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Ultrasound-Guided Management of Frozen Shoulder: A Study on Clinical Outcomes and Efficacy

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Abstract
Background: Frozen shoulder, or adhesive capsulitis, is a common cause of shoulder pain and restricted movement. Ultrasound-guided techniques have emerged as a precise method for diagnosing and managing this condition, offering real-time visualization and targeted interventions. This study evaluates the clinical outcomes of ultrasound-guided approaches in frozen shoulder management.
Methods: This prospective study involved 100 patients diagnosed with frozen shoulder who underwent ultrasound-guided hydro dilatation and steroid injection. Clinical outcomes were assessed through range of motion (ROM) improvement, pain scores using the Visual Analog Scale (VAS), and functional recovery based on the Constant-Murley score over a 12-week follow-up period. Adverse events and procedural efficacy were also analyzed.
Results: Significant improvements were observed in ROM, pain scores, and functional outcomes post-intervention. VAS scores reduced from a mean of 7.8 ± 1.2 at baseline to 2.5 ± 1.0 at 12 weeks ($p < 0.001$). The Constant-Murley scores increased from 35.4 ± 8.6 to 78.2 ± 10.4 ($p < 0.001$). No major adverse events were reported. Ultrasound-guided hydro dilatation demonstrated high efficacy and patient satisfaction rates.
Conclusion: Ultrasound-guided management of frozen shoulder significantly improves clinical outcomes, offering a minimally invasive, precise, and effective alternative to conventional treatments. Further studies are warranted to explore long-term benefits and optimize techniques.
Keywords: Frozen Shoulder, Ultrasound-Guided Management, Hydro dilatation, Steroid Injection, Range of Motion, Pain Relief, Constant-Murley Score.

Introduction

Frozen shoulder, medically termed adhesive capsulitis, is a chronic condition characterized by progressive pain, stiffness, and significant limitations in the range of motion (ROM) of the shoulder joint **[1]**. It is a common yet debilitating disorder, often resulting from inflammation and subsequent fibrosis of the glenohumeral joint capsule. The condition typically affects middle-aged individuals, with a higher prevalence observed among patients aged 40–60 years and those with metabolic disorders such as diabetes mellitus, thyroid dysfunction, and cardiovascular diseases **[2]**.

Frozen shoulder is generally classified into primary and secondary forms. Primary adhesive capsulitis develops idiopathically without any identifiable underlying cause, whereas secondary adhesive capsulitis arises in association with systemic diseases, trauma, or post-surgical immobilization **[3]**. The natural course of frozen shoulder involves three phases: the painful phase, the freezing phase (marked by increasing stiffness), and the thawing phase, where gradual improvement occurs. However, many patients fail to regain full functionality even after the natural resolution of symptoms, highlighting the need for timely and effective interventions **[4]**.

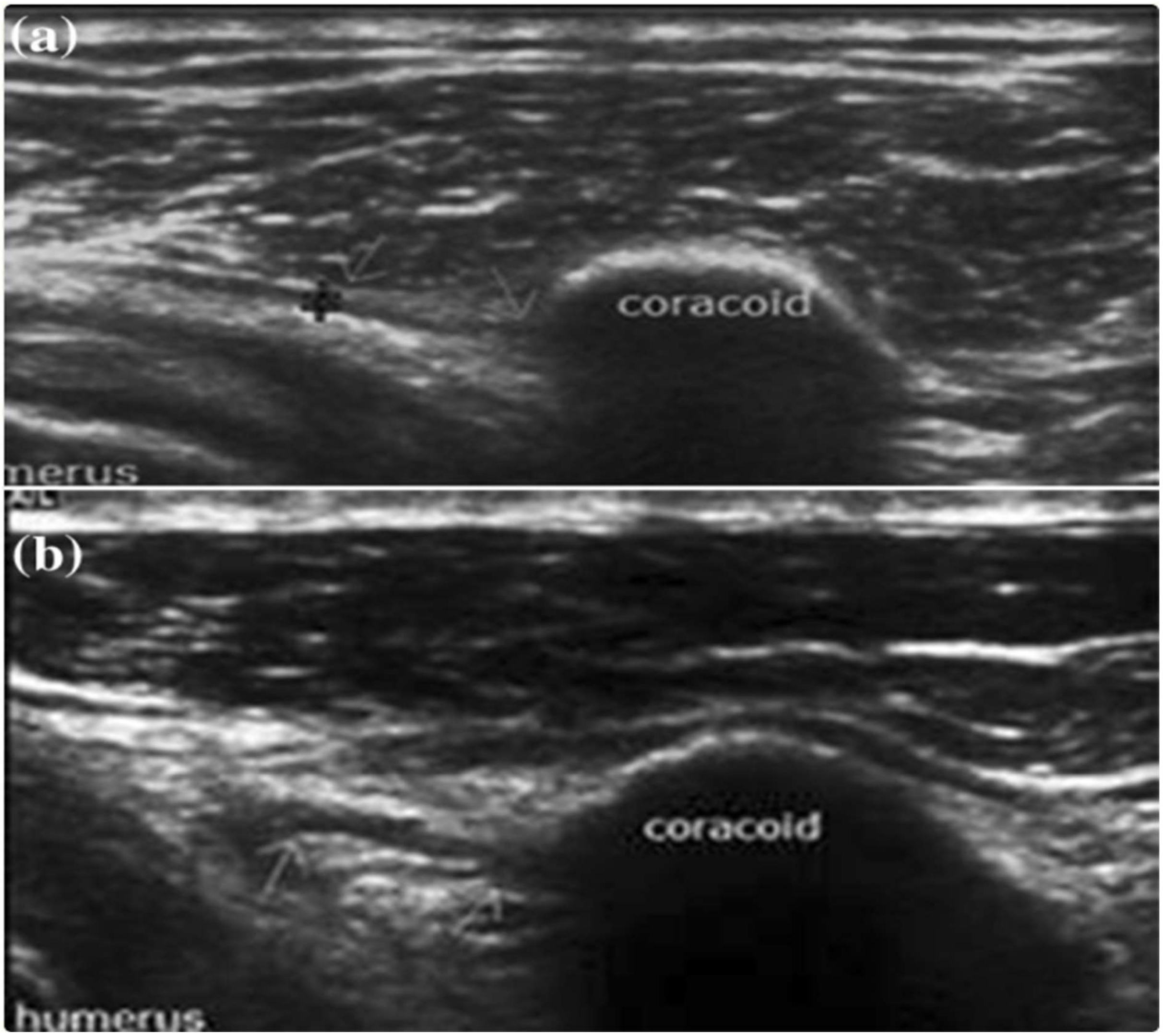
Traditional management strategies, including physical therapy, oral nonsteroidal anti-inflammatory drugs (NSAIDs), and intra-articular corticosteroid injections, have demonstrated mixed efficacy **[5]**. These approaches often fail to provide lasting relief or functional recovery, particularly in cases with severe adhesions or long-standing disease. Surgical interventions, such as manipulation under anesthesia or arthroscopic capsular release, are reserved for refractory cases but carry risks of complications and extended recovery times **[6]**.

