

## The Effect of the Extracorporeal Shock Wave Therapy on Scaphoid Fracture Nonunions

AMR E. AHMED, M.Sc.\*; OMAIMA KATTABEI, Ph.D.\*; AHMED F. GENEDY, M.D.\*\* and  
ABER RAMADAN, Ph.D.\*

*The Department of Basic Sciences, Faculty of Physical Therapy, Cairo University\* and The Department of Physical Medicine, Military Medical Academy\*\*, Cairo*

### Abstract

**Background:** The scaphoid is the most frequently fractured carpal bone, typically as a result of a fall onto an outstretched hand. Nonunion that caused by poor blood supply is an important complication of scaphoid fracture. The purpose of this study was to investigate the effect of the extracorporeal shock wave therapy on the healing of scaphoid fracture nonunion.

**Subjects:** Thirty patients from both genders were diagnosed with scaphoid fracture for more than six weeks without healing for more than six months, aged 20 to 50 years and were divided into two equal groups; fifteen patients each.

**Method:** Subjects were randomly divided into 2 groups; group A (control group) received conservative treatment (immobilization with cast and follow-up). Group B (experimental group) received three ESWT sessions followed by immobilization by cast. X-ray radiographs were obtained before and after treatment.

**Results:** There were significant statistical differences between the 2 groups, where the treatment group showed greater improvement in the healing response.

**Conclusion:** ESWT is an effective method in treatment of scaphoid fracture nonunion.

**Key Words:** Scaphoid bone – Nonunion fracture – Shock wave therapy.

### Introduction

THE word Scaphoid is derived from Greek language. “Skaphos” in Greek means boat. Scaphoid is a boat shaped bone. Scaphoid bone is also known as navicular. The articular cartilage covers 80% of the bone surface. It is placed at 45° to the longitudinal axis of the wrist. It articulates with capitate, trapezium, and trapezoid distally, distal radius proximally and lunate medially. The scaphoid is a biomechanically important, boat-shaped carpal bone “skaphos”, that articulates with the distal

radius, trapezium, and capitate. During radial deviation and dorsiflexion of the wrist, the scaphoid encroaches on the radius, limiting this motion. If this motion is forceful (e.g., a fall on an outstretched arm), enough stress on the scaphoid occurs to fracture it [1].

The scaphoid is the most frequently fractured carpal bone, typically as a result of a fall onto an outstretched hand. The fracture usually crosses the long axis of the bone. Fractures of its proximal part or its 'waist' may fail to unite because the proximal fragment has lost its blood supply: Avascular necrosis of the proximal fragment is then inevitable. The blood supply of the scaphoid comes from the radial artery, feeding the bone on the dorsal surface near the tubercle and scaphoid waist. Because the proximal portion has no direct blood supply, nonunion caused by poor blood supply is an important complication of scaphoid fracture [2].

Scaphoid fractures account for almost 75% of all carpal fractures. The usual mechanism is a fall on the hand with wrist extended. The critical movement is probably a combination of dorsiflexion and radial deviation, with the force passing between the two rows of carpal bones; the scaphoid, lying partly in each row, fractures across its waist. The injury is rare in children and in the elderly. The blood supply of the scaphoid diminishes proximally. This accounts for the fact that 1% of distal-third fractures, 20% of middle-third fractures and 40% of proximal fractures result in non-union or avascular necrosis of the proximal fragment [3].

Shock waves is defined as a sequence of single sonic pulses characterized by high peak pressure (100MPa), fast pressure rise (<10ns) and short lifecycle (10µs), are conveyed by an appropriate

**Correspondence to:** Dr. Amr E. Ahmed, The Department of Basic Sciences, Faculty of Physical Therapy, Cairo University

generator to a specific target area with the energy density in the range of 0,003-0,890mJ/mm<sup>2</sup> [4].

A shock wave is essentially a pressure disturbance that propagates rapidly through a medium. It can be defined thus: A large amplitude compression wave, as that produced by an explosion or by supersonic motion of a body in a medium [5].

