ADHESIVE CAPSULITIS OF THE SHOULDER JOINT; CORRELATION BETWEEN THE UTRASONOGRAPHIC AND MRI FINDINGS

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ABSTRACT:

Background: *Adhesive capsulitis, also known as "Frozen Shoulder," is a debilitating condition characterized by Progressive pain and restricted range of motion of the Glenohumeral Joint. It mainly affects middle-aged females and shows some evidence for an association with endocrinological, rheumatological, and autoimmune diseases. Early diagnosis and Treatment of adhesive capsulitis can lead to markedly improved clinical status. Diagnosis is usually based on physical examination alone. Imaging investigations, however, can help diagnose unclear situations where symptoms appear to overlap with other shoulder disorders.*

Aim of the work: *to correlate between the Ultrasonographic and Magnetic Resonance Imaging (MRI) findings of Adhesive Capsulitis of the shoulder (ACS).*

Patients and Method: *This study was carried out on 30 patients, of any age group, having shoulder pain and restricted range of motion for longer than 15 weeks. The patients had both US & MRI examinations; findings of the two modalities were recorded and compared.*

Results: *there was a statistically significant agreement (P value= 0.001) between US & conventional MRI, US demonstrated CHL, IGH and rotator interval changes.*

Conclusion: *Based on the results, high resolution US with dynamic real-time assessment was proven to be sensitive, specific with significant agreement to conventional MRI in detecting adhesive capsulitis pathology. So, ultrasound can be used as an initial modality for patients with chronic shoulder pain and limitation of movements.*

Keywords: *Chronic shoulder pain and limitation of movements, CHL, inferior glenohumeral ligament, shoulder ultrasound, shoulder MRI.*

INTRODUCTION:

Frozen Shoulder, sometimes referred to as Adhesive Capsulitis (AC), is a common inflammatory shoulder joint disease that affects 2-3% of the population, primarily women in the 40–70 years 'age group [(1)].

A painful shoulder is a common presentation of AC, and it can be mistaken for a number of other painful shoulder conditions, including subacromial impinge-ment, calcific tendonitis, early glenohumeral arthritis, rotator cuff pathology, and calcific tendonitis [(2&3)].

Restricted passive range of motion (ROM) is crucial for making an accurate diagnosis of frozen shoulder. While calcifying tendinitis, subacromial bursitis,

and partial rotator cuff tears can cause excruciating pain and impair active range of motion, passive range of motion is preserved [(4)].

There are two types of diseases that increase a patient's risk of developing adhesive capsulitis: (1) diseases that affect the shoulder and proximal upper extremity (these include Biceps tendon tendinopathy, Subdeltoid bursitis, and Rotator cuff tendinopathy) and (2) diseases that are not related to the shoulder region (such as diabetes, myocardial infarction, stroke, tuberculosis, Parkinson's disease, and reflex sympathetic dystrophy) [(5)].

AC is typically diagnosed clinically. When a patient has less severe clinical symptoms, imaging can help rule out conditions like bursitis, rotator cuff tears, or other disorders [(6)].

AIM OF THE WORK:

This study aims to establish a correlation between the features of adhesive capsulitis of the shoulder (AC) as seen on ultrasonography and those seen on magnetic resonance imaging (MRI).

PATIENTS AND METHOD:

Thirty patients were enrolled in this cross-sectional study (18 Females and 12 males), age ≥ 20 years, they all had shoulder pain and various degrees of movement limitation for months and more.

They were referred to the Radiology department (Ultrasound and MRI unit) at Ain Shams University hospitals and private centers, at the period between June 2022 and June 2023, from orthopaedic, rheumatology and physical medicine departments.

The study was approved by the local research ethical committee, Faculty of Medicine, Ain Shams University.

Prior to their inclusion in this study, patients provided informed oral consent clarifying the details of the procedure.