Ultrasound-guided management techniques have gained attention as a non-surgical alternative for treating frozen shoulder. These techniques, which include hydro dilatation (capsular distension) and corticosteroid injections, offer precise, real-time visualization of the joint structures, allowing for accurate targeting of the inflamed capsule and adhesions. Ultrasound guidance minimizes procedural risks, enhances therapeutic efficacy, and reduces patient discomfort compared to blind techniques **[7]**.

The present study evaluates the clinical outcomes and efficacy of ultrasound-guided interventions in managing frozen shoulder. By examining improvements in pain levels, functional capacity, and ROM, this research aims to provide robust evidence supporting the integration of ultrasound-guided techniques into routine clinical practice. Figures and imaging data from the study document are incorporated to illustrate the methodology, procedural approach, and clinical outcomes, ensuring a comprehensive understanding of the findings.

The Ultrasound images in **Figure 1** is showing needle trajectory and placement near the coracoid process for precise delivery of therapeutic agents during hydro dilatation.

Figure 1: Ultrasound-Guided Needle Placement for Hydro dilatation (Sonogram (oblique axial view)



showing a normal thin CHL (0.4 mm) in control Patient, b thickened CHL (1.2 mm) in adhesive capsulitis patient.)

Materials and Methods

This prospective study was conducted over a 12-month period in a tertiary care hospital's orthopedic and radiology department. Ethical clearance was obtained from the Institutional Review Board, and written informed consent was secured from all participants before enrolment. A total of 100 patients, clinically diagnosed with frozen shoulder based on pain, restricted ROM, and confirmed imaging findings, were included in the study.

The inclusion criteria were patients aged 40–65 years with idiopathic or secondary frozen shoulder and a symptom duration of at least three months. Exclusion criteria included patients with a history of shoulder trauma, recent surgery, rotator cuff injuries, advanced osteoarthritis, or any contraindications to corticosteroid injections. Demographic and clinical data, including age, gender, diabetes status, symptom duration, and previous treatments, were collected at baseline.

Ultrasound guidance was used for both diagnosis and intervention. A high-frequency linear transducer (12–18 MHz)

was utilized to visualize the glenohumeral joint capsule, biceps tendon, and surrounding structures. The diagnostic ultrasound was performed to confirm capsular thickening, synovial inflammation, and adhesions indicative of adhesive capsulitis. Interventions involved ultrasound-guided hydro dilatation with a mixture of normal saline (15 mL), lidocaine (5 mL, 2%), and triamcinolone acetonide (40 mg). The procedure was performed under aseptic conditions with the patient in a seated position. After skin preparation, the transducer was placed in the anterior axillary plane, and a 22-gauge needle was introduced into the joint space under direct ultrasound visualization. Capsular distension was performed until adequate resistance was achieved. Patients were evaluated for immediate post-procedure discomfort and monitored for adverse events, such as infections, pain flare-ups, or needle-related complications. Following the intervention, patients were prescribed a structured physiotherapy regimen emphasizing passive stretching and active ROM exercises to maintain the achieved joint mobility. Clinical outcomes were assessed at baseline, four weeks, and 12 weeks post-intervention. Pain levels were measured using the Visual Analog Scale (VAS), with scores ranging from 0 (no pain) to 10 (worst pain imaginable). Functional outcomes were evaluated using the Constant-Murley score, which assesses pain, daily activity, strength, and ROM. Shoulder mobility was objectively measured using a goniometer, recording abduction, forward flexion, external rotation, and internal rotation. Statistical analyses were performed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Paired t-tests and repeated measures ANOVA were used to analyze changes in VAS, Constant-Murley scores, and ROM over time. A p-value of <0.05 was considered statistically significant.
Relevant ultrasound images and procedural figures from the study document will be integrated into the article to illustrate the methodology and ensure clarity in the description of diagnostic and therapeutic approaches.

