Mulligan Mobilization Versus Extracorporeal Shockwave Therapy on Ultrasonographic Changes in Patients with Adhesive Capsulitis: A Randomized Controlled Trial

Mohamed R. Gaber[1], Amir M. Saleh[2], Magda R. Zahran[3], Omran K. Qenawy[4], Sahar Mahmoud Hassan[5], Heba M. Elfeky[6]

[1]Assistant lecturer of physical therapy, Basic science Department, Faculty of physical therapy, Sphinx university, Egypt.
ORCID: 0009-0001-7589-5537
Email: Mohamedragab.pt.cu@gmail.com

[2] Professor of physical therapy, Basic science Department, Faculty of physical therapy, Cairo University, Egypt.
Email: amirsalehed@hotmail.com

[3] Assistant Professor of physical therapy, Basic science Department, Faculty of physical therapy, Cairo University, Egypt.
ORCID: 0000-0003-3495-7508
Email: Magdaramadan2000@yahoo.com

[4] Assistant Professor, Department of Diagnostic Radiology, Faculty of Medicine, Assiut university, Egypt.
Email: omranshow@yahoo.com

[5]Department of physical therapy, Cairo University hospitals, Cairo, Egypt.
Department of physical therapy, College of Applied Medical Sciences, Qassim University, Buraydah, Saudi Arabia
Email: smmh007@yahoo.com
ORCID: 0000-0002-0132-1733

[6] Lecturer of physical therapy, Basic science Department, Faculty of physical therapy, Cairo University, Egypt.
ORCID: 0000-0003-4317-1312
Email: Heba.elfeky@cu.edu.eg

Abstract

BACKGROUND: The debilitating illness identified as adhesive capsulitis (AC) is marked by pain and limited shoulder movements. Various physiotherapy interventions are used; however, comparative evidence remains limited.

OBJECTIVE: To compare the impacts of Mulligan mobilization and extracorporeal shockwave therapy (ESWT) on pain, range of motion (ROM), functional impairment, hand grip strength, and ultrasonographic findings in patients with AC.

METHODS: A randomized controlled trial was executed on 60 patients with AC. Participants were randomized into three groups: Mulligan mobilization integrated with conventional physiotherapy, ESWT integrated with conventional physiotherapy, and a control group that underwent conventional physiotherapy only. Evaluated outcomes involved inferior capsule thickness assessed using a diagnostic musculoskeletal ultrasound imaging device, pain evaluated by the Visual Analogue Scale (VAS), the ROM assessed by a digital goniometer, functional disability assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, and hand grip strength measured utilizing the Jamar Plus digital hand dynamometer.

RESULTS: No significant variations were noted across groups at baseline ($p>0.05$). The shockwave group reported substantial reduction in capsular thickness and pain along with improved handgrip strength. The Mulligan group indicated significant improvements in ROM and DASH scores.

CONCLUSION: Both Mulligan mobilization and shockwave therapy, when combined with conventional physiotherapy, were more effective than conventional treatment alone. Shockwave therapy was more beneficial in alleviating pain, increasing handgrip strength, and promoting structural changes through decreasing inferior capsule thickness. Mulligan mobilization was superior in improving ROM and functional results.

Keywords: adhesive capsulitis, Mulligan mobilization, shockwave therapy, ultrasound, handgrip strength.

Abbreviation list: Adhesive capsulitis (AC), Disabilities of the arm, shoulder and hand (DASH), extracorporeal shockwave therapy (ESWT), range of motion (ROM), Visual Analog Scale (VAS).

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1. Introduction

Adhesive capsulitis (AC), or frozen shoulder, is an illness leading to considerable pain and restricted shoulder ROM, impairing function and lowering physical wellness [(1)].

AC is a prevalent illness impacting those aged 30 to 60; its etiology is idiopathic, associated with sedentary lifestyles, post-traumatic, or related to other pathological disorders [(2,3)]. AC affects 2% to 5% of the general population [(4,5,6)], with higher rates in women [(4,7)].