Patient selection:

The **Inclusion Criteria** were Patients with painful shoulder and restricted range of motion for longer than 15 weeks, Patients with restricted motion > 30 degrees in two or more planes, Patients of any age group, Patients of both sexes and oriented, co-operative patients. While **the exclusion criteria** were**:** Patients with MRI contraindications (cardiac pacemaker-claustrophobia-patients with metal implant), Patients with other causes of limited external rotation. Patients presented in trauma or accident and unconscious, disturbed patients.

Every patient was subjected to the following:

Obtaining a history that includes (age, gender, side affected, and chronic illness history), clinical analysis, radiological investigations: shoulder Ultrasonography (US) and conventional MRI. Results of the ultrasonographic examination are compared to MR examination results, which are used as our study's reference.

Ultrasound examination:

Device: US assessment was done with 5-12 MHZ linear array transducer of TOSHIBA machine.

Patient Preparation:

Full exposure of the affected shoulder.

Technique: US was done with varying degrees of patient arm rotation and joint stress manoeuvres while the patient was seated on a backless chair. Patient positioning must be comfortable for both the patient and operator. The following were examined: Axillary recess/ Inferior Glenohumeral ligament (IGH), Rotator Interval and Coracohumeral ligament (CHL). As well dynamic assessment was done.

MRI examination:

Device: Philips Ingenia (1.5 Tesla) magnet unit.

Patient Preparation: Metallic objects were removed from the patient's clothes. Patients were told how important it was to be calm with no motion during the examination.

Patient position: The patient takes a supine position with head directed towards the scanner pore and arm at a side with palm facing up. The patient's arm should be positioned neutrally to slightly externally rotated. Surface coil was used.

Technique: The following sequences were followed: Axial T1, PD or STIR sequences, Coronal oblique T1, T2 and STIR weighted sequences and Sagittal oblique T2 weighted sequences.

The US and the MRI were interpreted by two different radiologists who have long experience in Musculoskeletal Imaging; both were blinded to patient's data and to the results of each other.

Statistical analysis:

The collected data was revised, coded, tabulated and introduced to a PC using Statistical package for Social Science (SPSS 25). Data was presented and suitable analysis was done according to the type of data obtained for each parameter.

1. Descriptive statistics:

Mean, Standard deviation (± SD) and range for parametric numerical data, while Median and Interquartile range (IQR) for non-parametric numerical data. Frequency and percentage of non-numerical data.

2. Analytical statistics:

Sensitivity and Specificity for quantitative Diagnostic measures was calculated by using ROC curve, and for qualitative Diagnostic measures the equation used for sensitivity was True positive by the test / (True positive by the test + False Negative by the test) and for Specificity the equation was True Negative by the test / (True Negative by the test + False positive by the test). PPV=true positive by test / all positive by the test (True positive by the test + False Positive by the test). NPV=true negative by test / all negative by the test (True negative by the test + False negative by the test).

Kappa statistics to compute the measure of agreement between two investigational methods Kappa's over 0.75 is excellent, 0.40 to 0.75 is fair to good, and below 0.40 is poor.

P- value: level of significance: P>0.05: non-significant (NS), P< 0.05: significant (S).

Ethical considerations:

The Ain Shams University faculty of medicine's regional ethical committee granted their approval for our study (MS 224/2022). Throughout all phases of the study, participants' privacy and confidentiality will be protected.

RESULTS:

Among the 30 patients, there were 18 females representing 60% & 12 males representing 40%. In our study, most of patients were between 41 to 60 years old by 66.7%, 20 to 40 years old represent 10% and 23.3% has >60 years old.

Most of patients had hypercholesterolemia by 63.3% followed by diabetes by 53.3%, 36.7% had HTN and only one patient (3.3%) had rheumatoid.

There were 19 patients (63.3%) diagnosed by US to have thickened IGH ligament and axillary recess > 2mm. sixteen patients (53.3 %) have thickened CHL (3.9 ± 1.15 mm), 20 patients (66.7 %) have rotator interval changes by US. four patients (13.3%) have no features of adhesive capsulitis by US.

