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ORIGINAL RESEARCH

Focused, radial and combined shock wave therapy in treatment of calcific shoulder tendinopathy

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ABSTRACT

Objective: The aim of this work is to compare the clinical, functional, and ultrasonographic outcomes of focused, radial, and combined extracorporeal shock-wave therapy (ESWT) in the treatment of calcific shoulder tendinopathy.

Methods: we enrolled 45 patients with calcific shoulder tendinopathy, their ages ranged from 30 to 68 (50.93 ± 9.44) years, classified according to the line of treatment into three groups, all received four sessions of ESWT 1 week apart.

Group I: 15 patients received focused shock waves (F-SW) 1500 shocks.

Group II: 15 patients received radial shock waves (R-SW) 2000 shocks.

Group III: 15 patients received combined focused and radial shock waves (C-SW). All patients were evaluated by musculoskeletal ultrasound (MSK US) before treatment, at 1 week and at 3 months after the last session.

Results: In the three studied groups, there was a significant improvement in shoulder pain, active range of motion (ROM), and shoulder function by shoulder disability questionnaire (SDQ) at 1 week after the end of treatment and after 3 months follow up. Moreover, there was a significant sonographic reduction in calcification size in the three groups. At the end of the study, the best improvement as regards a decrease of calcification size was obtained in group III when compared with group I and group II.

Conclusion: These results demonstrated clinical, functional, and sonographic improvement in all groups. The best therapy in calcific shoulder tendinopathy appears to be combined focused and radial ESWT compared to interventions alone. Level 1 Evidence Randomized control study.

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KEYWORDS
Shoulder; tendinopathy; extracorporeal shock wave; ultrasonography

Introduction

Calcific shoulder tendinopathy is a common problem characterized by the deposition of calcium hydroxyapatite crystals in the rotator cuff (RC) tendons. It typically occurs between the fourth and the fifth decades of life and most frequently affects the supraspinatus tendon near its insertion [1]. The exact pathophysiologic mechanism of calcific tendinopathy of the shoulder is still unknown. Metabolic, vascular, and degenerative changes and overuse could be a calcification trigger for the tendon tissue [2].

Patients with calcific shoulder tendinopathy present with shoulder pain which is worse at night or after activities, a decrease of active ROM, and a decrease of muscular strength [3].

Musculoskeletal ultrasound (MSK US) is very helpful in the diagnosis and guided treatment of calcific shoulder tendinopathy. It shows the presence of deposits and also defines their locations in the tendon, plus their size and shape (hyperechoic and arc-shaped) in the resting phase, and non-arc shaped (fragmented, cystic, nodular) in the resolving phase [4].

Most patients can be treated conservatively with pain medications, physical modalities, ROM exercises, and sub-acromial corticosteroid injections [5]. Some patients are resistant to conventional conservative treatment and remain with chronic symptoms. These patients can be treated with other modalities such as ESWT, needling and lavage, and surgical intervention [6]. Surgery, however, is costly and has many complications such as rotator cuff defects during removal of the deposits which may require intra-operative repair and long postoperative rehabilitation [7].

Extracorporeal shock-wave therapy has been used in the treatment of many musculoskeletal disorders such as; proximal plantar fasciitis, lateral epicondylitis, calcific shoulder tendonitis, and patellar tendinopathy with high success rates. It was found that ESWT can help reduction of inflammation, destruction of calcifications, tissue regeneration, and chronic pain relief [8].

There are two different types of ESWT; F-SW in which the energy generated converges in adjustable focus at a selected depth in the body tissues where the maximal pressure is reached. The other type is R-SW, in which the maximal pressure is at the skin surface and then diverges as it penetrates deeper. An effectiveness difference could differ concerning their generation devices, physical characteristics, and mechanism of action. Unlike focused, RSWT has a different linear pressure, low energy values, relatively low velocity of propagation, and short duration of the rise time [9].

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Key points: - Effectiveness of extracorporeal shock wave therapy (ESWT) in treatment of calcific shoulder tendinopathy.

So our study compares the clinical, functional, and ultrasonographic outcomes of focused, radial, and combined ESWT in the treatment of calcific shoulder tendinopathy.

Patients and methods

In this Randomized control study, we enrolled 45 patients with calcific shoulder tendinopathy (Figure 1).

Their ages ranged from 30 to 68 years, 28 of 45 patients were females, the right side was affected in 60% of the patients and the left side in 40%.

