six successful weeks. The data were collected before and after the same period of treatment for both groups. *Assessment*: Evaluation procedures were carried out to measure scar thickness using ultrasonography and Vancouver Scar Scale (VSS) was completed before and after treatment. *Results:* Post treatment results showed that there was a significant improvement difference in scar thickness in both groups in favor of the study group. Percentage of improvement of scar thickness in the study group was 42.55%, while it was 12.15% in the control group. There was also a significant improvement difference between results obtained using VSS in both groups in favor of the study group. *Conclusion:* Extracorporeal shock wave therapy is effective in management of post burn scars.
Key Words: Extracorporeal shock wave therapy, post burn scars, ultrasonography, Vancouver scar scale.

Introduction

In burn patients, scar evolution may lead, according to its pathology, to the formation of scar contractures, hypertrophic scars, and keloids. Physical therapy and, in many cases, pressure and exercise can aid in controlling contracture burn scars, but authors wanted to investigate a new conservative method for the management of post burn scars[1]. Extracorporeal shock waves (ESWs), adapted from the technology used to break up kidney stones[2].

Hypertrophic scars are typically raised, red or pink, and sometimes pruritic but do not exceed the margins of the original wound, whereas keloids infiltrate into surrounding normal tissue and rarely regress. Hypertrophic scars usually subside with time, whereas keloids continue to evolve over time, without a quiescent or regressive phase[3].

Hypertrophic scars occur when the body overproduces collagen, which causes the scar to be raised above the surrounding skin. Hypertrophic scars take the form of a red raised lump on the skin. Keloid scars are a more serious form of scarring, because they can carry on growing indefinitely into a large, tumors (although benign) neoplasm[4].

This seems especially true that hypertrophic scars are common in areas of highly elastic skin (e.g., the lower face, submental triangle, anterior chest and neck). The wound hyperemia seen universally following burn wound healing should begin to resolve about 9 weeks after epithelialization. In wounds destined to become hypertrophic, increased neovascularization occurs with increasing (rather than decreasing) erythema after 9 weeks. Available tools to modify the progression of hypertrophic scar formation are limited in number and effectiveness. These tools include scar massage, compression garments, topical silicone, steroid injections, and surgery. In some contractures over major joints, serial casting may be useful[5].

Shock waves used in ESWT are high amplitude sound waves from a transient pressure disturbance that propagate in three-dimension space with a sudden rise from ambient pressure to its maximum pressure at the wave front. The waves are transmitted to the patient through either water or a coupling gel. A shock wave is a sonic pulse that has certain physical characteristics. There is an initial rise of a high peak pressure, sometimes more than 100 mPa (1000 bar) within less than 10 ns (nanoseconds), followed with a low tensile amplitude (up to 10 MPa), a short life cycle of approximately 10 µs and a broad frequency spectrum in the range of 16 to 20 MHz; Shock waves differ from ultrasound waves that are typically biphasic and have a peak pressure of 0.5 bar. In essence, the peak pressure of shock wave is approximately 1000 times that of ultrasound wave[6].

The initial therapeutic introduction of shock waves to the human body was to noninvasively treat kidney stones (lithotripsy), this technology has evolved to be considered the procedure of primary choice for urolithiasis[7].

Experimental

This study was carried out on 40 adult patients of both sexes suffering from scar contractures which cause functional limitations or immature hypertrophic scars in different areas of body as a result of burn injuries, their ages ranged from 20 to 45 years and selected from burn outpatient clinic at Faculty of Physical Therapy, Cairo University, Egypt. Patients were randomly assigned into two equal groups; group A (Study group) and group B (Control group).Group A received ESWT and traditional physical therapy program (deep friction massage and stretching exercises) and group B received traditional physical therapy program (deep friction massage and stretching exercises). Patients with the following conditions were excluded from the study; Patients who had skin abnormalities (Patients with active skin disease within the treatment areas e.g.: psoriasis, cancer and other disease), Patients had immunodeficiency disorders, patients with mature hypertrophic scars and Pregnant female were also excluded.

