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Correlations between Clinical Examination, Ultrasonography and MRI Findings in Different Causes of Painful or Limited Range of Movement in the Shoulder Joint

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Abstract

Background: In clinical practice, reduced shoulder movement with an unclear cause continues to be a significant issue. This condition is known as adhesive capsulitis when the range of motion is completely limited. Other conditions such as rotator cuff tendinopathy or tears, with or without impingement, should be taken into consideration.

Aim of Study: To assess the contribution of magnetic resonance imaging (MRI) and ultrasound in the diagnosis of various shoulder joint range of motion restrictions to clinical examination.

Material and Methods: There were 100 patients in the study, a total of 102 shoulders with painful and restricted shoulder movements. There were 56 male cases (56%) and 44 female cases (44%). Every patient had a clinical examination, a B-mode dynamic ultrasound and an MRI. For each patient, a provisional diagnosis was reported clinically, by ultrasound (US) and by MRI.

Results: Most patients (78.4%) had painful limited range of motion (ROM), 21.6% had painful non-limited active ROM, 58.8% had painful non-limited passive ROM and none had limited passive range. There were different etiologies for restricted ROM: Rotator cuff tendinopathy, tear, shoulder impingement syndrome and adhesive capsulitis. Diagnostics for rotator cuff tears and tendinopathy showed moderate and high agreement, respectively, between MRI and ultrasound. However, in terms of adhesive capsulitis, there was little agreement between, clinical, MRI and ultrasound. In addition. The diagnosis of shoulder impingement syndrome by MRI, clinical and ultrasonography evaluations agreed fairly well. The diagnostic accuracy of US was higher than clinical examination in rotator cuff tendinopathy and tear being 78.4% and 88.2% respectively. Patients with painful passive range had statistically significant thicker rotator interval and axillary recess thickness by US and statistically significant thicker coracohumeral ligament (CHL) and axillary capsule by MRI as well as rotator interval and subcoracoid fat infiltration (*p*-values <0.05).

Conclusion: We came to the conclusion that even though the patients' range of motion was restricted, the US can still be used to diagnose a variety of shoulder conditions with the highest performance in rotator cuff tendinopathy and tear. Since MRI showed a strong correlation with the clinical assessment of painful passive ROM, we also concluded that MRI is superior to other methods for diagnosing adhesive capsulitis in its early stages before passive movement becomes limited. The entire care process is positively impacted by this advancement in patient assessment and management.

Key Words: *Ultrasonography – MRI – Clinical examinations – Restrictive range of movement – Shoulder joint.*

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Abbreviations:

AC : Acromioclavicular.
AR : Axillary recess.
CHL : Coracohumeral ligament.
LHBT : Long head of biceps tendon.
MHz : Mega Hertz.
MRI : Magnetic resonance imaging.
MSK : Musculoskeletal.
NPV : Negative predictive value.
p-value : Probability value.
PPV : Positive predictive value.
SD : Standard deviation.
SPSS : Statistical Package for the Social Science.
SST : Supraspinatus tendon.
STIR : Short time inversion recovery.
RC : Rotator cuff.
RI : Rotator interval.
ROC : Region operating characteristic.
ROM : Range of motion.
MHz : Mega Hertz.
US : Ultrasound/Ultrasonography.
WI : Weighted image.
2D : Two dimensional.

Introduction

SHOULDER issues frequently result from problems impairing one's ability to perform daily tasks. A clinical evaluation should be performed to determine the patient's active range of motion and degree of shoulder mobility. This will support the diagnosis and offer crucial details regarding functional restrictions **[1].**

A physical examination that includes inspection, palpation, and range-of-motion assessment may be necessary to evaluate shoulder issues **[2].**

In clinical practice, reduced shoulder range of motion (ROM) with an unclear cause continues to be a significant issue. This condition is referred to as adhesive capsulitis when the range of motion is completely limited. When a patient presents with a limited range of motion in the shoulder, other conditions to be taken into account are tendinopathy or tear in the rotator cuff (with or without impingement), biceps tendinopathy, glenohumeral osteoarthritis, acromioclavicular arthropathy, and subacromial and subdeltoid bursitis **[3].**

While each modality has limitations in certain situations, MRI and ultrasonography of the shoulder have demonstrated encouraging outcomes in the diagnosis of rotator cuff disease. Although it's an operator-dependent tool, ultrasound is used as the primary screening method because it's so affordable. The data on diseases other than rotator cuff disease is limited, but it has demonstrated high sensitivity and specificity primarily for rotator cuff disorders. MRI is thought to be a very effective diagnostic method for diseases of the shoulder. Nevertheless, patients with ferromagnetic implants and other cardiac devices that are incompatible with MRIs are among its drawbacks **[4].**

Determining the exact pathology is essential in choosing the right treatment for shoulder disorders because they can develop into chronic conditions **[5]**. In this study, we sought to determine the efficacy of MRI and ultrasound in identifying the precise cause of shoulder jointrange restriction in correlation with the clinical examination to determine the best course of treatment.