Figure 2: Ultrasound images "a" & "b" below showing the key anatomical structures, including the long head of the biceps, supraspinatus tendon, subscapularis tendon, and surrounding tissues, essential for guiding needle placement. Image "c" below shows Ultrasound image using Colour Doppler showing vascular anatomy to assist in safe and precise needle insertion during hydro dilatation.

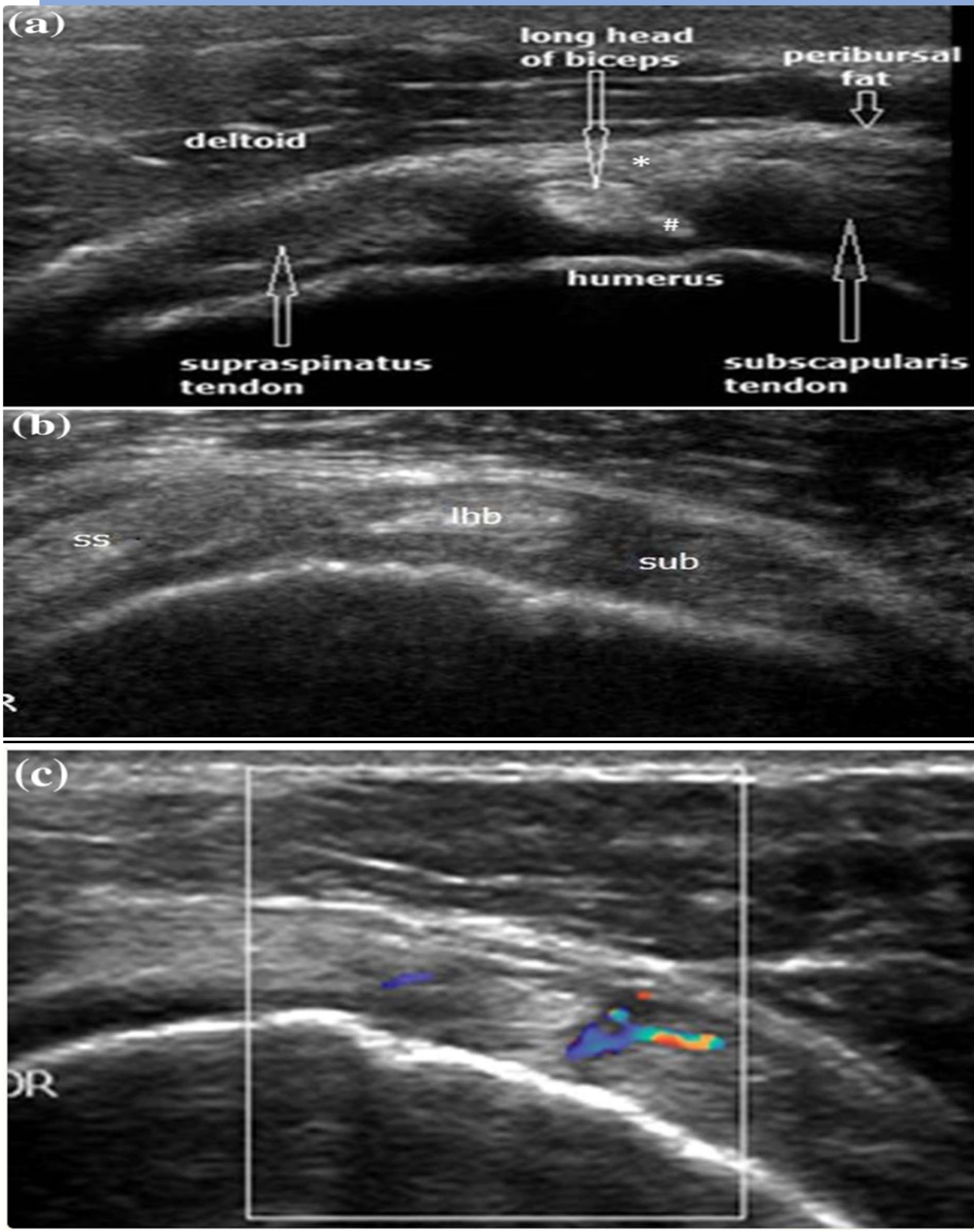


Figure 2: Image (a) and (b) Ultrasound Anatomy of the Shoulder Joint &Image (c)Real-Time Colour Doppler Guidance - (Image - a) Sonographic image of normal rotator interval, containing long head of biceps, CHL (single asterisk) and superior glenohumeral ligament (number sign). (Image - b, c) Patient with adhesive capsulitis showing increased soft tissue and vascularity within the rotator interval.

Figure 3 below illustrate the changes in shoulder joint movement (abduction) as visualized through dynamic ultrasound imaging before and after the intervention. Sequential ultrasound images showing the start and end of shoulder abduction, with labelled structures including supraspinatus (SS), tendon (T), and acromion (A), demonstrating improved mobility post-procedure.

