VACUOTHERAPY VERSUS SHOCK WAVE THERAPY ON SURGICAL SCARS

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ABSTRACT

Background: *Worldwide attention for post-surgical scar as a visible endpoint of healing. Potential evidence regarding vacuotherapy as an alternative therapy, and well-known shock wave therapy for their therapeutic benefits on surgical scars. Purpose: To determine efficacy of vacuotherapy versus shock wave therapy on post-surgical scars.*
Method: *Forty participants of both genders with immature surgical scars <6 months from Kafr Shokr Specialized Hospital, and Dermatology Hospital, Banha, age range was 20-45 years old, free from any post-surgical complications. They were randomly allocated into two equal groups in numbers; Group A received extracorporeal shock wave therapy one session every two weeks; and Group B received vacuotherapy 3 sessions per week, from June 2023 to March 2024. Evaluation involving scar pliability, vascularity, pigmentation and height using Vancouver scar scale and objective scar pliability and elasticity using modified schiotz tonometer. Statistical analyses with significance level 0.05 level.*
Result: *Unsignificant differences revealed at baseline analysis. Both groups had revealed a significant decrease in Vancouver scar scale reported values, and a significant increase in modified schiotz tonometer reported values post treatment. While, there was significant increase in group I compared with group II post treatment in term of scar pliability, vascularity, pigmentation, height, and elasticity.*
Conclusion: *Both vacuotherapy and shock wave therapy are valuable. Shock wave therapy was superior in terms of scar pliability, vascularity, pigmentation, height, and elasticity. Therefore, shock wave therapy could be recommended in immature surgical scars with functional restrictions management.*
Keywords: *Shock Wave Therapy, Surgical car, Vacuotherapy, Vancouver Scar Scale*

INTRODUCTION

Moderate evidence suggested the global burden of post-surgical scar as a disability leading cause with remarkable socioeconomic impacts, which consumed huge healthcare costs with obvious negative impact on quality of life (1). Current estimated evidence of distributing perceptions such as pain, tenderness or itchiness, and functional limitations in form of contractures as consequences of problematic scars. In addition, scar esthetics can also have a negative influence on psychosocial factors (2).

Such mentioned complains including physical dysfunction post-surgical incisions may due to surgical scars, therefore optimal restoration of injured skin requires a complex sequence of physiological interactions to form appropriate scar tissue and repair the dermal lesion (3). Every year, >100 million individuals developed postsurgical scars in developed countries results from selective surgical procedures involving around 55 million operative interventions (4).

Almost remodeling of surgical scar is a process that begins 14 up to 21 days post-operatively and can last almost indefinitely in the setting of impaired wound healing. By 21 days, wounds gain approximately 20% of their final strength and can reach a maximum of 70%. Dysregulation of the remodeling process can be clinically evident as hypertrophic scars (5). The traditional algorism initiated with clinical experience of plastic and reconstructive surgeons has long revealed that scar formation varies with depth of injury particularly in whom with single injury (6).

Numerous conservative therapeutic modalities have been addressed i.e., ultrasound therapy, collagen injection, and chemical peels even steroid injection (7).

Where, Extracorporeal shockwave therapy (ESWT) has addressed as is a non-invasive physical therapy modality so, in the same line recently clinical trials have shown encouraging, significant correlations of ESWT, with an improved healing rate and complete epithelialization, depending on wound size. ESWT has a mechanotransduction effect that converted into biochemical responses, thus influencing some fundamental cell functions such as migration, proliferation, differentiation, and apoptosis (8,9).

As well, vacuotherapy was defined as a non-invasive modality characterized by lifting layers of the skin by negative mechanical suctioning pressure effect that is used to mobilize the skin folds (10).

In addition, vacuotherapy has a potential benefit have led to a new definition for mechanotherapy: therapeutic interventions that reduce and reverse injury to damaged tissue or promote the homeostasis of healthy tissue by mechanical means at the molecular, cellular or tissue level (11).

Furthermore, A local suction of the skin is created using heat or mechanical forces. This method allowed him to perform the massage in a more consistent and less time-consuming way that used to apply for treating traumatic and scars (12).

To available data, there is a research red era showing actual awareness among healthcare providers, whom focus on minimizing complications and gaining as possible prognosis of surgical scar (13).

Therefore, current study was conducted to determine efficacy of vacuotherapy versus shock wave therapy on post-surgical scars, as well provide physical therapists as healthcare team members with valuable conclusion assists them in clinical decision making.

