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The Effect of Anterior Versus Posterior Glide Joint Mobilization on External Rotation Range of Motion in Patients With Shoulder Adhesive Capsulitis

STUDY DESIGN: Randomized clinical trial.

OBJECTIVE: To compare the effectiveness of anterior versus posterior glide mobilization techniques for improving shoulder external rotation range of motion (ROM) in patients with adhesive capsulitis.

BACKGROUND: Physical therapists use joint mobilization techniques to treat motion impairments in patients with adhesive capsulitis. However, opinions of the value of anterior versus posterior mobilization procedures to improve external rotation ROM differ.

METHODS AND MEASURES: Twenty consecutive subjects with a primary diagnosis of shoulder adhesive capsulitis and exhibiting a specific external rotation ROM deficit were randomly assigned to 1 of 2 treatment groups. All subjects received 6 therapy sessions consisting of application of therapeutic ultrasound, joint mobilization, and upper-body ergometer exercise. Treatment differed between groups in the direction of the mobilization technique performed. Shoulder external rotation ROM measured initially and after each treatment session was compared within and between groups and analyzed using a 2-way ANOVA, followed by paired and independent *t* tests.

RESULTS: There was no significant difference in shoulder external rotation ROM between groups prior to initiating the treatment program. A significant difference between groups ($P = .001$) was present by the third treatment. The individuals in the anterior mobilization group had a mean improvement in external rotation ROM of 3.0° (SD, 10.8°; $P = .40$), whereas the individuals in the posterior mobilization group had a mean improvement of 31.3° (SD, 7.4°; $P<.001$).

CONCLUSIONS: A posteriorly directed joint mobilization technique was more effective than an anteriorly directed mobilization technique for improving external rotation ROM in subjects with adhesive capsulitis. Both groups had a significant decrease in pain. *J Orthop Sports Phys Ther 2007;37(3):88-99. doi:10.2519/jospt.2007.2307*

KEY WORDS: frozen shoulder, manual therapy, physical therapy

Primary adhesive capsulitis and *frozen shoulder* are current terms used to describe an insidious onset of painful stiffness of the glenohumeral joint.[2,10,41] Secondary adhesive capsulitis, on the other hand, is associated with a known predisposing condition of the shoulder (eg, humerus fracture, shoulder dislocation, avascular necrosis, osteoarthritis, or stroke).[38,57,59] Primary adhesive capsulitis affects from 2% to 3% of the general population and is the main cause of shoulder pain and dysfunction in individuals aged 40 to 70 years.[38] Shaffer et al[57] found that neither pain nor motion restriction seen with primary adhesive capsulitis was related to age, menopause, hand dominance, affected side, nature of onset, duration of symptoms, or associated medical conditions. The range of motion (ROM) impairments associated with primary adhesive capsulitis can impact a patient's ability to participate in self-care and occupational activities.[2,59] Even though this condition is considered self-limiting, with most patients having spontaneous resolution within 3 years,[10,20,21,35] some patients can suffer long-term pain and restricted shoulder motion well beyond 3 years.[57] A disability of this duration places severe emotional and economic hardship on the afflicted person.[42,56] Most patients are unwilling to suffer this pain, prolonged disability, and sleep deprivation without seeking treatment.[38,46,64]

Most authorities agree that adhesive capsulitis is caused by inflammation of the joint capsule and synovium that eventually results in the formation of capsular contractures.[8,17,40,48,46,62] The capsule does not become adhered to the humerus, as the term *adhesive* implies, but the contracted capsule holds the humeral head tightly against the glenoid fossa.[46] Clinically, there is global loss of both passive and active ROM of the glenohumeral joint,[5,11,2138,65] with external rotation usually being the most restricted physiologic movement.[5,38,42]

Currently, no standard medical, surgical, or therapy regimen is universally accepted as the most efficacious treatment for restoring motion in patients with shoulder adhesive capsulitis.[16,35] While

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physical therapy is commonly prescribed for this condition,[22,48,64,65] some studies have found little treatment benefit.[3,5,7,11] Rehabilitation programs consisting of exercise, massage, and modalities have been shown to improve shoulder ROM in all planes except external and internal rotation.[29] There is evidence, however, that joint mobilization procedures can lessen the associated glenohumeral rotational deficits characteristic of this condition, especially external rotation.[26,42,54,63] The optimal direction of force and movement application for the joint mobilization to restore external rotation, however, is not clear. Traditionally, physical therapists have used an anterior glide of the humeral head on the glenoid technique to improve external rotation ROM, a choice based on the "convex-on-concave" concept of joint surface motion.[12,69,30] In contrast, Roubal et al[54] used a posteriorly directed glide manipulation based on the "capsular constraint mechanism"[23] to restore external as well as internal rotation ROM. To our knowledge, there are no studies comparing the effects of posteriorly directed versus anteriorly directed glenohumeral joint mobilization techniques to improve shoulder external rotation ROM in patients with adhesive capsulitis.

The purpose of this study was to determine the direction of movement and force application (anterior versus posterior) for glenohumeral joint mobilization that would result in the greatest improvement in shoulder external rotation ROM in individuals with primary adhesive capsulitis. The outcome of this study could potentially guide clinical decision making regarding the most effective direction of mobilization to improve shoulder external rotation in those patients.

METHODS

Subjects

From October 2003 to January 2005, the primary researcher (A.J.) evaluated 58 consecutive patients, whom 1 of 4 orthopedic surgeons diagnosed with adhesive capsulitis or frozen shoulder and referred to an outpatient physical therapy clinic for treatment. Thirty-eight of those patients were excluded from participation because they did not meet the following inclusion/exclusion criteria: (1) idiopathic or primary adhesive capsulitis (ie, insidious onset with no history of major trauma),[21] not excluding minor injuries,[5,16,35] (2) unilateral condition, (3) age between 25 to 80 years, (4) normal findings on radiographs within the previous 12 months, (5) no previous shoulder surgeries to the affected shoulder, (6) no previous manipulations under anesthesia of the affected shoulder, (7) and external rotation ROM restriction that worsened with shoulder abduction. Patients were also excluded from the study if they had shoulder girdle motor control deficits associated with neurological disorders (eg, stroke, or Parkinson's disease).

