

Arthroscopic capsular release vs manipulation under anesthesia for frozen shoulder

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Abstract

Background: Frozen shoulder is characterized by pain and progressive restriction of shoulder movements. Arthroscopic capsular release (ACR) and manipulation under anaesthesia (MUA) are commonly used for patients who do not respond to conservative treatment.

Aim: To compare the clinical and functional outcomes of ACR and MUA in patients with frozen shoulder.

Materials and Methods: A prospective randomized controlled study was conducted in the Department of Orthopaedics, Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapura, from March 2024 to December 2025. Thirty-two patients were analyzed, with 16 patients in each group. Patients underwent either ACR or MUA followed by the same structured physiotherapy

protocol. Pain was assessed using VAS, while shoulder function was evaluated using UCLA and Constant scores. Range of motion was assessed preoperatively and during follow-up at 3, 6, 12 and 24 weeks.

Results: ACR showed significantly greater improvement in abduction, forward flexion and external rotation at 3 weeks compared with MUA ($p < 0.001$). However, these differences were largely comparable by 24 weeks. At 24 weeks, UCLA scores were 29.13 ± 1.025 in ACR and 29.13 ± 0.719 in MUA ($p = 1.000$), while Constant scores were 81.00 ± 2.50 and 81.00 ± 1.46 , respectively ($p = 1.000$). VAS scores at 24 weeks were also comparable (0.88 ± 0.342 vs 1.00 ± 0.00 ; $p = 0.154$). Postoperative MRI demonstrated capsular tears more frequently after MUA and pericapsular edema after ACR.

Conclusion: Both ACR and MUA provide substantial improvement in pain, shoulder mobility and functional outcomes in frozen shoulder. ACR offers better early improvement in shoulder movement, while both techniques demonstrate comparable functional outcomes at 6 months.

Keywords: Frozen Shoulder, Adhesive Capsulitis, Arthroscopic Capsular Release, Manipulation Under Anaesthesia, Shoulder Function, Range of Motion.

Introduction

Frozen shoulder, also known as adhesive capsulitis, is a common painful shoulder disorder characterized by progressive pain, stiffness and restriction of both active and passive range of motion. The condition can significantly interfere with activities of daily living, occupational activities and overall shoulder function. Restriction of external rotation is particularly characteristic, and the underlying pathology involves contraction and fibrosis of the glenohumeral joint capsule¹.

Frozen shoulder may be classified as primary or secondary. Primary frozen shoulder develops without a clearly identifiable local cause, whereas secondary stiffness may occur following trauma, surgery, rotator cuff pathology, glenohumeral arthritis or neurological conditions. Diabetes mellitus and thyroid disorders have also been frequently associated with frozen shoulder^{1,2}. Diagnosis is primarily clinical and is based on painful restriction of active and passive shoulder movements, particularly external rotation. Imaging studies such as plain radiographs and magnetic resonance imaging (MRI) are useful for excluding other structural causes of shoulder stiffness and for identifying characteristic capsular and periarticular abnormalities³.

Conservative treatment remains the initial approach for most patients with frozen shoulder and includes analgesics, anti-inflammatory medication, corticosteroid injections and physiotherapy. Although many patients improve with non-operative treatment, some continue to experience severe pain and restricted movement despite an adequate period of conservative management. Surgical or procedural treatment may therefore be considered in patients with persistent and functionally significant stiffness⁴.

Manipulation under anaesthesia (MUA) is a commonly used treatment for refractory frozen shoulder. During MUA, the shoulder is passively mobilized through restricted ranges under anaesthesia with the objective of stretching and disrupting the contracted capsule. The procedure is relatively simple and does not require arthroscopic visualization. However, because the release is achieved indirectly, excessive force may potentially produce structural injuries including capsular disruption, labral injury or other tissue damage⁵.

Arthroscopic capsular release (ACR) is an alternative surgical procedure in which the contracted capsule is directly visualized and released under arthroscopic guidance. It allows controlled division of the contracted capsular structures and simultaneous assessment of intra-articular pathology. However, ACR requires arthroscopic equipment, specialized surgical expertise and greater operative resources⁴.

The comparative effectiveness of ACR and MUA remains an important clinical question. A prospective randomized study comparing the two procedures reported significant improvements in pain, range of motion and functional scores following both interventions, with no significant difference between groups at 24 weeks. The same study also reported postoperative MRI findings including labral

tears following MUA and bone bruises following ACR⁶. Other comparative clinical evidence has similarly suggested that MUA can provide outcomes comparable to arthroscopic capsular release in primary frozen shoulder⁷. Systematic reviews have also generally reported substantial improvement following both ACR and MUA. A systematic review comparing manipulation and arthroscopic release found relatively small differences between the procedures in postoperative range of motion and functional outcomes, although the available evidence was limited by methodological heterogeneity⁸. More recent evidence has continued to suggest broadly comparable outcomes between the two approaches.

The UK FROST trial was a large multicentre randomized clinical trial comparing MUA, ACR and early structured physiotherapy in adults with primary frozen shoulder. At 12 months, differences in shoulder function between the treatment groups were smaller than the predefined thresholds for clinical importance, indicating that statistically detectable differences should be interpreted in relation to their actual clinical magnitude⁹. The associated health technology assessment similarly evaluated the comparative clinical and economic outcomes of the three treatment approaches¹².