MATERIALS AND METHODS

This study was designed as a Pre/ Posttreatment, randomized controlled study. Approval of the ethical committee of Faculty of Physical Therapy, Cairo University, Egypt (P.T.REC/012/004684), the procedures of the present study were discussed thoroughly and each participant has signed a written informed consent. Upon results of prior pilot study, and by using G*POWER statistical software (version 3.1.9.2; Franz Faul, University at Kiel, Germany). Current study sample size was calculated as a function of expected change in vancouver scar scale (VSS) values as a primary outcome of surgical scar. In order to detect a mean difference according to ElShazly et al (14), so required sample size was twenty patients in each group under the assumption of a two-sided type I error of 5% and a power of 80%, effect size of 1.61.

Participants: Forty participants of both genders (14-females, and 6-males) with immature surgical scars <6 months from Kafr Shokr Specialized Hospital, and Dermatology Hospital, Banha, were allocated randomly into two equal groups (twenty patient for each), with age range was 20-45 years old, free from any post-surgical complications.

Group A: received extracorporeal shock wave therapy one session every two weeks.

Group B: received vacuotherapy 3 sessions per week.

Randomization were conducted using a computer- generated randomized table using SPSS program "version 25 for windows; SPSS Inc., Chicago, Illinois, USA". Each participant had one identification number that was used to assign participants into two equal groups in number (n=20), sequentially numbered index cards were secured in opaque envelopes.

Inclusion Criteria: Participants` age range 20-45 years old of both genders. Each participant`s main complains were immature scars <6 months and/ or scar contractures causing functional restrictions and were free of any postsurgical complications, except post-surgical scar.

Exclusion Criteria: All participants with metallic implants at or near treatment site, cardiac pacemakers or other electronic devices implants, also whom have skin abnormalities i.e., psoriasis, have severe illness or immunodeficiencies disorders, particularly whom with mature scars or pregnant females were excluded from the study.

Assessment Instrument

Vancouver scar scale: is widely used to measure scar properties over time objectively in binary manner. It has acceptable reliability and validity in measuring scar pliability, vascularity, pigmentation and height for determining effectiveness of therapeutic interventions (15).

Modified Schiotz tonometer: is an assessment tool, widely utilized for objective scar pliability and elasticity determination. It is a riester, Germany, 0124 was used to provide repeatable and objective scar pliability and elasticity assessment. It is a simple clinical technique for monitoring scar (16).

Therapeutic Instrument

Extracorporeal shock wave device: is a FDA-approved i MAS TERPULSE MP-100 model manufactured by Seguranca Swiss. It has Falcon hand piece with R15, D20S, and D115 Applicators; V-ACTOR® HF optional 1-31Hz, based on simple operating procedures with a logical control system and an easy-to-read graphical LCD.

Vacuotherapy: INTELECT NEO Chattanooga DJO France SAS. Device dimensions without touch screen are 40*40*56 centimeters with optional LCD touch screen. Its vacuum range is up to 600 mbar maximum with continuous per setting hold.

Evaluating Procedures

History taking: Detailed medical history was taken from each participant at the baseline of current study then recorded.

Specific outcome measures

Vancouver scar scale measurement procedures: It was used to assess scar tissue` pigmentation, vascularity, pliability, and height. Each item scored for a) pigmentation as follows 0'Normal, 1'Hyypopigmentation' and 2'hyperpigmentation'; for b) vascularity as follows 0'Normal', 1'Pink', 2'Red' and 3'Purple'; for c) pliability as follows 0'Normal', 1'Supple', 2'Yielding' and 3'Firm', 4'Banding', and 5'Contructure'; finally for d) height as follows 0'Normal/ flat', 1' range 0-2mm', 2'rnage 2-5mm' and 3'range >5mm' with maximum possible total score being 13 (17).

Modified Schiotz tonometer measurement procedures: for each patient using modified Schiotz tonometer for objective scar pliability and elasticity assessment in a simple clinical technique. Each patient was positioned in a well-supported comfortable position with applied modified Schiotz tonometer vertically (figure 1), over scar and provided 0-20 score range, then researcher used accompanied table to convert redden score supplied by the device into mmHg value (16).

Figure (1). Modified Schiotz tonometer procedures.