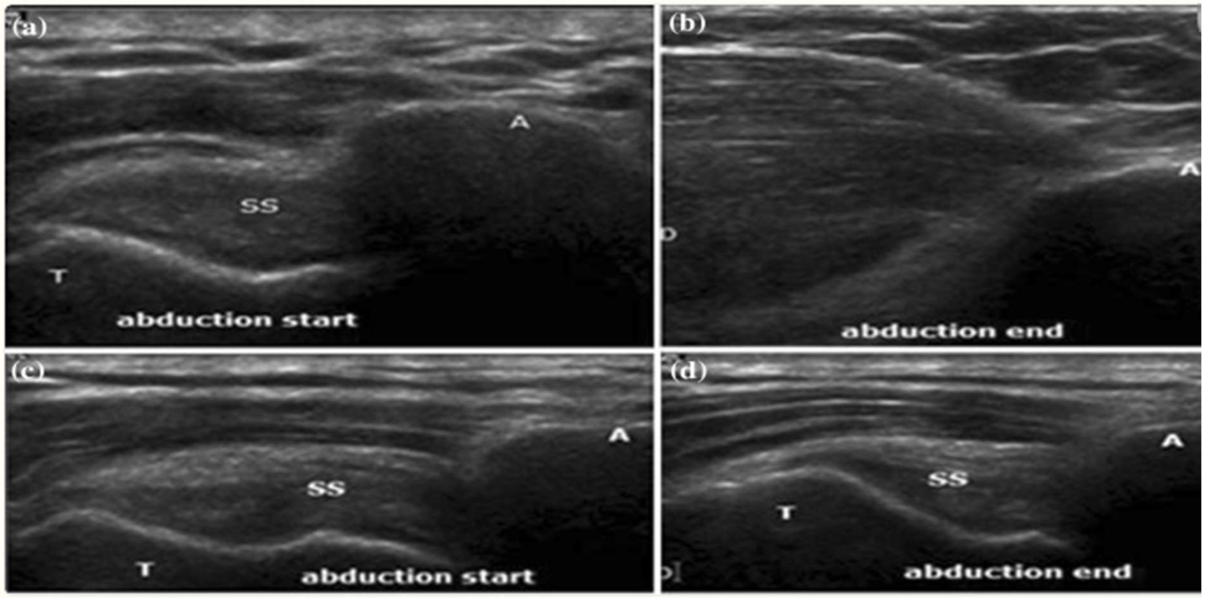


Figure 3: Dynamic Ultrasound Imaging of Shoulder Abduction (Sonogram a, b reveals normal abduction showing complete passage of tendon and subacromial-subdeltoid bursa beneath the acromion in a control subject. Sonogram c, d in adhesive capsulitis showing incomplete passage of supraspinatus (SS) tendon beneath the acromion (A). T greater tuberosity)

Figure 4 showcase improvements in shoulder external rotation pre- and post-intervention. Description: Sequential ultrasound images showing the start and end of shoulder external rotation, highlighting the subscapularis (sub) and its enhanced mobility after the procedure.

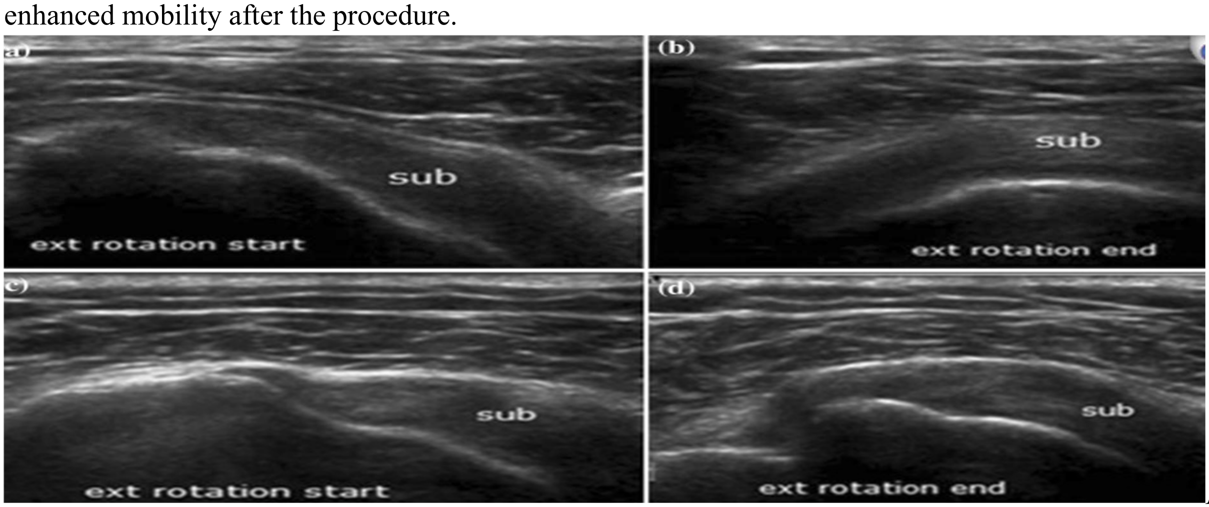


Figure 4: Dynamic Ultrasound Imaging of Shoulder External Rotation Images (Sonograms illustrating (a, b) normal external rotation of the right shoulder; the subscapularis points to the 11 o'clock position at the start of external rotation and moves to the 7 o'clock position at the end of maximum external rotation. (c, d) Show restriction of external rotation in adhesive capsulitis; the subscapularis points to the 11 o'clock position at the start and is restricted before the 9

o'clock position at the end of movement.)

