

# AXILLARY ULTRASOUND AND LASER COMBINED WITH POSTISOMETRIC FACILITATION IN TREATMENT OF SHOULDER ADHESIVE CAPSULITIS: A RANDOMIZED CLINICAL TRIAL

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## ABSTRACT

**Objectives:** The purpose of this study was to compare axillary ultrasound, laser, and postisometric facilitation technique with standard care in the management of shoulder adhesive capsulitis.

**Methods:** This is a randomized clinical trial study. Fifty-nine participants with shoulder adhesive capsulitis were selected and randomly assigned for eligibility. Forty-five participants were assigned into 3 equal groups of 15, and 14 participants were excluded from the study. The participants were blinded to their group allocation. Standard care group (A) received traditional physical therapy treatment in the form of pulsed ultrasound, scanning laser, supervised exercise program, and home exercise program; group B received the same physical therapy program as group A, except that the ultrasound and scanning laser were applied to the axillary region of the painful shoulder; and group C received the same modified physical therapy program as group B plus postisometric facilitation technique to the painful shoulder. All dependent variables were measured by the second author, who was blinded to the participant's intervention group. The first author administered treatment to all 3 groups. All participants received 12 sessions (3 times/wk for 4 weeks). Pain level and shoulder range of motion (ROM; flexion, abduction, and external rotation) were recorded 3 times (pretreatment, immediately posttreatment, and 4 weeks of treatment).

**Results:** Mixed-design multivariate analysis of variance indicated significant pain reduction with significant ROM increase in all groups posttreatment and after 4 weeks. Post hoc analysis for within groups revealed that shoulder ROM and pain levels improved significantly posttreatment compared with pretreatment ROM in all groups, with the greatest improvement in group C. Between-group analysis revealed that pain-free shoulder flexion, abduction, external rotation, and pain level improved significantly in group C compared with groups A and B immediately after treatment and after 4 weeks of follow-up ( $P < .05$ ). Improvements reported in group B is more than in group A, and C is more than in groups A and B.

**Conclusions:** Combining axillary ultrasound and laser with postisometric facilitation had a greater effect in reducing pain and improving shoulder ROM in patients with shoulder adhesive capsulitis compared with axillary ultrasound and laser with traditional exercise. (*J Manipulative Physiol Ther* 2016;39:330-338)

**Key Indexing Terms:** *Bursitis; Adhesive Capsulitis; Frozen Shoulder*

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**A**dhesive capsulitis (AC), also known as “frozen shoulder,” is a common condition involving glenohumeral pain and loss of motion. It is defined by the American Shoulder and Elbow Surgeons as “a condition of uncertain etiology characterized by significant restriction of both active and passive shoulder motion that occurs in the absence of a known intrinsic shoulder disorder.”<sup>1</sup> It is the common cause of shoulder pain which is estimated to affect between 2% and 5% of the general adult population<sup>2</sup> and 10% to 20% of people with diabetes.<sup>3</sup> It is most frequent in women and in patients older than 40 years, with bilateral shoulder involvement occurring in up to 20% to 30% of the patients.<sup>4</sup> It is characterized by a spontaneous onset of pain with progressive stiffness of glenohumeral joint which can lead to a gross loss of function.<sup>2</sup> Adhesive

capsulitis is classically described as having 3 stages. Stage I involves pain (freezing or painful stage) and lasts from 3 to 9 months and is characterized by an acute synovitis of the glenohumeral joint. Stage II (frozen or transitional stage) involves pain and restricted movement, and lasts from 4 to 12 months. Finally, stage III (thawing stage) involves painless restriction and lasts from 12 to 42 months.<sup>5,6</sup> Its unclear etiology has led to its poor understanding and unclear opinions on its appropriate treatment,<sup>7</sup> although most authors agree that it involves an aspect of inflammatory change during the initial phase of the disease, followed by restriction of the joint capsule in the later stages. Further arthroscopic studies have shown fibrous contracture of the rotator interval and coracohumeral ligament which account for the marked restriction in range of movement, especially loss of lateral rotation.<sup>2</sup>