In this study, it was important to include subjects whose primary shoulder ROM restriction was due to a capsular lesion versus muscular tightness. Based on clinical experience and cadaver studies,[45] the ROM deficit pattern chosen by the investigators of this study to establish capsular tightness was glenohumeral external rotation deficit becoming worse as the shoulder was abducted. Glenohumeral external rotation ROM deficit was attributed to muscle flexibility deficit (eg, subscapularis flexibility deficits) if the glenohumeral external rotation ROM deficit became less as the shoulder was abducted. Patients whose external rotation ROM did not change as the arm was abducted were also excluded from the study.

Twenty patients (4 men and 16 women) between the ages of 37 and 66 years met the inclusion/exclusion criteria and were invited to join and participate in this study. Prior to participation, all subjects signed the California Experimental Subject's Bill of Rights, the Institutional Review Board Authorization for Use of Protected Health Information Form, and a consent form approved by the Institutional Review Boards of both Loma Linda University and Beaver Medical Group.

As the subjects joined the study, each was randomly assigned to 1 of 2 treatment groups: the anterior mobilization (AM) or the posterior mobilization (PM) group. The randomization was predetermined by using a random-numbers table. Folders labeled with the group name and subject number were made ahead of time and used sequentially as the subjects joined the study.

All 20 subjects who joined the study had a Health Maintenance Organization (HMO) for their medical insurance. Two subjects had had open-heart surgery within the previous 6 months. No subjects reported treatment for diabetes, thyroid, or cervical problems. None of the subjects had received previous physical therapy for their shoulder. All subjects remained under medical care for their shoulder condition, 3 subjects were taking an anti-inflammatory medication (2 in the PM group and 1 in the AM group). No subject had steroid injections while participating in the study.

Two subjects, both in the PM group, left the study. One subject, after the third treatment session, for personal reasons, requested arthroscopic surgery to obtain a definitive diagnosis of her condition. The presence of adhesive capsulitis was confirmed during surgery and she received manipulation under anesthesia. The second subject left the study after the fourth treatment session as a result of a fall that injured her affected shoulder.

Upon entering the study, each subject was given a handout with the instruction to use his/her involved arm in pain-free activities of daily living. Activities that involved resisted motions (eg, pushing, pulling, opening or closing stiff doors, gardening, vacuuming, sawing) or lifting objects that weighed more than 2 kg were discouraged. No home exercise program was given.

Tests and Measures

Before the first treatment and after the last treatment, each subject marked a visual analogue scale (VAS) for pain.[50] This

rating scale was chosen because it has demonstrated validity in the measurement of chronic pain. As Bulgen et al[5] found, even though patients with shoulder adhesive capsulitis have chronic pain, they mostly experience it with motion. It is, therefore, difficult for these patients to report pain levels. Price et al[50] describes 2 aspects of pain (intensity and unpleasantness). In this study we asked subjects to mark on the 10-cm vertical line the relative unpleasantness that their problem caused them; the higher up the line, the greater the unpleasantness.

Each subject also completed a 5-item self-assessment function questionnaire regarding how shoulder pain and impairment affected sleep, general daily activities, and specific tasks (dressing, grooming, and reach) that usually require shoulder external rotation ROM (**APPENDIX**). The 5 questions were taken from the 21-item self-administered questionnaire developed by L'Insalata et al[34] for shoulder disorders. These questions were selected because (*a*) they more directly reflected the difficulties that are common in patients with adhesive capsulitis, (*b*) they focused on specific activities that normally require external rotation ROM, and (*c*) it made the questionnaire shorter and easier to complete in less time. Each question was a multiple-choice question that had 5 selections scored from 4 (worst score) to 0 (best score). Initial pain scores, questionnaire scores, and demographic data were used to determine group similarity at the beginning of the study.

Glenohumeral external rotation ROM was chosen for the primary outcome measure and was assessed using methods adapted from the protocol described by Heljm et al,[26] at baseline and again after each of the 6 treatment sessions. Because patients with adhesive capsulitis present with global glenohumeral ROM restrictions, which usually limit shoulder abduction to less than 90°, the humerus was placed into full available abduction for each individual before actively externally rotating the shoulder (**FIGURE 1**). At the initial evaluation, the mean (range) shoulder abduction angle of the subjects was 53° (30°-80°).

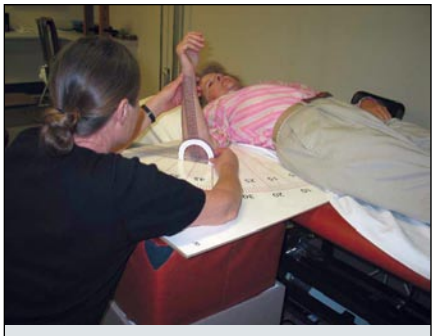

FIGURE 1. Active external rotation measurement technique. Each subject's baseline abduction angle was the same abduction angle used for each active external rotation measurement.

Each subject's baseline shoulder abduction angle was recorded and the glenohumeral joint was passively placed at the baseline abduction angle prior to the measurement of shoulder external rotation at each subsequent session. This method was chosen because there is a wide variation in ROM deficits in patients with adhesive capsulitis. It was considered more clinically meaningful to measure each individual's improvement in external rotation ROM at his/her baseline maximum shoulder abduction angle, rather than measuring each subject at a predetermined abduction position.

To maintain a consistent shoulder abduction angle for all measurement sessions, a wall goniometer (Sammons Preston Rolyan, Bolingbrook, IL) was adapted by cutting it in half along the 90° measurement line, then mounting it with clear tape to a 6-mm-thick high-density pressboard. One half of the board goniometer was used for measuring right shoulders and the other for measuring left shoulders. The board goniometer was placed on a moveable table and carefully positioned parallel to the sternum, with its axis under the glenohumeral joint. To properly position the axis, the humerus was passively moved from neutral into available pain-free arc of abduction, so that the humerus lined up with each of the lines on the board goniometer.