The work has been carried out in accordance with the ethics of committee for experiments at Faculty of Physical Therapy, Cairo University involving humans, and patients signed a consent form to participate in the study.

The assessment approaches were: ultrasonographic measurement of scar thickness and macroscopic evaluation according Vancouver Scar Scale with items (vascularity, pigmentation, pliability and height) before the treatment and after 6 successive weeks.

Patients underwent sessions of ESWT twice a week for 6 weeks. ESWT was administered on an outpatient basis; the selected treatment area was usually the most uncomfortable for the patient. Patient placed into comfortable position that allowed the vision of the treated area. All the patients were briefed on the possible emission of sound and light from the device. Each treatment region covered with 2500 to 3000 impulses with average session time 10-15 min[1].

Statistical Analysis

Descriptive statistics and t-test for comparison of pre and post treatment mean values of scar thickness and VSS between study and control groups. Paired t test used for comparison between pre and post treatment mean values of scar thickness and VSS in each group. The level of significance for all statistical tests was set at

$p < 0.05$. All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows.

Results

The statistical analysis for patient's socio-demographic data (age, sex) revealed a non significant difference between both groups.

Statistical analysis of results showed a significant improvement in scar thickness and VSS in group A and group B after 6 weeks of treatment as follows:

Results of scar thickness: The mean ± SD pre treatment of group A was 6.72 ± 1.62 mm and that post treatment was 3.86 ± 0.73 mm. The mean difference between pre and post treatment was 2.86 mm and the percent of improvement was 42.55%. There was a significant decrease in the scar thickness in the study group post treatment compared with pre treatment (p = 0.0001).). While in group B the mean ± SD pre treatment of group B group was 6.58 ± 1.43 mm and that post treatment was 5.78 ± 1.17 mm. The mean difference between pre and post treatment was 0.8 mm and the percent of improvement was 12.15%. There was a significant decrease in the scar thickness in the control group post treatment compared with pre treatment (p = 0.0001) as shown in table 1 and figure 1.

Results of VSS: The mean ± SD VSS pre treatment of study group was 8.75 ± 1.71 and that post treatment was 4.5 ± 1.73. The mean difference between pre and post treatment was 4.25 and the percent of improvement was 48.57%. There was a significant decrease in the VSS in the study group post treatment compared with pre treatment (p = 0.0001) While in group B The mean ± SD VSS pre treatment of control group was 8.9 ± 1.61 and that post treatment was 7.65 ± 1.78. The mean difference between pre and post treatment was 1.25 and the percent of improvement was 14.04%. There was a significant decrease in the VSS in the control group post treatment compared with pre treatment (p = 0.0001) as shown in table 2 and figure 2.

Table (1): scar thickness before and after treatment for each group:

	Group A		**Group B**	
	Pre	**Post**	**Pre**	**Post**
$\overline{X}$	6.72	3.86	6.58	5.78
SD±	±1.62	±0.73	± 1.43	± 1.17
t- value	10.9		8.61	
p- value	0.0001		0.0001	
Significance	Significant		Significant	

$\overline{X}$ **: Mean** **t value : Paired t value** **p value : Probability value**
SD : Standard deviation

Table (2): VSS before and after treatment for each group.

	Group A		**Group B**	
	Pre	**Post**	**Pre**	**Post**
$\overline{X}$	8.75	4.5	8.9	7.65
SD±	± 1.71	± 1.73	± 1.61	± 1.78
t- value	17.76		10.16	
p- value	0.0001		0.0001	
Significance	Significant		Significant	

$\overline{X}$ **: Mean** **t value : Paired t value** **p value : Probability value**
SD : Standard deviation