Although AC is considered to resolve spontaneously within 1 or 2 years, 50% of patients will experience pain or some mild restriction of movement, whereas 11% will experience some residual disability several years after treatment. Consequently, an appropriate treatment protocol is very important.<sup>7</sup> Treatment regimens for AC include a trial of conservative therapy, followed by more invasive procedures.<sup>1</sup> Many authors report a high level of success with nonoperative physical therapy treatment.<sup>7</sup> Numerous physiotherapeutic techniques have been used to treat AC including mobilization, electrotherapy, acupuncture, and home exercises with patients being referred for a steroid injection if necessary.<sup>2,8</sup> A recent systematic review<sup>9</sup> indicated that treatment of AC included a variety of manual and manipulative therapy (MMT) procedures such as high-velocity low-amplitude manipulation, end-range mobilization (ERM), midrange mobilization, and mobilization with movement (MWM) of the shoulder only and/or of the shoulder girdle. These techniques produced short-term significant improvements in range of motion (ROM), with a smaller effect for decreasing pain, compared with exercise alone.<sup>9</sup>

Several studies<sup>10–13</sup> found significant benefit using MMT. Of these, only Nicholson<sup>10</sup> prescribed exercise that was more intensive than basic. According to Brantingham et al,<sup>9</sup> the greatest change noted with MMT was an increase in ROM and function rather than a decrease in pain. Manual and manipulative therapy procedure can also include postisometric relaxation technique applied to a single or multiple joints with stretching. There is low level of evidence for the treatment of AC using MMT with and without exercise and/or multimodal therapy.

Mobilization with movement (as developed by Mulligan<sup>14,15</sup>) involves sustained pressure to a fixed painful joint while the patient actively performs movement in the same joint. If the active movement is pain-free, the orientation of the joint is considered adequate. The principle for this type of joint mobilization is based on analyzing and correcting minor positional faults within the joint. Combining this technique with kinesiotaping improved the active ROM in the painful shoulders.<sup>16</sup>

Passive stretching of the shoulder capsule and soft tissues by means of ERM techniques has been reported to restore the normal extensibility of shoulder capsule and tight soft tissues.<sup>12,17–19</sup> After anterior-posterior and inferior glide mobilizations close to the end-range of abduction in participants with AC, researchers have reported a significant increase in glenohumeral abduction.<sup>20</sup> Other researchers have also reported the positive effects of ERM on glenohumeral ROM.<sup>12,19</sup> Because adequate humeral elevation and external rotation as well as scapular tipping and upward rotation are related to improvements in AC symptoms, specific mobilization techniques performed close to the glenohumeral end-range of movement may provide additional benefits when using scapular mobilization techniques.<sup>21,22</sup>

A number of different types of interventions have been reported as benefiting shoulder pain. These include ultrasound (US) therapy,<sup>8,23</sup> myofascial (friction massage), and ischemic compression therapy that eliminate trigger points located around the joint.<sup>8,24</sup> Despite reports that manipulation was the preferred therapy for treating shoulder girdle disorders,<sup>25</sup> a recent systematic review of the use of manipulative therapy in treating shoulder pain concluded that there was a low level of evidence to support use of the intervention, adding the recommendation that there is a need for more well-designed trials investigating multimodal management of shoulder pain.<sup>26</sup>

Some providers combine different therapeutic interventions in treating AC. For example, adding scapulothoracic exercises to the glenohumeral ROM exercises contributes to decreasing pain and increasing ROM in patients with AC.<sup>27</sup> The combined soft tissue mobilization with proprioceptive neuromuscular facilitation was reported to improve the glenohumeral external rotation and overhead reach in patients with shoulder disorders.<sup>28</sup> In addition, Wies<sup>5</sup> indicated in his study on 8 patients with frozen shoulder that soft tissue mobilization in combination with home exercise program may be a useful approach for improving soft tissue restrictions.<sup>5</sup> It is widely accepted that physical therapy and stretching should be used in the conservative management of frozen shoulder.<sup>8–13</sup> Simple home exercise programs with analgesia have been shown to be effective, whereas others suggest more intensive supervised physical therapy in the form of passive stretching and manual mobilization. A more invasive procedure such as hydrodilatation (which aims to rupture capsular contractures by distension of the joint with a large amount of normal saline solution) and nerve block has been supported.<sup>1</sup>