External rotation measurement was taken with a standard 30-cm goniometer.[4] The goniometer was adapted by cutting off the range from 180° to 360° so that the stationary arm could lay flat against the surface of the board goniometer, as shown in **FIGURE 1**. To reduce measurement bias, the back of the goniometer scale was covered with white adhesive paper before the study.[53] Two goniometers were made: 1 for measuring the right shoulder and 1 for measuring the left shoulder. Once each individual's limit of passive, pain-free abduction was attained, the humerus was allowed to rest on the abduction board and shoulder external rotation was measured. With the stationary arm of the adapted goniometer flat against the board goniometer, the moving arm was lined up with the shaft of the ulna. Then, the tester gave a verbal cue to actively "roll the forearm backward" as far as he/she could. There was no external passive force applied during the measurement. After the measurement, the therapist held the goniometer position carefully, turned it around, read the angle, and recorded the angle on the data sheet.

The external rotation measurement was taken by an experienced physical therapist assistant (D.M.). Before the study commenced, the therapist underwent training for competency for the external rotation measurement technique on patients with glenohumeral joint restrictions. Competency was presumed when repeated measurements were within 3°.[4] After the initial training, intrarater reliability was determined on 15 consecutive shoulders with ROM deficits identified in the clinic. Each set of measurements was within 5 minutes. Between each measurement, the subject was repositioned on the treatment table, the abduction board was removed and repositioned, the humerus was taken back to neutral abduction and external rotation, and the goniometer (angle values covered with tape) was taken to 180°. $ICC_{3,1}$[49] for external rotation was .99, with a 95% CI of .98 to .99.

The physical therapist assistant mea-

sured the first 14 subjects who participated in the study (13 of which remained in the study). This measurer was blinded to treatment and group placement of these subjects. Due to taking a position at another facility, measurements for the final 6 subjects (5 of which remained in the study) were taken by the primary investigator (A.J.). This measurer was therefore not blinded to the treatment or group placement of these subjects. Intrarater reliability was determined for the primary investigator on 21 shoulders with ROM deficits. $ICC_{3,1}$ for external rotation was .98, with a 95% CI of .95 to .99.

Intervention

The targeted capsule was preheated[67] by the use of thermal ultrasound.[13,14] The intention was to alter the viscoelastic properties of the connective tissue and maximize the effectiveness of the stretch mobilizations to follow.[32,51,52,68] Ultrasound was administered to the anterior capsule of those in the AM group and to the posterior capsule of those in the PM group, with the intent to provide the target tissue with a moderate to vigorous temperature rise of 3°C to 4°C, which is deemed adequate to alter the viscoelastic properties of connective tissue.[13,14] Ultrasound doses were determined individually for each subject, as the capsule is at different depths on different individuals due to different body sizes and types. In general, most posterior capsules were treated using 1-MHz ultrasound because it was determined that the capsule was 2 to 5 cm deep and most anterior capsules were treated with 3 MHz, as the capsule was determined to be 0.5 to 2 cm deep.[13,14] If a subject was large, 1 MHz may have been used to target the anterior capsule; if a subject was thin, 3 MHz may have been used for the posterior capsule. The specific parameters chosen were at the discretion of the researcher and were recorded at the first treatment and repeated for each of the following treatments. All ultrasound treatments were applied at 1.5 W/cm^2 continuously for 10 minutes, using a Sonicator Ultrasound Generator (ME 730; Mettler Electronics Corporation, Anaheim, CA). A coupling gel[15] (Tyco Health Care Group LP, Mansfield, MA) was used and the sound head was moved in a circular pattern at the rate of approximately 4 cm/s. The area covered by the ultrasound head was about twice the size of the sound head. Subjects were instructed to report any discomfort. If the subject reported discomfort, the sound head was moved more rapidly and, if this was not adequate, the intensity of the dose was reduced. Two subjects needed the intensity reduced for 2 treatments, until they were more comfortable with the higher dose. Both of these subjects were in the AM group.

Joint mobilization followed the ultrasound treatment as soon as the subject could be positioned appropriately. To minimize joint compression and possible periarticular soft tissue damage, lateral traction of the glenohumeral joint was performed before and during the mobilization procedures.[42,54] The joint mobilization procedures used in this study were stretch mobilizations,[30] which loaded the restricting tissue at a slow rate and maintained a low load over a prolonged period[61,67] at the end of the available abduction and/or external rotation ROM[28] with a linear, gliding movement produced by bone translation.[30] These were Kaltenborn grade III mobilizations, which apply force "after the slack of the joint has been taken up," to stretch tissues crossing the joint.[30] The end range position of the mobilization was held for at least 1 minute. No oscillatory motions were performed.[37] Each stretch mobilization was repeated so that a total of 15 minutes of sustained stretch was performed at each treatment session.

FIGURE 2A shows the initial position for the initial technique for the AM group.[30] In this position, the researcher maintained a lateral humeral distraction in its midrange position, while the anterior stretch mobilization was performed to end range, at the end range of abduction and external rotation. As the subject was able to tolerate a stronger stretching force, he/she was positioned prone to allow the therapist to utilize the subject's body weight and gravity to generate the

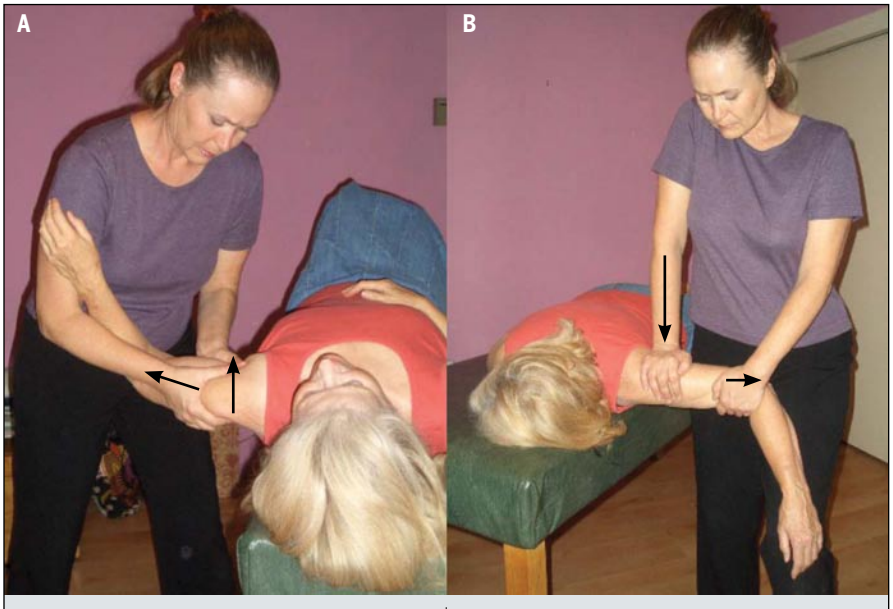

FIGURE 2A. Initial position for the anterior mobilization. At the end range of abduction and external rotation, a lateral humeral distraction in its midrange position is maintained while the anterior stretch mobilization was performed to end range.

