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The efficacy of different types of mobilization techniques in patients with primary adhesive capsulitis of the shoulder: a systematic review

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Abstract

Objective: To systematically review the literature for efficacy of isolated articular mobilization techniques in patients with primary adhesive capsulitis (AC) of the shoulder.

Data Sources: PubMed and Web of Science were searched for relevant studies published before November 2014. Additional references were identified by manual screening of the reference lists.

Study Selection: All English language RCTs evaluating the efficacy of mobilization techniques on range of motion (ROM) and pain in adult patients with primary AC of the shoulder were included in this systematic review. Twelve RCTs involving 810 patients were included.

Data extraction: Two reviewers independently screened the articles, scored methodological quality and extracted data for analysis. The review was conducted and reported according to the PRISMA Statement. All studies were assessed in duplicate for risk of bias using the Physiotherapy Evidence Database scale for randomized controlled trials.

Data Synthesis: The efficacy of 7 different types of mobilization techniques was evaluated. Angular mobilization (N=2), CYRIAX approach (N=1) and Maitland's technique (N=6) showed improvement in pain score and ROM. With respect to translational mobilizations (N=1), posterior glides are preferred to restore external rotation. Spine mobilizations combined with glenohumeral stretching and both angular and translational mobilization (N=1) had a superior effect on active ROM compared to sham ultrasound. High intensity mobilization (N=1) showed less improvement in

Constant Murley Score compared to a neglect group. Finally, positive long-term effects of Mulligan's technique (N=1) were found on both pain and ROM.

Conclusion: Overall, mobilization techniques have beneficial effects in patients with primary AC of the shoulder. Due to preliminary evidence for many mobilization techniques, the Maitland's technique and the combined mobilizations seem recommended at the moment.

Key words: Adhesive capsulitis; frozen shoulder; mobilization; systematic review; efficacy

List of abbreviations: AC= adhesive capsulitis, Flex-SF= flexion level scale of the shoulder function, ROM= Range of Motion

Adhesive Capsulitis (AC) of the shoulder is often defined as a disorder characterized by progressive pain and loss of active and passive mobility of the glenohumeral joint. The annual incidences are 3 to 5% in the general population and even up to 40% in diabetics [1], [2]. It mainly affects people between the ages of 40-60 years, with women more commonly affected than men [3]. AC is mainly divided into two types in the literature, the idiopathic or primary form and the acquired or secondary form. Although no specific cause is identified in primary AC, the development of secondary AC is associated with recent surgery, immobilization or trauma and also with systemic, extrinsic or intrinsic disorders. Systemic disorders include a history of diabetes mellitus and thyroid disorders [4]. Extrinsic disorders are not directly related to the shoulder and include cardiopulmonary diseases, cervical spine pathology, stroke, Parkinson's disease, and humerus fractures. Intrinsic disorders are associated with the glenohumeral joint soft tissues or structures, including rotator cuff pathologies, biceps tendinitis, calcific tendinitis, and AC joint arthritis [1], [5], [6]. Adhesive capsulitis lasts approximately 12 to 42 months in total and consists of three phases. It starts with a painful phase, which lasts 2 to 9 months. Subsequently a stiff phase

occurs (lasting 3 to 12 months), defined by stiffening and restriction of shoulder range of motion. The recovery phase is the final phase of the disease and is characterized by regaining movement and function over approximately 5 to 26 months. Some patients may not recover entirely and remain with some movement restriction [7]. Additionally, after having AC on one side, the individual risk to develop AC in the contralateral shoulder increases by 5-34%. [6].

With AC, a decrease of capsular extensibility is seen as one of the most important pathological mechanisms that result in large mobility deficits. Consequently, the restoration of glenohumeral motion is of great clinical importance to patients with AC, as this would largely improve shoulder function [8], [9].

Kelley et al. [6] published current evidence-based recommendations and clinical practice guidelines for the treatment of patients with AC. The interventions comprised of corticosteroid injections in the short term (4-6 weeks), patient education, physical modalities (ultrasound and electrical stimulation), joint mobilizations, translational mobilizations, manipulations and stretching exercises. They concluded that some physiotherapeutic interventions show evidence regarding reduced pain or increased mobility in the short and long term.