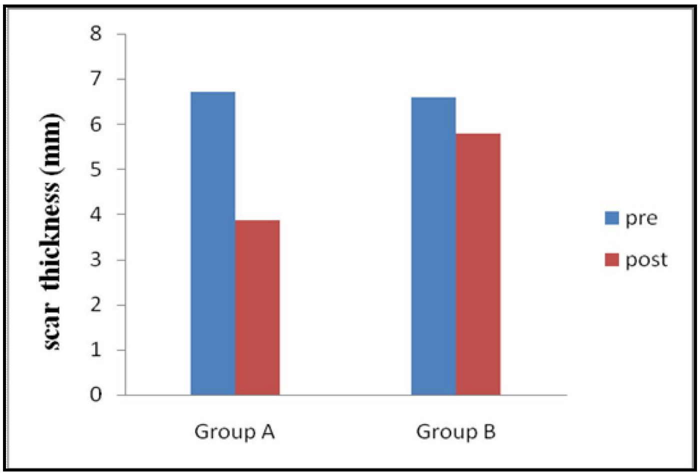

Figure (1): comparison of scar thickness Mean values before and after treatment for each group.

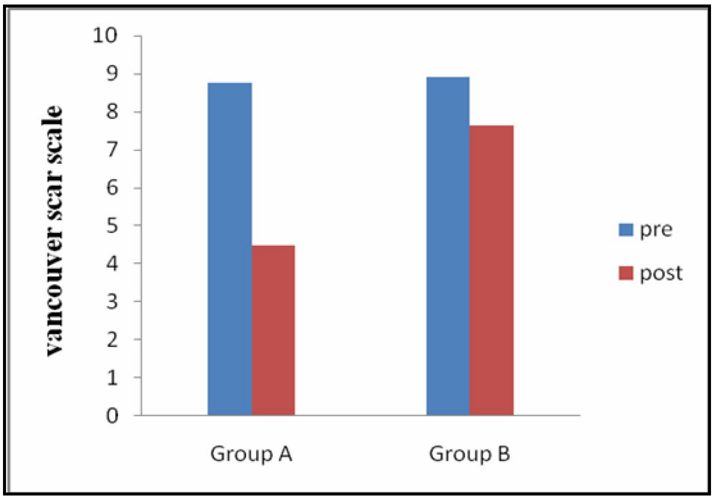

Figure (2): comparison of VSS before and after treatment Mean values for each group.

Statistical analysis results revealed that; There was no significant difference in the mean values of scar thickness between both groups pre treatment (p = 0.76). While there was a significant decrease in scar thickness in group A post treatment compared to that of group B (p = 0.0001) as shown in table3and figure3.

There was no significant difference in mean values of VSS between both groups pre treatment (p = 0.77). While there was a significant decrease VSS in group A post treatment compared to that of group B (p = 0.0001) as shown in table 4 and figure 4.

Table (3): Scar thickness before and after treatment for both groups:

	Pre treatment		**Post-treatment**	
	Group A	**Group B**	**Group A**	**Group B**
$\overline{X}$	6.72	6.58	3.86	5.78
SD±	±1.62	±1.43	± 0.73	± 1.17
t- value	0.29		-6.15	
p- value	0.76		0.0001	
Significance	Non significant		Significant	

$\overline{X}$: Mean **t value : Paired t value** **p value : Probability value**

SD : Standard deviation

Table (4): VSS before and after treatment for both groups:

	Pre treatment		Post-treatment	
	Group A	**Group B**	**Group A**	**Group B**
$\overline{X}$	8.75	8.9	4.5	7.65
SD±	± 1.71	± 1.61	± 1.73	± 1.78
t- value	-0.28		-5.66	
p- value	0.77		0.0001	
Significance	Non significant		Significant	

$\overline{X}$ **: Mean** **t value : Paired t value** **p value : Probability value**