FIGURE 2B. Progression of the anterior mobilization. At the end range of abduction and external rotation (held by researcher's thigh), a lateral humeral distraction in its midrange position is maintained, while the anterior stretch mobilization was performed to end range.

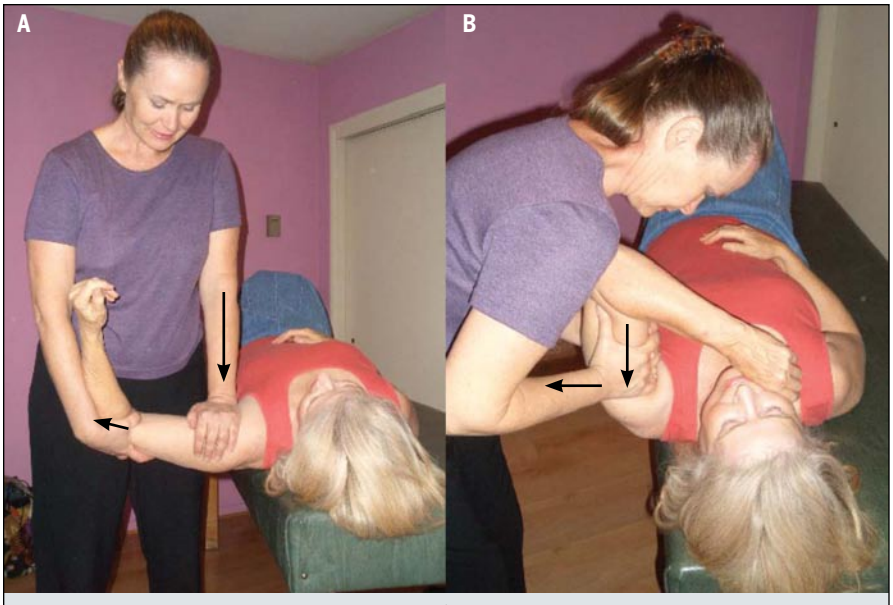

FIGURE 3A. Initial position for the posterior mobilization. At the end range of abduction and external rotation a lateral humeral distraction in its midrange position is maintained, while the posterior stretch mobilization was performed to end range.

FIGURE 3B. Progression of the posterior mobilization. At the end range of flexion and external rotation, a lateral humeral distraction in its midrange position is maintained, while the posterior stretch mobilization was performed to end range.

mobilization force in a similar combined fashion of distraction to midrange and anterior glide to end range (**FIGURE 2B**). Only 3 of the 10 subjects in the AM group had sufficient pain resolution and improvement in ROM to tolerate the increased stretching force associated with the prone position.

FIGURE 3A shows the initial position for the PM group. In this position, the researcher maintained a lateral humeral distraction in its midrange position while the posterior stretch mobilization was performed to end range, at the end range of abduction and external rotation. The position chosen for the progression of the posterior mobilization takes the humerus into flexion, with the intent to provide a greater stretch to the posterior capsule (**FIGURE 3B**). This is a similar position to the one used by Roubal et al[54] for their study using manipulation. In this position, the humerus was taken into end range external rotation only, as abduction was not a component of the technique. This position was tolerated by only 3 of the 8 subjects and for only a part of the treatment during the last 2 treatment sessions.

During the joint mobilization (anterior and posterior), the subject was instructed to describe his/her sensation, so the therapist could modify the force or position as necessary to maintain a moderate stretch on the targeted tissue. Pain levels associated with the adhesive capsulitis varied among subjects, and the force of the mobilization was modified if the subject requested; however, each subject was encouraged to tolerate the pain to allow a moderate stretch sensation at each bout of mobilization. During the sustained pressure of the posterior glide mobilization procedure, in 4 subjects a sudden "giving way," accompanied by an audible "pop," occurred. These were painless and associated with an immediate increase in external rotation ROM, as well as more shoulder comfort reported by the subject. This did not occur with any anterior glide mobilizations.

Upon completion of the mobilizations at each of the 6 treatment sessions, external rotation ROM measurements were taken according to the protocol described earlier. To reduce postmobilization soreness, each subject then exercised on an upper-body ergometer (Tru-Kinetics Upper Cycle; Henley International Inc, Sugarland, TX) for 3 minutes in the forward direction only, at an arm position height that allowed pain-free movement.

Each subject was treated for 6 sessions. The subjects were asked to schedule therapy sessions 2 to 3 times per week. The average time frame for the 6 visits for the AM group was 15.4 days and for the PM group was 21.6 days. One subject in the PM group, for personal family reasons, had a 15-day gap between sessions 4 and 5. During this time she lost 2° of shoulder external rotation range. The short duration of the study was designed to optimally assess the changes attributable to the mobilizations and to minimize the changes due to the natural history of adhesive capsulitis.