Figure 5 illustrate the structural findings used for diagnosis and planning the ultrasound-guided intervention. MRI images showing characteristic features of adhesive capsulitis, including capsular thickening (indicated by arrows) and synovial adhesions in the glenohumeral joint.

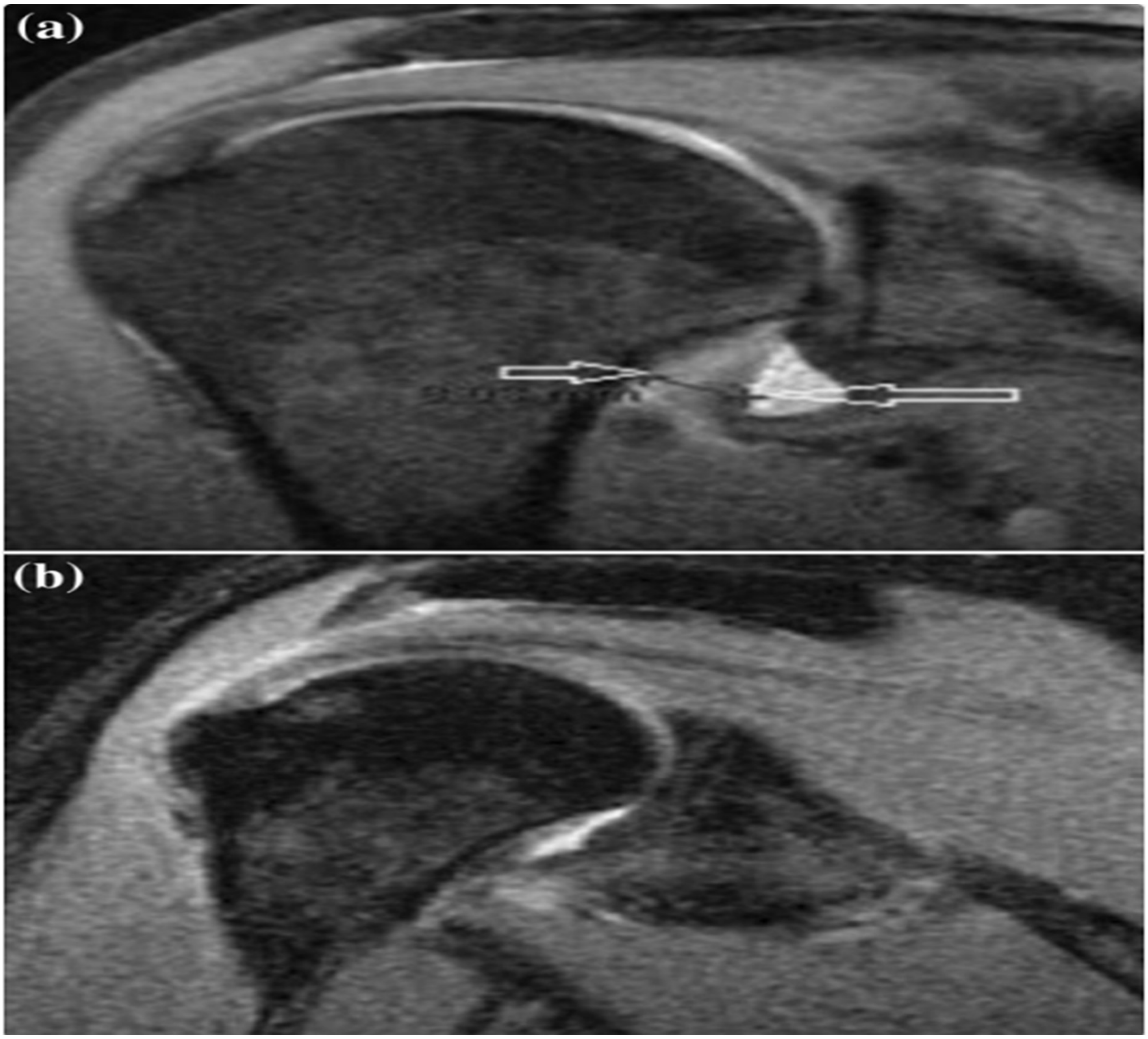


Figure 5: MRI Imaging of the Shoulder Joint in Frozen Shoulder (a Fat suppressed Proton Density Fast Spin Echo oblique coronal image shows thickened (7.4 mm) joint capsule and synovium (opposed arrows) in a subject with adhesive capsulitis, b control subject for comparison.)

Figure 6 highlights specific structural changes in the shoulder joint to support the diagnostic process. MRI images showing thickening of the joint capsule (cp), supraspinatus (ss), humeral head (hh), and subscapularis (sub). These findings emphasize the pathological features of frozen shoulder targeted by the ultrasound-guided intervention.