Nineteen patients (63.3 %) were diagnosed to have thickened Inferior Glenohumeral Ligament/ Axillary Recess by US out of 19 cases (63.3 %) detected by MRI with subsequent US sensitivity & specificity

of 100% and 100.0% respectively.

Sixteen patients (53.3 %) were diagnosed to have thickened coracohumeral ligament by US out of 17 cases (56.7%) detected by MRI with subsequent US sensitivity & specificity of 94.12% and 100.0%respectively.

Twenty patients (66.7 %) were diagnosed to have rotator interval changes by US out of 20 cases (66.7 %) detected by MRI with subsequent US sensitivity & specificity of 100.0% and 100.0% respectively.

Table 1: Demographic data for the study group

		N	%
Gender	Female	18	60%
	Male	12	40%
Age	20 – 40	3	10.0%
	41 – 60	20	66.7%
	>60	7	23.3%
Hypercholestrolemia	Yes	19	63.3%
	No	11	36.7%
Diabetes	Yes	16	53.3%
	No	14	46.7%
Hypertension	Yes	11	36.7%
	No	19	63.3%
Rheumatoid	Yes	1	3.3%
	No	29	96.7%
Thyroid disease	Yes	0	0%
	No	30	100%

Table 2: Axillary recess, CHL and Rotator interval parameter by U/S and MRI for the studied group

		N	%
CHL thickness on US (3.9 ± 1.15 mm)	No	14	46.7%
	Yes	16	53.3%
CHL thickness on MRI	No	13	43.3%
	Yes	17	56.7%
Axillary recess >2mm / Thickened IGH ligament parameter on US	No	11	36.7%
	Yes	19	63.3%
Axillary recess/ IGH ligament parameter on MRI	No	11	36.7%
	Yes	19	63.3%
Rotator Interval parameter on US	No	10	33.3%
	Yes	20	66.7%
Rotator interval parameter on MRI	No	10	33.3%
	Yes	20	66.7%

Table 3: Dynamic assessment by U/S for the studied group

		N	%
Limitation of abduction on US	No	12	40.0%
	Yes	18	60.0%
Limitation of external rotation on US	No	5	16.7%
	Yes	25	83.3%

Table 4: Other findings on US and MRI for the studied group

		N	%
Non adhesive findings on US and MRI	No	26	86.7%
	Yes	4	13.3%

Table 5: Sensitivity and specificity of U/S to detect the disease among the study group using MRI as a gold standard test to detect the thickness.

		MRI		%	Kappa	p-Value (sig.)	Sensitivity	Specificity
		Yes	No					
		N (%)	N (%)					
CHL thickness U/S	Yes	16 (94.1%)	0 (0%)	96.67%	0.933	<0.001 (S)	94.12%	100.0%
	No	1 (5.9%)	13 (100%)					
Axillary recess U/S	Yes	19 (100%)	0 (0%)	100.0%	1.00	<0.001 (S)	100.0%	100.0%
	No	0 (0%)	11 (100%)					
Rotator Interval U/S	Yes	20 (100%)	0 (0%)	100.0%	1.00	<0.001 (S)	100.0%	100.0%
	No	0 (0%)	10 (100%)					
Combination U/S	Yes	26 (96.3%)	0 (0%)	96.67%	0.84	0.001 (S)	96.3%	100.0%
	No	1 (3.7%)	3 (75%)					

Case 1:

Clinical data:

Female patient, 47 years old, hypertensive, diabetic with hypercholesterolemia and normal thyroid function. Presented with right shoulder pain, restriction of external rotation and abduction.