We selected the patients from the outpatient clinics of physical medicine, rheumatology, and rehabilitation department, Xxx university hospitals. We obtained approval from the ethical committee of Xxx University Hospital following the declaration of Helsinki, and all participants signed informed consent. From January 2016 to January 2019. **Inclusion criteria**: Patients with calcific shoulder tendinopathy were diagnosed clinically by diagnostic criteria for upper limb disorders proposed by the United Kingdom Health and Safety Executive Workshop [10] and by MSK US [11] with no improvement after 3 months of treatment with conventional physical therapy as ultrasound, laser, and exercise, or medical treatment or local corticosteroid injection. **Exclusion criteria**: Other causes of shoulder pain as previous trauma or operation of the shoulder, shoulder arthritis, referred pain to the shoulder region from sites extrinsic to the shoulder joint as the cervical spine, brachial plexus, thoracic outlet, peripheral nerve affection, wound or local infection in the shoulder, and hemiplegic patients. Also, contraindications for shock-wave therapy as: Age under 18 years, malignancy, and clotting problems, or use of anticoagulants.

Patients with calcific shoulder tendinopathy were randomly allocated by using simple random numbers **according to the line of treatment into three groups** [12].

Group I (F-SW group)

Included 15 patients received F-SW, 1500 shocks, with energy level (0.3 mj/mm^2) and frequency (4 Hz) [13].

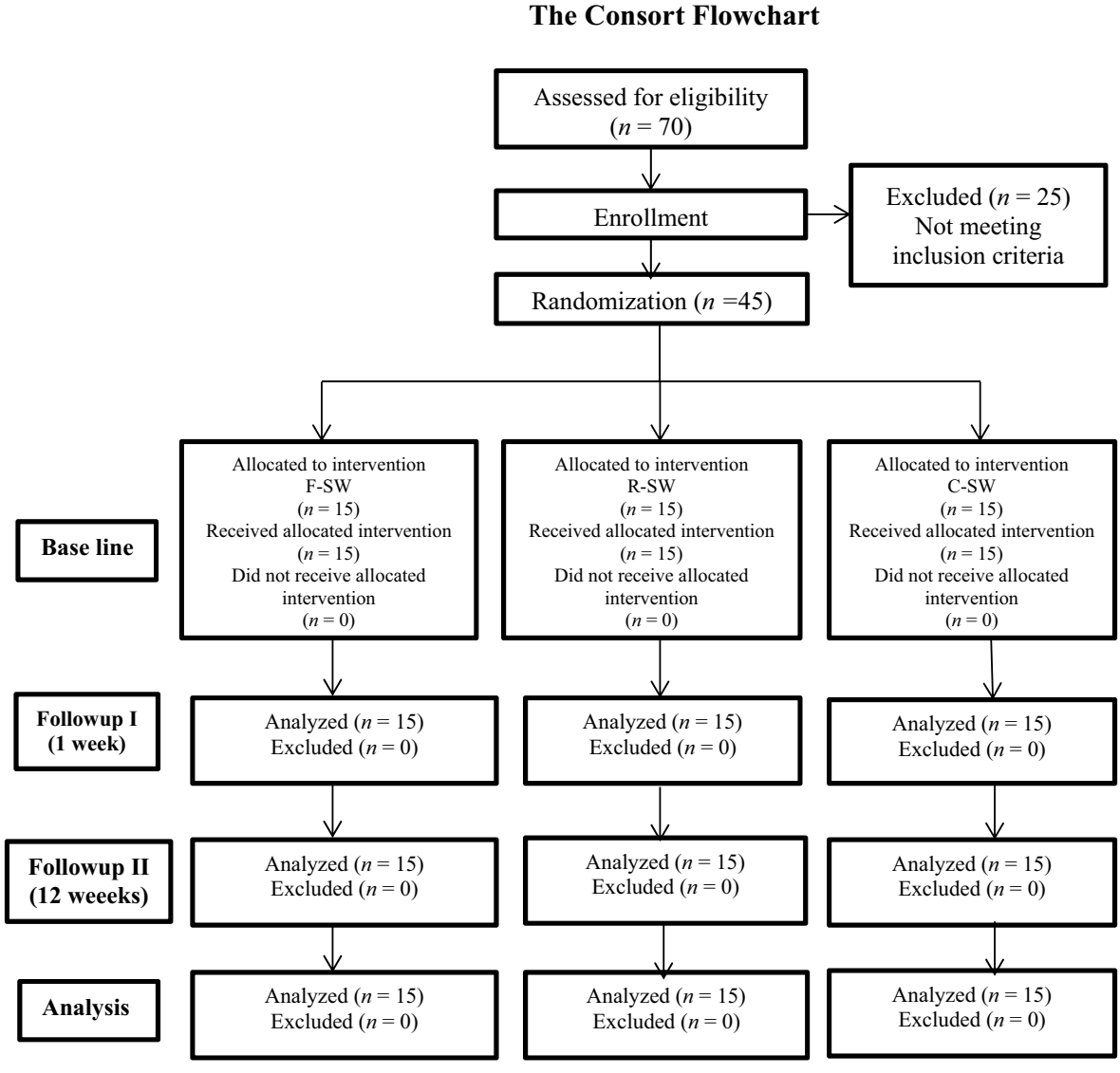

Figure 1. CONSORT flow chart for the patients through the study. F-SW, focused shock waves. R-SW, radial shock waves. C-SW, combined shock waves. n, number.