Shock waves were initially employed as a non invasive treatment for kidney stones, and it has become a first line intervention for such conditions. In the process of the animal model experimentation associated with this work, it was identified that shock waves could have an effect on bone. This lead to a series of experimental investigations looking at the effect of shock waves on bone, cartilage and associated tissues (tendon, ligament, fascia) resulting in what is now becoming an intervention of increasing popularity, most especially for the recalcitrant lesions of these tissues, though the clinical uses are expanding and now include wound management, treatment of fractures and numerous additional applications [6].

The shock waves are sound waves that are generated by a source that create vibrations which are then transported through tissues via fluid and solid. Shock wave therapy involves delivering intermittent sound waves that can travel only through fluids, gases and solids. They penetrate into the area to be treated via an interface, for instance, a gel applied to the skin. Low energy waves (<0,1mJ/mm<sup>2</sup>) relieve pain, whereas high energy waves (0,2 to 0,4mJ/mm<sup>2</sup>) increase the regional blood flow, produce capillary lesions and promote growth of new capillaries [7].

*The purpose of the study was to determine:*

The effect of the ESWT on the healing of Scaphoid fracture nonunion.

### Subjects and Methods

This study was conducted in Kobri El-Koba Military Hospital from March 2017-May 2017 to investigate the effect of ESWT on Scaphoid fracture nonunions.

*Subjects:* 30 patients diagnosed with scaphoid fracture were chosen from Naser Polyclinic-General Authority of Health Insurance according to the following criteria:

*Inclusion criteria:*

- Thirty patients who had scaphoid fracture for more than 6 months.
- Their age was ranged from 20 to 50 years.

- All patients had scaphoid fracture for more than 6 months.

*Exclusion criteria:*

- Patients who have open or neoplastic fracture.
- Patients who have local infection.
- A bone gap more than 0.5cm.
- Patients with internal fixation.
- Pregnant women.
- Patients with pacemakers.
- Patients receiving anticoagulants or immunosuppressive drugs.

*Patients were randomly divided (simple randomization) into two equal groups in number:*

- *Study group:* This group was be composed of 15 patients who received the extracorporeal shock wave therapy followed by immobilization by cast.
- *Control group:* This group was be composed of 15 patients who received the regular medical conservative treatment.

*Instrumentations:*

- 1- Treatment instrument: Extracorporeal Shock Wave Therapy.

*Description:*

*Apparatus name:* Gymna Shock master 5000.

*Country:* Belgium.

*Its uses:* ESWT devices have been used for the treatment of plantar fasciitis, achilles tendinopathy, pseudarthrosis, fracture nonunion, femoral head necrosis, tibial stress syndrome, greater trochanter pain syndrome, delayed bone-tendon healing, subacromial pain, calcific tendinitis of the shoulder, rotator cuff tendinopathy, patellar tendinopathy, osteoporosis and lateral epicondylitis.

*2- Assessment instrument:*

The following tool was used to assess the healing response:

- 1- X-ray radiography.

*Procedures of the study:*

A verbal explanation about the importance of the research and main points of achievement eas explained to every patient. The procedures of the study were divided into two main categories:

*A- Therapeutic procedures:*

All patients in the 2 groups received the medical conservative treatment (immobilization and follow-up).

*Procedures of the extracorporeal shock wave therapy (study group):*

The pressure pulses was focused on the fracture gab and on the adjacent cortical structures with X-ray localization, 1500 shots was used and the energy will be  $0,2\text{mJ}/\text{mm}^2$ .

Each treatment cycle included 3 sessions at intervals of 72 hours between sessions; a maximum 3 cycles of treatment was given at 1 month interval.

After ESWT treatment, immobilization was required to achieve the full stabilization of the fracture.

*B- Measurement procedures:*

X-ray radiography: Antro-posterior and oblique views of the scaphoid bone were taken pre and post-treatment.