Therapeutic procedures

Extracorporeal shock wave treatment (Group A only): ESWT first explained in details, then with 0.25mJ/mm2 energy flux density, 6Hz, and 30-50 shocks/cm2 per area thus each region was covered with 2500-3000 shocks per session that consumed average 8-10 minutes, one session every two weeks for eight weeks. Participants had been re-examined (18).

Vacuotherapy (Group B only): Initially, vacuotherapy program explained, then vacuotherapy with 250-900 millibar, and 0.25-0.5Hz for 30-40 minutes per session, three sessions per week for eight weeks. Participants had been re-examined (14).

Statistical Analysis: SPSS version 25 was used to conduct analysis, where descriptive statistics was calculated mean, standard deviation (SD) per each group. Inferential statistical analysis using paired T- test to compare pre and post-test reported values and to compare between both groups. The association between outcome measures was analyzed using Spearman correlation coefficient. The level of significance was settled at 0.05 (19).

Participants characteristics No significant differences regarding age with mean and standard deviation for group A was 33.8± 5.52 years, while for group B was 34.2± 4.76 years, as t value was -0.267 and p-value was 0.793. As well, gender distribution represented no significant difference (p >0.05).

Effect of treatment on vancouver scar scale values

Pretreatment comparison: No significant difference in VSS scores between both groups' pretreatment (p 0.666), with VSS scores pretreatment of group A was 8.65 ± 1.42, and that of group B was 8.7± 1.38.

Posttreatment comparison: A highly significant difference in VSS scores between both groups' posttreatment (p 0.001), with VSS scores posttreatment of group A was 4.25 ± 1.33, and that of group B was 4.95± 1.09.

Between groups` comparison: Highly significant differences between both groups A, and B pre and posttreatment VSS scores with mean differences 4.4 with percentage of change 33.85% for group A, and 3.75 with percentage of change 28.85% for group B, table (1) and figure (2).

Table (1): Comparison of pretreatment, posttreatment mean values of VSS

VSS	ESWT	Vacuotherapy	Mean differences	P-value
	$\overline{X}$ ±SD	$\overline{X}$ ±SD		
Pretreatment	8.65± 1.42	8.7± 1.38	-0.05± 0.04	0.666
Post treatment	4.25± 1.33	4.95±1.09	-0.07± 0.24	0.000
Mean differences	4.4± 1.09	3.75± 0.71		
% of change	33.85%	28.85%		
P-value	0.000	0.000		

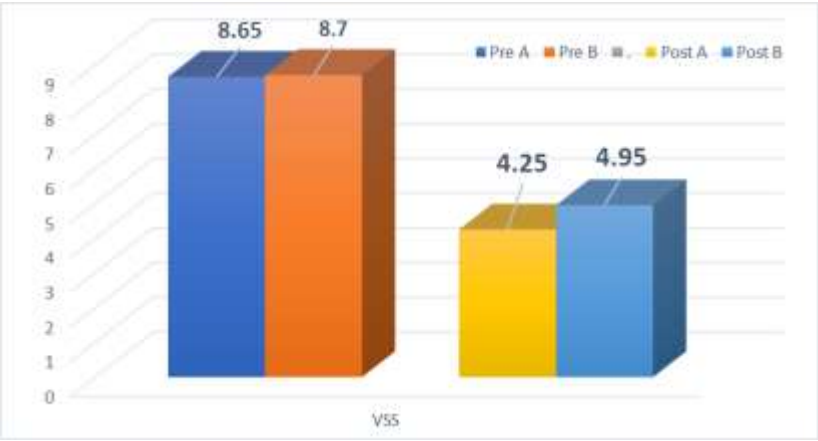

Figure (2). Mean VSS score at pretreatment, posttreatment of groups A and B

Effect of treatment on modified Schiotz tonometer values.

Pretreatment comparison: No significant difference in modified Schiotz tonometer values of both groups' pretreatment (p 0.792) pretreatment of group A was 15.32 ± 2.12, and that of group B was 15.19± 2.18.

Posttreatment comparison: A high significant difference in modified schiotz tonometer values between both groups' posttreatment (p 0.001) with posttreatment of group A was 7.35 ± 1.11, and that of group B was 10.3± 1.59.

Between groups` comparison: Highly significant differences between both groups A, and B pre and posttreatment modified Schiotz tonometer scores with mean differences 7.97 with percentage of change 39.85% for group A, and 4.89 with percentage of change 24.45% for group B, table (2) and figure (3).