Group II (R-SW group)

Included 15 patients received R-SW, 2000 shocks, with energy level (2.5 bars) and frequency (10 Hz) [14].

Group III (C-SW group)

Included 15 patients received combined focused and radial shock waves in each session, 1500 shocks, and 2000 shocks, respectively, with the same previous parameters.

Patients of the three groups received four sessions, 1 week apart. Session duration lasts from 10 to 15 min. The contact head was positioned at the marked site of calcification which was defined by sonography before each treatment with an adequate amount of coupling gel. A cold pack was sometimes applied after the session to relieve pain and discomfort. No, medications or exercise were prescribed during treatment.

The shock-wave programs used in this study were done by DUOLITH SD1 Tower produced by STORZ MEDICAL AG. This device can generate F-SW (electromagnetically) and R-SW (pneumatically).

Method of evaluation

All patients were assessed clinically by complete history taking: with special attention to shoulder pain site, duration, character, and relation to activity, history of trauma or operation in the shoulder, and previous treatment. Assessment of degree of shoulder pain during movement by (VAS) [15]. Goniometric assessment of active shoulder ROM (Abduction and internal rotation). Functional assessment of the shoulder by (SDQ) [16].

All the patients underwent US examination of the shoulder using SAMSUNG MEDISON (UGEO H60), with linear array transducers with frequencies ranging between 9 and 13 MHz. It was used to assess calcific shoulder tendinopathy as regards to calcification site and size. In this study the size of the calcific plaque was measured by mm at its maximal diameter. The previous clinical, functional, and ultrasonographic assessment was done for all the patients studied before treatment, 1 week, and 12 weeks after treatment.

Statistical analysis of the data

A power size calculation was made. Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. Qualitative data were described using the number and percent. The Kolmogorov–Smirnov test was used to verify the normality of the distribution. Quantitative data were described using mean and standard deviation. ANOVA test for normally distributed quantitative variables was used to compare between more than two groups. The significance of the obtained results was judged at the 5% level.

Results

The baseline data, including age, sex, disease duration, affected side, VAS, ROM, SDQ, sonographic findings (calcification site and size) in the three groups showed no significant differences ($p > 0.05$).Table 1

There was significant clinical, functional, and ultrasonographic improvement at 1 week and 3 months after treatment in the three groups studied ($p < 0.001$*).Table 2

Combined focused and radial ESWT was significantly better than the use of focused or radial ESWT alone in all clinical, functional, and ultrasonographic parameters studied at 1 and 3 months after treatment. ($p < 0.001$*).Table 3

At 1 week and 3 months after treatment, there were no significant differences between focused and radial ESWT as regards clinical, functional, and ultrasonographic outcomes. Table 3

At the end of the study, only 3 cases in group I, 4 cases in group II and 10 cases in group III showed complete resorption of calcification whereas 12 patients in group I, 11 in group II, and 5 in group III showed a significant decrease of calcification size. Figures 2 and 3.

None of our patients needed surgical intervention after the completion of treatment sessions. Patients with residual pain

Table 1. Baseline Characteristics of 45 patients with calcific shoulder tendinitis.

Characteristic	Group I (F-SW)(15)	Group II (R-SW) (15)	Group III (C-SW)(15)	Test of Sig.	P
Age (years)	50.53 ± 6.78	53.47 ± 10.04	48.80 ± 11.02	F = 0.757	0.747
Sex Male/Female	6/9	5/10	6/9	χ2 = 0.0	1.0 00
Disease Duration (ms)	8.07 ± 5.35	8.93 ± 6.95	10.27 ± 7.69	H = 0.522	0.770
Affected side (R/L)	10/5	9/6	8/7	χ2 = 2.955	0.565
VAS	8.07 ± 0.96	7.73 ± 1.22	7.85 ± 1.58	H = 0.434	0.805
ROM					
Abduction	114.0 ± 27.20	106.0 ± 38.28	87.33 ± 29.57	H = 4.172	0.124
	P1 = 0.127 P2 = 0.500 P3 = 0.315				
Internal rotation	39.0 ± 15.25	39.66 ± 19.03	29.0 ± 8.70	H = 3.553	0.169
	P1 = 0.247 P2 = 0.146 P3 = 0. 154				
SDQ	85.83 ± 16.23	84.89 ± 14.42	87.54 ± 14.92	F = 0.117	0.890
Calcific. site					
Supraspinatus	12	11	13	χ2 = 0.833	0.659
Subscapularis	3	4	2		
Calcific. Size (mm)	9.57 ± 4.95	9.52 ± 3.79	11.04 ± 4.78	H = 1.326	0.515
	P1 = 0.173 P2 = 0.827 P3 = 272				

SDQ; shoulder disability questioner, VAS: visual analog scale, ROM: range of motion

p1: p-value for comparing between group I and group II, p2: p-value for comparing between group I and group III p3: p-value for comparing between group II and group III

χ2: Chi square test F: F for ANOVA test H: H for Kruskal Wallis test

Table 2. Shoulder pain, ROM, functional, and ultrasonographic outcome after treatment in the three groups.