Data Analysis

To determine similarity between the groups at baseline, subject age, height, and body mass were compared using independent *t* tests. Descriptive statistics on gender, dominant arm, side of affected arm, occupation, and any previous minor injury to the affected shoulder recalled by the subject were compared using chi-square tests for homogeneity. The median, minimum, and maximum values were recorded for the duration of symptoms and compared using the Mann-Whitney *U* test. Shoulder abduction angles, shoulder external rotation angles, and VAS scores for pain at baseline were analyzed using independent *t* tests. The function questions were scored from 0 to 4 (best score to worst score). This questionnaire included 3 separately scored domains: pain at night (question 1), overall function (question 2), and specific activities (questions 3-5) . Scores were recorded as median, minimum, and maximum. Questions 1 and 2 were compared between groups using chi-square tests. Because of the wider scale for analysis, the combined scores of questions 3 through 5 were compared between groups using the

TABLE 1 Comparison of Subject Characteristics at Baseline by Group

Subject Characteristics	AM Group (n = 10)	PM Group (n = 8)	*P* Value
Age (y)*	54.7 ± 8.0	50.4 ± 6.9	.24†
Height (cm)*	166.9 ± 10.2	168.7 ± 11.4	.74†
Body mass (kg)*	80.1 ± 24.6	71.8 ± 19.3	.44†
Gender (females, males)	8, 2	6, 2	.80‡
Dominant arm	10 right	8 right	
Affected arm	9 right, 1 left	3 right, 5 left	.02‡
Occupation	6 sedentary, 4 manual	6 sedentary, 2 manual	.50‡
Minor injury recalled§	3 yes, 7 no	3 yes, 5 no	.74‡
Symptoms duration (mo)‖	8.4 (2,12)	10.9 (4,60)	.36¶

Abbreviations: AM, anterior mobilization; PM, posterior mobilization.
** Means ± SD.*
† Independent t test.
‡ Chi-square test.
§ Previous minor/trivial injury[5,16,35,46] to affected shoulder.
‖ Median (minimum, maximum).
¶ Mann-Whitney U *test.*

TABLE 2 Comparison of Clinical Characteristics at Baseline by Group*

Clinical Characteristics	AM Group (n = 10)	PM Group (n = 8)	*P* Value
Passive abduction (°)	55.0 ± 9.4	51.3 ± 10.8	.63†
Active external rotation (°)	11.1 ± 15.5	1.3 ± 16.8	.21†
VAS pain scale (cm)	8.3 ± 2.9	7.4 ± 2.3	.48†
Function Q1‡	3.7 ± 0.7	3.9 ± 0.3	.65§
Function Q2‡	2.3 ± 0.7	2.7 ± 0.9	.70§
Function Q3-5‖	8.7 ± 2.1	8.9 ± 1.9	.90¶

Abbreviations: AM, anterior mobilization; PM, posterior mobilization; VAS, visual analogue scale.
** Values expressed as mean ± SD.*
† Independent t test.
‡ Q1 and Q2 (scores 0-4; 0 = best, 4 = worst).
§ Chi-square test.
‖ Q3-5 (scores as above are summed, from 0-12).
¶ Mann-Whitney U *test*

Mann-Whitney *U* test. Because not all the questions in a domain were used from the L'Insalata et al[34] questionnaire, the reliability and validity of the questions used in this study are unknown.

External rotation ROM was measured initially and at the end of each of the 6 treatment sessions and compared between groups using a 2-by-7 mixed-model analysis of variance (ANOVA), with group (2 levels) as the independent factor and measurement session as the repeated factor. Since there was a significant group-by-time interaction, independent *t* tests were performed between groups for each time interval and paired *t* tests performed within groups to assess the difference in the external rotation ROM compared to baseline for each group separately. Because of the number of tests performed, alpha was set at .003, to make correction for multiple comparisons.

The differences between baseline and the final treatment session VAS pain scores were compared within and between groups using a 2-way mixed-model ANOVA. Functional changes within each group over time were analyzed using Wilcoxon signed-ranks tests. Questions 1 and 2 were analyzed between groups at baseline and after 6 treatments using chi-square tests, and the combined questions 3 through 5 were analyzed using Mann-Whitney *U* tests. The Spearman rho was used to find if there were any significant correlations between changes in VAS pain scores and changes in the function scores, changes in VAS pain scores and changes in shoulder external rotation, and changes in function scores and changes in shoulder external rotation, independent of group. The alpha was set at .05.

RESULTS

Subjects

Of the initial 58 patients that were evaluated, 38 subjects were excluded for the following reasons: abnormal radiographs (n = 13), presented with a proximal humerus fracture (n = 1), rotator cuff tears as diagnosed by arthrograms (n = 2), neurological conditions of cerebral palsy and stroke (n = 2), a diagnosis of tendonitis (n = 1), presented after having a manipulation under anesthetic (n = 3), planning on manipulation under anesthetic before 6 visits (n = 2), shoulder external rotation ROM deficits primarily attributed to muscle flexibility deficits, including 1 with external rotation ROM that did not change with abduction (n = 14), and did not have English comprehension sufficient to understand the consent forms (n = 2).

Twenty subjects joined the study. Two subjects left the study before completion of the 6 treatment sessions. Data from these subjects were omitted from the analyses (**FIGURE 4**). Demographic data for the remaining 18 subjects who completed all treatment sessions are presented in **TABLES 1** and **2**. At baseline, the groups were determined to be similar except for the side of the affected arm. All subjects had marked painful restriction of active and passive shoulder ROM with external rotation being most limited. Thus the subjects in this study were presumed to be in Neviaser's stage II to IV.[40,41]

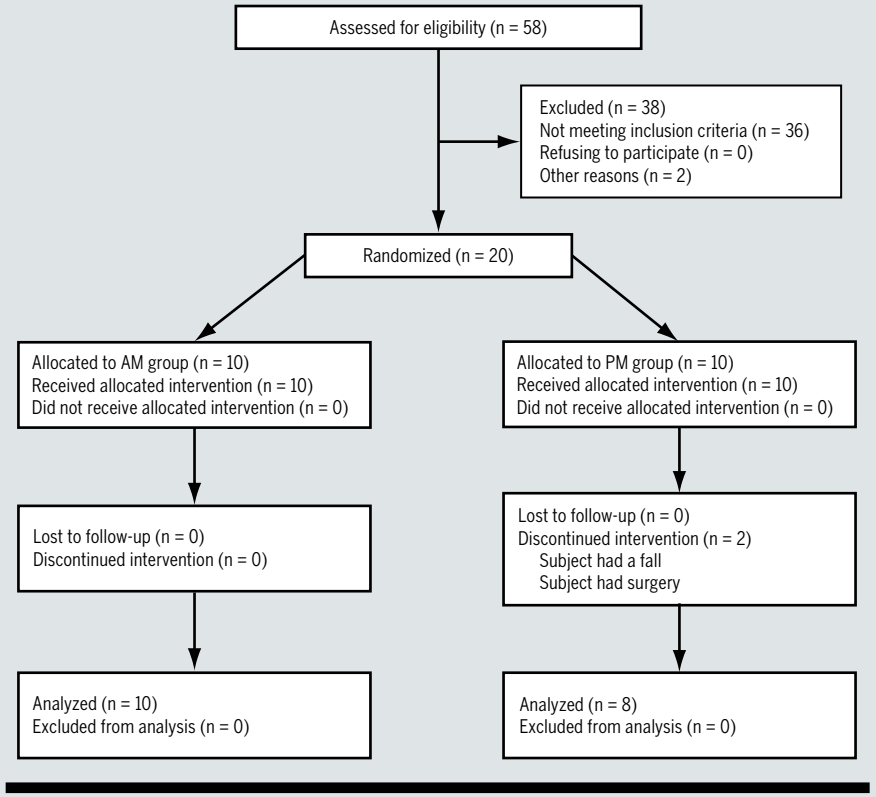

FIGURE 4. Flow diagram of subject progress through the phases of the randomized trial.