The disease advances through three stages: freezing, frozen, and thawing. A definitive standardized procedure for AC has not been established. The objective of any intervention is to alleviate discomfort and rehabilitate shoulder mobility [(8)].

Multiple conservative therapeutic modalities have been incorporated into the treatment of AC, involving physical therapy, manual therapy techniques, electrotherapy modalities, and pharmacological interventions [(2,9)]. Among these, Mulligan mobilization techniques have been widely utilized to enhance joint motions and alleviate pain by employing sustained accessory glides combined with active movement [(10)].

Alternatively, extracorporeal shockwave therapy (ESWT) has garnered heightened interest as a non-intrusive technique that promotes pain relief, enhances tissue healing, and improves functional outcomes through its mechanical and biological effects on soft tissues [(Error! Reference source not found.)]. Recent evidence suggests that ESWT may play a significant role in alleviating discomfort and boosting shoulder functioning in individuals with AC [(11,13)].

Despite the increasing use of these interventions, there is limited evidence comparing their combined clinical and structural effects, particularly using ultrasonographic assessment. Few studies have investigated structural changes such as inferior capsule thickness alongside functional outcomes, including pain, range of motion, DASH score, and handgrip strength.

Therefore, this trial was intended to verify the impact of Mulligan mobilization and ESWT on clinical and ultrasonographic findings in patients with AC.

2. Materials and methods

2.1. Design

The study was recorded prospectively on ClinicalTrials.gov (NCT07310810), with data gathered at outpatient clinics at Sphinx University in Egypt. The Research Ethics Committee of the Faculty of Physical Therapy, Cairo University (No.: P.T.REC/012/005863) granted authorization, and informed consent was obtained from all patients.

2.2. Participants

Sixty patients with AC were selected from Sphinx University's outpatient clinics in Egypt. Patients between the ages of 40 and 60 were allocated based on the eligibility criteria [(2,3,5,14)]: shoulder pain persisted for two months or more and restriction of at least 25% in two or more shoulder movements compared to the contralateral side [(17,18)].

Patients weren't included if they had histories of shoulder fracture or dislocation, previous shoulder surgeries, neurological disorders affecting the upper limb, or had received any invasive shoulder therapy in the last three months [(19)].

Randomization:

Patients were randomized and equally allocated into three groups (n = 20 each) via a simple randomization method. Allocation was masked utilizing sealed opaque envelopes; each patient chose an envelope containing the group assignment.

2.3 .Interventions

Group A (Mulligan mobilization group): Patients received Mulligan mobilization techniques plus a conventional physiotherapy program. The Mulligan technique was applied as sustained accessory glides combined with active movement (Mobilization with Movement (MWM)) within the pain-free range. The patient had three sessions a week for 4 weeks. MWM for shoulder abduction was done while seated. While the patient actively executed shoulder abduction, the therapist situated themselves postero-laterally to the impaired side and administered lateral and inferior gliding to the upper proximal head of the humerus of the impaired shoulder, applying more pressure at the range-end. The glide was sustained during the motion until the patient's arm reverted to a neutral posture. The technique was pain-free for the patient during the entire session. The procedure was 3 sets of 10 repetitions [20].

For shoulder external rotation (ER), the patient was positioned supine with the scapula at the treatment table's edge. The therapist, situated laterally to the impacted shoulder, fastened a mobilization belt around his waist. The patient's shoulder and elbow were flexed at 90 degrees. The therapist held the distal humerus while positioning the belt adjacent to the joint line. The therapist laterally displaced the shoulder, encouraging the patient to actively execute external rotation (ER) while exerting excessive pressure at the terminal range. The glide was kept until the arm reverted to a neutral stance. The technique was devoid of pain for the patient during the entire session. The procedure was 3 sets of 10 repetitions [14,20].