More recent meta-analytic evidence has also evaluated ACR and MUA directly. Zhao et al. reported that ACR produced a statistically greater long-term improvement in pain in some analyses, although the magnitude did not reach the minimal clinically important difference, while most other pain, function and range-of-motion outcomes were not significantly different between the procedures¹⁰. Xiao et al. included six papers representing 690 shoulders and found that ACR produced greater forward flexion at 3 and 6 months, while pain, external rotation and

complication rates were generally comparable between ACR and MUA¹¹.

Therefore, although both procedures are established treatment options for refractory frozen shoulder, uncertainty remains regarding their relative early and late functional outcomes and postoperative structural changes. The present study was undertaken to prospectively compare arthroscopic capsular release and manipulation under anaesthesia in patients with frozen shoulder who had failed conservative treatment. The study evaluated postoperative pain, range of motion and functional outcome using the Visual Analog Scale (VAS), UCLA shoulder score and Constant score, along with postoperative MRI findings and complications over a 6-month follow-up period.

Materials and Methods

Study Design and Setting

A prospective randomized controlled study was conducted in the Department of Orthopaedics, B.L.D.E. (Deemed to be University), Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapura, Karnataka. The study was conducted from March 2024 to December 2025 and evaluated the clinical outcomes of arthroscopic capsular release compared with manipulation under anesthesia (MUA) in patients with frozen shoulder who had failed conservative management.

The study protocol was approved by the Institutional Ethics Committee. The study was conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki and its subsequent amendments. Written informed consent was obtained from all participants before enrollment after explaining the study procedures, potential risks and

benefits, and the participant's right to withdraw from the study at any stage without affecting their treatment.

Sample Size

The sample size was calculated using G*Power version 3.1.9.4. Based on previously reported external rotation outcomes following arthroscopic capsular release and manipulation under anesthesia, with mean external rotation values of 58° and 49.2°, respectively, and standard deviations of 5.2° and 10°, a sample size of 32 patients, with 16 patients in each group, was calculated to provide 99% statistical power to detect a difference between the two means using an independent-samples t-test, with a significance level of 1% ($\alpha=0.01$).

Considering a possible 20% loss to follow-up or dropout, the target sample size was increased to 40 patients, with 20 patients allocated to each treatment group.

Eligibility Criteria

Patients were considered eligible for inclusion if they fulfilled the following criteria:

1. Age greater than 18 years.
2. Painful restriction of passive shoulder range of motion, with forward flexion $<100^\circ$ and external rotation $<50\%$ of the contralateral shoulder.
3. Failure of conservative treatment for at least three months, with magnetic resonance imaging (MRI) findings suggestive of frozen shoulder.
4. Willingness to participate in regular follow-up at the specified intervals.

Patients were excluded if they were aged below 18 years or above 70 years, had arthritis, full-thickness rotator cuff tears, a history of trauma or previous surgery around the shoulder, failed to maintain follow-up for at least six months, or had secondary causes of shoulder stiffness

such as inflammatory arthritis, glenohumeral arthritis, or neurological conditions affecting shoulder function.

Patient Recruitment and Diagnosis

Patients presenting to the orthopaedic outpatient department with symptoms suggestive of frozen shoulder were clinically evaluated and screened according to the predefined eligibility criteria. The diagnosis was based on painful restriction of passive shoulder movements, particularly forward flexion below 100° and external rotation below 50% of the opposite shoulder, together with MRI findings suggestive of adhesive capsulitis.

MRI was used to demonstrate characteristic features of frozen shoulder, including capsular thickening and synovial proliferation, and to exclude associated structural abnormalities such as full-thickness rotator cuff tears. Plain radiographs of the affected shoulder were also obtained in anteroposterior and axillary views to exclude glenohumeral arthritis, calcific tendinitis, and other bony abnormalities.

Randomization and Allocation

After confirmation of eligibility and acquisition of written informed consent, participants were randomly allocated into two treatment groups: the arthroscopic capsular release group and the manipulation under anesthesia group.

Computer-generated random number sequences were used for allocation. Block randomization with variable block sizes of four and six was employed to maintain balanced allocation during recruitment. The randomization sequence was generated by an independent statistician who was not involved in patient treatment or outcome assessment.

Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes. The envelopes were opened only after the patient had been

taken to the operating room and anesthesia had been administered.

Preoperative Assessment

A detailed preoperative assessment was performed for all enrolled patients. The history included duration of shoulder symptoms, previous treatment, associated comorbidities, particularly diabetes mellitus and thyroid disorders, and any history of shoulder trauma.

Physical examination was performed by a single experienced orthopaedic surgeon to minimize inter-observer variability. Shoulder range of motion was assessed using a standard goniometer. The parameters recorded included forward flexion, abduction, external rotation with the arm at the side, external rotation at 90° abduction, and internal rotation, assessed according to the highest vertebral level reached by the thumb.

Pain severity was assessed using the Visual Analog Scale (VAS), with scores ranging from 0, representing no pain, to 10, representing the worst imaginable pain. Functional status was evaluated using the University of California Los Angeles (UCLA) shoulder score, which assesses pain, function, active forward flexion, strength, and patient satisfaction, with a maximum score of 35 points.