External Rotation ROM

There were no significant differences in shoulder external rotation ROM between groups at baseline (**TABLE 2**). Following 6 treatment sessions, in the AM group, 2 subjects lost external rotation ROM (–16° and –13°), 1 had no change (0°), and 7 showed improvement (3°-18°). In the PM group, shoulder external rotation ROM improved in all subjects (22°-45°). The largest improvement in ROM for the subjects in the AM group (18°) was less than the smallest ROM improvement for the PM group (22°). **FIGURE 5** presents the data for shoulder external rotation ROM at baseline and again after each treatment, for both groups. This graph shows the progressive improvement of shoulder external rotation in the group treated with posterior mobilization techniques compared to the relative lack of improvement in the group treated with anterior mobilization techniques. **TABLE 3** presents comparison of the change in external rotation ROM between baseline and after each of the 6 treatment sessions. There was no significant difference at baseline between the 2 groups. A significant difference was noted between groups for sessions 3 to 6, with the difference in shoulder external rotation ROM between the groups increasing at each session.

For the AM group, comparisons with baseline value indicate a significant improvement in shoulder external rotation only at the time of the third visit. This is in contrast to the PM group, in which a significant difference compared to baseline was present for sessions 3 to 6, with a consistently greater difference in mean values. At the end of the 6 treatment sessions, the AM group had a mean (±SD) improvement of 3.0° ± 10.8° (95% CI, –4.8° to 10.8°; $P = .40$), whereas the PM group had a mean improvement of 31.3° ± 7.4° (95% CI, 25.1° to 37.5°; $P<.001$).

Pain Scores

TABLE 4 compares the VAS pain scores measured at baseline and during the final treatment session for both groups. There was no significant difference ($P = .31$) between the 2 groups initially or by the end of the treatment sessions. Both groups had a significant ($P = .01$) decrease of pain by the end of treatment. The AM group reduced by 1.7 cm and the PM group reduction was 2.5 cm.

Functional Questionnaire Scores

TABLE 5 shows baseline and final scores for the functional questionnaire. There was no significant difference between the groups for any of the functional questions. Within the AM group over time, however, there was improvement ($P = .02$) with question 1 related to pain at night that disturbs sleep.

For the combined groups, there was a significant correlation between the change in VAS pain scores and a change in combined function questions 3 through 5 ($r_s = .61$, $P = .01$). A change in external rotation range was negatively correlated with a change in question 2 ($r_s = –.57$, $P = .01$). Since smaller values indicated better function, this indicated that as external rotation improved, the subjects had improvement in overall daily function.

DISCUSSION

The results of this study indicate that posterior glide stretch mobilizations combined with therapeutic ultrasound and upper extremity exercises using the upper body ergom-

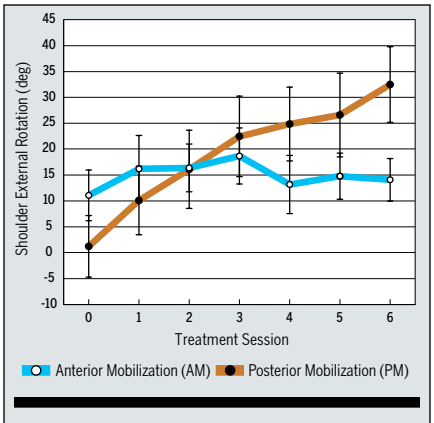

FIGURE 5. Comparison of external rotation at baseline and after each treatment by group (mean ± SEM).

eter were effective in treating external rotation ROM deficits commonly found in patients with adhesive capsulitis. This result is consistent with the findings of Roubal et al[54] and Placzek et al,[47] who with a posterior gliding manipulation found marked increases in external rotation as well as internal rotation ROM. In contrast, anterior glide mobilization techniques applied in combination with the same program of therapeutic ultrasound and upper body ergometer exercises were not effective in improving shoulder external rotation ROM.

At baseline, the groups were similar except for the dominance of the affected arm. In the AM group, all but 1 subject (90%) had adhesive capsulitis on the dominant (right) side. In the PM group, less than half (47.5%) of the subjects had adhesive capsulitis on the dominant (right) side. Binder et al[3] reported long-term outcomes of adhesive capsulitis in 40 subjects and found that initially (the first 8 months) the dominant arm consistently showed a better ROM (except for rotation); however, the nondominant arm had an accelerated recovery at a later stage, ending up with better range (except for rotation) by 40 to 48 months. In this study, the sample sizes were too small to perform tests of significances between dominant and nondominant shoulders in each group. Further studies could include dominance of the affected shoulder in the inclusion/exclusion criteria.

To specifically address the aim of the study (optimal glide direction), a minimalist design would have been preferred (anterior versus posterior glide only, without ultrasound or exercise). Providing accepted intervention approaches for all patients, such as physical agents and therapeutic exercise, was required by the Beaver Medical Group Institutional Review Board and is in fact consistent with standard clinical practice. Therefore, the effectiveness of the joint mobilization techniques must be interpreted in conjunction with the other interventions provided to all subjects.