As described above, there are reasons to suggest that mobilization techniques may be effective in reducing pain and disability in patients with AC of the shoulder. Mobilization is defined as a low-velocity and small- or large-amplitude movement applied anywhere within a joint ROM [10] to improve the corresponding extensibility of the shoulder capsule and stretch the specific tightened soft tissues to induce beneficial effects [11]. Mobilization techniques are commonly used to improve range of motion and include both angular and translational mobilizations. Angular mobilizations are often applied as continuous passive motion or dynamic splinting. An external motorized device provides low-load continuous

passive motion to move the joint passively through a specified ROM, creating a prolonged-duration stretch [9]. This is an established method of overcoming joint stiffness and histologically hypothesized for enhancing the healing of connective tissues [12], [13]. The Dynasplint® Shoulder System is developed to apply a low-load prolonged-duration stretch to increase time at end-range and achieve permanent elongation of connective tissue [14]. By applying translational mobilizations, the humeral head is shifted in the preferred direction, while the elbow remains fixed [15]. The therapist can either translate in an anterior, posterior or inferior direction [16], [17]. In addition, individual mobilization techniques can be combined, which is implemented in e.g. Mulligan's and Maitland's techniques. Mulligan's technique includes a combination of sustained manual application of gliding force to the joint with a simultaneous active movement of the joint by the patient [18]. Studies that have used this technique on the elbow and ankle, revealed a beneficial effect on pain and joint range of motion [19], [20]. Maitland's technique is based on the 5- grade classification system of Maitland and describes the amplitude of the rhythmic oscillating mobilization in the specified range of movement [11]. Furthermore, mobilizations can be performed beyond the pain threshold. These so-called high intensity techniques do not refer to the frequency that patients are treated, but include active exercises up to and beyond the pain threshold, passive stretching and manipulation of the glenohumeral joint, and home exercises aimed at stretching and maximal reaching with the intent to restore range of motion and reduce pain [21]. Deep friction massage, as employed by Cyriax and Russel [22], is often used prior to and in conjunction with mobilization techniques. The purpose of friction massage is to reduce abnormal fibrous adhesions and to make scar tissue more mobile in sub-acute and chronic inflammatory conditions by realigning the normal soft tissue fibers.

Many suggestions for mobilization techniques are available, but it is still a matter of debate what the optimal direction of force and movement application should be to restore joint

mobilization in patients with AC of the shoulder [23]. Therefore, it is of importance to compare the treatment effects of different mobilization techniques. The aim of this systematic review is to evaluate the efficacy of isolated articular mobilization techniques in patients with primary AC of the shoulder, in order to identify which technique(s) may be most beneficial in the restoration of joint mobility and reduce pain in patients with AC.

Methods

This systematic review is reported following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines [24].

Eligibility Criteria

The PICOS- method [25] was used to derive key words. The present systematic review attempted to include articles that described the results of clinical trials (S) evaluating the efficacy of isolated articular mobilization techniques (I) on range of motion (ROM) and pain (O) in patients with primary AC of the shoulder (P). The comparison (C) was undefined in order to evaluate the efficacy of any isolated mobilization techniques in patients with primary AC of the shoulder.

Information sources and search strategy

Both PubMed and Web of Science databases were searched to retrieve relevant articles. The search was conducted until November 2014. A prefabricated template was used for study selection designed by the Belgian Health Care Knowledge Centre [26]. The following keywords were used: “frozen shoulder”, “adhesive capsulitis”, "periarthritis" (MeSH), “periarthritis”, "musculoskeletal manipulations" (MeSH), “musculoskeletal manipulations”, “manual therapy”, “manual techniques”, “manipulation”, “manual translation”, “articular translation”, “manual mobilization”, “manual mobilisation”, “mobilization”, “mobilisation”,

123 “traction” (MeSH), “traction”, “glide”, “gliding”, "treatment outcome" (MeSH), "treatment
124 outcome", “therapy effect”, “efficacy” and “effectiveness”.

125 *Study Selection*

126 To be included in the present systematic review, articles had to meet the selection criteria
127 noted in Table 1.

128 *Data Items and Collection*

129 The following specific information was extracted from each included trial: (a)
130 characteristics of the trial sample (number of participants, gender, age, stadium of the
131 disease and the trial’s inclusion and exclusion criteria); (b) type of mobilization technique
132 (mobilization modality, intervention frequency, solely or combined with other treatment
133 techniques); (c) type of control intervention; (d) outcome assessment; and (e) therapy
134 effect (outcome measure, assessment intervals and results). The included studies were
135 divided between both review authors for data extraction and were checked by the other
136 author. The methods of the included studies are heterogeneous (e.g. length of follow-up
137 and treatment period and sample differences); therefore, the approach of a box score or
138 meta-analysis to quantify the results is not appropriate.

139 *Risk of Bias in Individual Studies*

140 Methodological quality was assessed independently by 2 researchers, who were blinded
141 from each other’s quality assessment. After individually rating the selected articles, the
142 rating of both researchers were compared and potential differences were discussed in a
143 consensus meeting. Scorings were checked by a third researcher. Risk of bias in the
144 different studies was assessed with the PEDro-scale [27]. According to the study design and
145 the risk of bias, studies could score a level of evidence A2 (RCT of good quality, sufficient
146 sample size and double- blinded) or B (if previous criteria were not fulfilled).
147 Recommendations are graded based on the level of evidence (www.cbo.nl).