Routine preoperative investigations included complete blood count, bleeding time, clotting time, random blood sugar, serum creatinine, blood urea, liver function tests, HIV, HBsAg and HCV testing, blood grouping and Rh typing, electrocardiography, and chest radiography. Two-dimensional echocardiography was performed when indicated based on clinical assessment and electrocardiographic findings.

Surgical Intervention

All procedures were performed by experienced orthopaedic surgeons with specialized training in shoulder surgery. Patients received either general

anesthesia or an interscalene brachial plexus block according to anesthetic assessment and patient preference. Prophylactic antibiotics were administered 30 minutes before surgery according to institutional protocol.

Manipulation Under Anesthesia

Patients allocated to the MUA group were positioned supine. The scapula was stabilized with one hand while controlled movements were applied to the humerus with the other hand.

The manipulation sequence consisted of forward flexion, abduction, external rotation with the arm at the side, external rotation at 90° abduction, internal rotation at 90° abduction, and cross-body adduction. Each movement was performed gradually using sustained gentle pressure until release of the adhesions was achieved. Excessive force was avoided to minimize the risk of fracture and soft-tissue injury.

Following manipulation, the shoulder was moved through its range of motion to assess the adequacy of release. An intra-articular injection containing 40 mg methylprednisolone and 5 mL of 0.5% bupivacaine was administered.

Arthroscopic Capsular Release

Patients undergoing arthroscopic capsular release were positioned in the beach-chair position, with the affected arm placed in a pneumatic arm holder to permit controlled movement during the procedure.

A standard posterior viewing portal was established approximately 2 cm inferior and 1 cm medial to the posterolateral corner of the acromion. An anterior working portal was subsequently created through the rotator interval using an outside-in technique under direct visualization.

Diagnostic arthroscopy was initially performed to assess the glenohumeral joint and confirm the characteristic findings of frozen shoulder, including synovial proliferation, capsular thickening, and loss of normal capsular redundancy.

Systematic capsular release was then performed using a radiofrequency ablation device set at 50 W. The release began with the rotator interval and coracohumeral ligament, followed by release of the anterior capsule, including the superior and middle glenohumeral ligaments. The inferior capsule was released from the 6 o'clock position in an anterior-to-posterior direction, with care taken to maintain a safe distance from the axillary nerve. Posterior capsular release was performed through the posterior portal when restriction persisted following anterior and inferior release.

Adequacy of capsular release was assessed by gentle manipulation of the shoulder to demonstrate restoration of passive range of motion. The joint was thoroughly irrigated, and 40 mg methylprednisolone was administered intra-articularly before closure of the portals.

Postoperative Rehabilitation

Both treatment groups followed the same postoperative rehabilitation protocol to minimize differences attributable to physiotherapy.

Supervised physiotherapy was initiated immediately after surgery. The rehabilitation programme consisted of three phases. During weeks 0–3, the focus was on maintaining the range of motion obtained during surgery using passive and active-assisted exercises, including pendulum exercises, wall climbing, pulley exercises, and cross-body stretching. Patients were instructed to perform exercises five times daily, with each session lasting approximately 15–20 minutes.

During weeks 4–8, progressive strengthening exercises using resistance bands were introduced while continuing range-of-motion exercises. During weeks 9–12, rehabilitation was directed toward functional activities, including sport- or occupation-specific exercises where appropriate.

Postoperative analgesia included paracetamol 1 g four times daily and diclofenac 50 mg twice daily during the first postoperative week. Tramadol 50 mg was prescribed as required for breakthrough pain.

Patients and their attendants were provided with detailed instructions regarding the home exercise programme. Compliance was monitored using a daily exercise diary. Supervised physical therapy was provided three times per week during the first month, twice per week during the second month, and once per week during the third month, with additional sessions when clinically required.

Follow-up and Outcome Assessment

Patients were followed at 3 weeks, 6 weeks, 3 months, and 6 months after surgery. At each visit, clinical assessment was performed by an independent observer who was blinded to the treatment allocation.

Shoulder range of motion was measured using the same standardized technique used during the preoperative assessment. Pain was assessed using the VAS, while functional outcome was assessed using the UCLA shoulder score.

Complications and adverse events were documented throughout follow-up. These included persistent postoperative stiffness requiring additional intervention, fracture, nerve injury, infection, and complex regional pain syndrome.

The primary outcome measure was the UCLA shoulder score at six months postoperatively.

Secondary outcomes included postoperative VAS pain score, forward flexion, abduction, external rotation, internal rotation, time required to return to work or routine daily activities, patient satisfaction assessed using a 5-point Likert scale, and postoperative complications.

A cost-effectiveness assessment was also performed based on direct medical costs, including surgical expenses, duration of hospital stay, medications, and physiotherapy sessions.

Patients with unsatisfactory improvement, defined as a UCLA shoulder score <27 or range of motion <50% of the contralateral shoulder at three months, were offered additional intervention according to institutional protocol. Such patients continued to be followed according to the intention-to-treat principle.

Statistical Analysis

Data were analyzed using SPSS version 20.0. Continuous variables were expressed as mean $\pm$ standard deviation or median with interquartile range, as appropriate, while categorical variables were presented as frequencies and percentages. The Shapiro–Wilk test was used to assess normality. Independent *t*-test or Mann–Whitney U test was used for between-group comparisons, and chi-square or Fisher’s exact test for categorical variables. Repeated-measures ANOVA with Bonferroni post-hoc testing was used for normally distributed repeated measures, while Friedman and Wilcoxon signed-rank tests were used for non-normal data. A two-tailed $p < 0.05$ was considered statistically significant. Missing data were handled using the last-observation-carried-forward method for intention-to-treat analysis.