*C- Data analysis:*

- In this study, the mean, the standard deviation and the standard error were calculated for all patients (2 groups of the study) after the detected time of the study and Chi square test was used to compare the healing response between both groups at pre and post-treatment.
- The level of significance was set at the 0.05 level.



Fig. (1): ESWT apparatus.



Fig. (2): Immobilization with cast.



Fig. (3): ESWT application.



Fig. (4): X-ray of scaphoid fracture.

## Results

Statistical analysis was conducted using SPSS for windows, Version 20 (SPSS, Inc., Chicago, IL). The current test involved two independent variables. The first one was the between subject factor which had two levels (group A received conservative treatment and group B received ESWT followed by immobilization). The second one was the (measuring periods); within subject factor which had two levels (pre-treatment, post-treatment). In addition, this test involved one tested dependent variable (healing response) which is nominal variable. As there was no variation at pre treatment that all response in both groups was unhealed, so the McNemar test cannot be used and the frequency distribution and its percent only used to describe the difference within groups. While between groups Chi square test was used to com-

pare the healing response between both groups at pre and post-treatment. With the initial alpha level set at 0.05.

*General characteristics:*

The current study was conducted on thirty patients suffered from scaphoid fracture nonunion. They were assigned randomly into two equal studies groups.

*Group A:*

Fifteen patients with scaphoid fracture nonunion were included in this group. The data in (Table 1) and Figs. (5-7) represented their mean age (39±7.37) years, mean weight (80.8±5.22) kilograms (Kg), and mean height (169.66±5.36) centimeters (cm) respectively.

*Group B:*

Fifteen patients with scaphoid fracture nonunion were included in this group. The data in (Table 1) and Figs. (5-7) represented their mean age (39.6±8.3) years, mean weight (80.4±6.5) kilograms (Kg), mean height (171.33±4.67) centimeters (cm) respectively. There was no significant difference between both groups in their ages, weights, and heights where their *t* and *p*-values were (*t*=-0.209, *p*=0.836), (*t*=0.186, *p*=0.854), and (*t*=-0.907, *p*=0.372) respectively.

*Sex distribution:*

The sex distribution of control group revealed that there were 6 females with reported percentage of 40% and 9 males with reported percentage of 60%. The sex distribution of study group revealed that there were 4 females with reported percentage of 26.6% and 11 males with reported percentage of 73.4% as shown in (Table 2). Chi square revealed there was no significant differences between both groups in sex distribution (*p*>0.05).

*Healing response:*

*1- Within groups:*

As presented in (Table 3) and illustrated in Fig. (8), within groups comparison the frequency distribution of the healing response for group A in the "pre-treatment" was 15 subjects with unhealed response that reported percentage of 100%. As well as in the "post-treatment" was 15 subjects with unhealed response that reported percentage of 100%. Meanwhile, the frequency distribution of the healing response for study group in the "pre-treatment" was 15 subjects with unhealed response that reported percentage of 100%. While in the "post-treatment" were 12 subjects with healed response that reported percentage of 80% and 3

subjects with unhealed response that reported percentage of 20%.

*2- Between groups:*

As presented in (Table 3), the effect of the tested group (first independent variable) on the healing response by using Chi square revealed that the frequency distribution of the healing response of the "pre treatment" between both groups revealed that there was no significant difference ( $\chi^2 = 0.000$  and *p*=1.00). While, Chi square revealed that the frequency distribution of the healing response of the "post-treatment" between both groups showed that there was significant difference ( $\chi^2 = 24$  and *p*=0.0001 \*) and this significant increase in healing response in favor of study group.