Recently, Ma et al<sup>29</sup> compared 2 different treatment approaches in the management of AC: physical therapy that included joint mobilization and whole-body cryotherapy with physical therapy that included joint mobilization. They concluded that when whole-body cryotherapy is added to the treatment intervention, significant improvements occur.<sup>29</sup> The effect of intra-articular hyaluronic acid (HA)

injections plus physical therapy was compared with that of physical therapy alone in a study by Hsieh et al.<sup>30</sup> The authors concluded that intra-articular HA injections did not produce added benefits for patients with AC who were already receiving physical therapy. Thus, the use of intra-articular HA injections for patients with AC of the shoulder should be carefully assessed to reduce unnecessary medical expenditures.<sup>30</sup>

Several review studies illustrated different treatment protocols and their effects in reducing symptoms of pain and limitation of ROM in AC, although the most recent review recommended future studies to incorporate other interventions within the scope of physiotherapy practice.<sup>31</sup> Muscle energy technique (MET) has been advocated for the treatment of shortened and/or weakened muscles, restricted joints, and lymphatic drainage.<sup>32</sup> It is a form of osteopathic manual treatment in which the patient's muscles are actively engaged as part of applying the treatment. It has 6 main variations: (1) isometric contraction using reciprocal inhibition, (2) isometric contraction using post isometric relaxation (without stretching), (3) isometric contraction using post isometric relaxation (with stretching) also known as postfacilitation stretching, (4) isotonic concentric contraction, (5) isotonic eccentric contraction (isolytic), and (6) isokinetic (combined isotonic and isometric contractions).<sup>33</sup> We could find no previous studies that investigated the effect of MET on AC.<sup>34</sup> The aim of this study is to compare axillary US, laser, and postisometric facilitation technique (MET) with standard care in the management of AC.

## METHODS

### Participants

This is a randomized clinical trial conducted between 2010 and 2012 at the outpatient clinic of the Faculty of Physical Therapy, Cairo University, Egypt. Forty-five participants (27 women and 18 men) ranging in age from 40 to 60 years with a diagnosis of unilateral shoulder AC (stage II) by their referring physician were recruited for the trial. The main presenting symptoms were shoulder pain with restricted ROM that compromised activities of daily living. The Research Ethics Committee of the Faculty of Physical Therapy at Cairo University approved the study. All participants provided written informed consent. Clinical trial registry number is PACTR201304000516174.

### Inclusion Criteria

Groups were matched at baseline. Participants were included in the study if they met the following inclusion criteria: painful, restricted active and passive ROM of the shoulder, capsular pattern of motion restriction, and absence of radiologic evidence of glenohumeral joint arthritis. The duration of symptoms for all participants ranged from 3 to 8 months.

### Exclusion Criteria

Participants were excluded from the study if they had the following: local corticosteroid injection to the affected shoulder within the last 3 months or current corticosteroid therapy, neuromuscular disease, shoulder symptoms due to other causes (eg, shoulder impingement syndrome, rotator cuff tear) currently pregnant, history of metastatic cancer or diagnosis of cancer within 12 months, unstable angina, insulin-dependent diabetes, and history of shoulder surgery.

### Randomization

The assistant selected an envelope at random and assigned each participant to 1 of 3 groups according to the number in the envelope. The participant was blinded to their group allocation. The 3 groups were as follows: group A (standard care group) received traditional physical therapy treatment in the form of pulsed US, scanning laser, supervised exercise program, and home exercise program; group B received the same physical therapy program as group A, except that the US and scanning laser were applied to the axillary region of the painful shoulder; and group C received the same modified physical therapy program as group B plus postisometric facilitation technique (MET) to the painful shoulder. All dependent variables were measured by the second author (E.S.M.), who was blinded to the participant's intervention group. The first author (E.H.M.), a physiotherapist with more than 20 years experience in manual therapy and orthopedic and neurologic rehabilitation, was responsible for administering treatment to all 3 groups.