Variable	Group	Before	After	Follow up	Test of Sig.	p
VAS (range, 0–10)	**Group I**	8 (2)	6 (3)	4 (3)	Fr =	<0.001*
	Median (IQR)				28.526	
	$p_1 = 0.006$*, $p_2 < 0.001$*, $p_3 = 0.014$*					
	Group II	7 (2)	5 (3)	3 (3)	Fr =	<0.001*
	Median (IQR)				27.527	
	$p_1 = 0.003$*, $p_2 < 0.001$*, $p_3 = 0.001$*					
	Group III	8 (2)	5 (3)	0 (3)	Fr =	<0.001*
	Median (IQR)				29.525	
	$p_1 = 0.005$*, $p_2 < 0.001$*, $p_3 = 0.011$*					
ROM						
Abduction (range, 0–180)	**Group I**	114.0 ± 27.20	133.0 ± 23.59	151.7 ± 19.61	F =	<0.001*
					33.411	
	p1 = 0.001*, p2 < 0.001*, p3 < 0.001*					
	Group II	106.0 ± 38.28	129.0 ± 33.39	151.0 ± 27.01	F = 20.461	<0.001*
	p1 = 0.001*, p2 < 0.001*, p3 = 0.018*					
	Group III	87.33 ± 29.57	132.0 ± 35.29	174.0 ± 6.32	F = 53.011	<0.001*
	p1 < 0.001*, p2 < 0.001*, p3 = 0.002*					
Internal rotation (range, 0–90)	**Group I**	39.0 ± 15.25	59.33 ± 13.34	66.0 ± 11.21	F = 16.587	<0.001*
	p1 = 0.001 *, p2 < 0.001*, p3 = 0.150					
	Group II	39.66 ± 19.03	61.33 ± 15.40	75.66 ± 10.15	F = 21.031	<0.001*
	$p_1 = 0.001$*, $p_2 < 0.001$*, $p_3 = 0.042$*					
	Group III	29.0 ± 8.70	62.67 ± 11.78	78.67 ± 7.43	F = 107.21	
	p1 < 0.001*, p2 < 0.001*, p3 < 0.001*					
SDQ (range, 0–100)	**Group I**	85.83 ± 16.23	56.75 ± 23.04	34.17 ± 23.05	F = 22.762	<0.001*
	p1 = 0.001*, p2 < 0.001*, p3 = 0.016*					
	Group II	84.89 ± 14.42	50.26 ± 21.82	29.16 ± 18.55	F = 34.638	<0.001*
	p1 < 0.001*, p2 < 0.001*, p3 = 0.010*					
	Group III	87.54 ± 14.92	42.36 ± 21.60	17.16 ± 15.84	F = 60.854	<0.001*
	$p_1 < 0.001$*, $p_2 < 0.001$*, $p_3 = 0.001$*					
Calcific. Size (mm)	**Group I**	8.70 (8.3)	5 (4.7)	3 (4)	Fr =	<0.001*
	Median (IQR)				22.349	
	$p_1 = 0.010$*, $p_2 < 0.001$*, $p_3 = 0.839$					
	Group II	9 (7.2)	5 (2.2)	4.7 (5)	Fr =	<0.001*
	Median (IQR)				28.000	
	$p_1 = 0.001$*, $p_2 < 0.001$*, $p_3 = 0.100$					
	Group III	11 (8.2)	7 (7)	0 (5.3)	Fr =	<0.001*
	Median (IQR)				28.737	
	p1 = 0.003*, p2 < 0.001*, p3 = 0.028*					

Fr: Friedman test, Sig. bet. periods was done using Post Hoc Test (Dunn's)
F: F test (ANOVA) with repeated measures, Sig. bet. periods was done using Post Hoc Test (adjusted Bonferroni)
p: p-value for comparing between the studied periods
p_1: p-value for comparing between before and after
p_2: p-value for comparing between before and Follow up
p_3: p-value for comparing between after and Follow up
*: Statistically significant at $p \leq 0.05$
SDQ; shoulder disability questioner, VAS; visual analog scale, ROM: range of motion

after the end of sessions showed improvement with the exercise program which included stretching and strengthening of muscles around the shoulder.

In our study, there were no reported side effects with ESWT treatment except for, pain during the treatment session, mild hematoma, and petechia (two patients in group II and two patients in group III). Most symptoms disappeared within minutes or hours after treatment.

