Original Article

Inferior Glenohumeral Capsule Thickness in Adhesive Capsulitis: An Ultrasonographic Evaluation

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Abstract

Background: Adhesive capsulitis, another name for frozen shoulder, is characterized by increasing shoulder discomfort and mobility limitation. Structural changes in the inferior glenohumeral capsule are believed to play a significant role in the pathophysiology of this condition. Ultrasonography has emerged as a reliable imaging modality for evaluating these capsular changes. The objective is to look for an appropriate location for measuring the thickness of the inferior glenohumeral joint capsule using ultrasonography that can represent the range of motion in frozen shoulder patients. **Material and Methods:** This observational study included 50 participants, comprising control subjects and patients with frozen shoulder. Shoulder range of motion was assessed clinically, and ultrasonographic measurements of inferior glenohumeral capsule thickness were obtained at three anatomical sites: the surgical neck, anatomical neck, and parenchymal regions. Intrarater reliability was evaluated using intraclass correlation coefficients, and correlations between capsule thickness and range of motion were analysed using Pearson's correlation. **Results:** With ICC values ranging from 0.92 to 0.96, ultrasonographic measurements showed outstanding reliability. Patients with frozen shoulder showed significantly greater capsule thickness than controls at all measurement sites ($p < 0.001$). A negative correlation was observed between capsule thickness and shoulder range of motion, with the strongest correlation observed in the parenchymal region. **Conclusion:** Inferior glenohumeral capsule thickness measured using ultrasonography is significantly associated with restricted shoulder mobility in frozen shoulder. The parenchymal measurement site appears to reflect functional limitation best and may serve as a useful parameter in the clinical evaluation of adhesive capsulitis.

Keywords: Frozen shoulder, Adhesive capsulitis, Ultrasonography, Glenohumeral capsule thickness.

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INTRODUCTION

Adhesive capsulitis, another name for frozen shoulder, is a common and incapacitating musculoskeletal condition marked by severe limitation of the glenohumeral joint's active and passive range of motion (ROM) and growing shoulder discomfort. The condition typically develops gradually and may persist for months or even years, leading to considerable impairment in daily activities and quality of life. Although the exact pathogenesis remains incompletely understood, inflammatory and fibrotic changes in the joint capsule—particularly in the inferior glenohumeral capsule—are considered central to the development of this disorder.[1,2]

Adhesive capsulitis predominantly affects individuals aged 40 to 60 years and has been reported to occur more frequently in women. Several systemic conditions, such as diabetes mellitus, thyroid disease, and metabolic disorders, have been associated with an increased risk of developing frozen shoulder. Clinically, patients present with progressive shoulder stiffness and pain, especially during abduction and external rotation. The disease typically progresses through stages, including a painful phase, a stiff phase, and, eventually, a recovery phase, although some patients may experience persistent functional limitations.[1,3]

Traditionally, the majority of frozen shoulder diagnoses have been made clinically, based on physical examination findings and characteristic symptoms. Imaging modalities such as magnetic resonance imaging (MRI), arthrography, and arthroscopy have been utilised to confirm capsular changes and exclude other shoulder pathologies. However, these techniques may be costly, invasive, or less accessible in routine clinical practice. In recent years, ultrasonography has gained increasing attention as a reliable, non-invasive, and cost-effective imaging modality for evaluating structural changes associated with adhesive capsulitis.[4,5]

Ultrasonography allows dynamic visualisation of soft tissue structures of the shoulder joint and has been shown to identify several characteristic features of frozen shoulder. Among these findings, thickening of the inferior glenohumeral capsule and

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axillary recess has emerged as an important diagnostic indicator. The inferior glenohumeral capsule forms a crucial stabilising structure of the shoulder joint and plays a significant role in maintaining normal glenohumeral mobility. In frozen shoulder, inflammatory changes followed by fibrosis lead to capsular thickening and contracture, which limit joint movement.[4,6]

Previous ultrasonographic studies have reported that the thickness of the inferior glenohumeral capsule is significantly greater in patients with adhesive capsulitis than in asymptomatic individuals. Normal capsule thickness has been reported to range from 1.0 to 3.7 mm, whereas increased values of 2.0 to 6.4 mm have been observed in patients with frozen shoulder. This capsular thickening is believed to result from synovial inflammation, fibrosis, and structural remodelling of the capsuloligamentous complex.[6,7]