Group B (shockwave therapy group): Patients received ESWT plus the same conventional physiotherapy program. Shockwave therapy was applied once weekly for four consecutive weeks [15,17], allowing sufficient time for tissue response and biological effects between sessions. The patient sat on a chair with his/her arm resting. Shockwave gel was administered as a light coating across the shoulder joint. The shockwave probe was held perpendicularly on the front and back aspects of the shoulder joint [16]. Each session consisted of 2000–3000 shocks delivered at 8–10 Hz and an energy density of 0.1–0.3 mJ/mm², according to patient tolerance [17,21].

Group C (control group): Patients received the conventional physiotherapy program alone, which involved stretching exercises, ROM exercises, and electrotherapy modalities such as ultrasound and laser therapy [22,23].

2.4. Outcome Measures

The study outcomes were measured prior to and after the treatment period for all participants. Inferior capsular thickness was evaluated using musculoskeletal ultrasonography to detect structural changes associated with adhesive capsulitis [24,25,26], Pain level was evaluated via the Visual Analog Scale (VAS) [27]. Shoulder ROM (abduction and external rotation) [23,28], was measured using a Baseline Absolute + Axis digital goniometer (3B Scientific, USA) [29]. Functional disability was evaluated utilizing the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire [30,31]. Hand grip strength was tested by the Jamar Plus+ hand dynamometer (Patterson Medical, USA), which has been widely reported as a valid and reliable instrument for assessing grip strength [32].

Statistical Analysis:

ANOVA and Chi-squared tests were employed to examine subject characteristics and sex distribution, respectively. The Shapiro-Wilk test evaluated data normality, whereas Levene's test assessed variance homogeneity. A mixed MANOVA assessed the inter- and intra-group impacts on VAS, shoulder ROM, DASH, inferior capsule thickness, and handgrip strength. Bonferroni-corrected post-hoc analyses were performed for multiple comparisons, with a significance level established at $p<0.05$ for all tests. SPSS version 25 for Windows was applied for statistical tests (IBM SPSS, Chicago, IL, USA).

Results

- *Subject characteristics*:

Table 1 displays the subjects' demographics in all groups. No substantial changes were noted across groups in age, weight, height, BMI, and distribution of sex ($p > 0.05$).

Table 1. Participants' basic characteristics.

	Group A	Group B	Group C	p-value
	mean ± SD	mean ± SD	mean ± SD	
Age (years)	52.10 ± 5.65	54.75 ± 6.95	53.10 ± 4.88	0.36
Weight (kg)	80.15 ± 9.63	78.25 ± 7.63	80.60 ± 9.28	0.68
Height (cm)	168.30 ± 7.12	166.30 ± 5.36	167.70 ± 8.75	0.67
BMI (kg/m²)	28.25 ± 2.35	28.25 ± 1.88	28.61 ± 1.63	0.81

Sex, n (%)				
Females	7 (35%)	8 (40%)	7 (35%)	930.
Males	13 (65%)	12 (60%)	13 (65%)	

SD, Standard deviation; p-value, Probability value

<u>Impact of treatment on VAS, shoulder ROM, DASH, inferior capsule thickness, and hand grip strength:</u>

Mixed MANOVA indicated a substantial interaction between treatment and time ($F = 81.98$, $p = 0.001$, $\eta^2 = 0.90$). Time had a substantial main effect ($F = 768.73$, $p = 0.001$, $\eta^2 = 0.98$). Treatment had a substantial main impact ($F = 12.56$, $p = 0.001$, $\eta^2 = 0.59$).

Within-group comparison

Following treatment, there was a notable reduction in VAS, DASH, and inferior capsule thickness in all groups relative to before intervention ($p<0.05$). Furthermore, a notable increase was detected in shoulder external rotation (ER) and abduction ROM in all groups following intervention in comparison to before treatment ($p < 0.001$). Handgrip strength indicated a substantial increase in all groups following therapy ($p < 0.001$) (Table 2).

Between-group comparison

Post-treatment comparison indicated that Group B exhibited a notable decrease in VAS and inferior capsule thickness, together with a substantial increase in handgrip strength, in comparison to groups A and C ($p<0.05$).