Discussion

This study was to compare clinical, functional, and sonographic outcomes of focused, radial, and combined ESWT in the treatment of calcific shoulder tendinopathy.

The most important findings of the present study were that, there is no statistically significant difference in the effectiveness of F-SW and R-SW therapy for treating calcific shoulder tendinopathy and that combining both focused and radial ESWT resulted in a significantly better outcome in shoulder pain, ROM, function, and ultrasonographic findings.

In our three studied groups, there was a significant improvement of shoulder pain (VAS), active shoulder ROM, and shoulder function (SDQ) at 1 week and 3 months after treatment compared with before treatment and also at 3 months after treatment compared with 1 week after treatment. The best improvement of active shoulder abduction and internal rotation was obtained in group III when compared with group I and group II.

Our results were confirmed by others, **Ioppolo et al., (2012)** [13] studied 46 patients with calcific shoulder tendinopathy treated by F-SW, patients were divided into 2 groups comparing between 2 energy levels. Each group received four sessions, 1 week apart, 2400 shocks (0.20 mj/mm^2 in the high-energy group and 0.10 mj/mm^2 in the low energy group) and found a significant improvement of (VAS) in both groups after 3 months follow up with a better significant improvement in the higher energy group.

Table 3. The mean difference of improvement of VAS, ROM, functional, and ultrasonographic findings in the three studied groups.

Variable	period	Group I	Group II	Group III	Test of Sig.	p
VAS	Before/After Mean + SD	1.74 ± 0.96	1.80 ± 1.08	3.45 ± 1.29	H = 13.371	0.001*
	Median (IQR)	2 (2)	1 (1)	3 (2)		
		p1 = 0.926, p2 = 0.002*, p3 = 0.001*				
	Before/Follow up Mean + SD	4.40 ± 2.35	4.47 ± 1.72	6.58 ± 1.92	H = 8.578	0.014*
	Median (IQR)	4 (5)	3 (2)	7 (3)		
		p1 = 0.930, p2 = 0.009*, p3 = 0.003*				
	After/Follow up Mean + SD	2.66 ± 1.87	2.67 ± 1.54	3.13 ± 1.59	H = 0.890	0.641
	Median (IQR)	3 (3)	3 (3)	3 (3)		
ROM						
Abduction	Before/After Mean + SD	19.0 ± 16.06	23.0 ± 19.44	44.67 ± 28.94	H = 7.688	0.021*
	Median (IQR)	20 (15)	20 (30)	35 (60)		
		p1 = 0.655, p2 = 0.010*, p3 = 0.032*				
	Before/Follow up Mean + SD	37.67 ± 22.59	45.0 ± 34.07	86.67 ± 31.26	H = 16.269	<0.001*
	Median (IQR)	40 (15)	30 (60)	80 (45)		
		p1 = 0.498, p2 < 0.001*, p3 = 0.002*				
	After/Follow up Mean + SD	18.66 ± 13.68	22.0 ± 26.24	42.0 ± 37.07	H = 3.212	0.201
	Median (IQR)	20 (20)	10 (50)	40 (70)		
Internal rotation	Before/After Mean + SD	20.33 ± 11.56	21.66 ± 8.99	33.66 ± 13.43	H = 8.965	0.011*
	Median (IQR)	10 (20)	20 (50)	35 (25)		
		p1 = 0.727, p2 = 0.007*, p3 = 0.008*				
	Before/Follow up Mean + SD	27.0 ± 13.20	36.0 ± 16.27	49.67 ± 13.56	H = 13.414	<0.001*
	Median (IQR)	30 (35)	40 (50)	50 (45)		
		p1 = 0.107, p2 < 0.001*, p3 = 0.019*				
	After/Follow up Mean + SD	6.66 ± 9.76	14.33 ± 13.47	16.0 ± 14.66	H = 4.400	0.111
	Median (IQR)	10 (20)	10 (15)	10 (30)		
SDQ	Before/After Mean + SD	29.07 ± 16.35	34.63 ± 17.87	45.17 ± 21.06	H = 4.547	0.103
	Median (IQR)	33.33 (21.43)	39.56 (35.72)	42.86 (43.59)		
	Before/Follow up Mean + SD	51.66 ± 19.94	55.73 ± 20.64	70.38 ± 16.75	H = 6.782	0.034*
	Median (IQR)	50 (35.72)	54.29 (37.09)	69.24 (26.93)		
		p_1 = 0.587, p_2 = 0.010*, p_3 = 0.042*				
	After/Follow up Mean + SD	22.58 ± 25.17	21.09 ± 22.64	25.20 ± 18.69	H = 0.676	0.713
	Median (IQR)	13.34 (35.71)	21.48 (18.58)	30.77 (18.75)		
Calcific. Size	Before/After Mean + SD	3.24 ± 3.30	4.27 ± 3.02	4.55 ± 2.11	H = 0.056	0.972
	Median (IQR)	3.9 (5.3)	4.3 (5)	4.3 (2.3)		
	Before/Follow up Mean + SD	5.72 ± 3.64	5.58 ± 2.79	8.83 ± 3.49	H = 7.354	0.025*
	Median (IQR)	5.7 (4.5)	5.8 (4)	7.2 (5)		
		P_1 = 0.928, p_2 = 0.017*, p_3 = 0.021*				
	After/Follow up Mean + SD	2.48 ± 1.44	1.31 ± 1.58	4.28 ± 3.18	H = 7.929	0.019*
	Median (IQR)	1.5 (3)	1 (3)	3 (6.4)		
		P_1 = 0.771, p_2 = 0.007*, p_3 = 0.004*				