SD : Standard deviation

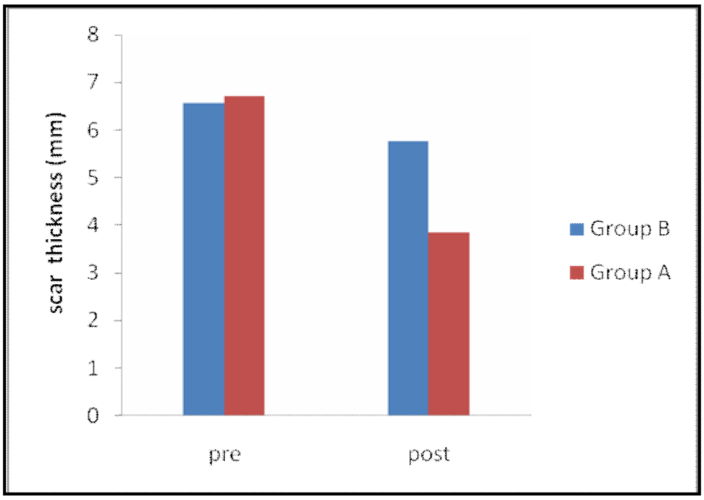

Figure (3): comparison of scar thickness Mean values before and after treatment for both groups

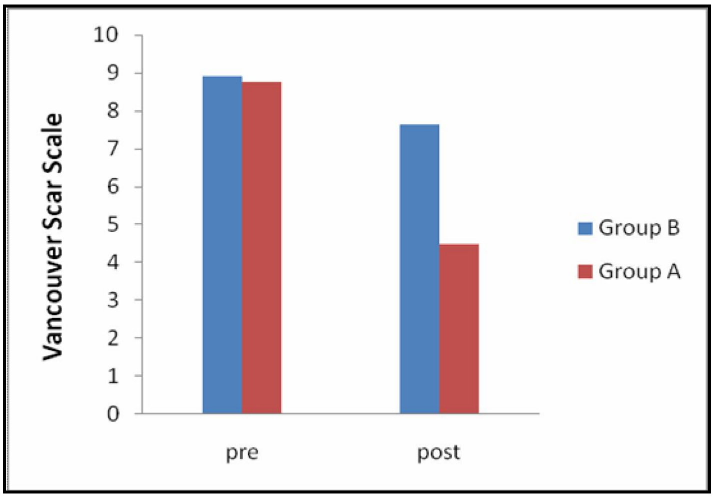

Figure (4): comparison of VSS before and after treatment Mean values for both groups

Discussion

The results of this study showed that patients who have hypertrophic scars following burn injuries had a significant decrease in scar thickness and scar appearance according to ultrasonographic measurement and VSS respectively after application of ESWT in addition to the traditional physical therapy program. The statistical analysis revealed a significant decrease of scar thickness in the study group than that of the control group; the percentage of improvement was 42.55%and 12.15%for the two groups respectively. Also there is a significant improvement of scar appearance according to VSS in the study group than that of the control group.

Shock waves are acoustic waves. The high-level energy that shock waves produce terminates in a burst of energy similar to a mini-explosion. This energy was used as ESWT for the first time in the 1980s, when it was successfully introduced to urology and gastroenterology as lithotripsy[2, 8].

Laura et al. compared between the effects of different doses of extracorporeal shock wave therapy on normal fibroblast proliferation in vitro. 1 hour after the shock-wave treatment, the cell viability showed an apparent decrease related both to the energy and the number of impulses applied: a constant decrease was observed in relation to the number of impulses (300, 1,000, 2,000) with a maximum reduction in viability at 2,000 impulses (viability 18%) while there was no statistically significant association between energy levels (0.11 and 0.22 mJ/mm^2) and fibroblast viability. The authors concluded that shock waves had a dose-dependent destructive effect on cells in suspension, but they also seemed to have a dose-dependent stimulatory effect on cell proliferation[9].