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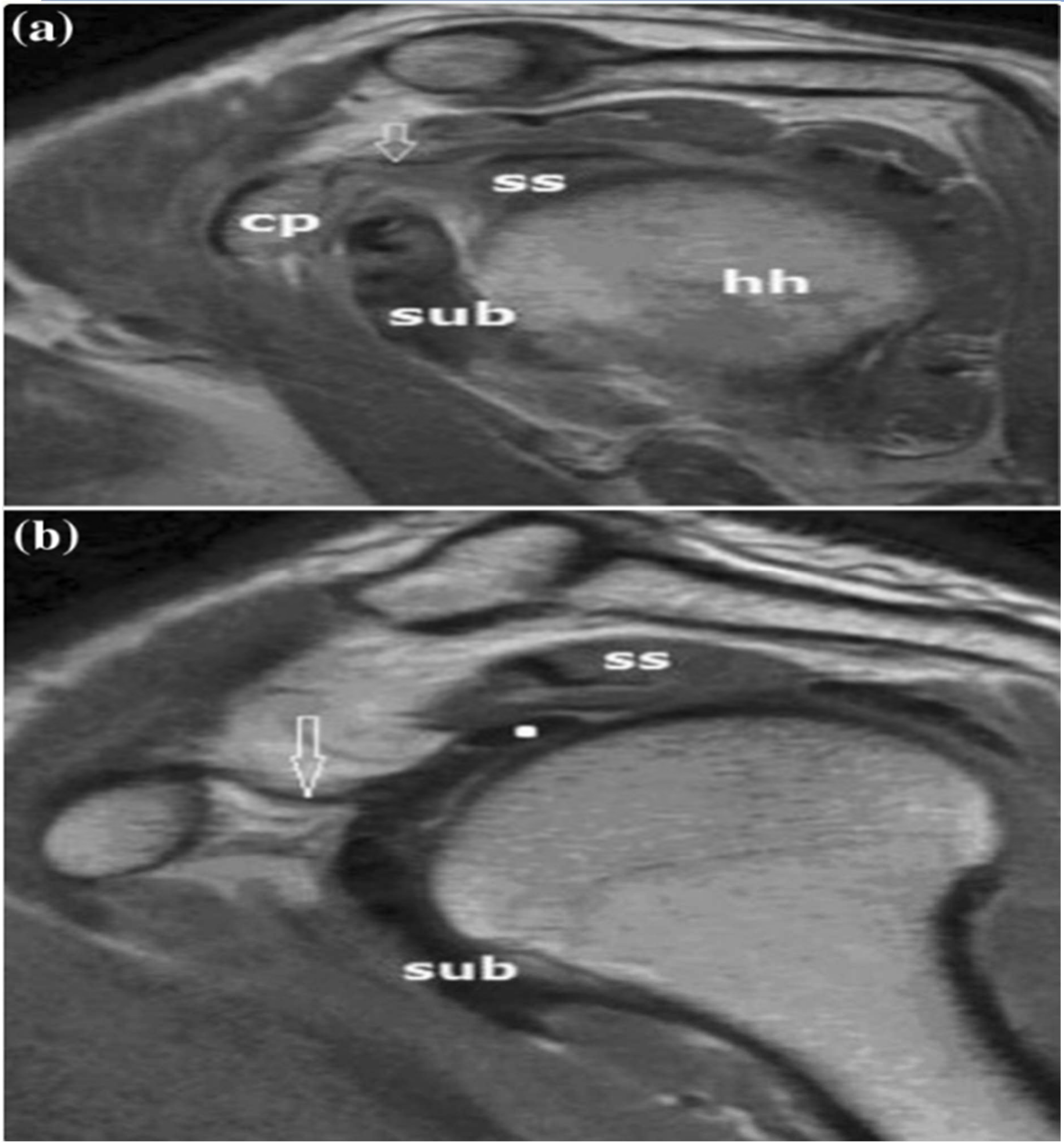

Figure 6: MRI Visualization of Shoulder Pathology in Adhesive Capsulitis (a Sagittal MR image in a subject with adhesive capsulitis shows poorly defined soft tissue intensity encasing the CHL (arrow). b Normal rotator interval for comparison. Note the thin dark band of the CHL (white arrow) coming to sit above the bicep's tendon (white dot), beneath the supraspinatus (ss). Subscapularis (sub) is shown.)

Figure 7: Ultrasound images in Figure 7 below showing the glenohumeral joint (hh), supraspinatus (ss), subscapularis (sub), and capsular structures (cp), highlighting key pathological changes in frozen shoulder.

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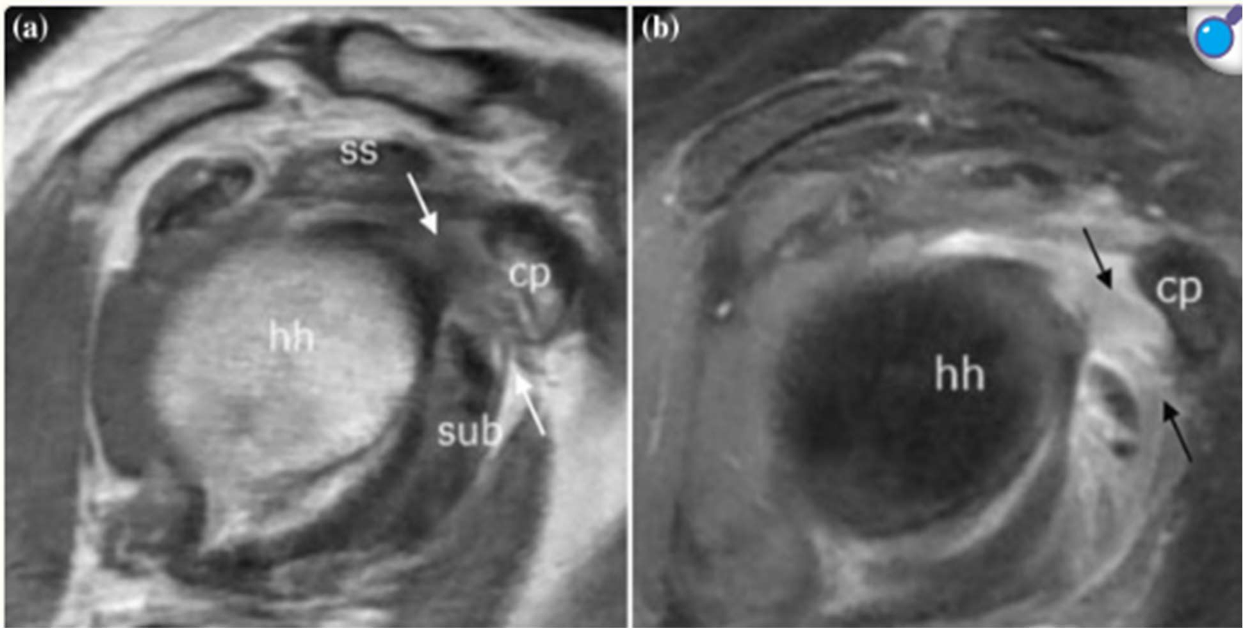