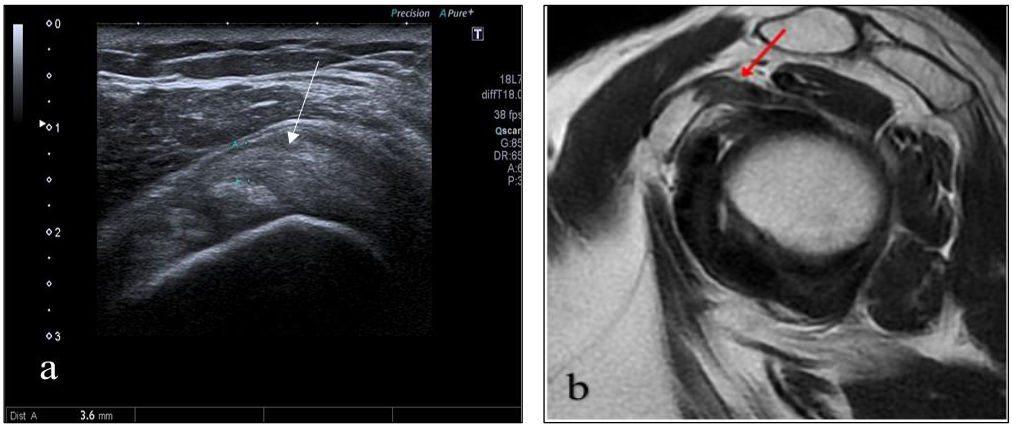

Figure 1: (a) US image showing thickened CHL (white arrow), (b) MR T2 WI sagittal view showing thickened CHL (red arrow)

Case 2:

Female patient, 45 years old, not diabetic, not hypertednsive. Presented with left shoulder pain and restriction of abduction.

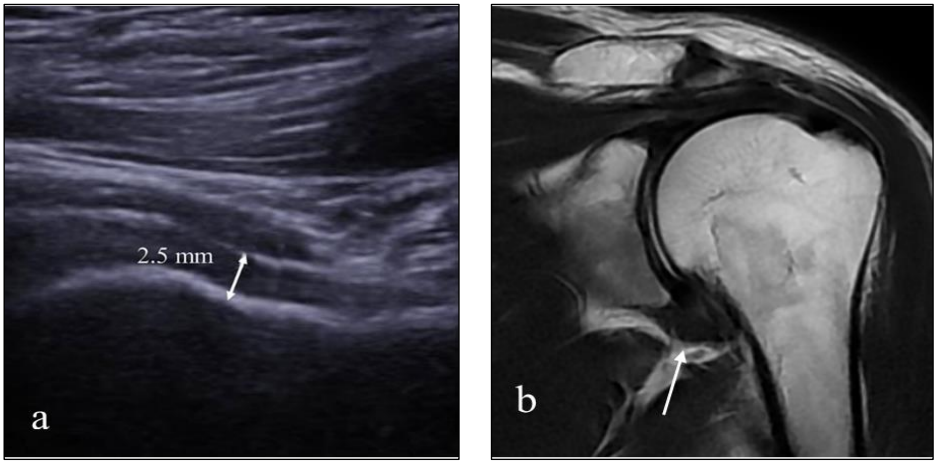

Figure 2: (a) US image showing thickened IGH ligament. (b) MR T2 WI coronal view showing thickened IGH ligament (white arrow).

Case 3:

Female patient, 50 years old, diabetic (insulin dependent). Presented with right shoulder pain, restriction of external rotation and abduction restriction.