Group A exhibited a notable decrease in VAS, DASH, and inferior capsule thickness, along with a substantial increase in the ROM of shoulder ER and abduction in comparison to group C ($p<0.05$). Nonetheless, no statistically significant variance was noted in handgrip strength among groups A and C following therapy ($p = 0.49$).

Group A exhibited a notable improvement in shoulder ER and abduction ROM, alongside a substantial decrease in DASH scores, relative to group B after treatment ($p<0.05$) (Table 3).

Table 2. ***Mean VAS, shoulder external rotation, and abduction ROM pre- and post- study of all groups:***

	Group A	**Group B**	**Group C**
	mean ± SD	**mean ± SD**	**mean ± SD**
VAS			
Pre-treatment	8.10 ± 0.79	8.05 ± 0.76	7.70 ± 0.98
Post treatment	6.25 ± 1.07	4.15 ± 0.81	7.05 ± 0.94
MD (% of change)	1.85 (22.84%)	3.90 48.45%)	0.65 (8.44%)
95% CI	1.51: 2.19	3.56: 4.24	0.31: 0.99
	p = 0.001	***p = 0.001***	***p = 0.001***
External rotation ROM (degrees)			
Pre-treatment	27.15 ± 4.83	29.25 ± 5.91	28.40 ± 4.47
Post treatment	63.25 ± 6.93	45.25 ± 6.97	38.45 ± 5.33
MD (% of change)	-36.10 (132.97%)	-16.00 (54.70%)	-10.05 (35.39%)
95% CI	-38.21: -33.99	-18.11: -13.89	-12.16: -7.94
	p = 0.001	***p = 0.001***	***p = 0.001***
Abduction ROM (degrees)			
Pre-treatment	120.75 ± 5.68	121.95 ± 5.53	119.25 ± 6.93
Post treatment	155.50 ± 9.72	147.95 ± 8.61	139.80 ± 8.09
MD (% of change)	-34.75 (28.78%)	-26.00 (21.32%)	-20.55 (17.23%)

95% CI	-37.48: -32.02	-28.73: -23.27	-23.28: -17.82
	p = 0.001	***p = 0.001***	***p = 0.001***
DASH			
Pre-treatment	63.25 ± 5.20	65.39 ± 4.59	63.75 ± 6.26
Post treatment	30.38 ± 5.21	45.00 ± 5.07	49.75 ± 5.90
MD (% of change)	32.87 (51.97%)	20.39 (31.18%)	14.00 (21.96%)
95% CI	31.27: 34.48	18.78: 21.99	12.39: 15.61
	p = 0.001	***p = 0.001***	***p = 0.001***
Inferior capsule thickness (mm)			
Pre-treatment	2.54 ± 0.22	2.51 ± 0.23	2.53 ± 0.25
Post treatment	2.11 ± 0.27	1.77 ± 0.25	2.41 ± 0.22
MD (% of change)	0.43 (16.93%)	0.74 (29.48%)	0.12 (4.74%)
95% CI	0.31: 0.55	0.62: 0.85	0.01: 0.24
	p = 0.001	***p = 0.001***	***p = 0.03***
Handgrip strength (kg)			
Pre-treatment	24.15 ± 6.43	23.65 ± 5.32	22.75 ± 6.53
Post treatment	27.25 ± 6.18	33.80 ± 6.45	24.85 ± 7.21
MD (% of change)	-3.10 (12.84%)	-10.15 (42.92%)	-2.10 (9.23%)
95% CI	-4.11: -2.09	-11.16: -9.14	-3.11: -1.09
	p = 0.001	***p = 0.001***	***p = 0.001***

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p value, Probability value

Table 3. ***Comparison of VAS, shoulder external rotation and abduction ROM, DASH, inferior capsule thickness, and hand grip strength across all groups after treatment.***