Results

Selection of studies

The process of study selection is presented in Figure 1. Most studies were excluded based on the intervention. A total of twelve studies were included in the systematic review.

Risk of bias and level of evidence

As previously stated, all studies were evaluated with the PEDro-scale. There was a 98% (130 of 133 items) agreement between the two researchers when scoring the selected items. After a second review, both researchers agreed on differences in rating. The final score of each study is presented in Table 2. The methodological quality varied between 4/11 and 10/11 on the PEDro-scale. According to the PEDro-classification most of the studies showed a methodological quality of level B. Many studies lost points on blinding of patients [8], [9], [21], [23], [28]–[34], therapist [8], [9], [21], [23], [28]–[35], and assessor [9], [21], [23], [28], [30], [34]. Additionally, the concealment of allocation items was often not attained [8], [9], [21], [28], [30], [31], [34]. Most studies scored well on randomization and comparability of groups. Only one study was double blinded and received level of evidence A2 [35].

Study Characteristics

To allow deeper interpretation and translation of the results, characteristics regarding the study population, intervention, follow-up period and main results of the studies are presented in Table 3. Level of conclusion of the most important outcome parameters is summarized in Table 4.

Subjects

This review addressed 810 patients with primary AC with a mean age varying between 47.1 [34] and 58.9 [28]. Adult patients with unilateral restricted shoulder movement [33] or external rotation deficit [23], [30] were included mostly if symptoms of pain and stiffness were present for minimum two [31], [34] to three months [8], [21], [28], [29], [32], [35]. Most studies included patients in the stiff phase [8], [9], [28]–[30], [33]; two studies included both the painful and stiff phase [9], [33], while the rest of the studies did not specifically define the phase [21], [23], [31], [32], [34], [35]. Glenohumeral restrictions were further defined in a number of studies: four studies included patients with 50% loss of passive shoulder movement compared to the unaffected side [8], [21], [28], [32], one study reported a 25% loss of ROM [29] and one used a restriction of 30° in 2 planes of movement [35]. The aforementioned restrictions had to be present in at least 1 [8], [28] or 2 [32], [35] of the three movement directions (i.e., forward flexion, abduction in the frontal plane, or external rotation in 0° or 90° abduction). Corresponding exclusion criteria for patients were secondary AC of the shoulder, including rotator cuff pathologies [9], [29], [31], [32], [35], diabetes mellitus [21], [29], [32], [34], a history of surgery on the affected shoulder [21], [29], [30], [32], [33], shoulder osteoarthritis [35], rheumatoid arthritis [29], [32] and neurological disorders [8], [23], [34].

Type of mobilization techniques

Seven types of mobilization techniques were evaluated: angular mobilization [9], [30], translational mobilization [23], spine mobilizations combined with glenohumeral stretching and both angular and translational mobilization [35], high intensity techniques beyond pain threshold [21], CYRIAX approach [31], Mulligan's technique [28] and Maitland's technique [8], [29], [30], [32]–[34].

Outcome measures

Most studies reported the effect of mobilization techniques on pain [8], [9], [23], [28], [31], [33]–[35] and ROM [8], [9], [23], [28], [30]–[35]. Pain was measured using a Visual Analogue Scale [8], [9], [23], [28], [31], [33], [34] or Likert Scale [35]. In addition, the Constant Murley Score [9], [21] described pain and ROM after treatment.

Study duration

Frequency, total duration and follow-up of all therapies are diverse. Frequency of therapies varied from 1 [35] to 5 [9], [28], [33], [34] times a week. Total duration lasted one week [31] up until 90 days [30]. Follow-up fluctuated between two weeks [31] and two years [21].

Effect of mobilization techniques

It can be seen from the data in table 4 that 4 / 8 studies (all level B) reported reduced **pain** following a mobilization program. In addition, 8 /10 (7 with level B, 1 with level A2) studies reported a beneficial effect of mobilization techniques on **ROM.**

Effect of angular mobilization

The utilised techniques regarding angular mobilizations were continuous passive motion [9] and dynamic splinting [30]. Dundar et al. [9] compared continuous passive motion with traditional therapy, consisting of pendulum exercises and stretching and found a reduction in pain after continuous passive motion. No improvement in the **Constant Murley Score** (including pain and ROM evaluations) was found. Gaspar et al. [30] compared a cortical steroid injections with dynamic splinting, provided by the Dynasplint® Shoulder System, Maitland's technique [11] and a combination of both. Dynamic splinting [30] had a superior effect on **ROM** compared to the cortical steroid injections, but no significant difference between intervention groups was found.

Effect of translational mobilization

Johnson et al. [23] compared the effect of posterior and anterior glide mobilizations on **ROM and pain**. A reduction in pain was reported in both experimental groups, while the progression in ROM was favourable for posterior glide mobilizations.