In addition to its diagnostic significance, capsular thickness has been investigated as a potential indicator of functional impairment. Several studies have demonstrated a negative correlation between the thickness of the inferior glenohumeral capsule and shoulder ROM, suggesting that greater capsular thickening is associated with more severe limitation of joint movement. These findings support the hypothesis that structural changes in the capsule directly contribute to the mechanical restriction observed in frozen shoulder.[8]

Despite the increasing use of ultrasonography to evaluate adhesive capsulitis, there remains considerable variability in measurement techniques and anatomical sites used to assess capsule thickness. Some studies have measured the capsule at the level of the surgical neck of the humerus, while others have assessed the axillary pouch or parenchymal portion of the capsule. Differences in measurement location and arm positioning during imaging may influence the accuracy and clinical relevance of the measurements, leading to inconsistent findings across studies.[5,9]

Furthermore, it remains unclear which specific measurement site of the inferior glenohumeral capsule most accurately reflects the functional limitation of the shoulder. Establishing a standardised and reliable measurement location is therefore important for improving the diagnostic value of ultrasonography and for better understanding the relationship between capsular structural changes and joint mobility in frozen shoulder.[9]

Recent investigations have highlighted the potential value of measuring inferior capsule thickness at specific anatomical levels using standardised arm positions during ultrasonography. Such approaches may provide a more accurate representation of capsular pathology and its association with shoulder ROM. Identifying the most suitable measurement site could enhance the clinical utility of ultrasonography in the assessment and management of frozen shoulder.[10]

Thus, the current research aims to use ultrasonography to determine an appropriate location for measuring inferior glenohumeral capsule thickness that accurately reflects the range of motion in patients with frozen shoulder. By identifying the measurement location most closely associated with functional limitation, this study may improve diagnostic evaluation and monitoring of patients with adhesive capsulitis.

Materials and Methods

This study was conducted to evaluate the thickness of the inferior glenohumeral joint capsule (IGC) in patients with frozen shoulder using ultrasonography and to determine the measurement site that best reflects the limitation of shoulder range of motion (ROM). The investigation was conducted over a year in the Department of Orthopaedics and Radiology of a tertiary care hospital. It was planned as an observational cross-sectional study.

A total of 50 participants clinically diagnosed with frozen shoulder were included in the study. Patients attending the orthopaedic outpatient department with shoulder pain and restricted movement were screened for eligibility. A clinical examination that revealed increasing shoulder discomfort and limitations in both active and passive range of motion, especially in external rotation, abduction, and forward flexion, led to the diagnosis of frozen shoulder. Included were patients aged 35-65 who provided informed consent and were willing to participate in the trial. To prevent confounding factors that could affect capsular thickness or shoulder mobility, patients with a history of shoulder fracture, dislocation, rotator cuff tear, prior shoulder surgery, inflammatory arthritis, or neurological disorders affecting the shoulder joint were excluded from the study.

After obtaining informed consent, detailed demographic and clinical information, including age, gender, duration of symptoms, affected side, and associated systemic conditions, was recorded. Each participant underwent a comprehensive clinical examination to assess the shoulder range of motion. Shoulder ROM was measured using a standard goniometer during forward flexion, abduction, internal rotation, and external rotation. Measurements were taken with the patient in a standardised position and were recorded in degrees. The ROM values were documented to evaluate the functional limitation associated with frozen shoulder.