Outcome	**Group A vs B**		**Group A vs C**		**Group B vs C**		**η2**
	MD (95% CI)	**p value**	**MD (95% CI)**	**p value**	**MD (95% CI)**	**p value**	
VAS	2.10 (1.38: 2.82)	0.001	-0.80 (-1.52: -0.08)	0.02	-2.90 (-3.62: -2.18)	0.001	0.64
External rotation ROM (degrees)	18 (13.09: 22.91)	0.001	24.80 (19.89: 29.71)	0.001	6.80 (1.89: 11.71)	0.004	0.73
Abduction ROM (degrees)	7.55 (0.83: 14.27)	0.02	15.70 (8.98: 22.42)	0.001	8.15 (1.43: 14.87)	0.01	0.36
DASH	14.62 (-18.74: -10.51)	0.001	-19.37 (-23.49: -15.26)	0.001	-4.75 (-8.86: -0.64)	0.02	0.71
Inferior capsule thickness (mm)	0.34 (0.15: 0.53)	0.001	-0.30 (-0.48: -0.11)	0.001	-0.64 (-0.82: -0.45)	0.001	0.54
Grip strength (kg)	-6.55 (-11.60: -1.50)	0.008	2.40 (-2.65: 7.45)	0.49	8.95 (3.90: 14.00)	0.001	0.26

MD, Mean difference; CI, Confidence interval; p value, Probability value; η^2, Partial Eta Squared.

3. Discussion

The findings illustrated in Table 3 revealed that both Mulligan mobilization and ESWT produced significant improvements in patients with AC in contrast with conventional treatment alone. However, the pattern of improvement differed between interventions. The ESWT group demonstrated greater improvement in pain intensity, inferior capsule thickness, and handgrip strength. The Mulligan mobilization group indicated better gains in shoulder ROM and functional performance, as assessed by the DASH questionnaire. These results revealed that although both therapeutic procedures were beneficial, each modality exhibited distinct therapeutic advantages regarding specific clinical and ultrasonographic outcomes.

Ultrasonographic findings revealed a greater reduction in the inferior capsule thickness, in the ESWT group (Fig 1). This suggests that shockwave therapy may have a beneficial effect on the structural changes associated with adhesive capsulitis, possibly through promoting tissue remodeling and reducing fibrosis [33].

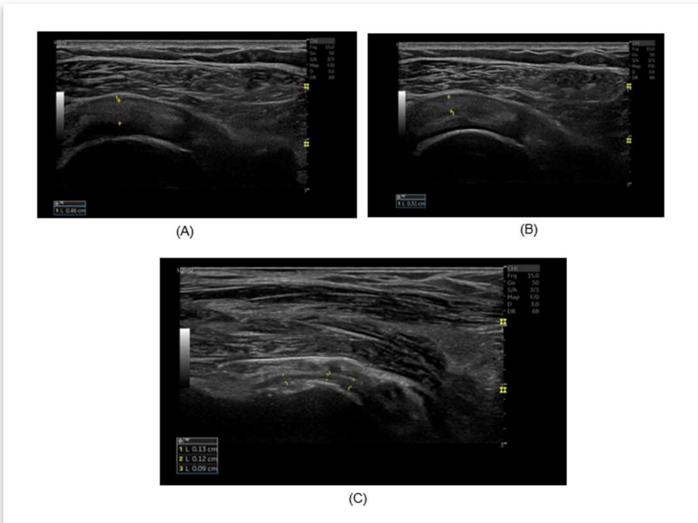

Fig 1: **Ultrasonography of the inferior capsule thickness in adhesive capsulitis patients. (A,B) Pre-intervention ultrasound scans demonstrating baseline inferior capsule thickness. (C) Post-intervention ultrasound scans demonstrating inferior capsule thickness following treatment.**

Our results correspond with those of Nambi et al.[34], who stated that ESWT is beneficial in decreasing coracohumeral ligament thickness and improving ROM.

Our findings are also consistent with the systematic review done by Cortes-Perez et al. [35], which examined the efficacy of ESWT in alleviating pain and tissue thickness while improving functional outcomes. These outcomes are further corroborated by Chou et al.[36], who reported that ESWT enhances tissue perfusion, promotes angiogenesis, and stimulates BMP7 activity, which may explain the observed reduction in tissue thickness and overall clinical improvement in the present study.