Table (2): Mean differs in outcome measures

Modified Schiotz tonometer	ESWT $\overline{X}$ **±SD**	**Vacuotherapy** $\overline{X}$ **±SD**	**Mean differences**	**P-value**
Pretreatment	15.32± 2.12	15.19± 2.18	0.13± 0.06	0.792
Post treatment	7.35± 1.11	10.3± 1.59	-2.95± 0.48	0.000
Mean differences	7.97± 1.01	4.89± 0.59		
% of change	39.85%	24.45%		
P-value	0.000	0.000		

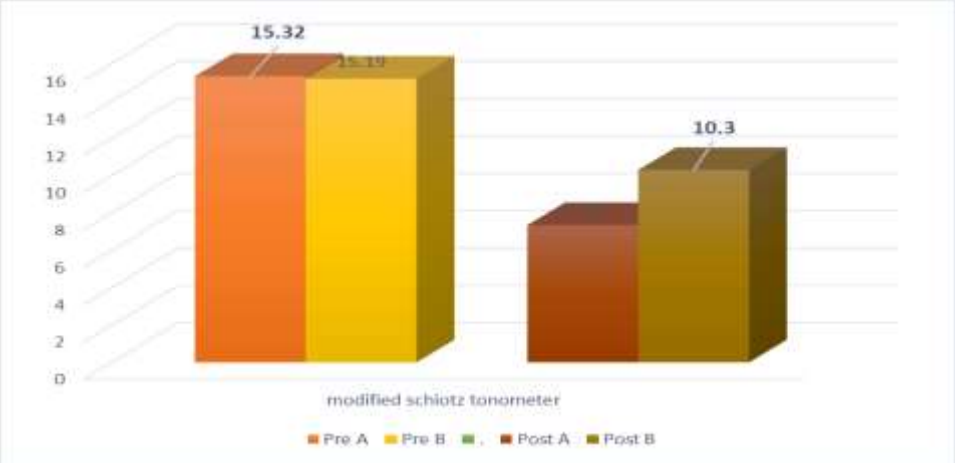

Figure (2). Mean modified Schiotz tonometer score at pretreatment, posttreatment of groups A and B.

DISCUSSION

Up to date, ESWT was shown effective in acute and chronic wounds with unknown mechanisms. Also, vacuotherapy was reported to have a wide array of beneficial effects on scars, plus pruritus and skin hydration. Ideal non-invasive scar treatment should be safe, well tolerated by patients, have low associated complication rates, is easy to apply, cost-effective, and can be used in an outpatient setting (20).

Our results revealed a significant decrease in vancouver scar scale output and significant increase in modified schiotz tonometer values in both groups at post treatment compared with that pretreatment ($p < 0.001$). There were highly significant differences between both groups A, and B pre and posttreatment VSS scores with mean differences 4.4 with percentage of change 33.85% for group A, and 3.75 with percentage of change 28.85% for group B ($p < 0.001$). In addition, there were highly significant differences between both groups A, and B pre and posttreatment modified schiotz tonometer values with mean differences 7.97 with percentage of change 39.85% for group A, and 4.89 with percentage of change 24.45% for group B ($p < 0.001$).

Present study findings were agreed with current physical therapy guidelines ensured noninvasive management for surgical scars, using approved FDA medical devices i.e., extracorporeal shock wave therapy and vacuotherapy as physical therapy treatment modalities for post-surgical scars. In addition, could explained reported findings due to mechanobiological point of view, that could be explained that neoangiogenic capacity could be related to inhibition of endothelial cell apoptosis immediately post ESWT application (21).

Wang et al (22) had reported compared ESWT versus steroid injection on thirty-nine patients with keloid scars, with ESWT were applied three sessions along six weeks. They reported a significantly reduced height with comparable functional gains. They agreed with our findings in their explanations that based on reduced scar collagenous structure through remodeling model. Collagen II is a nonprincipal matrix, also collagen III extensively secreted via fibroblast. Therefore, recovery mechanism accelerated with ESWT program through degradation of collagen II, MMP-13 that is an enzyme targeting decomposition (12).

As well, d'Agostino et al (23) had stated specific mechanism could explained ESWT that addressed as a non-invasive increased cell proliferation, cell activity, cell concentration, and decreased cell apoptosis, and improvement in blood flow perfusion and tissue regeneration that result in hypoxic microenvironment.