TABLE 3 Change in External Rotation Range of Motion by Group*

Sessions Compared	AM Group (n = 10)	PM Group (n = 8)	*P* Value†
1-0	5.1 ± 7.8	8.9 ± 7.5	.32
95% CI	(−0.5, 10.7)	(2.6, 15.2)	
Paired *t* test‡	*P* = .07	*P* = .01	
2-0	5.3 ± 10.2	14.9 ± 9.6	.06
95% CI	(−2.0, 12.6)	(6.8, 22.9)	
Paired *t* test‡	*P* = .14	*P* = .003	
3-0	7.6 ± 4.6	21.3 ± 10.0	.001
95% CI	(4.3, 10.9)	(12.9, 29.6)	
Paired *t* test‡	*P* = .001	*P* = .001	
4-0	2.1 ± 12.0	23.6 ± 9.2	.001
95% CI	(−6.5, 10.7)	(15.9, 31.3)	
Paired *t* test‡	*P* = .59	*P*<.001	
5-0	3.7 ± 11.3	25.4 ± 6.8	<.001
95% CI	(−4.4, 11.8)	(19.7, 31.1)	
Paired *t* test‡	*P* = .33	*P*<.001	
6-0	3.0 ± 10.8	31.3 ± 7.4	<.001
95% CI	(−4.7, 10.7)	(25.0, 37.5)	
Paired *t* test‡	*P* = .40	*P*<.001	

Abbreviations: AM, anterior mobilization; CI, confidence interval; PM, posterior mobilization.
**Values expressed as mean ± SD degrees of change between baseline and after each treatment session. All subjects attended all treatment sessions.*
† Independent t test comparing AM group and PM group.
‡ Within-group difference (testing mean difference, 0).

TABLE 4 Comparison of Baseline and Final VAS Pain Scores by Group

Time	AM Group (n = 10)	PM Group (n = 8)	*P* Value*
Baseline	8.3 ± 2.9	7.4 ± 2.3	.31
Session 6	6.6 ± 3.8	4.9 ± 2.5	
P value†	.01	.01	

Abbreviations: AM, anterior mobilization; PM, posterior mobilization; VAS, visual analogue scale.
** 2-way mixed-model analysis of variance (between subjects).*
† 2-way mixed-model analysis of variance (within subjects).

The mobilization positions chosen for this study were from physical therapy textbooks[12,25,30] for both the initial and progression positions. The positions of the initial mobilization procedures were in a similar amount of shoulder abduction for both the anterior and posterior glides. The positions chosen for the more aggressive mobilization techniques (**FIGURES 2B** and **3B**) were different in regard to the flexion versus the abduction position of the shoulder, which may have impacted results of this study. The more aggressive techniques were only used in a minimal number of patients for a minimal number of sessions. Future studies should consider glide direction, as well as other factors related to joint mobilization techniques, such as shoulder abduction and flexion angles. A multicenter study with the ability to attract a larger number of subjects would be needed to accomplish this.

Our findings agreed with those of Shaffer et al[57] in that as subjects experienced less pain their function improved. Despite the change in ROM, the PM

TABLE 5 Comparison of Functional Improvement by Group

Function Questions	AM Group (n = 10)	PM Group (n = 8)	*P* Value
Question 1 (scores, 0-4)			
Baseline*	4.0 (2-4)	4.0 (3-4)	.65†
Final*	3.0 (1-4)	4.0 (1-4)	.40†
P value‡	.02	.14	
Question 2 (scores, 0-4)			
Baseline*	2.0 (1-3)	2.5 (1-4)	.70†
Final*	2.5 (1-3)	2.0 (0-3)	.23†
P value‡	1.00	.06	
Questions 3-5 (scores, 0-12)			
Baseline*	8.5 (6-12)	9.0 (6-11)	.90§
Final*	7.0 (2-10)	6.0 (1-9)	.36§
P value‡	.10	.05	

Abbreviations: AM, anterior mobilization; PM, posterior mobilization.
** Values expressed as median (range).*
† Chi-square test.
‡ Wilcoxon signed-ranks test.
§ Mann-Whitney U *test.*

group did not indicate a corresponding change in function, probably because of the difficulty in capturing valid measurements of functional deficits with the questionnaire used in this study. We suggest that a functional task (eg, overhead reach)[18] be selected for measurement of functional improvement rather than a questionnaire.

One subject left the PM group to have arthroscopic surgery and manipulation. However, the external rotation ranges for the first 3 treatment sessions that the subject completed show her gaining 15°. Including this subject in an intention-to-treat analysis would not have been a true representation of the effects of the mobilization procedure, so it was decided to not include her data.

Novotny et al[43] studied the glenohumeral joint in vitro using techniques in which only the capsule and articular surface contact controlled the motion of the humerus. They found that at low moments the humeral head initially translates across the glenoid surface in the direction opposite to the motion, due to the joint surface geometry, as consistent with the concave-convex rule. Then, with increasing moment and angle of rotation, the humeral head changes direction as the capsule tightens, "pushing the humeral head back along the glenoid surface."[43] Thus, it is thought that the tension in the capsular tissues rather than joint surface geometry controls the translatory movements of the humeral head.[27,39] Asymmetrical capsular tightness has the potential to impact humeral head motion, especially when tension in the capsule increases as the arm is taken further into elevation. Ludewig and Cook[36] found that patients with shoulder symptoms showed greater anterior translation of the humeral head in 30° to 60° of scapular plane elevation of the humerus and a decrease in the mean posterior translation of the humeral head in higher elevations (60°-120°), as compared to an asymptomatic comparison group. Harryman et al[24] found that a tightened rotator cuff interval caused a reduction in posterior and inferior translation of the humeral head. In patients with adhesive capsulitis, capsular contractures develop, usually in the area of the rotator cuff interval.[62] It is common with these patients to palpate the humeral head displaced in an anterior position, with respect to the uninvolved shoulder.[42,54] Roubal et al[54] suggest that these anterior capsular structures may "draw the humeral head to its anterior-most excursion," thus limiting anterior and posterior glide and affecting external and internal rotation. Harryman et al[23] found in their cadaver studies that altering the capsule (tightening or cutting) affects the translation of the humeral head on the glenoid during physiologic movement of the humerus. They suggest that a tight rotator cuff interval "may not only limit the ROM, but it may also produce unwanted obligate anterosuperior translation," thus limiting the posterior translation associated with external rotation.[24] Roubal et al[54] suggest that by manipulating the humeral head posteriorly, they might have increased the total allowable excursion of the capsule, thus improving external and internal rotation. The results of this study are not at odds with the concave-convex rule. Our results do, however, support the concept that the capsule plays an important role[9,33] in dictating the humeral head translation, possibly in the opposite direction to the expected effect of joint geometry if restricted.[19,43] Thus, the normal shoulder joint requires adequate coordination of all passive and active stabilizers[1,58] to maintain shoulder stability[9,59,31,66] and pathological changes in any of these can lead to unphysiological translations of the humeral head relative to the glenoid fossa.[23]

Karduna et al[31] found that joint conformity had an influence on translations during active positioning but not during passive positioning. Joint mobilization is a passive movement applied to the joint surfaces,[42] so shoulder mechanics under passive conditions need to be considered. The joint glides that accompany glenohumeral motions support the clinical practice of restoring translational movement to restore full physiological motion in the shoulder joint,[44] even though care must be taken in attributing joint translations to external mobilizing glides.