Effect of spine mobilizations combined with glenohumeral stretching and both angular and translational mobilization

Buchbinder et al. [35] included spine mobilization, glenohumeral stretching, gliding and angular mobilization in the experimental intervention and compared it with sham ultrasound. For active **ROM** the combined technique proved to be superior, but no beneficial effects were found in terms of pain.

Effect of high intensity techniques beyond pain threshold

Diercks et al. [21] included intensive mobilizations up to and beyond the pain threshold in addition to stretching and compared the results with a supervised neglect group receiving traditional therapy below the pain threshold. The **Constant Murley Score** was reported as an outcome variable, which showed less improvement with high intensity techniques beyond pain threshold.

Effect of CYRIAX approach

Guler-Uysal et al. [31] compared a CYRIAX approach of deep friction massage and mobilization exercises to a traditional therapy supplemented with hot pack and short wave diathermy. A positive effect of CYRIAX on **pain and ROM** was reported.

Effect of Mulligan's technique

Doner et al. [28] compared the effect of the Mulligan's technique to conventional stretching exercises. Both strategies were found to be effective in reducing **pain** and restoring **ROM**, but the immediate and long-term effects were in favor of Mulligan's technique.

Effect of Maitland's technique

Six studies made use of the Maitland technique as an intervention [8], [29], [30], [32]–[34]. As stated earlier Gaspar et al. [30] included this technique in their experiment; the effect on **ROM** was in favor of the intervention groups compared to cortical steroid injections. Paul et al. [33] found no superior effect of the Maitland technique on **pain and ROM** compared to mobilization in flexion and abduction stance. The Maitland technique had a beneficial effect on **pain and ROM** when compared to a supervised exercises program as used in the study of Kumar et al. [34]. A study by Vermeulen et al. [8] tried to unravel if there would be a difference between high-grade versus low-grade mobilization techniques, which resulted in a favorable effect of using high-grade mobilization on improving **ROM**. Two independent studies of the research group of Yang et al. [29], [32] implemented the Maitland technique, which showed significant progression on the flexion level scale of shoulder function (**FLEX-SF**) in favor of end-range mobilization and mobilization with movement. In addition, both mobilizations showed improvement of the FASTRAK motion analysis outcomes. Hand behind back and external rotation **ROM** increased in the ERM group compared to the mid-range mobilization group.

Discussion

Summary of evidence

Overall, mobilization techniques have beneficial effects in patients with primary AC of the shoulder, with strength of conclusions varying between moderate and preliminary evidence. Particularly Maitland's technique and spine mobilizations combined with glenohumeral stretching and both angular and translational mobilization seem recommended at the moment. Due to the preliminary evidence, more studies are needed on assessing the effect of angular, translational and high intensity mobilization techniques, CYRIAX approach and Mulligan's technique on pain and ROM.

The use of angular mobilization showed very limited preliminary evidence to reduce pain and improve ROM in primary AC (weak evidence) compared to corticosteroid injections or usual therapy. Angular mobilizations are preferable to corticosteroid injections, but no differences were found between intervention groups consisting of angular mobilization techniques, Maitland's mobilizations or a combination of both [30], which could be explained by a lack of power.

Preliminary evidence was found for the use of translational mobilization in primary AC. Only one study was found on the use of translational mobilization, therefore the results must be interpreted with caution. Posterior glides proved to be superior to anterior glides to restore external rotation ROM, but optimal glide direction and duration of stretch mobilizations to restore ROM needs to be evaluated in further research. Care should be taken in generalizing the results of this study, because of the small sample size and inclusion of only one therapist [23].

Preliminary evidence was also found for the effect of high intensity techniques beyond pain threshold in AC patients. According to their beliefs, Diercks et al. [21] found an

adverse effect of the high intensity technique compared to the supervised neglect group on the Constant Murley Score. They suggested that intensive passive stretching may affect the natural course of the disease by activating the inflammatory reaction, when applied during the inflammation and proliferation stage and perhaps also during the early fibrotic stage. This indicates the importance of timing and therapy adjustments according to the different stages of AC. It is important to note that this study does not present detailed information about the composition of the techniques used.

Buchbinder et al. [35] observed additional effects of spine mobilizations combined with glenohumeral stretching and both angular and translational mobilization on ROM for at least 6 months, which may be clinically important. The lack of pain reduction could be explained by the fact that there was less potential for additional effect of the device on this outcome. Further trials are needed to confirm the beneficial effects of the studied interventions and to determine whether other sequential or combination of treatments may result in better outcomes.

The CYRIAX approach of deep friction massage and mobilization exercises showed very limited preliminary evidence on pain and ROM in the early phase of treatment. This technique is easily applicable, since it does not require special equipment and no anaesthesia. However, long-term follow-up results are unknown and should be provided in future research. It should be noted that the exact mobilization exercises that were used in this study were not described properly.