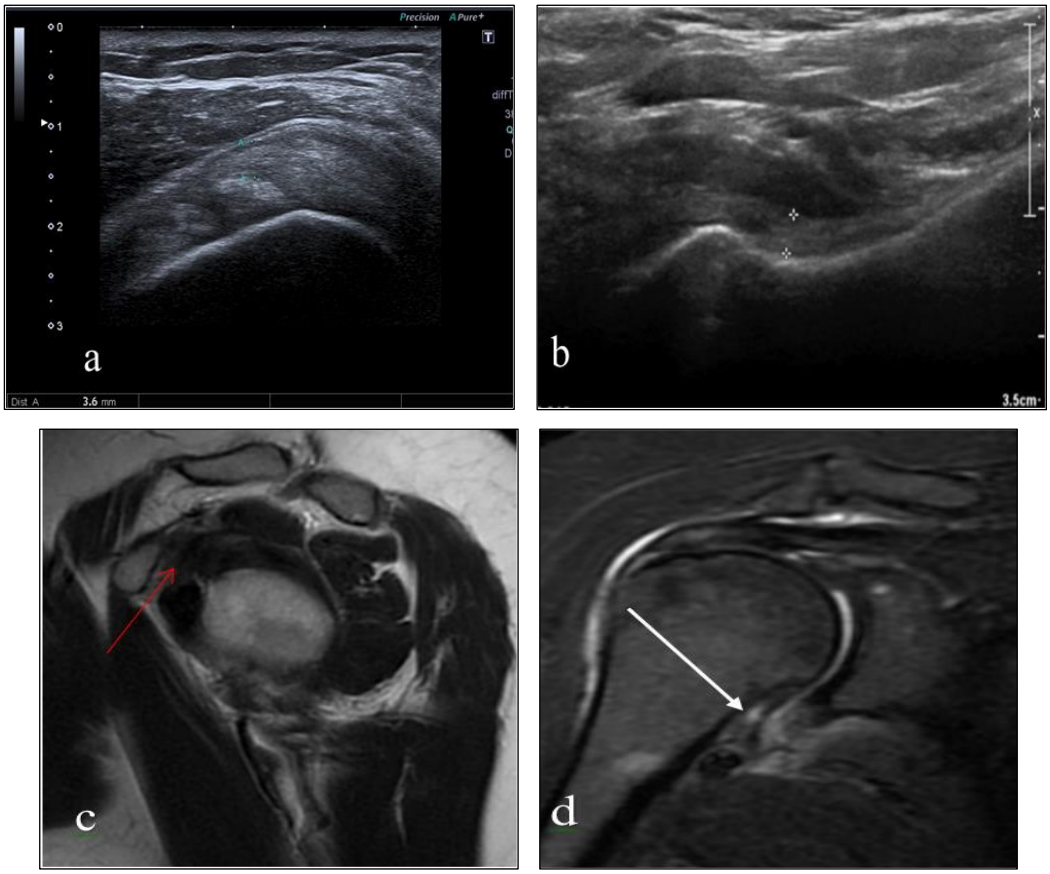

Figure 3: (a) US image showing thickened CHL. (b) US image showing thickened IGH ligament. (c) MR T2WI sagittal view showing ill-defined RI region with obliteration of fat plane (red arrow) (d) MR STIR coronal view showing hyperintense and thickened IGH ligament (white arrow).

DISCUSSION:

The study includes 30 patients with chronic shoulder pain and restricted movement, which are clinically diagnosed as Adhesive Capsulitis.

In our sample, 12 patients (representing 40%) were males and 18 patients (representing 60%) were females. Unlike *Wang et al.* [7], who found that adhesive capsulitis was equally common in both sexes. Most cases 20 were in age group (41-60 years) with percentage 66.7%.

Among the study group, incidence of diabetes was higher. This comes in hand with *Wang et al.* [7], *Barbosa et al.* [8] *and Cho et al.* [9]

Our study reported a statistically significant difference in incidence of hypercholesterolemia among the study group. Relationship between shoulder adhesive capsulitis (AC) and hypercholesterolemia is known.

This study supports the co-incidence of diabetes and dyslipidemia among patients with adhesive capsulitis, as reported by *Austin et al.* [10] *and Park et al.* [11].

Only two studies had analyzed the correlation between the axillary recess/inferior glenohumeral ligament thickening at ultrasound and MRI *Kim et al.* [12] *& Sernik et al.* [13]

Many studies had investigated the accuracy of ultrasound and MRI separately.

In our study, out of 30 patients, there were 19 patients (63.3%) diagnosed by US to have thickened IGH ligament > 2mm. Sixteen patients (53.3 %) have thickened CHL (3.9 ± 1.15 mm), 20 patients (66.7 %) have rotator interval changes by US. Four Patients (13.3%) have no features of adhesive capsulitis by US.

Nineteen patients (63.3 %) were diagnosed to have thickened inferior glenohumeral ligament/ axillary recess by US out of 19 cases (63.3 %) detected by MRI with subsequent US sensitivity & specificity of 100% and 100.0% respectively.