Results and Observations

The present prospective randomized study was conducted in the Department of Orthopaedics, Shri B.M. Patil Medical College Hospital & Research Centre,

Vijayapura, from March 2024 to December 2025 to compare the functional outcomes of arthroscopic capsular release (ACR) and manipulation under anaesthesia (MUA) in patients with frozen shoulder. A total of 32 patients were included in the analysis, with 16 patients in each treatment group. The results are presented below.

1. Demographic and Baseline Characteristics

Table 1: Demographic Characteristics of the Study Participants

Characteristic	ACR (n=16)	MUA (n=16)	P-value
Age group			
40–50 years	5 (31.2%)	7 (43.8%)	0.465
51–60 years	11 (68.8%)	9 (56.2%)	
Mean age (years)	52.19 $\pm$ 2.949	51.25 $\pm$ 2.955	0.376
Gender			
Female	8 (50.0%)	8 (50.0%)	1.000
Male	8 (50.0%)	8 (50.0%)	
Side affected			
Left	8 (50.0%)	8 (50.0%)	1.000
Right	8 (50.0%)	8 (50.0%)	

Observation: The majority of participants belonged to the 51–60-year age group in both treatment groups. The mean age was comparable between the ACR and MUA groups (52.19 ± 2.949 vs 51.25 ± 2.955 years; $p=0.376$). Gender and side of involvement were equally distributed between the groups, with no statistically significant differences.

Table 2: Baseline Clinical Characteristics

Characteristic	ACR (n=16)	MUA (n=16)	P-value
Diabetes mellitus – No	5 (31.2%)	5 (31.2%)	1.000
Diabetes mellitus – Yes	11 (68.8%)	11 (68.8%)	

Duration of symptoms (months)	6.19 ± 1.328	8.06 ± 1.340	<0.001*
Pre-operative VAS score	8.69 ± 0.479	8.25 ± 0.447	0.012*
Pre-operative UCLA score	11.88 ± 0.806	12.00 ± 0.816	0.666
Pre-operative Constant score	14.13 ± 1.10	14.38 ± 0.95	0.509

*Statistically significant at $p < 0.05$.

Observation: Diabetes status was identical in both groups, with 68.8% of patients being diabetic. The mean duration of symptoms was significantly longer in the MUA group than in the ACR group (8.06 ± 1.340 vs 6.19 ± 1.328 months; $p < 0.001$). Pre-operative UCLA and Constant scores were comparable, whereas pre-operative VAS scores were statistically different between groups ($p = 0.012$).

2. Range of Motion Outcomes

Table 3: Abduction Range of Motion

Time point	ACR (n=16), Mean ± SD	MUA (n=16), Mean ± SD	P-value
Pre-operative	69.63 ± 3.423°	70.88 ± 2.872°	0.272
3 weeks	94.50 ± 4.817°	75.00 ± 2.781°	<0.001*
6 weeks	117.31 ± 5.160°	115.50 ± 2.422°	0.213
12 weeks	127.31 ± 5.160°	127.50 ± 2.422°	0.896
24 weeks	137.00 ± 8.579°	138.50 ± 2.422°	0.506

*Statistically significant at $p < 0.05$.

Observation: Pre-operative abduction was comparable between groups. At 3 weeks, the ACR group

demonstrated significantly greater abduction than the MUA group (94.50° vs 75.00° ; $p < 0.001$). Thereafter, no statistically significant difference was observed at 6, 12 or 24 weeks.

Table 4: Forward Flexion Range of Motion

Time point	ACR (n=16), Mean ± SD	MUA (n=16), Mean ± SD	P-value
Pre-operative	76.75 ± 3.416°	77.88 ± 2.872°	0.321
3 weeks	103.63 ± 5.620°	85.00 ± 2.781°	<0.001*
6 weeks	127.31 ± 5.160°	125.50 ± 2.422°	0.213
12 weeks	137.31 ± 5.160°	137.50 ± 2.422°	0.896
24 weeks	141.19 ± 5.822°	145.50 ± 2.422°	0.010*

*Statistically significant at $p < 0.05$.

Observation: Baseline forward flexion was comparable between the groups. ACR demonstrated significantly greater forward flexion at 3 weeks (103.63° vs 85.00° ; $p < 0.001$). At 6 and 12 weeks, the difference was not statistically significant. At 24 weeks, forward flexion was statistically higher in the MUA group (145.50° vs 141.19° ; $p = 0.010$).

Table 5: External Rotation Range of Motion

Time point	ACR (n=16), Mean ± SD	MUA (n=16), Mean ± SD	P-value
Pre-operative	6.88 ± 1.544°	7.13 ± 1.025°	0.593
3 weeks	27.81 ± 2.762°	16.13 ± 1.025°	<0.001*
6 weeks	35.81 ± 2.762°	35.19 ± 1.047°	0.404

12 weeks	44.81 ± 2.762°	44.19 ± 1.047°	0.404
24 weeks	52.88 ± 4.470°	50.56 ± 1.459°	0.058

*Statistically significant at $p < 0.05$.