Very limited preliminary evidence is found for the effect of Mulligan's technique on pain and ROM. The positive result of the Mulligan's technique on pain and ROM should be interpreted with caution, since it was only investigated in one study. This technique was

chosen for the advantage of increasing ROM in addition to providing analgesia, but since it is a hands-on treatment, it is not possible to perform the study in a blinded manner [28].

The Maitland technique showed a beneficial effect on ROM, FLEX-SF and FASTRAK. The study of Kumar et al. [34] showed that adding the Maitland technique to the supervised exercise program gives advantages in terms of pain and ROM. Mobilization techniques performed in the specific plane close to the end-range improve the corresponding extensibility of the shoulder capsule and stretch the specific tightened soft tissues to induce beneficial effects. The neurophysiologic effect could result from the rhythmic oscillatory movement of the Maitland's technique that stimulates the peripheral mechanoreceptors and inhibits the nociceptive receptors [11]. However, Paul et al. [33] did not find these superior effects on pain and ROM, which could be explained by the used measurement tool that may have been less reliable. Therefore, further studies, which establish the biomechanical rationale behind the effect of countertraction with appropriate tools, will need to be undertaken.

High-grade and low-grade mobilization in primary AC patients yielded results according to expectations. Although the effect of the high-grade mobilization was superior, the low-grade group also achieved a considerable clinical improvement. Therefore, low-grade mobilization could be the preferred treatment mode for those who are anxious about experiencing pain. The largest improvement was attained during the treatment itself, but ongoing progression of shoulder function was seen and can be explained by the initial improvement [8]. Furthermore, as a control group was not included in this study, the findings may be a result of natural improvement. In addition, two other studies used this technique and found a beneficial effect of end-range mobilization and mobilization with movement in favor of the mid-range mobilization techniques [29]. This could be explained by the fact that the latter may only extend the adhesive capsule, while the end-range

mobilization and mobilization with movement techniques can stretch the adhesive capsule and associated contracted periarticular structures. The appropriate treatment for each individual with primary AC of the shoulder may be dependent on the course and duration of symptoms. The multi-treatment design limits the generalizability of the finding to normal clinical practice. Yang et al. [32] concluded that end-range mobilization and scapular mobilization are important techniques for primary AC of the shoulder. Subjects with larger shoulder kinematics were included in the control group. This homogenous subgroup was unlikely to improve with treatment, which could have biased the results.

Study limitations

This review has certain limitations that should be taken into account when interpreting its results. First, the main weakness of this review is the risk of bias; most studies failed to achieve blinding of the patients [8], [9], [21], [23], [28]–[34], therapist [8], [9], [21], [23], [28]–[35] and assessor [9], [21], [23], [28], [30], [34] and concealment of allocation items [8], [9], [21], [28], [30], [31], [34] were often not attained. Therefore, a note of caution is due here. However, only one of the twelve studies was not randomized [30], and in one study randomization was completed after patients had been allocated on basis of shoulder kinematics [32].

Second, it should be noted that characteristics of the included studies were heterogeneous. Inclusion criteria varied among most studies, such as duration and classification of injury and magnitude of loss of ROM. The majority of the mobilization techniques included patients in the stiff phase, while some studies did not specifically report the phase. It would seem reasonable that mobilization techniques would be most effective in the stiff phase to improve mobility, but not all studies took this into consideration. Therefore, the timing of the therapy at specific times in the disease's progress is an important issue for future research. In some studies the sample size was

small, which may have resulted in a lack of statistical significance due to type II error (not enough power) [8], [9], [23], [28]–[32]. Multiple treatment techniques and outcome measures were used and the description of some utilised mobilization techniques was insufficient. For example, ROM was measured differently by most included studies, either active or passive ROM, total or only glenohumeral ROM [36] and different positions were used (flexion, abduction, internal or external rotation and hand behind back). Therefore, the results must be interpreted with caution as marked heterogeneity was apparent for ROM. The use of ROM investigations should be normalized in further studies to generalize the results. It would not be ethical to use a sham group; thus the control group in most studies was also treated with therapy. In some studies hot packs were used to deliver superficial heating to increase the extensibility of collagen [28], [31], [33]. The application of heat has potentiated the effect of stretching on improving ROM in healthy people and may have influenced the results [37].

Follow-up, total duration and frequency of the therapy also varied among studies. Additionally, patient activity between post-test and follow–up were not always controlled. The benefits of the particular treatment over a longer follow-up period were unknown in most studies. As Struyf & Meeus [36] previously mentioned, it is difficult to take the self-limiting aspect of AC into account. In most studies the follow-up period is limited to only 3 months [9], [23], [28]–[32], [35], which seems to be insufficient knowing that AC can last up to several years. Although mobilization techniques seemed beneficial to reduce pain and increase ROM, there is little evidence to suggest that these techniques, as well as physical therapy or other therapy modalities, can alter disease prognosis and duration [6]. Therefore, further research with a longer follow-up period is warranted to establish long-term effects.