### Outcome Measures (Dependent Variables)

Outcome measures were level of pain and ROM. Level of pain was measured using numeric pain scale ranging from 0 to 10. Participants marked their responses on a 10-cm numeric scaled line, where 0 means "no pain" and 10 means "worst pain imaginable." Pain-free active flexion, abduction, and external rotation of the shoulder were expressed in degrees. The ROM was measured using baseline bubble inclinometer which has been shown to have high intraexaminer reliability and validity.<sup>35</sup> Shoulder flexion and abduction were measured with the participant in the sitting position, whereas external rotation was measured in the supine position. Each ROM measurement was recorded 3 times, with the average being used as the final reading. Pain and ROM measurements were recorded 3 times during the course of treatments: twice in the first session (pretreatment and posttreatment) and again after 4 weeks of treatment.

### Techniques (Treatment, Independent Variables)

**Postisometric Facilitation Technique.** This MET technique has been advocated for the treatment of restricted and

fibrotic soft tissues (fascia and muscle).<sup>33</sup> The technique involves isometric contraction of the muscle followed by isometric relaxation followed by stretching. When performing isometric facilitation with the shoulder in flexion, the participant was seated with his/her back supported and the therapist standing facing the participant's painful shoulder. The participant's shoulder joint was flexed to the maximum available range with the elbow completely flexed. The participant performed isometric contraction of the shoulder extensors against maximum resistance provided by the therapist. The isometric contraction lasted for 10 seconds followed by relaxation for 5 seconds. This allowed the shortened shoulder extensors to relax and permit easier stretching. The therapist then stretched the participant's shoulder extensors to the limit of the painful range.

For all MET maneuvers, once the participant's performance had improved, the duration of the isometric contraction was extended to 20 seconds.<sup>33</sup> Each exercise was repeated 5 times in each session. The stretching position was maintained for 20 seconds. The duration of each postisometric facilitation session ranged from 9 to 13 minutes. Each participant received 12 treatment sessions over a 4-week period (3 sessions/wk for 4 weeks).

**Pulsed US.** Pulsed US (ProSound ULS-1000, Medserve Limited, United Kingdom) was administered according to the following specification: medium transducer, 3 MHz pulsed type (1:1), and 1.5 W/cm<sup>2</sup> applied for 10 minutes.<sup>36</sup>

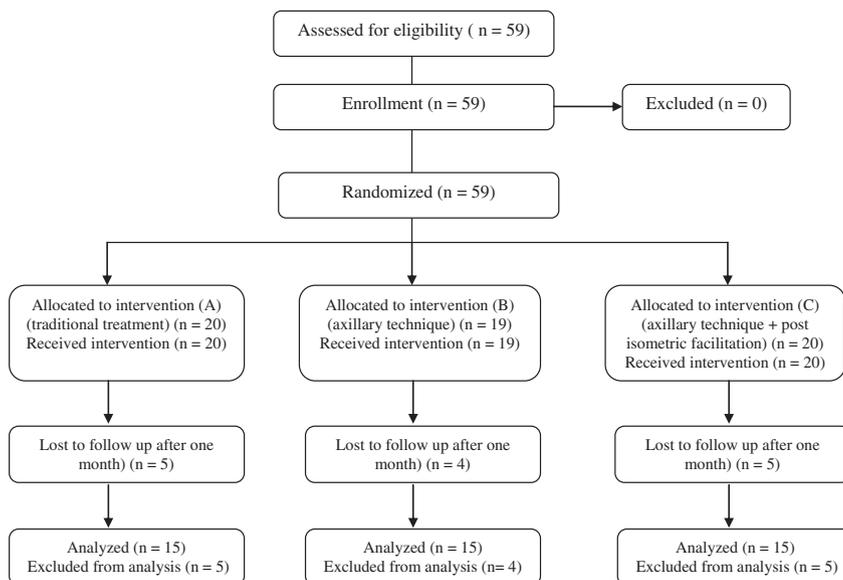
**Laser.** All participants received scanning laser (ASA s.r. Bravo Tereza Serie He-Ne, Italy). Laser specifications were as follows: 850 nm wave length and pulsed application with 8 W applied for 20 minutes. In group A, US and laser were applied over painful points of the shoulder (most commonly at the lateral and anterior borders of the acromion) while the participant was in sitting

position. In groups B and C, US and laser were applied at the axillary area (Fig 1) not at the painful points while the participant was in supine position with the arm semi abducted and externally rotated. The axillary approach for application of US and laser was adopted as the axilla is the site of the axillary pouch of the capsule, which has been implicated in inflammation and adhesion within the shoulder joint that may interfere with the ROM<sup>37</sup>. Ltoi and Tabata<sup>37</sup> reported that the axillary pouch is obliterated in many cases of frozen shoulder and this obliteration has been correlated with a decrease in both internal and external rotation. Axillary adhesions can slowly tighten and cause the shoulder joint to lose mobility over time.<sup>38</sup>