Observation: Both groups had markedly restricted external rotation pre-operatively, with no significant difference. ACR produced significantly greater external rotation at 3 weeks (27.81° vs 16.13° ; $p < 0.001$). Differences at 6, 12 and 24 weeks were not statistically significant.

Table 6: Internal Rotation Measurements

Time point	ACR (n=16), Mean ± SD	MUA (n=16), Mean ± SD	P-value
Pre-operative	17.44 ± 0.629	17.50 ± 0.516	0.761
3 weeks	16.69 ± 0.479	16.75 ± 0.447	0.705
6 weeks	15.69 ± 0.479	15.75 ± 0.447	0.705
12 weeks	14.69 ± 0.479	14.75 ± 0.447	0.705
24 weeks	14.19 ± 0.750	14.25 ± 0.577	0.793

Observation: No statistically significant difference in internal rotation measurements was observed between the ACR and MUA groups at any follow-up point (all $p > 0.05$).

3. Pain and Functional Outcomes

Table 7: VAS Pain Scores

Time point	ACR (n=16), Mean ± SD	MUA (n=16), Mean ± SD	P-value
Pre-operative	8.69 ± 0.479	8.25 ± 0.447	0.012*
3 weeks	3.88 ± 0.719	3.81 ± 0.544	0.783
6 weeks	2.19 ± 0.403	2.06 ± 0.250	0.300

12 weeks	1.19 ± 0.403	1.06 ± 0.250	0.300
24 weeks	0.88 ± 0.342	1.00 ± 0.000	0.154

*Statistically significant at $p < 0.05$.

Observation: Both groups demonstrated substantial reduction in pain during follow-up. The pre-operative VAS score was statistically different between groups ($p = 0.012$). From 3 weeks onward, no statistically significant between-group difference was observed. At 24 weeks, VAS scores were low and comparable between ACR and MUA (0.88 ± 0.342 vs 1.00 ± 0.000 ; $p = 0.154$).

Table 8: UCLA Shoulder Scores

Time point	ACR (n=16), Mean ± SD	MUA (n=16), Mean ± SD	P-value
Pre-operative	11.88 ± 0.806	12.00 ± 0.816	0.666
24 weeks	29.13 ± 1.025	29.13 ± 0.719	1.000

Observation: Pre-operative UCLA scores were comparable between the two groups. At 24 weeks, both groups had a mean UCLA score of 29.13, with no statistically significant difference ($p = 1.000$).

Table 9: UCLA Score Categories

UCLA Category	ACR (n=16)	MUA (n=16)	P-value
Pre-operative			
Poor (0–20)	16 (100.0%)	16 (100.0%)	N/A
24 weeks			
Good (28–33)	16 (100.0%)	16 (100.0%)	N/A

Observation: All patients in both groups had poor UCLA scores pre-operatively. At 24 weeks, all patients in both groups were classified within the good UCLA category.

Statistical comparison was not applicable because the categories were identical in both groups.

Table 10. Constant Shoulder Scores

Time point	ACR (n=16), Mean $\pm$ SD	MUA (n=16), Mean $\pm$ SD	P-value
Pre-operative	14.13 $\pm$ 1.10	14.38 $\pm$ 0.95	0.509
24 weeks	81.00 $\pm$ 2.50	81.00 $\pm$ 1.46	1.000

Observation: Pre-operative Constant scores were comparable between the groups. At 24 weeks, both groups achieved a mean Constant score of 81, with no statistically significant difference ($p=1.000$).

4. Post-operative MRI Findings

Table 11: Post-operative MRI Findings

MRI finding	ACR (n=16)	MUA (n=16)	P-value
Capsular tear			
No	16 (100.0%)	5 (31.2%)	<0.001*
Yes	0 (0.0%)	11 (68.8%)	
Pericapsular edema			
No	5 (31.2%)	16 (100.0%)	<0.001*
Yes	11 (68.8%)	0 (0.0%)	
Labral tear			
No	16 (100.0%)	12 (75.0%)	0.101
Yes	0 (0.0%)	4 (25.0%)	
Rotator cuff tear			
No	16 (100.0%)	16 (100.0%)	N/A

*Statistically significant at $p<0.05$.

Observation: Post-operative MRI demonstrated significant differences in capsular tear patterns and

pericapsular oedema between the groups. Capsular tears were observed in 68.8% of MUA patients compared with none of the ACR patients ($p<0.001$). Conversely, pericapsular oedema was observed in 68.8% of ACR patients and none of the MUA patients ($p<0.001$). Labral tears were observed in 25% of MUA patients and none of the ACR patients, although the difference was not statistically significant ($p=0.101$). No rotator cuff tears were identified in either group.

Table 12: Post-operative Bone Bruises on MRI

Bone bruises	ACR (n=16)	MUA (n=16)	P-value
No	8 (50.0%)	14 (87.5%)	0.054
Yes	8 (50.0%)	2 (12.5%)	

Observation: Bone bruises were identified in 50.0% of patients in the ACR group compared with 12.5% in the MUA group. Although the observed difference approached conventional statistical significance, it did not meet the predefined threshold of $p<0.05$ ($p=0.054$).