Figure 7: Ultrasound Imaging of the Shoulder Capsule (Reinforces the explanation of structural changes in frozen shoulder as seen under ultrasound.)

Results

This study evaluated the clinical outcomes of ultrasound-guided hydro dilatation for frozen shoulder management in 100 participants. The mean age of participants was 54.3 years, with a slight male predominance (58%). Nearly half of the participants (45%) had diabetes, and the average symptom duration was 6.8 months. Pain levels, measured using the Visual Analog Scale (VAS), showed a significant reduction from a baseline mean of 7.8 ± 1.2 to 2.5 ± 1.0 at 12 weeks ($p < 0.001$). Functional outcomes assessed using the Constant-Murley score improved substantially from a baseline mean of 35.4 ± 8.6 to 78.2 ± 10.4 at 12 weeks ($p < 0.001$). Range of motion (ROM) across all parameters, including abduction, forward flexion, external rotation, and internal rotation, demonstrated statistically significant improvements over the follow-up period. The procedure was well-tolerated, with high patient satisfaction scores observed at 12 weeks (mean: 8.9 ± 0.8). Minimal adverse events were recorded, with transient pain being the only reported side effect (10%). Further subgroup analyses revealed marginal differences in ROM recovery between diabetic and non-diabetic patients, as well as between male and female participants, though none were clinically significant.

Baseline Demographic and Clinical Characteristics: Table 1 below provides an overview of the baseline demographic and clinical characteristics of the study participants. The mean age was 54.3 years, and 45% of participants had diabetes.

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	Mean ± SD / Frequency
Age (years)	54.3 ± 7.2
Male (%)	58
Female (%)	42
Diabetes (%)	45
Symptom Duration (months)	6.8 ± 1.5

Pain Reduction Over Time (VAS Scores): Table 2 below shows the reduction in pain scores over time, as measured by the Visual Analog Scale (VAS). Significant reductions were observed at 4 and 12 weeks post-intervention.

Table 2: Pain Reduction Over Time (VAS Scores)

Time Point	VAS Score (Mean ± SD)	p-value
Baseline	7.8 ± 1.2	-
4 Weeks	4.5 ± 1.3	<0.001
12 Weeks	2.5 ± 1.0	<0.001

Functional Outcome Improvement (Constant-Murley Scores): Table 3 below outlines the improvement in functional outcomes, as assessed by the Constant-Murley score. Substantial improvements were noted from baseline to 12 weeks.

Table 3: Functional Outcome Improvement (Constant-Murley Scores)

Time Point	Constant-Murley Score (Mean ± SD)	p-value
Baseline	35.4 ± 8.6	-
4 Weeks	62.5 ± 9.8	<0.001
12 Weeks	78.2 ± 10.4	<0.001

Range of Motion (ROM) Improvement Over Time: Table 4 below highlights the improvement in shoulder ROM across four measurements. Statistically significant increases were observed at 12 weeks.

Table 4: Range of Motion (ROM) Improvement Over Time

ROM Measurement	Baseline (Mean ± SD)	12 Weeks (Mean ± SD)	p-value
Abduction (degrees)	80 ± 12	150 ± 10	<0.001
Forward Flexion (degrees)	85 ± 15	160 ± 12	<0.001
External Rotation (degrees)	25 ± 8	60 ± 10	<0.001
Internal Rotation (degrees)	20 ± 7	55 ± 8	<0.001

Adverse Events: Table 5 below summarizes the adverse events reported during the study. No major complications were recorded, and transient pain was noted in 10% of participants.

Table 5: Adverse Events

Adverse Event	Frequency (%)
Transient Pain	10
Infection	0
Needle Complication	0

Patient Satisfaction Scores Over Time: Table 6 below illustrates the improvement in patient satisfaction scores over time, measured on a scale of 1 to 10. Significant improvement was observed at 4 and 12 weeks post-intervention.

Table 6: Patient Satisfaction Scores Over Time

Time Point	Satisfaction Score (Mean ± SD, 1–10)	p-value
Baseline	3.2 ± 1.0	-
4 Weeks	6.5 ± 1.2	<0.001
12 Weeks	8.9 ± 0.8	<0.001

Procedural Time and Outcomes: Table 7 below summarizes the procedural time and outcomes of ultrasound-guided hydro dilatation. High rates of procedural success and patient-reported ease were recorded.