**Supervised Exercise Program.** Self exercises included (1) Codman's or pendulum exercises (circumduction) and (2) passive stretching exercises (for shoulder extensors, adductors, and internal rotators) such as "climbing the wall exercise" (ie, facing a wall about three-quarters of an arm's length away and raising the affected arm up to the shoulder level using only one's fingers without using shoulder muscles).<sup>7</sup> The home exercise program includes the same exercises as in supervised exercise program. The participant was instructed to perform exercises 1-2 times/d within pain-free ROM, and gradually build up the number of repetitions and to stop performing exercises if they exacerbate symptoms.

**Data Analysis**

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 20 for Windows (SPSS, Chicago, IL). One-way analysis of variance was conducted to determine whether the 3 groups differed on the baseline characteristics: age, sex, weight,



**Fig 1.** Flow diagram for the study.



**Fig 2.** Axillary ultrasound application for patients with shoulder adhesive capsulitis.

height, average length of symptoms, and pretreatment dependent variables. As a prerequisite for parametric analysis, data were screened for normality assumptions, homogeneity of variance, and presence of extreme scores. The independent variables are the groups receiving treatment intervention with 3 levels (groups A, B, and C). The dependent variables are shoulder ROM (flexion, abduction, and external rotation) and pain level. All measurements were collected 3 times: before treatment (pretreatment), immediately after treatment (posttreatment), and one month after treatment (4 weeks). Because data were normally distributed, parametric assumption was not violated, so mixed-design multivariate analysis of variance (MANOVA) was conducted to test the within-group and between-group differences with  $\alpha$  level of significance set at .05.

RESULTS

Fifty-nine participants were assessed for eligibility (Fig 2). Fourteen participants were lost to follow-up assessments: 5 in group A due to family care and personal matters, 2 in group B due to transportation problems and other issues, another 2

**Table 2.** Mixed-Design MANOVA for Time as Within-Participant Variable and Groups as Between-Participant Variable) and the Interaction Between Both

	F	P	Observed power $\alpha$ (.05)
Treatment (between participants)	8.071	.000	1.000
Time (within participants)	111.456	.000	1.000
Treatment $\times$ time interaction	14.428	.000	1.000

MANOVA, multivariate analysis of variance.

in group B and 5 in group C due to spontaneous cessation of symptoms. Participants' characteristics at baseline were similar for all groups ( $P > .05$ ). No significant differences were found between groups for age, sex, weight, height, average length of symptoms, and pretreatment pain scores (Table 1). Forty-five participants completed the study. Mixed-design MANOVA of within and between groups' variations indicated significant treatment, time, and treatment  $\times$  time interaction effect (Table 2). No significant changes were reported among the 3 groups in the pretreatment measurements of shoulder flexion, abduction, external rotation, and pain level ( $P > .05$ ; Table 3). Post hoc analysis for multiple comparisons within groups revealed that shoulder flexion, abduction, and external rotation ROM improved significantly posttreatment compared with pretreatment ROM in all groups, with the greatest improvement in group C. The same improvement was reported in pain levels through the 3 treatment times. Between groups analysis revealed that pain-free shoulder flexion, abduction, external rotation, and pain level improved significantly in group C compared with groups A and B immediately after treatment and after 4 weeks follow-up ( $P < .05$ ). Improvements reported in group B is more than in group A, and C is more than in groups A and B (Table 3; Figs 3 and 4).