Conclusion

Based on the present systematic literature review, overall mobilization techniques have beneficial effects in patients with primary AC of the shoulder. Maitland's technique and spine mobilizations combined with glenohumeral stretching and both angular and translational mobilization seems recommended for the moment. Due to limited homogeneity and limited number of studies with appropriate level of evidence, more studies are needed on assessing the effect of angular, translational and high intensity mobilization techniques, CYRIAX approach and Mulligan's technique on pain and ROM.

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Figure 1: Flow chart of study selection

Table 1. Study selection criteria

Inclusion criteria	Exclusion criteria
- Adult patients with primary AC of the shoulder, in any stadium; - The study assessed the efficacy of all kinds of articular mobilization techniques; - The outcome measure should be pain or ROM to assess the efficacy of the treatment; - Clinical trials published in full text; - Studies in English or Dutch; - Full text available.	- Secondary AC of the shoulder; - Manipulations under anesthesia of the affected shoulder; - Case reports, reviews, letters-to-the editor, clinical trials, trial of an intervention and retrospective studies.

Table 2: Results of the methodological assessment of mobilization techniques in patients with primary adhesive capsulitis

Author	Criteria											Quality score	Level of Evidence
	1	2	3	4	5	6	7	8	9	10	11		
Buchbinder et al.,2007 [36]	1	1	1	1	1	0	1	1	1	1	1	10	A2
Diercks et al.,2004 [21]	1	1	0	1	0	0	0	1	1	1	1	7	B
Doner et al., 2013 [29]	1	1	0	1	0	0	0	1	1	1	1	7	B
Dundar et al., 2009 [9]	1	1	0	1	0	0	0	1	1	1	1	7	B
Gaspar et al., 2009 [31]	0	0	0	1	0	0	0	0	1	1	1	4	B
Guler-Uysal et al., 2004 [32]	1	1	0	1	0	0	1	1	1	1	1	8	B
Johnson et al., 2007 [23]	1	1	1	1	0	0	0	1	1	1	1	8	B
Kumar et al,, 2012 [28]	1	1	0	1	0	0	0	1	1	1	1	8	B
Paul et al. , 2014 [35]	1	1	1	1	0	0	1	1	1	1	1	9	B
Vermeulen et al., 2006 [8]	1	1	0	1	0	0	1	1	1	1	1	8	B
Yang et al., 2007 [30]	1	1	1	1	0	0	1	0	1	1	1	8	B
Yang et al., 2012 [33]	1	1	1	1	0	0	1	1	1	1	1	9	B

Criteria: 1) Eligibility criteria were specified; 2) Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received); 3) Allocation was concealed; 4) The groups were similar at baseline regarding the most important prognostic indicators; 5) There was blinding of all subjects; 6) There was blinding of all therapists who administered the therapy; 7) There was blinding of all assessors who measured at least one key outcome; 8) Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; 9) All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"; 10) The results of between-group statistical comparisons are reported for at least one key outcome; 11) The study provides both point measures and measures of variability for at least one key outcome.