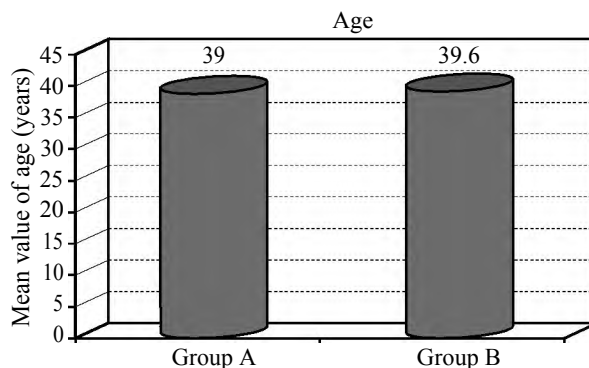


Fig. (5): Mean value of the age for both groups.

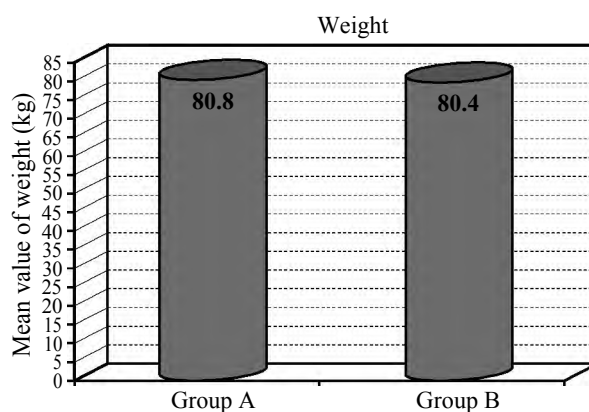


Fig. (6): Mean value of the weight for both groups.

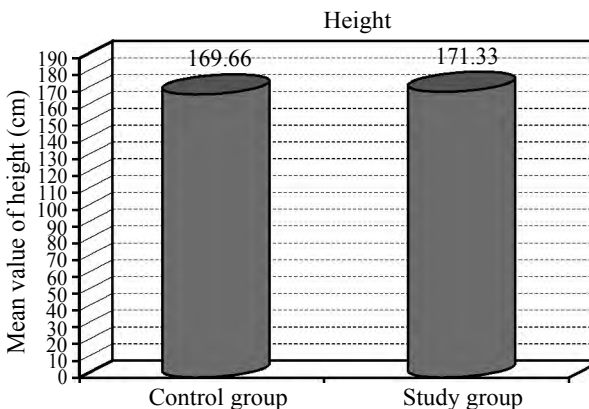


Fig. (7): Mean value of the height for both groups.

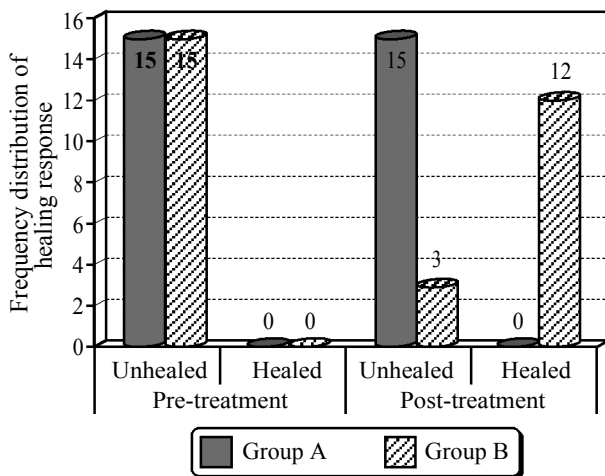


Fig. (8): Frequency distribution of healing response in pre and post-treatment at both groups.

Table (1): Physical characteristics of patients in both groups.

Items	Control group Mean ± SD	Study group Mean ± SD	Comparison		S
			t-value	p-value	
Age (yrs)	39±7.37	39.6±8.3	-0.209	0.836	NS
Weight (Kg)	80.8±5.22	80.4±6.5	0.186	0.854	NS
Height (cm)	169.66±5.36	171.33±4.67	-0.907	0.372	NS

\*SD : Standard Deviation. S : Significance.  
p : Probability. NS : Non-Significant.

Table (2): Distribution of sex in both groups.