SDQ; shoulder disability questioner, VAS; visual analog scale, ROM: range of motion
p: p-value for comparing between the studied groups
p_1: p-value for comparing between group I and group II
p_2: p-value for comparing between group I and group III
p_3: p-value for comparing between group II and group III
*: Statistically significant at $p \leq 0.05$

Malliaropoulos et al., (2017) [17] studied 67 patients with calcific shoulder tendinopathy treated with R-SW with individualized protocol according to the tolerance of each patient, and they found a significant reduction in VAS immediately after treatment and after 3 months follow up when compared with before treatment. They also found that the treatment became increasingly successful with the passage of time, with significant improvement of pain at 3 months follow up when compared with immediately after treatment.

It was suggested that the immediate analgesic effect of ESWT is achieved through hyperstimulation analgesia (gate-control theory), and by increasing local pain-inhibiting substances leading to elevation of the pain threshold and also by increasing the release of neuropeptides which causes vasodilatation and help to wash out the inflammatory mediators [18].

The long-term analgesic effect of ESWT was explained by the ability of ESWT to cause selective destruction of unmyelinated

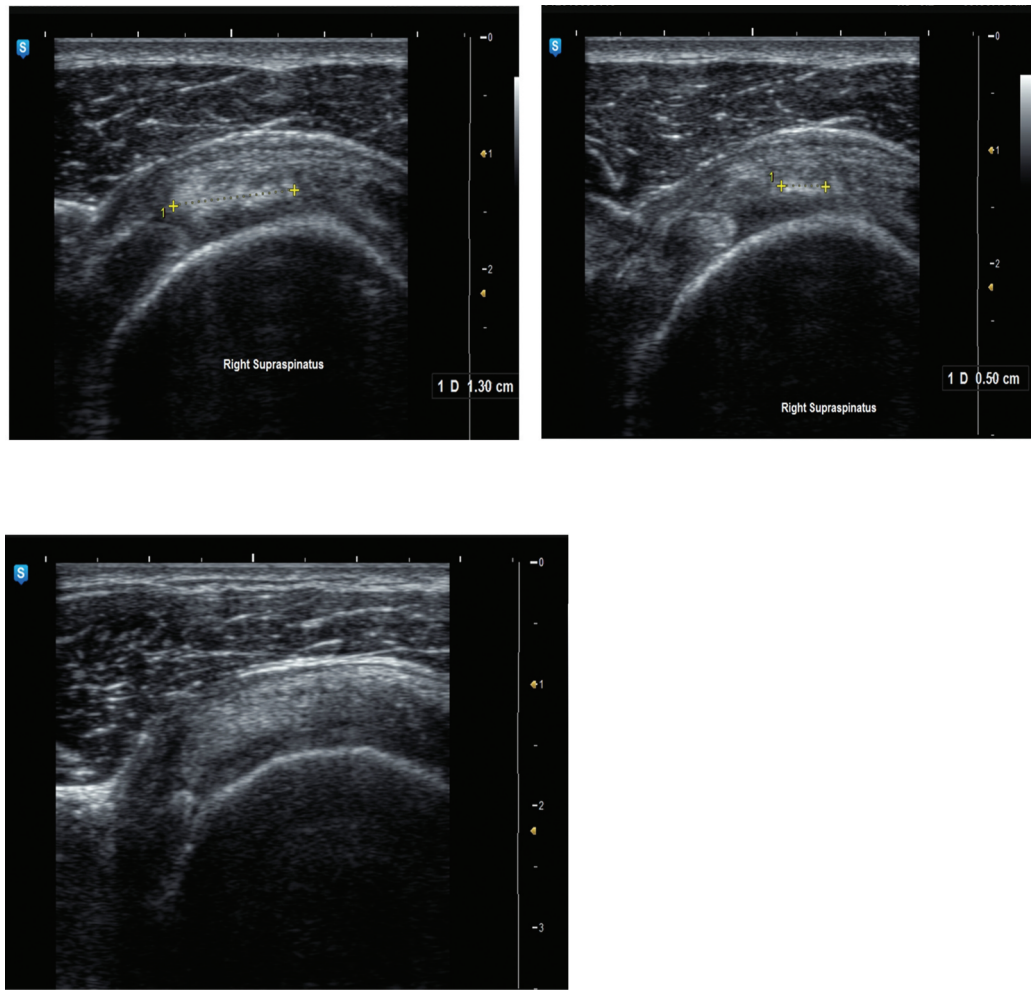

Figure 2. Before treatment; right supraspinatus tendon showing calcification measuring 13 mm. At 1 week after end of treatment with combined shock-wave therapy; there was partial resorption of calcification (5 mm). after 3 months follow up; there was more improvement of right supraspinatus tendon with complete resorption of calcification.