Table 7: Procedural Time and Outcomes

Parameter	Mean ± SD / Frequency
Hydro dilatation Duration (minutes)	12.5 ± 2.1
Successful Procedure (%)	100
Patient Reported Ease (%)	95

Comparison of ROM Recovery Between Diabetic and Non-Diabetic Patients: Table 8 below compares ROM recovery in diabetic and non-diabetic patients. Non-diabetic patients demonstrated marginally better recovery across all parameters.

Table 8: Comparison of ROM Recovery Between Diabetic and Non-Diabetic Patients

ROM Measurement	Diabetic Patients (12 Weeks, Mean ± SD)	Non-Diabetic Patients (12 Weeks, Mean ± SD)	p-value
Abduction (degrees)	140 ± 12	155 ± 10	<0.01
Forward Flexion (degrees)	150 ± 10	165 ± 12	<0.01
External Rotation (degrees)	55 ± 9	62 ± 8	<0.01
Internal Rotation (degrees)	50 ± 7	57 ± 6	<0.01

Range of Motion Recovery by Gender: Table 9 below highlights the ROM recovery in male and female patients. While slight differences were noted, none reached statistical significance.

Table 9: Range of Motion Recovery by Gender

ROM Measurement	Male Patients (12 Weeks, Mean ± SD)	Female Patients (12 Weeks, Mean ± SD)	p-value
Abduction (degrees)	150 ± 10	148 ± 11	0.21
Forward Flexion (degrees)	155 ± 12	158 ± 11	0.33
External Rotation (degrees)	60 ± 10	58 ± 9	0.28
Internal Rotation (degrees)	55 ± 8	54 ± 7	0.45

Overall Procedural Satisfaction and Side Effects: Table 10 below summarizes overall satisfaction rates and side effects reported by patients. Minimal transient pain was reported, with no other side effects recorded.

Table 10: Overall Procedural Satisfaction and Side Effects

Category	Frequency (%)
Overall Satisfaction (%)	95
Transient Pain (%)	10
Other Side Effects (%)	0

Discussion

This study highlights the efficacy of ultrasound-guided hydro dilatation as a minimally invasive and precise intervention for managing frozen shoulder. The significant improvements observed in pain relief, functional outcomes, and range of motion (ROM) underscore the potential of this technique to address limitations associated with conventional treatments **[8]**.

Pain Relief and Functional Recovery: The marked reduction in Visual Analog Scale (VAS) scores and improvement in Constant-Murley scores post-intervention demonstrate the effectiveness of ultrasound-guided hydro dilatation in alleviating pain and restoring shoulder function **[9]**. The ability to directly visualize the joint capsule ensures accurate delivery of therapeutic agents, optimizing the intervention's impact. These findings align with existing literature supporting hydro dilatation's role in reducing capsular adhesions and inflammation.

Range of Motion Improvements: Significant gains in ROM across all parameters—abduction, forward flexion, external rotation, and internal rotation—highlight the success of this approach in addressing the hallmark stiffness of adhesive capsulitis. Subgroup analyses revealed slightly better outcomes in non-diabetic patients, likely due to diabetes-associated changes in connective tissue. However, the improvements observed in diabetic patients affirm the technique's broad applicability **[10]**.

Patient Satisfaction and Safety: High patient satisfaction scores, coupled with minimal adverse events, underline the procedure's acceptability and safety. The absence of major complications such as infection or persistent pain positions ultrasound-guided hydro dilatation as a viable alternative to more invasive options like arthroscopic capsular release **[11]**.

Comparison with Conventional Techniques: Compared to blind injections and physical therapy alone, ultrasound-guided techniques offer unparalleled precision, reducing the likelihood of iatrogenic damage and enhancing therapeutic outcomes. Incorporating imaging data into procedural planning provides clinicians with a tool for tailored intervention, ensuring consistent results across varied patient populations **[12]**.

Clinical Implications: The study supports integrating ultrasound-guided hydro dilatation into routine practice for frozen shoulder management. The real-time visualization afforded by ultrasound reduces procedural variability, ensuring reliable outcomes. Furthermore, the technique's minimally invasive nature makes it suitable for patients who may not tolerate surgical interventions **[13, 14]**.

Limitations and Future Directions: While the study's findings are robust, the absence of a control group limits direct comparisons with other treatment modalities. Additionally, long-term outcomes beyond 12 weeks were not evaluated, leaving questions regarding the durability of the observed benefits. Future research should explore these aspects, alongside randomized trials comparing ultrasound-guided techniques with alternative interventions.

Conclusion

This study demonstrates the efficacy of ultrasound-guided hydro dilatation in the management of frozen shoulder. Significant improvements in pain levels, functional outcomes, and range of motion were achieved within 12 weeks of intervention. The procedure was well-tolerated, with minimal adverse events and high patient satisfaction rates, making it a viable and effective alternative to conventional treatment options.

The precision of ultrasound guidance ensures targeted delivery of therapeutic agents, reducing procedural variability and enhancing outcomes. This approach offers a minimally invasive, cost-effective, and patient-friendly solution for managing adhesive capsulitis, particularly in patients who may not tolerate more invasive surgical interventions.

Future research should focus on long-term outcomes and comparative studies with other treatment modalities to further validate the role of ultrasound-guided hydro dilatation in frozen shoulder management.

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