The alleviation of pain was markedly more pronounced in the ESWT group, which may be credited to the analgesic effects of shockwave therapy [37], which are thought to involve modulation of nociceptor activity, reduction of inflammatory mediators, and enhancement of local blood flow [38,39,40]. These mechanisms may explain the superior pain outcomes observed in this group.

In contrast, the Mulligan mobilization group demonstrated further improvements in shoulder ROM, which was supported by the meta-analysis executed by Stathopoulos et al. [41], which reported that MWM techniques significantly improve ROM in patients with peripheral joint disorders. This may be explained by the concept of mobilization with movement, which aims to restore normal joint kinematics and correct positional faults. Improved arthrokinematics may facilitate increased mobility and reduce movement-related discomfort in patients with adhesive capsulitis [10,19].

Functional outcomes, as measured by the DASH questionnaire, were more favorable in the Mulligan group. This finding may be related to the direct association between improved ROM and the capability to do routine functional tasks [42]. Enhanced joint mobility likely contributed to better upper-limb function [43,44].

Handgrip strength showed greater improvement in the ESWT group. Although there is little evidence about the assessment of handgrip strength in patients with AC, as most earlier research has initially concentrated on pain intensity, ROM, and functional outcomes, our findings are consistent with Aldajah et al.[45] reporting that participants with lateral epicondylitis who received ESWT exhibited superior outcomes in VAS, DASH, and grip strength relative to those in the traditional physical treatment group. This improvement may be attributed to pain reduction and enhanced neuromuscular function, which consequently lead to better muscle performance and may explain the observed enhancement in handgrip strength in the current trial, despite the difference in pathology. This improvement may be explained by reduced pain inhibition and improved neuromuscular activation following shockwave therapy, allowing patients to generate greater force during grip assessment and better functional use of the upper limb [46]. Pain reduction is known to positively influence muscle performance [47,48], which may explain the observed improvement in grip strength.

Ultrasonographic findings revealed a greater reduction in capsular thickness, particularly at the inferior capsule, in the ESWT group. This suggests that shockwave therapy may have a beneficial effect on the structural changes associated with adhesive capsulitis, possibly through promoting tissue remodeling and reducing fibrosis [33].

Our results are in line with those of Nambi et al. [34], who stated that ESWT is beneficial in lessening coracohumeral ligament thickness and improving ROM.

Our findings are also consistent with the systematic review conducted by Cortes-Perez et al. [35], which demonstrated the impact of ESWT in alleviating pain and tissue thickness while enhancing functional outcomes in plantar fasciitis patients. These outcomes are further confirmed by Chou et al. [36], who reported that ESWT enhances tissue perfusion, promotes angiogenesis, and stimulates BMP7 activity, which may explain the observed reduction in tissue thickness and overall clinical improvement in the current study.

The present study's findings suggest that both extracorporeal shockwave therapy and Mulligan mobilization are effective in managing adhesive capsulitis, with ESWT being more effective in reducing pain and improving structural changes, while Mulligan mobilization provided better benefits in improving ROM and functional outcomes. These results are consistent with earlier research reporting the effectiveness of Mulligan techniques in improving joint mobility and function, as well as the .analgesic and regenerative effects of ESWT

These findings may guide clinicians in selecting appropriate interventions based on treatment goals, whether prioritizing pain reduction, functional recovery, or structural improvement.

4.1. Limitations

This study exhibited some limitations, including a brief intervention period, the absence of long-term follow-up, and a relatively small sample size.

4. Conclusion

Both Mulligan mobilization and shockwave therapy, when combined with conventional physiotherapy, were more effective than conventional treatment alone. Mulligan mobilization was superior in improving ROM and functional outcomes. Shockwave therapy was more advantageous in alleviating pain, enhancing handgrip strength, and promoting structural changes.

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