C-fibers which are known to be responsible for throbbing, chronic pain [19]. Thus, ESWT may selectively lead to dysfunction of peripheral sensory-unmyelinated nerve fibers responsible for pain transmission without affecting large-myelinated nerve fibers responsible for motor function [20].

Also, animal studies demonstrated that ESWT application can decrease the synthesis of substance P and calcitonin gene-related peptide (CGRP) in dorsal root ganglia. This leads to decreased neurogenic inflammation which is considered to play an important role in the pathogenesis of tendinopathy [21].

The improvement of shoulder function (SDQ) in the three studied groups after ESWT treatment may be explained by the improvement of pain with a subsequent increase of ROM. ESWT also produces a 'knocking' force on the tendon that may relieve adhesions resulting from the chronic tendinopathy [22].

In our patients with calcific shoulder tendinopathy, the calcific deposits were most commonly located in the supraspinatus tendon 80%, followed by the subscapularis tendon 20%.

Studies demonstrated that the most common site affected by calcific tendinopathy in the supraspinatus tendon is located between 1 and 2 cm medial to the tendon insertion on the greater tuberosity at the junction of fibrocartilage with the tendon (critical zone) which may be due to the poor vascularization of the tendon in this area which acts as a predisposing factor for tendon degeneration [23].

At the end of this study, 3 out of 15 patients (20%) in group I, 4 out of 15 patients (26.66%) in group II and 10 out of 15 patients (66.66%) in group III showed complete resorption of calcification whereas 12 patients in group I, 11 in group II, and 5 in group III showed a significant decrease of calcification size.

Albert et al., (2007) [23] studied patients with calcific shoulder tendinopathy treated with F-SW and found that total resorption of the calcification occurred in 15% of the patients in the high-energy group and 5% in the low energy group after 3 months follow up. **Mangone et al., (2010)** [24] studied 36 patients with calcific shoulder tendinopathy treated with R-SW and found that calcifications disappeared in 31% of his patients after 3 months follow up. Also, **Avancini-Dobrović et al., (2011)** [14] studied 30 patients with calcific shoulder tendinopathy treated with R-SW and found a significant decrease of calcification size after 6 months follow up compared with before treatment.

Several hypotheses have been suggested to explain the mechanism of action of ESWT in calcium resorption; however,