Lee et al. [14] study reported the diagnostic value of inferior joint capsule thickness measured by Ultrasound for the diagnosis of frozen shoulder and assessed the changes in the thickness of the inferior joint capsule depending on position of the arm. A cutoff value of 3.2 mm for Inferior joint capsule thickness on Ultrasound had a good diagnostic accuracy for frozen shoulder with a sensitivity and specificity of 73.2% and 77.5%, respectively. Arm position affects the thickness of the Inferior Joint Capsule.

In the study done by *Sernik et al.* [13], there was a 100% sensitivity and 96% specificity correlation found between the Axillary Recess Capsule thickness as evaluated by ultrasound and MRI in adhesive capsulitis patients.

Kim et al. [12] reported a correlation between the Ultrasound and MRI measurements of the Axillary Recess Capsule thickness capsule in patients clinically diagnosed with adhesive capsulitis. They reported a threshold of 3.2 mm on US for the axillary recess in healthy individuals (1.2 points higher than ours). Given that they selected 40° shoulder abduction and 90° elbow flexion during the US assessment, this discrepancy was most likely caused by different arm placement.

We selected a 90° shoulder abduction in order to provide a certain degree of axillary recess stretching and prevent overestimating the measurements by including soft tissue instead of the actual capsule-synovial complex of the Axillary Recess. The sensitivity was 88.6% and specificity was 97.7%.

The axillary pouch thickness's sensitivity and specificity were found to be 100% and 98%, respectively, in the *Stella et al.* [15] study, which is in good agreement with the findings

of our study.

According to *Cheng et al.* [16], there was a significant thickening of the inferior capsule (3.5±1.06 mm versus 1.6±0.72 mm) in patients with Frozen Shoulder. For the diagnosis of frozen shoulder, a threshold value of 3.5 mm or greater exhibited a sensitivity of 66.7% and a specificity of 93.3%.

According to *Michelin et al.* [17] study, the adhesive capsulitis patients' mean axillary pouch thickness, as determined by US, was 4 mm, while the asymptomatic control groups was 1.3 mm.

Sixteen patients (53.3 %) were diagnosed to have thickened CHL (coracohumeral ligament) by ultrasound out of 17 cases (56.7%) detected by MRI with subsequent US sensitivity & specificity of 94.12% and 100.0% respectively.

Without assessing accuracy, sensitivity, or specificity, *Karthikeyan et al.* [18] reported that CHL thickness is remarkably higher in adhesive capsulitis as compared to an age- and gender-matched control group.

According to *Wu et al.* [19]*'s* comprehensive review and meta-analysis, four ultrasonography features—thickness of the Coracohumeral ligament, thickening of the Inferior Capsule/Axillary Recess, irregularity of the Rotator Interval, and restriction of range of motion—were used to identify adhesive capsulitis. The specificities were 88.9, 95.7, 93.9 and 90.9 while the corresponding sensitivities were 64.4, 82.1, 82.6 and 94.3 respectively.

According to *Cheng et al.* [16], CHL was significantly thicker (mean, 3.1 mm) on ultrasonography in patients with adhesive capsulitis. For the diagnosis of frozen shoulder, a threshold value of 3 mm or greater exhibited an 88.9% specificity and a 64.4% sensitivity.

Tandon et al. [20] reported that the AC group had the highest mean thickness (1.2 mm) and ultrasound visibility of CHL (96.7%). It was found that a cut-off value of 0.7 mm was reliable for the diagnosis of Adhesive Capsulitis (sensitivity: 93.1%, specificity: 94.4%).

According to *Homsi et al.* [21], adhesive capsulitis patients had a significantly thicker Coracohumeral Ligament (3 mm) than those with asymptomatic (1.34 mm) and painful (1.39 mm) shoulders.