DISCUSSION

The results from the 2 physical therapy groups (traditional: group A; axillary: group B) showed that the axillary approach

**Table 1.** Baseline Characteristics of Participants With Adhesive Capsulitis in the 3 Groups (n = 45)

	Group A (n = 15)	Group B (n = 15)	Group C (n = 15)	P
Age (y)	50.4 (5.3)	50.06 (4.3)	49.5 (4.6)	> .05
Sex (men/women)	6/9	7/8	5/10	–
Right shoulder involved	11	10	10	–
Left shoulder involved	4	5	5	–
Weight	83.8 (11.5)	83.2 (7.2)	87.2 (7.8)	> .05
Height	171.2 (5.7)	168.9 (6.3)	168.6 (4.4)	> .05
Average length of symptoms (mo)	5.86 (1.59)	6.2 (1.74)	6.4 (1.68)	.68
Flexion ( $^{\circ}$ ), pretreatment	99.13 (16.07)	102.6 (12.6)	102.6 (14.19)	1.000
Abduction ( $^{\circ}$ ), pretreatment	63.4 (12.01)	60.8 (12.76)	61.06 (9.37)	1.000
External rotation ( $^{\circ}$ ), pretreatment	19.86 (5.59)	21.8 (8.22)	20.93 (7.22)	1.000
Pain score (pretreatment)	7.433 (0.883)	7.266 (0.728)	6.93 (0.90)	> .05

**Table 3.** Average Shoulder ROM (SD) Pretreatment, Posttreatment, and After 4 Weeks of Treatment and Post Hoc Analysis for Multiple Comparisons Between Groups

		Group A	Group B	Group C	Significance
Flexion	Pretreatment	99.13 (16.07)	102.6 (12.6)	102.6 (14.19)	>.05
	Posttreatment	106 (15.3)	109.06 (11.09)	112.86 (12.05)	>.05
	After 4 wk	106.13 (13.6)	112.8 (11.13)	118.33 (12.86)	A, C*
Abduction	Pretreatment	63.4 (12.01)	60.8 (12.76)	61.06 (9.37)	>.05
	Posttreatment	67.2 (11.73)	67.2 (11.75)	79.8 (11.23)	*A, C *B, C
	After 4 wk	71.73 (11.42)	72.66 (12.37)	100.66 (16.99)	*A, C *B, C
External rotation	Pretreatment	19.86 (5.59)	21.8 (8.22)	20.93 (7.22)	>.05
	Posttreatment	24.73 (6.92)	34.06 (9.77)	47.73 (10.85)	*A, B, C
	After 4 wk	25.26 (6.7)	34.93 (10.59)	50.6 (11.06)	*A, B, C
Pain	Pretreatment	7.43 (0.88)	7.26 (0.72)	6.93 (0.90)	>.05
	Posttreatment	5.53 (1.06)	4.73 (0.7)	3.86 (0.83)	*A, B, C
	After 4 wk	4.86 (1.06)	4.1 (0.92)	2.56 (0.49)	*A, C *B, C

ROM, range of motion.

>.05 = nonsignificant differences between each 2 groups.

\*A, B, C = significant differences between each 2 groups.

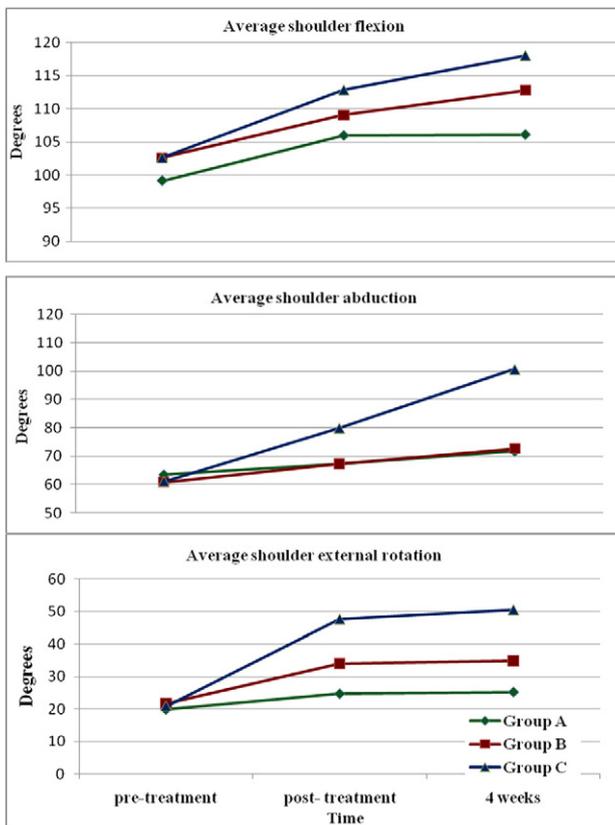
\*A, C = significant differences between groups A and C.