Extracorporeal shock wave therapy of 500 and 1000 shots elicited inhibitory effects on tendinitis repair and during evaluation of the effect of various ESW treatment schedules on the healing of collagenase-induced achilles tendinitis and investigation of biochemical and biomechanical properties of healing tendons; Rats with the collagenease-induced achilles tendinitis were given a single ESW treatment at 0.16 mJ/mm^2 energy flux density, with different number of shots. Low number (200) of impulses restored biomechanical and biochemical characteristics of healing tendons 12 weeks after treatment, while 500 and 1000 shots elicited inhibitory effects[10].

The influence of the energy density and the number of applied shockwaves on the viability of cell suspension of normal fibroblasts had been explored; The Authors reported that shock waves have a dose-dependent destructive effect on cells in suspension. The number of applied shots had a statistically significant influence on the decrease in growth potential compared to the control cells, a higher number of shock waves leading to a more severe depression in the growth potential of the shocked cells[11].

Extracorporeal shock wave therapy had a dose-dependent influence of shock waves on the healing of partial-thickness skin lesions in pigs. Low-dose shockwave treatment stimulated the re-epithelisation while intermediate-dose ESW treatment had no effect, and high-dose ESW treatment had an inhibiting effect[12].

Focused extracorporeal shockwave therapy could give added value to the non-invasive treatment of hypertrophic and contractile scars already in the first three months after wound closure. This was reported after a study was carried out to investigate the efficacy of extracorporeal shockwave therapy on the long-term outcome of hypertrophic scars. The assessment tools used were a Minolta Chromameter for redness, the DermaLab USB open chamber evaporimeter for trans-epidermal water loss, the Cutometer for elasticity and the Patient and Observer Scar Assessment Scale (POSAS) for clinical assessment. The results of the clinical assessments, measured by the POSAS, showed improvement for color ($p=.047$), pliability ($p<.0005$) and global score ($p<.04$). Only for POSAS pliability, reported by the patient, there was a statistically significant difference between the interventions in favors of the ESWT group ($p=.045$). The results of the objective assessments were almost all in favor of the ESWT group. Comparable results were only noticed for color (redness), where both groups showed a statistically significant improvement ($p<.0005$). Statistically significant improvements were also registered for color (brightness), elasticity and water vapor permeability in the ESWT group ($p<.02$). For water vapor permeability and elasticity, the ESWT group seemed to perform statistically significantly better than the control group. These results need to be confirmed by the results after six months and for a larger sample size[13].

Experimental study with Extracorporeal shock wave therapy was performed in 16 patients with post burn scars contractures, hypertrophic scars, or keloids twice a week for 6 weeks. After the first session, scars appeared more pliable, and color mismatch was less evident. At the end of the study period, patients reported that scars were less painful, less stiff, and thinner. Scar color became more similar to that of the surrounding skin and the texture less firm; the overall appearance was improved, and the patients considered their experience to be more acceptable. Movement also became less impaired. According to the VAS, scar appearance improved 3 points for three patients (18.75%), 2 points for eight patients (50%), 1 point for two patients (12.5%), and 0 points for three patients (18.75%). Finally the author concluded that extracorporeal shock wave therapy is a feasible and cost-effective treatment in the management of post burn pathologic scars[14].

From obtained results it could be concluded that, extracorporeal shock wave therapy with high dose is an effective therapeutic modality when it is added to the traditional physical therapy program of managing post burn hypertrophic scars as the delivery of shock waves to scar tissue is thought to cause microscopic injury that breaks down collagen fibers, which enables remodeling of scars. Higher doses of extracorporeal shock wave therapy have an inhibitory and destructive effect on fibroblast and control scarring at early post burn stages. It may have effect in change collagen fibers synthesis/degradation ratio. It is also can be prophylactic if it is used as early as the post burn scar is formed. Also extracorporeal shock wave therapy decrease pain and itching and thus decreases risk of friction forces upon scars and decrease inflammation. Better results of physical therapy treatment concerning contracture deformities caused by HTS around joints as a result of extracorporeal shock wave therapy effects on increasing pliability and decreasing thickness of scared tissues. Better cosmetic results can be obtained as a result of decreasing pigmentation.

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