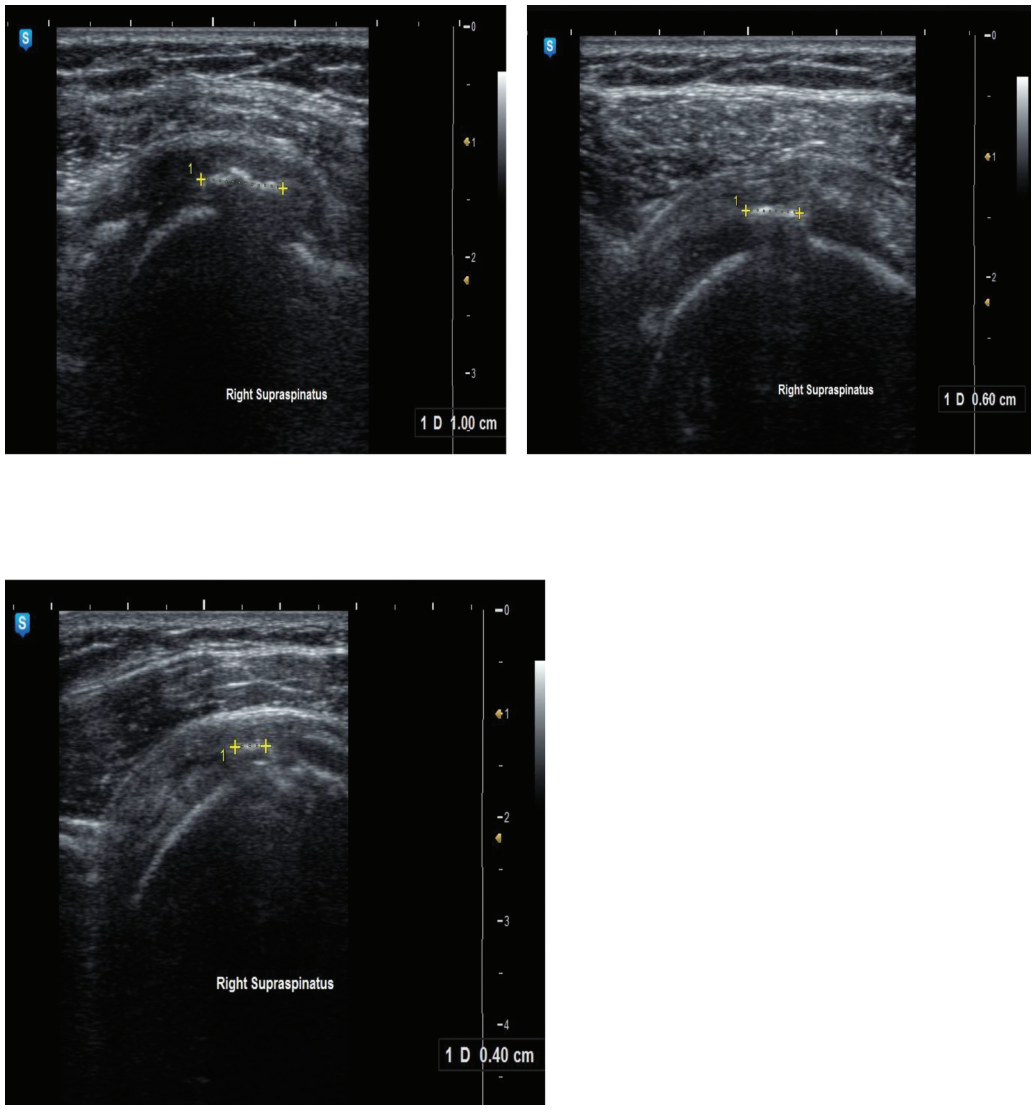

Figure 3. Before treatment; right supraspinatus tendon showing calcification measuring 10 mm. At 1 week after end of treatment with radial shock-wave therapy; there was partial resorption of calcification (6 mm). at the end of the study there was more improvement of right supraspinatus tendon calcification (4 mm).

the exact mechanism remains controversial. With regard to the direct mechanical effect, ESWT is thought to induce deposit fragmentation through a pressure increase inside the deposit leading to disorganization and disintegration of the deposit [25].

Other studies suggested that the negative phase of the shock wave causes cavitation at the tissue interfaces. During cavitation, air bubbles are formed as a result of the negative pressure. These bubbles subsequently have imploded with high speed, generating a second wave of shock waves or micro-jets of fluid. Breakdown of the cavitation bubbles disrupts the integrity of the calcification and the subsequent microjets enhances the effect, destroying the deposit [26].

With regard to the molecular effect, ESWT can enhance phagocytosis of the deposit by increasing the neovascularization and leukocyte chemotaxis. It was found that ESWT can increase neovascularization by increasing the production of von Willebrand factor, vascular endothelial growth factor (VEGF), endothelial nitric oxide synthetase (eNOS), and proliferating cell nuclear antigen (PCNA) [27]. **Branes et al., (2012)** were able to demonstrate the presence of neo-lymph angiogenesis from biopsies taken from rotator cuff repair surgery, previously treated with ESWT. Their hypothesis was that neo-lymph angiogenesis is related to improved calcium reabsorption observed after ESWT treatments [28].

This study showed that the best clinical, functional, and ultrasonographic improvement was obtained in group III (combined shock-wave group) and this can be due to getting the beneficial effects and the advantages of both focused and radial shock waves.

No, previous-reported literature as regards the comparison between focused and radial shock waves or the use of combined focused and radial shock waves in the treatment of calcific shoulder tendinopathy.

Focused shock waves have higher energy levels and can reach deeper into the tissues, but the energy generated by F-SW is transmitted to a small area of interest (focus) with the maximum energy level developing some centimeters subcutaneously. The effective focal zone of F-SW is very small; thus, the area of affected tissue that can be treated is also small. In contrast, R-SW develops their maximum energy at the skin

surface and distribute it radially into the tissues and this allows treating the original site of the disease (e.g., the calcification area), as well as other affected areas [29].

The limitation of our study was the short duration of follow-up. The obtained results should be confirmed by further clinical studies with larger patient numbers and longer follow-up periods.

Conclusion

There was a significant improvement of clinical, functional, and ultrasonographic findings after the use of focused, radial, or combined ESWT in calcific shoulder tendinopathy. The best improvement was obtained after the combined use of focused and radial ESWT when compared with focused or radial ESWT alone.

Recommendations

We recommend ultrasonographic assessment for cases of calcific shoulder tendinopathy and we advise the use of combined focused and radial ESWT as a safe and effective substitute for surgical treatment of calcific shoulder tendinopathy.

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Declaration of interest

There is no actual or potential conflict of interest in relation to this article.

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