Table 3. Population characteristics, intervention and results

Author	Subjects	Experimental Intervention (EI)	Control Intervention (CI)	Assessment	Outcome	Results
Buchbinder et al. (2007) [36]	N=156 ♀99 ♂57 55.0±9.3y 55.3±7.7y DO: 12	2x/w 2w– 1x/w 4w Stretch muscles glenohumeral joint Cervicothoracic spine mobilization Glenohumeral/p/accessory glide and angular mobilization Coordination and strength Rc and scapular stabilizers	2x/w 2w – 1x/w 4w Sham UltraSound	Baseline, 6w, 12w, 26w	Pain (Likert Scale)	EI=CI
					$ROM_{/a/FL,AB,ER,HBB}$	↑EI >↑ CI
Diercks et al. (2004) [21]	N=77 ♀47♂30 50±6y 51±7y	Physical therapy group > Pain threshold Active exercises Manipulation glenohumeral joint Stretching and maximal reaching	Supervised Neglect Group < Pain threshold Pendulum exercises Active exercises	1x/ 3m, up to 24m	Constant Score	↑ EI < ↑ CI (3m - 18m)
Doner et al. (2013) [29]	N=40 ♀31♂9 58.9±8.77y	5x/w 3w Hot pack TENS (20min, 100Hz, 0.05-0.07ms) Mulligan's technique (flexion, elevation, internal rotation)	5x/w 3w Hot pack TENS (20min, 100Hz, 0.05-0.07ms) Conventional passive stretching	Baseline, 3w, 3m	Pain (VAS)	↑ EI >↑ CI
					$ROM_{/a/,/p/,\ FL,AB,ER,HBB}$	↑ EI > ↑ CI
Dundar et al. (2009) [9]	N=57 ♀39 ♂18 56.3±7.8y 57.1±8.3y	1h/d, 5x/w, 4w Continuous Passive Motion gradual increase in motion Home: Passive ROM, pendulum exercises 1x/d, 12w	1h/d, 5x/w, 4w Conventional Physiotherapy Treatment: active stretching, pendulum exercises Home: same	Baseline, 4w, 12w	Pain (VAS)	↑ EI > ↑ CI
					ROM	↑ EI = ↑ CI
					Constant Score	↑ EI = ↑CI
Gaspar et al. (2009) [31]	N=62 55.6±7.9y	Standard (EI1) 2x/w Physical therapy Therapeutic exercise Moist heat Education Maitland $_{end\text{-}range}$ $ROM_{/p/a/}$ PNF	SDS (EI2) 2x/d, 7d/w Shoulder Dynasplint Systems	Combined (EI3) 2x/w EI1 + EI2	Control (CI) Cortical steroid injections	Baseline, 90d	$ROM_{/a/ER90}$	↑ EI1 = EI2 = EI3 > ↑ CI
Guler-Uysal et al. (2004) [32]	N=40 ♀28 ♂12 56.0±8.6y	CYR 1h, 3x/w 1-2 w (>80% normal ROM) Cyriax (CYR) consisting of Deep Friction Massage and manipulation Active stretching and pendulum exercises Home: Passive ROM, pendulum exercises 1x/d	PT 1h, 5x/w 1-2 w (>80% normal ROM) Physical Therapy (PT): Hot pack (20min), Short Wave Diathermy (220V/50Hz, 20min) Active stretching and pendulum exercises Home: same	Baseline, 1w, 2w	Pain (VAS)	↑ CYR > ↑ PT (NS)
					$ROM_{FL,\ AB,\ IR,\ ER}$	↑ CYR > ↑ PT (2w) NOT ROM_{AB}
Johnson et al. (2007) [23]	N=18 ♀14 ♂ 4 54.7±8.0y 50.4±6.9y DO: 2	AM 2-3/w 6 sessions total Anterior glide mobilization (AM) Ultrasound (1-3 MHz, 1,5W/cm^2, 10 min, anterior) Grade III mobilization End-stretch position > 1min, 15min total, 6x	PM 2-3/w 6 sessions total Posterior glide mobilization (PM) Ultrasound (1-3 MHz, 1,5W/cm^2, 10min, posterior) Grade III mobilization End-stretch position > 1min, 15min total, 6x	Baseline, after each session	Pain (VAS)	↑ AM = ↑ PM
					ROM_{ER}	↑ AM < ↑ PM (session 3 - session 6)

Kumar et al. (2012) [28]	N=40 ♀14 ♂ 26 47.9y 47.1y	2-3 glides/s, 30s, 5 sets, 3x/w, 4 w CI+ Maitland mobilization Glenohumeral caudal glides Glenohumeral caudal glides progression Glenohumeral postero-anterior glides Passive oscillatory movements		10x10s per exercise, 5x/w, 4w Supervised Exercises Program Codman exercises Shoulder wheel exercises Wall-ladder exercises Self-stretching exercises (AB,FL,ER,IR, AD)	Baseline, 4w	Pain (VAS)	↑ EI > ↑ CI
						$ROM_{ER/AB}$	↑ EI > ↑ CI
Paul et al. (2014) [35]	N=100 ♀35♂65 49.16 ± 6.09y 53.22 ± 6.74y	20 min, 5x/w, 2 w CI + weighted shoulder countertraction during mobilization, 2-3 kg Glides in Maitland grade I – IV		20 min, 5x/w, 2 w Moist heat Mobilization (4 sets, 8-12x) Home program ROM, function exercises (10x3/d)	Baseline, 2w	Pain (VAS)	↑ EI = ↑ CI
						ROM	↑ EI = ↑ CI
Vermeulen et al. (2006) [8]	N=100 ♀66♂34 51.6±7.6y 51.7±8.6y DO: 4	HGMT		LGMT	Baseline, 3m, 6m, 12m	Pain (VAS)	↑ HGMT = ↑ LGMT
		30min, 2x/w, up to 12w (> 6w + ROM=normal→0-1x/w); High- grade mobilization (Maitland mob grades III and IV) Inferior glides Posterior and lateral glides Anterior and medial glides Oscillatory movements (caudal, lateral and anterior)		30min, 2x/w, up to 12w (> 6w + ROM=normal→0-1x/w) Low- grade mobilization (Maitland mob grade II) Same glides and oscillatory movements 3min Proprioceptive neuromuscular facilitation $_{/p/}$ 2min Codman pendular exercises Without causing pain		$ROM_{ER/a/, /p/}$	↑ HGMT > ↑ LGMT /a/ER(12m), p/ER, p/AB (3 and 12m)
Yang et al. (2007) [30]	N=28 ♀24♂4 53.3±6.5y 58±10.1y DO: 7	A-B-A-C (EI1)		A-C-A-B (EI2)	Every 3w up to 12w	FLEX-SF	↑ EI1 = ↑ EI2 for ERM and MWM
		2x/w 30min mob + simple exercises, 12w A= mid-range mob, Maitland (MRM) B= end-range mob (ERM) C= mob with movement (MWM) 10-15 repetitions				FASTRAK motion analysis	↑ ERM = ↑ MWM SHR: ↑ MWM > ↑ ERM
Yang et al. (2012) [33]	N=32 ♀22♂10 54.3±7.6y 56.8±7.2y 54.9±10.3y DO: 2	Criteria-intervention (CrI)	Criteria- control (CC)	Control (CI)	4w, 8w	FLEX-SF	↑ CI > ↑ CC (8w) ↑ CrI > ↑ CC (8w)
		2x/w 3m CC+ End- range mobilization (Maitland grade IV) Scapular mobilization	2x/w 3m Mid-range mobilization /p/, stretch, physical modalities (Ultrasound; shortwave diathermy; Electrotherapy) Active exercises	2x/w 3m (Larger shoulder kinematics compared to CrL and CC) CC		FASTRAK motion analysis	↑ CI > ↑ CC (4-8w) ↑ CrI > ↑ CC (8w)
						$ROM_{/p/}$ Hand Behind Back	↑ CrI > ↑ CC (4w, 8w)
						$ROM_{/p/}$ External Rotation	↑ CrI > ↑ CC (4w, 8w)
						$ROM_{/p/}$ Internal Rotation	↑ CI = ↑ CC = ↑ CrI