In this study, the stretch mobilization procedures were performed for a total of 15 minutes of low-load stretch at end range external rotation and/or abduction during each treatment session, with the

intention to elongate the glenohumeral capsular contracture. Substantial improvements were made in the PM group in just 6 treatment sessions, in an average of 21.6 days. If a component of the improvement in external rotation ROM is associated with normalizing the humeral head position in the glenoid fossa, then it may be that stretch mobilizations of shorter duration are adequate to produce similar results. Further studies may determine the optimal duration of stretch mobilizations for improving external rotation ROM.

It is not known if posterior mobilization procedures would be effective with secondary adhesive capsulitis. Future studies focused on effectiveness of posterior stretch mobilization techniques for increasing external rotation ROM in these patients are recommended.

This study tried to initially define a homogenous group of patients with primary adhesive capsulitis. Some researchers, however, suggest that there are subgroups of this condition, due to the different areas of the capsule identified as having developed contractures.[55,56] If these subgroups can be identified by accessory motion testing, then different mobilization directions may be warranted. For example, there were 2 subjects in the AM group who had relatively good external rotation ROM gains (13° and 18°). These 2 subjects may represent a subgroup that could respond favorably to anterior mobilization techniques. Studies focusing on accessory motion deficits to identify capsular adhesions may further identify these potential subgroups of patients with adhesive capsulitis.[8]

It is noteworthy that in this study, 14 of the patients who were referred for physical therapy with the diagnosis of adhesive capsulitis actually had external rotation limitations fitting the authors' primary diagnosis of subscapularis muscle flexibility deficit. We suggest that patients be carefully evaluated for the source of the external rotation ROM deficit and that treatment be selected to address the specific deficit. For example, if glenohumeral external rotation ROM becomes greater as the shoulder is abducted, impairments in muscle flexibility are likely to be the primary restriction to ROM, and interventions such as soft tissue mobilization and muscle-stretching procedures should be selected to normalize the muscle flexibility deficits.[18] On the other hand, if glenohumeral external rotation ROM becomes less as the shoulder is abducted, indicating primarily capsular involvement, then treatment should be focused on the capsular-associated mobility impairments. From the results of this study, we recommend that perhaps posterior glide stretch mobilizations be considered for restoring external rotation. A multigroup clinical trial where subjects with presumed muscle flexibility and capsular restriction are randomly placed in intervention groups that receive either soft tissue mobilization and muscle-stretching procedures or posterior glide stretch mobilizations would verify whether it is beneficial for interventions to be selected to address the primary reason of the external rotation ROM restriction found during the physical examination.

There are, however, limitations to this study. The small sample size (AM group, n = 10; PM group, n = 8) and the inclusion of 1 therapist potentially affect the external validity of the results; thus care should be taken in generalizing these results to a wider population. A larger, multicenter, randomized clinical trial would be recommended to improve external validity of the results.

Another limitation of this study is that after the first 14 subjects, the measurer, who was blinded to the group assignment and therefore to the treatment received by the subjects, left the clinic where the study was being conducted. The last 6 subjects were, therefore, measured by the treating clinician who was not blinded to the treatment group. All measurements for a given subject in the study were measured by the same individual.[4]

This study consisted of a short course of treatment of 6 visits over a mean period of 18.5 days. This represents restrictions of 1 small clinic in which patients with managed healthcare typically get prescriptions of 6 visits at a time. A suggestion for future studies may be to have a longer course of 12 treatments, with a period of follow-up after completion of treatment. Because our patients received continued therapy beyond the study time, the subjects that did not progress well (the AM group) were given mobilizations in the opposite (posterior) direction from that point onward and showed gains in ROM similar to those found in the PM group during the study. Further research could include follow-up with a crossover design.

CONCLUSION

In this study, 2 similar groups were treated with a slow translatory glenohumeral joint mobilization stretch in 2 different directions, anterior and posterior. The group treated with the posterior mobilizations had significant improvement in shoulder external rotation ROM over the course of 6 treatment sessions, whereas the group treated with anterior mobilizations did not show significant improvement.

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APPENDIX

SHOULDER FUNCTION QUESTIONS

Patient Number _____ Date _____

Please answer the following questions regarding your affected shoulder.

1. **How often does the pain in your shoulder make it difficult for you to sleep at night?**
   a) Every day
   b) Several days a week
   c) One day a week
   d) Less than one day a week
   e) Never
2. **Considering all the ways you use your shoulder during daily personal and household activities (ie, dressing, washing, driving, household chores, etc), how would you describe your ability to use your shoulder?**
   a) Very severe limitation or unable
   b) Severe limitation
   c) Moderate limitation
   d) Mild limitation
   e) No limitation
3. **How much difficulty have you had putting on or removing a pullover, sweater or shirt due to your shoulder problem?**
   a) Unable
   b) Severe difficulty
   c) Moderate difficulty
   d) Mild difficulty
   e) No difficulty
4. **How much difficulty have you had combing or brushing your hair due to your shoulder problem?**
   a) Unable
   b) Severe difficulty
   c) Moderate difficulty
   d) Mild difficulty
   e) No difficulty
5. **How much difficulty have you had reaching shelves that are above your head due to your shoulder problem?**
   a) Unable
   b) Severe difficulty
   c) Moderate difficulty
   d) Mild difficulty
   e) No difficulty