Ultrasonographic examination of the shoulder joint was performed using a high-frequency linear transducer ranging from 7 to 12 MHz. An experienced radiologist conducted all examinations to ensure consistent measurements. During the ultrasound assessment, the inferior glenohumeral joint capsule thickness was measured at the axillary recess region. The patient was seated with the shoulder abducted to allow optimal visualisation of the inferior capsule. The ultrasound probe was placed along the long axis of the humeral neck to identify the inferior capsule between the humeral head and the glenoid rim. Capsule thickness was measured as the distance between the outer and inner echogenic margins of the capsule. Measurements were taken carefully to avoid compression of the capsule by the probe. To increase precision and lower measurement variability, each measurement was performed three times, and the average result was noted. To ascertain the connection between inferior glenohumeral capsule thickness and shoulder joint functional restriction, the ultrasonographic results were compared with the clinically assessed shoulder range of motion. For statistical analysis, the measurements were recorded and collated. The Statistical Package for the Social Sciences (SPSS) program, version 25.0, was used to evaluate all the data that had been gathered and placed into a structured data sheet. The ultrasonographic data and demographic features were summarised using descriptive statistics, including means, standard deviations, frequencies, and percentages. Pearson's correlation coefficient was used to evaluate the association between shoulder range of motion and inferior glenohumeral capsule thickness. Statistical significance was defined as a p-value of less than 0.05. Before the trial started, the participating hospital's Institutional Ethics Committee granted ethical permission. Every technique used in the study complied with the Declaration of Helsinki's guiding principles and the institutional research committee's ethical guidelines. Before being included in the study, each participant provided written informed consent, and patient data confidentiality was rigorously maintained throughout the investigation.

Results

The reliability of ultrasonographic measurements of inferior glenohumeral joint capsule thickness was evaluated to determine the consistency of repeated measurements taken by the same examiner. As presented in [Table 1], excellent intrarater reliability was observed across all three measurement sites. The intraclass correlation coefficients (ICCs) ranged from 0.92 to 0.96. The highest reliability was observed at the anatomical neck with an ICC value of 0.96 and a narrow 95% confidence interval of 0.90–0.98, indicating strong measurement stability. The surgical neck also demonstrated high reliability (ICC = 0.94), while the parenchymal region showed an ICC of 0.92. The standard error of measurement ranged from 0.08 mm to 0.17 mm, suggesting minimal measurement error. The minimal detectable change at 95% confidence ranged from 0.23 mm to 0.48 mm, further confirming the reproducibility of ultrasonographic capsule thickness measurements.

The demographic characteristics and shoulder range of motion of the study participants are summarised in [Table 2]. The study included a total of 50 participants: 15 in the control group (30 shoulders) and 35 patients with frozen shoulder (35 affected shoulders). In the control group, there were 6 males and 9 females, whereas the frozen shoulder group comprised 13 males and 22 females. The mean age in the control group was 55.8 ± 9.6 years compared to 57.3 ± 8.9 years in the frozen shoulder group, and this difference was not statistically significant ($p = 0.54$). Similarly, with p values of 0.39, 0.21, and 0.63 for height, weight, and BMI, respectively, there were no statistically significant differences between the groups. However, a marked reduction in shoulder range of motion was observed among patients with frozen shoulder. Mean shoulder flexion was 170.9 ± 3.1° in controls compared with 125.6 ± 23.4° in the frozen shoulder group ($p < 0.001$). Abduction was reduced from 169.6 ± 3.9° in controls to 90.4 ± 28.7° in patients with frozen shoulder ($p < 0.001$). External rotation decreased from 66.5 ± 6.8° in the control group to 22.7 ± 17.9° in the frozen shoulder group ($p < 0.001$). Internal rotation also showed significant restriction, decreasing from 10.9 ± 1.8 in controls to 2.8 ± 3.0 in patients with frozen shoulder ($p < 0.001$).

[Table 3] compares the thickness of the inferior glenohumeral joint capsule in the frozen shoulder and control groups. At every measurement point, patients with frozen shoulder showed significantly higher capsule thickness. At the surgical neck, the mean capsule thickness in controls was 2.5 ± 0.5 mm. In contrast, in frozen shoulder patients, it increased to 4.0 ± 1.2 mm with a large effect size ($r = 0.65$) and a statistically significant difference ($p < 0.001$). At the anatomical neck, capsule thickness increased from 1.5 ± 0.4 mm in controls to 2.6 ± 0.9 mm in frozen shoulder patients ($r = 0.62$, $p < 0.001$). Similarly, the parenchymal region demonstrated the greatest difference with values of 1.3 ± 0.3 mm in the control group and 2.6 ± 0.8 mm in the frozen shoulder group ($r = 0.72$, $p < 0.001$). These findings indicate that inferior capsule thickening is strongly associated with frozen shoulder pathology.