	Group A		Group B		Chi-square	
	Females	Males	Females	Males	$\chi^2$	p-value
No.	6 (40%)	9 (60%)	4 (26.6%)	11 (73.4%)	0.600	0.439
Total	15 (100%)		15 (100%)			

Table (3): Frequency distribution and Chi square tests of the healing response for each group at pre and post-treatment.

Healing response	Group A		Group B	
	Unhealed	Healed	Unhealed	Healed
Pre-treatment	15 (100%)	0 (0%)	15 (100%)	0 (0%)
Post-treatment	15 (100%)	0 (0%)	3 (20%)	12 (80%)
Group A vs. group B		Pre-treatment	Post-treatment	
$\chi^2$ -value		0.000	20	
p-value		1.00	0.0001*	

\*: Significant at alpha level <0.05.

### Discussion

This study was conducted to study the effect of ESWT on scaphoid fracture non union.

Thirty patients with scaphoid fracture non union (20 males and 10 females) aged from 20 to 60 years, randomly assigned into two groups, subjects in the control group received conservative treatment (immobilization with cast and follow-up) while

subjects in the study group received 3 sessions of ESWT with interval of 72 hours followed by immobilization for a month to achieve full stabilization of the fracture.

The results in the control group showed that the healing response was 0% (100% unhealed).

The results in the study group showed that the healing response was 80% healed while 20% unhealed.

The comparison between the control group and the study group showed that the healing response in the study group was 80% while in the control group was 0%.

This means that there was a statistically significant difference between both groups.

Finally, according to the previous discussion and the results of the present study, it could be suggested that ESWT can be an effective method in the treatment of scaphoid fracture nonunion.

### Conclusions:

Within the limitations of the study it can be concluded that ESWT is an effective method in treatment of scaphoid fracture nonunion.

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## تأثير العلاج بالموجات التصادمية على كسر الزورقيه الغير ملتئم

المقدمة: كسر عظمة الزورقيه هو الأكثر شيوعا بين عظام الرسغ كما يعتبر الكسر الغير ملتئم من المضاعفات الشائعة لكسر عظمة الزورقيه نتيجة لضعف الدورة الدموية.

الهدف: يهدف هذا البحث إلى دراسة لإختبار تأثير العلاج بالموجات التصادمية على كسر عظمة الزورقيه الغير ملتئم.

الأشخاص: وقد أجرى هذا البحث على ٣٠ مريض من الجنسين حيث تم تشخيصهم بكسر بعظمة الزورقيه الغير ملتئم لمدة تزيد عن ستة أشهر حيث تتراوح أعمارهم من ٢٠ إلى ٥٠ سنة تم تقسيمهم إلى مجموعتين متساويتين وتضم كل مجموعة ١٥ مريضا.

الطريقة: تم تقسيم المرضى عشوائيا إلى مجموعتين متساويتين وهما المجموعة التجريبية وتضم ١٥ مريضا والمجموعة الحاكمة وتضم ١٥ مريضا أيضا وشمل البرنامج العلاجي لمرضى المجموعة التجريبية (العلاج بالموجات التصادمية متبوعا بتثبيت الرسغ عن طريق جبيرة). في نفس الوقت تم علاج المجموعة الحاكمة بإستخدام برنامج العلاج التحفظى التقليدى ويشمل (تثبيت الكسر عن طريق جبيرة والمتابعة). وقد تم تقييم الحالات عن طريق أشعة أكس وقد أجريت القياسات لهاتين المجموعتين قبل وبعد الفترة العلاجية.

النتائج: وقد تم تحليل النتائج إحصائيا وقد وجد إختلافات ذات دلالة إحصائية بين المجموعتين بينما وجدت إختلافات كبيرة ذات دلالة إحصائية فى المجموعة التجريبية فى إلتئام كسر الزورقيه الغير ملتئم.

الختامة: تعتبر الموجات التصادمية طريقة علاجية فعالة لعلاج كسر الزورقيه الغير ملتئم.