\*B, C = significant differences between groups B and C.

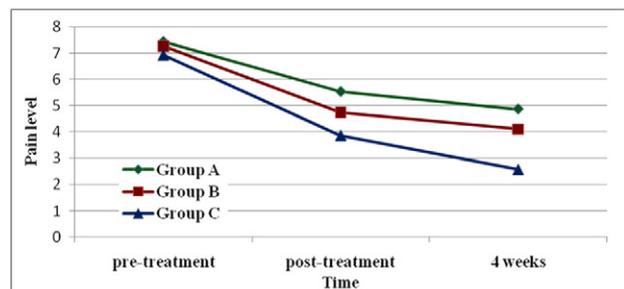
provided immediate improvement in shoulder external rotation and pain levels that were still present at 4 weeks. The addition of postisometric facilitation (group C) produced

even greater improvement in shoulder ROM compared with the other groups. Postisometric facilitation technique concentrates on breaking down adhesions between the capsule and the attaching tendons of surrounding muscles. Adding both therapeutic techniques (electrotherapy + postisometric facilitation) reduced manifestations of AC, mainly improving shoulder active ROM and reducing pain

The axillary recess (a pouch of the glenohumeral capsule evolving from the inferior rim of the glenoid cavity to the inferior part of the humeral head) plays an important role in AC. Capsular retraction or adhesions hinder normal expansion of capsule during shoulder mobility. As a result in order to regain the normal extensibility of the shoulder capsule, these adhesions should be broken down by mobilization, facilitation, or manipulation techniques.<sup>19</sup> The results of group C are supported by Vermeulen et al<sup>19</sup>, who performed ERM technique by passive stretching of the shoulder capsule in all planes to regain normal extensibility of shoulder capsule and concluded that this technique increased glenohumeral mobility. They added that the



**Fig 3.** Average shoulder flexion, abduction and external rotation pretreatment, posttreatment, and 4 weeks of treatment in the 3 groups.



**Fig 4.** Average pain score pretreatment, posttreatment, and 4 weeks of treatment in the 3 groups.

decreased joint capacity due to capsular retraction is an important feature of AC. To regain the normal extensibility of the shoulder capsule, passive stretching of the shoulder capsule in all planes of motion by means of ERM is recommended.<sup>17,19,39</sup>

These findings support the suggestions that greater limitation in glenohumeral ROM is seen in abduction and external rotation as reported by Godges et al,<sup>28</sup> who concluded in their study on 20 patients of limited glenohumeral external rotation ROM that soft tissue mobilization using contract-relax technique to the shoulder internal rotators followed by proprioceptive neuromuscular facilitation facilitating the flexion, abduction, and external rotation was effective in gaining glenohumeral external rotation during single intervention session. Moreover, Cyriax<sup>40</sup> initially proposed that tightness in a joint capsule would result in a pattern of motion restriction. He believed that an irritated capsule would restrict motion in a predictable pattern. In frozen shoulder, he proposed that external rotation would be more limited than abduction, which would be more limited than internal rotation.

In a similar context, researchers reported that limited external rotation in participants with frozen shoulder is related to tightened capsules and/or ligaments.<sup>21</sup> They added that capsular pattern is one in which external rotation is more limited than abduction, which in turn is more limited than internal rotation. In addition, they mentioned that although humeral external rotation is generally advocated as a treatment focus, scapular tipping and humeral external rotation should be managed together. Based on the previous explanation, improvement in the group receiving the new therapeutic approach in this study can be predicted by an increase in shoulder external rotation ROM.