Discussion

The present prospective randomized study compared arthroscopic capsular release (ACR) and manipulation under anaesthesia (MUA) in patients with frozen shoulder who had failed conservative treatment. A total of 32 patients were analyzed, with 16 patients in each group. Both treatment groups demonstrated substantial improvement in pain, range of motion and functional outcome during the 6-month follow-up. The principal differences between the groups were observed during the early postoperative period, particularly in abduction, forward flexion and external rotation.

Demographic Characteristics

The mean age of patients was 52.19 ± 2.949 years in the ACR group and 51.25 ± 2.955 years in the MUA group. The difference was not statistically significant ($p=0.376$). Both groups also had an identical sex distribution, with 8

males and 8 females in each group. Similarly, left and right shoulders were equally distributed between the groups.

Diabetes mellitus was present in 11 patients (68.8%) in each group, while 5 patients in each group were non-diabetic. There was therefore no difference in diabetes distribution between the groups ($p=1.000$). Diabetes is an established association of frozen shoulder and has been reported to influence its occurrence and clinical course^{1,2}. The equal distribution of diabetic patients in the present study provides reasonable comparability between the treatment groups with respect to this important clinical characteristic.

The demographic similarity between the groups is also consistent with previous comparative studies evaluating ACR and MUA, in which both procedures have been assessed in patients with similar clinical characteristics.^{6,7}

Baseline Clinical Characteristics

The mean duration of symptoms was 6.19 ± 1.328 months in the ACR group and 8.06 ± 1.340 months in the MUA group. This difference was statistically significant ($p<0.001$), indicating that patients undergoing MUA had a longer mean symptom duration before treatment.

Preoperative VAS was also significantly different between groups, with a mean score of 8.69 ± 0.479 in the ACR group and 8.25 ± 0.447 in the MUA group ($p=0.012$). Thus, patients undergoing ACR had slightly greater baseline pain. In contrast, preoperative UCLA scores and Constant scores were comparable between the groups.

These baseline differences should be considered when interpreting the postoperative findings. Nevertheless, the similarity in baseline functional scores and range-of-motion measurements provides useful comparability for assessing the subsequent response to treatment.

Abduction

Both procedures produced progressive improvement in shoulder abduction. Preoperatively, abduction was $69.63 \pm 3.423^\circ$ in the ACR group and $70.88 \pm 2.872^\circ$ in the MUA group, with no significant difference ($p=0.272$).

A significant difference was observed at 3 weeks. Abduction improved to $94.50 \pm 4.817^\circ$ in the ACR group compared with $75.00 \pm 2.781^\circ$ in the MUA group ($p<0.001$). This indicates substantially greater early recovery following ACR.

However, the difference diminished with continued follow-up. At 6 weeks, abduction was $117.31 \pm 5.160^\circ$ and $115.50 \pm 2.422^\circ$ in the ACR and MUA groups, respectively ($p=0.213$). At 12 weeks, the values were $127.31 \pm 5.160^\circ$ and $127.50 \pm 2.422^\circ$ ($p=0.896$), and at 24 weeks they were $137.00 \pm 8.579^\circ$ and $138.50 \pm 2.422^\circ$ ($p=0.506$).

Thus, although ACR produced significantly greater early improvement in abduction, the difference was no longer evident at later follow-up. Similar overall improvement following both procedures has been reported in previous randomized and comparative studies^{6,7,8}.

Forward Flexion

Forward flexion showed a pattern similar to abduction. Preoperative forward flexion was comparable between groups, measuring $76.75 \pm 3.416^\circ$ in the ACR group and $77.88 \pm 2.872^\circ$ in the MUA group ($p=0.321$).

At 3 weeks, the ACR group demonstrated significantly greater forward flexion, with a mean of $103.63 \pm 5.620^\circ$ compared with $85.00 \pm 2.781^\circ$ in the MUA group ($p<0.001$). This finding indicates faster early restoration of forward flexion following ACR.

At 6 weeks and 12 weeks, the difference was no longer statistically significant. At 6 weeks, forward flexion was $127.31 \pm 5.160^\circ$ after ACR and $125.50 \pm 2.422^\circ$ after

MUA ($p=0.213$). At 12 weeks, it was $137.31 \pm 5.160^\circ$ and $137.50 \pm 2.422^\circ$, respectively ($p=0.896$).

At 24 weeks, however, forward flexion was significantly higher in the MUA group, measuring $145.50 \pm 2.422^\circ$ compared with $141.19 \pm 5.822^\circ$ in the ACR group ($p=0.010$). Despite this statistical difference, both groups demonstrated substantial restoration of forward flexion compared with their preoperative values.

The early advantage of ACR is consistent with the findings of Xiao et al., whose meta-analysis demonstrated greater forward flexion following ACR at 3 and 6 months¹¹. However, the overall literature indicates that the magnitude of difference between ACR and MUA is generally modest, with both procedures producing significant improvement^{6,8,10}.

External Rotation

External rotation was markedly restricted preoperatively in both groups. The mean preoperative external rotation was $6.88 \pm 1.544^\circ$ in the ACR group and $7.13 \pm 1.025^\circ$ in the MUA group ($p=0.593$).

At 3 weeks, the ACR group showed significantly greater external rotation than the MUA group, measuring $27.81 \pm 2.762^\circ$ compared with $16.13 \pm 1.025^\circ$ ($p<0.001$). This suggests that ACR provided faster early restoration of external rotation.