According to *Mengiardi et al.* [22]*,* the Rotator Interval capsule thickness ≥7 mm has an 86% specificity and a 64% sensitivity in diagnosing adhesive capsulitis. A coracohumeral ligament thickness of less than 4 mm has a decreased sensitivity of 59% for AC, but a high specificity of 95%.

Twenty patients (66.7 %) were diagnosed to have rotator interval changes by US out of 20 cases (66.7 %) detected by MRI with subsequent Ultrasound sensitivity & specificity of 100.0% and 100.0% respectively.

Tandon et al. [20] demonstrated that patients with Adhesive Capsulitis had increased soft tissue in the Rotator Interval, with a high 86.2% sensitivity and 92.8% specificity.

According to *Cheng et al.* [16]*,* ultrasound-based rotator interval abnormality detection showed a 91.1% sensitivity and 92.5% specificity in the diagnosis of adhesive capsulitis.

According to *Lee et al.* [23], hyper vascularity on doppler examination with a sensitivity of 87–97% and 100% specificity are reported when hypoechoic soft tissue is seen inside the Rotator Interval.

Dynamic parameters:

It was noted that 83.3% of patients experienced limitations with external rotation and 60% of patients had dynamic restriction of abduction.

According to *Wu et al.* [24] systematic

review and meta-analysis, the study's results revealed that the ROM (range of motion) sensitivity was the highest (94.3, 95% CI: 84.3–98.8); restricting the shoulder's external rotation produced a diagnostic value that was statistically significant (p=0.0001).

In their study, *Karthikeyan et al.* [18] reported a statistically significant negative association between the external rotation and the degree of CHL thickness. Consequently, the external rotation range of motion was less when the CHL thickness was greater and vice versa. Therefore, it is clear that CHL plays an important role to the shoulder's external rotation movement. Additionally, a negative correlation was found, while it was not statistically significant, between abduction range of motion and CHL thickness.

Additionally, *Kanazawa et al.* [25] observed an important inverse correlation between the glenoid side Joint Capsule thickness and the MRI positions of the hand behind the back and external rotation.

According to *Do et al.* [26], there was a significant correlation between the thickness of the axillary recess and the motions of internal rotation ($R = 0.456$, $p < 0.001$) and forward elevation ($R = -0.28$, $p = 0.028$).

Wu et al. [24] study reported moderate negative correlation of CHL thickness with shoulder external rotation and internal rotation in adhesive capsulitis patients.

Conclusion:

The study has the advantage of having correlation to another diagnostic method. It is considered one of few studies that have correlated ultrasonographic signs of AC with MRI.

Regarding the findings of our study, it can be concluded that US showed comparable results to conventional MRI in detecting Adhesive capsulitis patients with high accuracy, sensitivity and specificity.

Ultrasound has a high diagnostic accuracy for the diagnosis of Frozen Shoulder using combination of parameters (IGH, CHL and rotator interval). The sensitivity, specificity of ultrasound for diagnosing adhesive capsulitis was 96.3% and 100% respectively, taking MRI as gold standard.

Study Limitations:

This study has some limitations. Firstly, ultrasound depends on the experience of the operator, and the measurement values vary based on the ultrasound machine. Other limitations as loss of randomization, lack of any interventions and being observational study. Sample size is considered small. Ultrasound as a technique by itself has interpersonal variations (inter physician/ inter patients). So, it is liable for some bias. Lack of matched control group is another limitation.

US has been found to be a reliable method for diagnosing adhesive capsulitis of the shoulder and distinguishing it from other causes of shoulder pain, despite these limitations. It makes sense, therefore, to use it as a preferred modality for these cases.

Conflict of interest:

no conflict of interest to declare.

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التهاب المحفظة اللاصق لمفصل الكتف:
العلاقة بين نتائج الموجات فوق الصوتية والتصوير بالرنين المغناطيسي

عمر فاروق كامل ، الشيماء محمد العادلي ، خالد سيد أحمد

قسم الاشعة التشخيصية - كلية الطب جامعة عين شمس

الكتف المتجمد او التهاب المحفظه اللاصق هو التهاب شائع في مفصل الكتف يُشاهد لدى 2-3% من السكان، ويصيب عادةً الإناث في الفئة العمرية 40-70 عامًا.