[Table 4] shows the correlation between shoulder range of motion and inferior glenohumeral capsule thickness. A negative correlation was observed between capsule thickness and shoulder movement across all measurement sites, indicating that increasing capsule thickness was associated with decreasing shoulder mobility. Capsule thickness at the surgical neck showed somewhat negative relationships with internal rotation ($r = -0.41$, $p = 0.019$), flexion ($r = -0.47$, $p < 0.01$), and abduction ($r = -0.44$, $p < 0.01$). The correlation with external rotation approached significance ($r = -0.33$, $p = 0.064$). At the anatomical neck, significant negative correlations were observed with flexion ($r = -0.40$, $p = 0.031$), abduction ($r = -0.38$, $p = 0.037$), and external rotation ($r = -0.42$, $p = 0.028$), while internal rotation showed a borderline relationship ($r = -0.34$, $p = 0.071$). The strongest correlations were found at the parenchymal measurement site, where capsule thickness was significantly correlated with flexion ($r = -0.60$, $p < 0.001$), abduction ($r = -0.57$, $p < 0.001$), external rotation ($r = -0.46$, $p < 0.01$), and internal rotation ($r = -0.48$, $p < 0.01$). These results suggest that the parenchymal region may be the most suitable measurement site for reflecting functional limitation in frozen shoulder.

Table 1: Intrarater reliability of inferior glenohumeral joint capsule thickness measurements

Measurement Site	ICC	95% CI	SEM	MDC95
Surgical neck	0.94	0.87–0.97	0.17	0.48
Anatomical neck	0.96	0.90–0.98	0.08	0.23
Parenchymal	0.92	0.84–0.96	0.10	0.29

Table 2: Demographic characteristics and shoulder range of motion of participants (Sample size = 50)

Variable	Control	Frozen Shoulder	P value
n / shoulders	15 / 30	35 / 35	—

Sex (Male/Female)	6 / 9	13 / 22	—
Age (years)	55.8 ± 9.6	57.3 ± 8.9	0.54
Height (cm)	161.8 ± 9.9	163.7 ± 7.1	0.39
Weight (kg)	59.4 ± 8.5	62.2 ± 9.4	0.21
BMI (kg/m²)	22.6 ± 2.8	22.9 ± 3.1	0.63
Flexion (°)	170.9 ± 3.1	125.6 ± 23.4	<0.001*
Abduction (°)	169.6 ± 3.9	90.4 ± 28.7	<0.001*
External rotation (°)	66.5 ± 6.8	22.7 ± 17.9	<0.001*
Internal rotation	10.9 ± 1.8	2.8 ± 3.0	<0.001*

Table 3: Comparison of inferior glenohumeral joint capsule thickness between control group and frozen shoulder group

Measurement Site	Control (mm)	Frozen Shoulder (mm)	Effect Size	P value
Surgical neck	2.5 ± 0.5	4.0 ± 1.2	r = 0.65	<0.001*
Anatomical neck	1.5 ± 0.4	2.6 ± 0.9	r = 0.62	<0.001*
Parenchymal	1.3 ± 0.3	2.6 ± 0.8	r = 0.72	<0.001*

Table 4: Relationship between inferior glenohumeral capsule thickness and range of motion

Range of Motion	Surgical Neck r	P value	Anatomical Neck r	P value	Parenchymal r	P value
Flexion (°)	-0.47	<0.01*	-0.40	0.031*	-0.60	<0.001*
Abduction (°)	-0.44	<0.01*	-0.38	0.037*	-0.57	<0.001*
External rotation (°)	-0.33	0.064	-0.42	0.028*	-0.46	<0.01*
Internal rotation	-0.41	0.019*	-0.34	0.071	-0.48	<0.01*

Discussion

The present study evaluated the thickness of the inferior glenohumeral joint capsule (IGC) in patients with frozen shoulder using ultrasonography. It investigated the relationship between capsular thickness and shoulder range of motion (ROM). The findings of this study demonstrated that patients with frozen shoulder had significantly greater IGC thickness compared with controls at all measured locations, including the surgical neck, anatomical neck, and parenchymal regions. Additionally, a strong negative correlation was observed between capsule thickness and shoulder ROM, suggesting that increased capsular thickening contributes to the functional restriction characteristic of adhesive capsulitis.