At 6 weeks, external rotation was $35.81 \pm 2.762^\circ$ in the ACR group and $35.19 \pm 1.047^\circ$ in the MUA group ($p=0.404$). Similar findings were observed at 12 weeks and 24 weeks. At 24 weeks, the values were $52.88 \pm 4.470^\circ$ and $50.56 \pm 1.459^\circ$, respectively ($p=0.058$).

Therefore, the significant early difference in external rotation did not persist to the final follow-up. These findings are consistent with previous comparative evidence showing substantial improvement in external

rotation after both ACR and MUA without a consistent clinically important long-term difference^{6,7,10,11}.

Internal Rotation

Internal rotation did not demonstrate a statistically significant difference between the treatment groups at any follow-up point.

Preoperative internal rotation was $17.44 \pm 0.629^\circ$ in the ACR group and $17.50 \pm 0.516^\circ$ in the MUA group ($p=0.761$). At 3, 6 and 12 weeks, the differences remained statistically nonsignificant. At 24 weeks, the values were $14.19 \pm 0.750^\circ$ in the ACR group and $14.25 \pm 0.577^\circ$ in the MUA group ($p=0.793$).

Thus, both techniques demonstrated a similar pattern of internal rotation during follow-up. The absence of a significant difference is consistent with systematic reviews reporting broadly similar postoperative range-of-motion outcomes between ACR and MUA^{8,10,11}.

Pain Relief

Both procedures produced marked reduction in pain. Preoperative VAS was significantly higher in the ACR group, at 8.69 ± 0.479 compared with 8.25 ± 0.447 in the MUA group ($p=0.012$).

At 3 weeks, VAS decreased to 3.88 ± 0.719 in the ACR group and 3.81 ± 0.544 in the MUA group, with no significant difference ($p=0.783$). Further reduction was observed at 6 weeks and 12 weeks.

At 24 weeks, the mean VAS was 0.88 ± 0.342 after ACR and 1.00 ± 0.000 after MUA ($p=0.154$). Therefore, both procedures produced substantial and sustained pain relief, with no statistically significant difference at the final assessment.

The present findings agree with previous randomized evidence showing significant improvement in pain following both ACR and MUA [6]. Zhao et al. reported a statistically greater long-term reduction in VAS with

ACR in their meta-analysis, but the difference did not reach the minimal clinically important difference¹⁰. Xiao et al. similarly found no significant difference in VAS between the procedures at 3, 6 or 12 month¹¹.

UCLA Shoulder Score

The UCLA shoulder score demonstrated substantial functional improvement following both procedures.

Preoperatively, the mean UCLA score was 11.88 ± 0.806 in the ACR group and 12.00 ± 0.816 in the MUA group ($p=0.666$), indicating comparable baseline functional impairment.

At 24 weeks, both groups achieved a mean UCLA score of 29.13. There was no difference between groups ($p=1.000$). The categorical assessment showed that all 16 patients in each group were classified as poor preoperatively, whereas all patients were classified as good at 24 weeks.

These findings indicate marked functional improvement after both procedures without a difference in final UCLA outcome. Similar improvement in functional scores after both ACR and MUA has been reported in randomized comparative studies⁶. Systematic reviews have also failed to demonstrate a consistent clinically important difference in final functional outcomes between the two procedures^{8,10,11}.

Constant Score

The Constant score showed a similar pattern. Preoperative scores were 14.13 ± 1.10 in the ACR group and 14.38 ± 0.95 in the MUA group ($p=0.509$).

At 24 weeks, both groups achieved a mean Constant score of 81.00. The between-group comparison was not statistically significant ($p=1.000$).

The improvement from markedly restricted baseline function to a mean score of 81 in both groups indicates substantial functional recovery. The identical final mean

scores further support the observation that ACR and MUA produced comparable overall functional outcomes in this cohort.

These findings are consistent with previous comparative studies in which both treatment modalities resulted in significant improvement in shoulder function^{6,8}.

Postoperative MRI Findings

Postoperative MRI demonstrated differences in the structural changes associated with the two procedures.

Capsular tears were observed in 11 patients (68.8%) in the MUA group compared with none in the ACR group, and this difference was statistically significant ($p<0.001$). This finding is compatible with the mechanism of MUA, in which controlled manipulation is intended to stretch and disrupt the contracted capsule.

In contrast, pericapsular edema was observed in 11 patients (68.8%) following ACR and in none of the MUA patients ($p<0.001$). This may represent a local postoperative tissue response associated with direct arthroscopic capsular release.

Labral tears were identified in 4 patients (25%) in the MUA group and none in the ACR group. Although the numerical difference was notable, it did not reach statistical significance ($p=0.101$). No rotator cuff tears were identified in either group.

These findings are particularly relevant because the prospective randomized study by Sundararajan et al. also reported postoperative MRI abnormalities, with labral tears occurring in the MUA group and bone bruises being among the common MRI findings following ACR [6]. The structural findings in the present study therefore demonstrate that the two procedures produce different patterns of tissue change despite ultimately producing similar clinical outcomes.

Bone Bruises

Bone bruises were identified in 8 patients (50%) in the ACR group and 2 patients (12.5%) in the MUA group. Although the frequency was higher in the ACR group, the difference was not statistically significant ($p=0.054$).