According to Lee et al (24), who proved that ESWT as a conservative noninvasive approach depends on exerted energy flux density, and therapeutic protocol parameters those play an important role in targeting of specific mechano-signaling pathways, with 0.12 mJ/mm2 being the optimal dose for activating mTOR-FAK pathway and 0.10 mJ/mm2 showed best results for inhibiting TGF-β1/Smad pathway. In the same line, could explains our findings based on that ESWT may lead to reduced tissue necrosis in wound healing by increasing cellular proliferation and procollagen production, as well ESWT has a significant shorter time to complete epithelialization (25).

On histopathological level, according to Cui et al (26) had stated that gained therapeutic benefits of ESWT may base on downregulation of alpha-SMA expression, myofibroblast phenotype, TGF-β1expression, fibronectin, and collagen type I are measured, and precursors of

extracellular matrix components, probably leads to new and thinner collagen fascicles and parallel orientation to dermo-epidermal junction (27).

On the other hand, Sukubo et al (28) had recommended application of ESWT within early healing and middle phases of surgical incision. They explained their advises based on the macrophage behaviour, which stated that ESWT aids in does not activate resting macrophages and inhibits M1 (pro-inflammatory) activation in the initial inflammatory phase and enhances the M2 (anti-inflammatory) activation in the late inflammatory phase, also ESWT regulates inflammation via TLR3 pathway in three phases. In an initiation phase, it induces a pro-inflammatory reaction mediated by cyclophilin A and IL6 (29).

Current therapies aimed at reducing scar formation include vacuotherapy as a sort of compression therapy, which is a standard first-line therapy for hypertrophic scars, which were found to reduce i burden of hypertrophic scarring in 60–85% (30). Mechanotransduction of compressive forces may lead to decreased collagen production and activation of matrix metalloproteinases that remodel ECM and thereby lead to decreased scar (1).

In addition, current study findings agreed with Zhao et al., (31) who had demonstrated positive results on planimetric scar characteristics and inhibition of TGF-β1/Smad signaling pathway with Radial ESWT, also reduced fibroblast density, plus α-smooth-muscle-actin expression in hypertrophic scar tissues of a rabbit model.

On agreement for our findings, prior clinical trial reviewed the effect of mechanical stretch including stretching exercise, massage, and splinting on hypertrophic scars after burn. They stated that there was no strong evidence indicating positive efficacy of mechanical stretch via stretching, massage, or splinting on hypertrophic scars (32).

Another conflicting opinion according to Merete who stated that vacuum therapy is a non-invasive modality used to mobilize skin folds that has a significant shoer-term effect on scar properties in terms of scar density for around couple of hours. Unless, Merete has reported reversed increase in scar thickness at dermal layer post treatment (33).

However, therapeutic vacuotherapy benefits revealed in our findings came in line with our findings, Moortgat et al (34) ensured usage vacuum therapeutic intervention for managing surgical scars in terms of scar tissue pliability, vascularity, thickness of skin folds, and elasticity and/ or roughness and pigmentation (35).

According to Qiu et al (36) numerous efforts exerted globally for discovering more efficient development of negative pressure therapy for managing of surgical scar. However, negative pressure therapy could permit a well-recognized scar remarkable effect on enhancing wound drainage and removing bacterial products (37).

In agreement with our findings, Cagney et al ensured recently that pressure differences around suppling capillaries for scar tissue, and within endothelial intercellular spaces regarding lymphatic capillaries positively response to applied negative vacuum therapy (38).

According to the current study results, it is important that physical therapists and other health professionals should consider the impact of adding either shock wave therapy or vacuotherapy in treatment of surgical scars with superiority to shock wave therapy in terms of scar pliability, vascularity, pigmentation, height, and elasticity. However, the authors of this study emphasize that more research will be needed before this can be considered definitely effective

CONCLUSION

Based on current study revealed results and we could conclude that both shock wave therapy and vacuotherapy are valuable for managing surgical scars. Shock wave therapy was superior in terms of scar pliability, vascularity, pigmentation, height, and elasticity. Therefore, could recommend shock wave therapy for immature surgical scars management.

Limitation of this study:

The limited sample population. Focusing on post-surgical incision scars. Moreover, current study populations were varied, since there is need to evaluate efficacy of physical therapy management on other scar types i.e., burn scars.

Conflict of interest: The authors confirmed that this article content has no conflict of interest.

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