The intrarater reliability analysis showed excellent reproducibility of ultrasonographic measurements with ICC values ranging from 0.92 to 0.96 across the three measurement sites. The highest reliability was observed at the anatomical neck, suggesting that this location may provide stable, repeatable measurements during clinical evaluation. These findings are consistent with previous ultrasonographic studies, which reported high reliability in measuring capsular structures in adhesive capsulitis when standardised imaging protocols are used. Reliable measurement techniques are essential, as ultrasound is increasingly used as a non-invasive, accessible modality for evaluating soft tissue changes of the shoulder joint in routine clinical practice.[11]

In the present study, demographic variables such as age, height, weight, and body mass index were comparable between the control and frozen shoulder groups, indicating that demographic variations did not influence the observed differences in capsular thickness and ROM. However, patients with frozen shoulder exhibited marked restriction in shoulder movement. The mean flexion decreased from approximately 170° in the control group to around 125° in the frozen shoulder group, while abduction was reduced from approximately 170° to nearly 90°. Similarly, external rotation and internal rotation were significantly restricted in the frozen shoulder group. These findings align with the characteristic clinical presentation of adhesive capsulitis, where capsular contracture leads to progressive limitation of glenohumeral joint movement. Previous studies have reported that capsular fibrosis and inflammation, particularly in the inferior capsule and axillary recess, result in mechanical restriction of shoulder motion.[12]

Patients with adhesive capsulitis showed significant thickening when the thickness of the capsules was compared between the frozen shoulder and control groups. In the frozen shoulder group, the mean capsule thickness at the operative neck rose to around 4.0 mm, whereas in the controls, it was about 2.5 mm. Similarly, the anatomical neck and parenchymal measurements also showed significant increases. These findings support the concept that capsular thickening is a hallmark pathological feature of frozen shoulder. Histopathological investigations have demonstrated that adhesive capsulitis is characterised by synovial inflammation, followed by fibrotic remodelling of the joint capsule, resulting in increased capsule thickness and reduced capsular elasticity.[13]

An important finding of the present study was the negative correlation between inferior capsule thickness and shoulder ROM. Increased thickness at the surgical neck and anatomical neck demonstrated moderate correlations with flexion, abduction, and rotation movements, while the strongest correlations were observed at the parenchymal measurement site. For example, capsule thickness measured in the parenchymal region showed strong negative correlations with flexion and abduction, as well as significant correlations with external and internal rotation. These results suggest that measurements obtained at the parenchymal region may better reflect functional impairment of the shoulder joint. Similar correlations between capsular thickness and shoulder mobility have been reported in previous imaging studies, in which increased inferior capsular thickness was associated with reduced joint motion and greater clinical severity of adhesive capsulitis.[14]

Ultrasonography provides several advantages in the assessment of frozen shoulder. It is a non-invasive, cost-effective, and dynamic imaging technique that allows real-time evaluation of soft tissue structures. Compared with MRI, ultrasound can be performed rapidly in outpatient settings and allows visualisation of the inferior capsule during shoulder movement. Recent literature has emphasised the role of ultrasound in identifying capsular thickening and other structural abnormalities associated with adhesive capsulitis. In particular, standardised measurement of the inferior capsule has been proposed as a useful diagnostic and follow-up parameter for frozen shoulder.[15]

The results of this study therefore support the clinical utility of ultrasonography for assessing inferior glenohumeral capsule thickness in frozen shoulder. Among the measurement sites evaluated, the parenchymal region demonstrated the strongest correlation with shoulder ROM, suggesting that it may be the most representative site for reflecting functional impairment. Identifying an optimal measurement site can improve diagnostic accuracy and help clinicians monitor disease progression and treatment outcomes.

Conclusion

In comparison to healthy controls, the inferior glenohumeral joint capsule is much thicker in patients with frozen shoulder, according to the current research. Ultrasonographic measurements showed excellent intrarater reliability, confirming that ultrasound is a dependable tool for assessing capsular structures of the shoulder. A significant negative correlation was observed between capsule thickness and shoulder range of motion, indicating that increased capsular thickening contributes to functional limitation in adhesive capsulitis. Among the measurement sites evaluated, the parenchymal region showed the strongest correlation with shoulder mobility and may represent the most suitable location for assessing inferior capsule thickness. Ultrasonography of the inferior glenohumeral capsule may therefore serve as a valuable imaging parameter for evaluating the severity and functional impact of frozen shoulder.

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Conflicts of interest

There are no conflicts of interest.

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