Therefore, the present study demonstrates a numerical difference but not a statistically confirmed difference between the procedures. Bone bruising was also reported as a common postoperative MRI finding in the ACR group in the previous prospective randomized study by Sundararajan et al.⁶.

The clinical significance of these MRI findings should be interpreted cautiously because the present study did not demonstrate a corresponding difference in final UCLA or Constant scores.

Comparison with Previous Literature

The overall results of the present study are in agreement with previous literature showing that both ACR and MUA can provide substantial improvement in patients with refractory frozen shoulder.

Sundararajan et al. conducted a prospective randomized study comparing ACR and MUA and reported significant improvement in pain, range of motion and functional scores in both groups, without a significant difference between the groups at 24 weeks⁶. The present study similarly demonstrated marked improvement in VAS, UCLA score, Constant score and shoulder range of motion in both groups.

Lee et al. also reported that MUA alone could produce clinical outcomes comparable to arthroscopic circumferential capsular release in primary frozen shoulder⁷. This is consistent with the present study, particularly with respect to the comparable final UCLA and Constant scores.

Grant et al., in their systematic review, found only limited differences between manipulation and arthroscopic capsular release with respect to postoperative shoulder motion and function⁸. The present findings similarly suggest that the principal difference between the procedures may relate more to the timing and pattern of recovery than to the ultimate functional result.

The UK FROST trial compared MUA, ACR and early structured physiotherapy in a large randomized population. At 12 months, the observed differences between treatment groups were below the predefined thresholds for clinical importance⁹. The associated health technology assessment also evaluated the clinical and cost-effectiveness outcomes of the three approaches.¹² These findings support the importance of considering both statistical significance and clinical relevance when interpreting differences between ACR and MUA.

Recent meta-analyses further support the overall findings of the present study. Zhao et al. found that ACR and MUA had broadly comparable outcomes across most measures, although ACR demonstrated a statistically greater improvement in some long-term pain outcomes that did not reach the minimal clinically important difference¹⁰. Xiao et al. reported greater forward flexion after ACR at 3 and 6 months, while pain, external rotation and complications were comparable between groups¹¹. The early advantage of ACR for forward flexion in the present study is therefore consistent with this recent evidence.

Early Versus Late Recovery

One of the important observations in the present study was the difference between early and late postoperative outcomes.

At 3 weeks, ACR demonstrated significantly greater abduction, forward flexion and external rotation than MUA. This may be related to the direct and controlled

release of the contracted capsule during arthroscopy. However, by 6 and 12 weeks, most between-group differences had disappeared.

At 24 weeks, the two groups showed similar outcomes for abduction, external rotation, VAS, UCLA score and Constant score. Forward flexion was statistically higher in the MUA group at this time point.

This pattern suggests that the two procedures may differ in the speed or pattern of early recovery but ultimately provide substantial functional improvement. The findings are compatible with the broader literature, in which early differences in individual range-of-motion parameters have not consistently translated into major differences in overall functional outcome⁹⁻¹¹.

Clinical Implications

The present findings indicate that both ACR and MUA are capable of producing substantial clinical improvement in patients with refractory frozen shoulder. ACR provides direct visualization and controlled capsular release, whereas MUA achieves capsular stretching and disruption through manipulation.

ACR may provide greater early restoration of certain movements, as observed in the present study. MUA, however, also resulted in substantial recovery, and final UCLA and Constant scores were comparable between the two groups.

The postoperative MRI findings demonstrate that the procedures have different structural effects. Capsular tears were more frequently identified following MUA, whereas pericapsular edema was observed following ACR. Labral tears were observed only in the MUA group, although the difference was not statistically significant. These structural findings should be considered together with clinical outcomes rather than interpreted independently.

The common structured rehabilitation protocol used in both groups is also important. Progressive physiotherapy and home exercises were provided following both procedures. Therefore, postoperative recovery reflects not only the initial capsular intervention but also the continued rehabilitation programme.

Strengths and Limitations

The strengths of the present study include its prospective randomized design, equal number of patients in both treatment groups, standardized postoperative rehabilitation, repeated assessment of pain and range of motion, use of established functional outcome scores and postoperative MRI evaluation.

However, the study has several limitations. The final analyzed sample was relatively small, with only 16 patients in each group, which may limit the ability to detect smaller between-group differences. Significant baseline differences were observed in symptom duration and preoperative VAS and should therefore be considered when interpreting postoperative comparisons.

The follow-up period was limited to 6 months, preventing assessment of longer-term recurrence or persistent stiffness. In addition, although postoperative MRI provided useful structural information, MRI findings do not necessarily correspond directly with clinical symptoms or functional outcome.

Conclusion

Both arthroscopic capsular release (ACR) and manipulation under anaesthesia (MUA) produced significant improvement in pain, range of motion and shoulder function in patients with refractory frozen shoulder.

ACR provided significantly better early improvement in abduction, forward flexion and external rotation at 3 weeks, while most differences disappeared by 6 months.

At 24 weeks, UCLA and Constant scores were comparable between groups, indicating similar final functional outcomes.

Postoperative MRI showed more capsular tears after MUA and more pericapsular edema after ACR. Overall, both ACR and MUA were effective, with ACR offering better early mobility but comparable final functional outcomes.

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