Min=minutes, H = hour, D = day, w = week, m = month, y=years, DO= drop-outs, Rc= rotator cuff, , /a/ = active, /p/ = passive, TENS = Transcutaneous electrical nerve stimulation, FL = flexion, AB = abduction, AD= adduction, IR = internal rotation, ER = external rotation, HBB= hand behind back, ROM = range of motion, PNF = proprioceptive neuromuscular facilitation, aRom = active Range of motion, ER90 = external rotation with the arm in 90 degrees of abduction, N = number, FLEX-SF = flexion level scale of the shoulder function, SHR = scapulohumeral rhythm, VAS= Visual Analogue Scale, mob= mobilization, NS= not significant. CYR= CYRIAX, HGMT= high-grade

mobilization technique, LGMT= low- grade mobilization technique, AM= anterior glide mobilization, PM= posterior glide mobilization, MRM= mid-range mobilization, ERM= end- range mobilization, MWM= mobilization with movement.

Table 4. Level of conclusion of the most important results, + = positive result, - = negative result, = = equal result of mobilization techniques compared to conventional therapy.

Outcome variables	Studies	Type of mobilization techniques	Level of evidence	Level of conclusion
Pain	+ Dundar et al. (2009) [9]	Angular mobilization	B	Moderate +
	+ Guler-Uysal et al. (2004) [32]	Cyriax approach	B	
	+ Doner et al. (2013) [29]	Mulligan's technique	B	
	+ Kumar et al. (2012) [28]	Maitland's technique	B	
	= Johnson et al. (2007) [23]	Translational mobilization	B	
	= Paul et al. (2014) [35]	Maitland's technique	B	
	= Vermeulen et al. (2006) [8]	Maitland's technique	B	
	= Buchbinder et al. (2007) [36]	Combined technique	A2	
ROM	+ Johnson et al. (2007) [23]	Translational mobilization	B	Moderate +
	+ Buchbinder et al. (2007) [36]	Combined techniques	A2	
	+ Guler-Uysal et al. (2004) [32]	Cyriax approach	B	
	+ Doner et al. (2013) [29]	Mulligan's technique	B	
	+ Gaspar et al. (2009) [31]	Angular + Maitland's technique	B	
	+ Kumar et al. (2012) [28]	Maitland's technique	B	
	+ Vermeulen et al. (2006) [8]	Maitland's technique	B	
	+ Yang et al. (2012) [33]	Maitland's technique	B	
	= Dundar et al. (2009) [9]	Angular mobilization	B	
	= Paul et al. (2014) [35]	Maitland's technique	B	
Constant Murley Score	= Dundar et al. (2009) [9]	Angular mobilization	B	Weak -
	- Diercks et al. (2004) [21]	High intensity mobilization	B	
FLEX-SF	+ Yang et al. (2007) [30]	Maitland's technique	B	Moderate +
	+ Yang et al. (2012) [33]	Maitland's technique	B	
FASTRAK	+ Yang et al. (2007) [30]	Maitland's technique	B	Moderate +
	+ Yang et al. (2012) [33]	Maitland's technique	B