The improvements reported for group C may be attributed to the change in muscle extensibility and increased tolerance to stretching after application of this technique. This is supported by several clinical trials investigating osteopathic management of spinal pain, which included MET as a treatment component and concluded that treatment significantly reduced the reported pain and disability in these trials.<sup>32,41</sup> Evidence suggests that MET (or similar isometric stretching techniques) is more effective than passive stretching for increasing muscle extensibility. Because MET produces joint motion while actively recruiting muscles, it may affect proprioceptive feedback, motor control, and motor learning.<sup>32</sup>

There is a lack of research on the use of MET alone as the intervention is usually used in conjunction with other techniques. However, some studies demonstrated an increase in the extensibility of muscles and spinal ROM and available evidence supports the use of this approach to treat restricted mobility and spinal pain.<sup>32</sup> The proposed mechanisms underlying the possible therapeutic effects of MET involve a variety of neurologic and biomechanical mechanisms, including hypoalgesia, altered proprioception,

motor programming and control, and changes in tissue fluid. Reflex muscle relaxation is commonly cited as a mechanism for length, ROM, and tissue texture changes following MET. However, studies support increased tolerance to stretching (hypoalgesia), not reflex relaxation, as the mechanism for increasing muscle extensibility.<sup>42</sup> Applications of MET to stretch and increase myofascial tissue extensibility seem to influence viscoelastic and plastic tissue property, and autonomic-mediated change in extracellular fluid dynamics.<sup>32</sup>

Several researchers recommended adding different techniques together to produce effective and significant improvements in ROM than separate program or supervised exercise program. For example, a study conducted on 20 participants with shoulder pain concluded that MWMs with kinesiotape have quicker effect on ROM of the painful shoulder than supervised exercise program.<sup>16</sup> Similarly, in this study, all groups experienced improvement in ROM (abduction and external rotation) and reduction in pain. The additional improvement in group C can be attributed to the addition of postisometric facilitation technique that corrected the positional fault in the joint. This is also supported by Dierks and Stevens,<sup>43</sup> who compared the effect of intensive physical rehabilitation treatment including passive stretching and manual mobilization (stretching group) vs supportive therapy and exercises within the pain limits (supervised neglect group) on 77 patients with frozen shoulder followed up for 2 years. They concluded that in patients treated with supervised neglect, 89% had normal or near-normal painless shoulder function at the end of observation period (constant score of 80). The group receiving intensive physical therapy treatment reached only 63% of the constant score of 80 after 24 months.

Our results are supported by Djordjevic et al,<sup>16</sup> who found that MWM promoted active movement that engaged additional proprioceptive tissues such as the Golgi tendon organ. Although our study did not include MWM, the same explanation may be applied to postisometric facilitation where improvements were seen in ROM and pain levels. This is of particular interest as several studies demonstrated that pain improved over time and was not affected by medical intervention.<sup>44</sup>

#### LIMITATIONS

Interpretation of the results is limited by the small sample size and the short follow-up period. Extending the follow-up period would have strengthened any conclusions drawn from the results. Participants who did not carefully perform the home program may influence the readings. This limitation could be minimized by careful instructions to the participants. As the primary author was also the treating practitioner, the results may be influenced by practitioner bias. Despite the high dropout rate, it can be considered as a

benefit from the treatment program, especially in groups B and C, which received the new treatment approach and most of them were lost in the follow-up period due to observable absence of pain and gain in ROM. Besides that, only active ROM and pain were measured, no function level or disability index was collected. In addition, objective outcome measures as magnetic resonance imaging were not used which could empower the results. Although groups included women and men, no comparisons were made between them. Future studies are needed to examine sex differences. Another limitation of this study was that there was no nontreatment group. It would also be useful to have a group with only postisometric facilitation and another group with only axillary approach.

## CONCLUSION

The approach outlined in this study for treating shoulder AC (axillary application of US and laser with postisometric facilitation technique) produced immediate and medium-term improvements in shoulder ROM, primarily abduction and external rotation, as well as a reduction in pain.

## FUNDING SOURCES AND POTENTIAL CONFLICTS OF INTEREST

No funding sources or conflicts of interest were reported for this study.

## CONTRIBUTORSHIP

Concept development (provided idea for the research): H.M.E., S.M.E.

Design (planned the methods to generate the results): H.M.E., S.M.E.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): H.M.E., S.M.E.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): H.M.E., S.M.E.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): H.M.E., S.M.E.

Literature search (performed the literature search): H.M.E., S.M.E.

Writing (responsible for writing a substantive part of the manuscript): H.M.E., S.M.E.

Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): H.M.E., S.M.E.

## Practical Applications

- Adding postisometric facilitation to program of treatment of AC increases ROM.
- Using axillary ultrasound and scanning laser improves ROM in AC.
- Adding both programs produces improvement in pain and ROM.

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