غالبًا ما يظهرAC على شكل كتف مؤلم، وهو عرض بعيد عن أن يكون محددًا ويشابه العديد من اضطرابات الكتف المؤلمة الأخرى مثل تمزقات (الكفه المدوره) العضلات المحيطه لمفصل الكتف، والتهاب الأوتار، والتهاب المفاصل العضدي المبكر، وما إلى ذلك.

يعد فقدان حركه الكتف اللاراديه مفتاحاً لتحديد التشخيص الحقيقي للكتف المتجمد. على الرغم من أن حالات مثل التهاب الجراب تحت الأخرم، والتهاب الأوتار، وتمزقات العضلات المحيطه لمفصل الكتف قد تترافق مع ألم شديد وفقدان حركه الكتف الاراديه، إلا أنه يتم الحفاظ على الحركه اللإراديه.

يمكن تقسيم الأمراض التي تؤهب المريض لتطور التهاب المحفظة اللاصق إلى فئتين عامتين: (1) تلك الموجودة في الكتف والأطراف العلوية القريبة (على سبيل المثال، اعتلال أوتار الكفة المدورة، واعتلال أوتار العضلة ذات الرأسين) و(2) أمراض خارج منطقة الكتف (مثل السكتة الدماغية والسكري واحتشاء عضلة القلب والسل ومرض باركنسون).

تشخيص الكتف المتجمد عادة ما يكون بالعلامات والفحص الاكلينكي. يعد التصوير مفيدًا للغاية في الحالات التي تكون فيها الأعراض الاكلينيكيه أقل حدة والتي قد يتم تشخيصها بشكل خاطئ على أنها تمزقات في الكفة المدورة أو التهاب زلالي وحالات أخرى.

في الوقت الحاضر، نظرًا لأن طرق التشخيص التقليدية غير فعالة في تشخيص ACS الكتف المتجمد بدقة، يفقد المرضى فرصة العلاج الطبيعي في الوقت المناسب وتحسين نوعية الحياة.

الهدف من دراستنا هو توضيح مدي الارتباط بين نتايج التصوير بالموجات فوق الصوتية والرنين المغناطيسي لالتهاب المحفظة اللاصق لمفصل الكتف.

اجريت هذه الدراسه علي 30 مريضا (18 أنثى و12 ذكر)، أعمارهم ≤ 20 سنة، جميعهم كانوا يعانون من آلام في الكتف ودرجات مختلفة من تقييد الحركة لعدة أشهر وأكثر.

وتم تحويلهم إلى قسم الأشعة (وحدة الموجات فوق الصوتية والرنين المغناطيسي) بمستشفيات جامعة عين شمس والمراكز الخاصة، خلال الفترة ما بين يونيو 2022 ويونيو 2023، من أقسام العظام والروماتيزم والطب الطبيعي.

تمت الموافقة على الدراسة من قبل لجنة أخلاقيات البحث بكلية الطب جامعة عين شمس.

تم فحص جميع المرضى بواسطة الموجات فوق الصوتيه والتصوير بالرنين المغناطيسي والذي تم استخدامه في دراستنا كمعيار، وتم تفسير التصوير بالرنين المغناطيسي والتصوير بالموجات فوق الصوتيه من قبل اثنين من أخصائيي الأشعة المختلفين الذين لديهم خبرة طويلة في تصوير العضلات والعظام، وكلاهما لم يتمكنا من رؤية بيانات المريض وبيانات المريض ونتائج بعضها البعض.

بناءً على النتائج التي توصلنا إليها، لا يوجد فرق واضح ذو دلالة إحصائية بين التصوير بالرنين المغناطيسي و الموجات فوق الصوتيه فيما يتعلق بالكشف عن أمراض التهاب المحفظة اللاصق (الكتف المتجمد) الذي يظهر حساسية ونوعية ودقة عالية مقارنة بالتصوير بالرنين المغناطيسي