Patients and Methods

The "Ethical Committee of the Faculty of Medicine of our university" has approved the study (Code: MS-567-2022).

A cross-sectional study included100 patients (102 shoulder joints)with painful shoulders and limited range of motion. They were between the ages of 18 and 60.

Referrals from the Rheumatology outpatient clinic to the radiology department occurred between November 2022 and August 2023. Every patient had a clinical examination, a B-mode dynamic ultrasound and an MRI. For each patient, a provisional diagnosis was reported clinically, by US and by MRI.

The study included patients with painful and restricted shoulder movements. Patients with contraindications for MRI, post-operative or post-traumatic cases, and patients who dismissed either or both of the two radiology assessments US or MRI were not included in this study.

History and clinical examination:

The following factors were taken into consideration when properly analyzing the patient's complaint; the laterality of the inspected shoulder (left or right), any medications, involvement in sports, and the beginning, course, duration, and history of any diseases. A highly qualified rheumatology consultant with more than 15 years of experience performed an extensive clinical assessment that included the following:

- Checking for any deformity, swelling, or prominent acromioclavicular joint, as well as deltoid wasting.
- Any soreness that is felt.

The evaluation of both passive and active movements encompasses the following ranges: 0-165° for forward flexion, 0-160° for backward extension, 0-140° for horizontal flexion, 0-165° for abduction, 0-165° for adduction, 0-165° for forward flexion, 70° and 100° for internal and external rotation, and 70° for internal and external rotation in extension.

- Tests of the rotator cuff, including the Cross-body Adduction, Drop arm, Hawkins, Neer, and Painful arc.
- Clinically, the patients were classified into 4 groups. Painful and limited active movement, painful and non-limited active movement, painful limited passive movement and painful non-limited passive movement.
- A provisional clinical diagnosis was reported for each patient.

Ultrasonographic examination:

An ultrasound examination was performed using the Toshiba Ultrasound Aplio 500; Toshiba Medical, Japan machine, which uses a high-frequency (14 MHz) linear probe. Experts in musculoskeletal radiology with ten years of experience performed the US examination without access to the MRI report or clinical evaluation. Every patient received a dynamic examination in addition to a 2D power Doppler in multiple planes, color, and greyscale. Each patient had the following evaluated, and a preliminary diagnosis was given.

1- The rotator cuff tendons: The subscapularis, supraspinatus, and infraspinatus tendons were examined in short and long axes. Tendon thickness,

echogenicity, Doppler vascularity and effusion were assessed. The tendon was reported as either normal, tendinopathic, partial thickness or full thickness tear.

2- The long head biceps tendon (LHBT) was examined in the rotator interval (RI) and the bicipital groove, both short and long axis. Tendon thickness, echogenicity, Doppler vascularity, and effusion were assessed. The tendon was reported as either normal, tendinopathic or torn.

3- The RI was measured in the oblique short-axis plane with the patient seated and with their fist resting at their side. The shortest distance between the peribursal fat and the long head of the biceps tendon was used to define the RI thickness. The presence of a power Doppler signal inside the RI was given a binary score of present or absent.

4- The patient's shoulder joint was externally rotated to stretch the coracohumeral ligament (CHL). A linear hyperechoic band that extended up to the RI and originated from the coracoid process was observed and measured.

5- The acromioclavicular joint was examined for capsular thickening or osteoarthritis features.

6- A dynamic arm-raising test assessed the possibility of impingement.

7- The patient's forearm was placed in a neutral position and their elbow was flexed at a 90° angle to determine the axillary recess (AR) thickness. On the mid-axillary line, the ultrasound probe was positioned longitudinally along the humeral shaft's long axis. The AR thickness was determined by measuring the distance between the bony cortex and the outer edge of the glenohumeral joint capsule at the humeral surgical neck.

MRI Examination:

In our study, the MRI was conducted using a high-field (1.5 T) superconducting magnet from Philips Medical Systems. A shoulder or surface coil was used. Each patient was lying supine, with the affected arm by their sides. The shoulder that was being examined was rotated externally. Internal rotation was avoided because of the potential for the supraspinatus and subscapularis tendons to appear distorted.

Axial fat-suppressed proton density and T2WI, coronal T1WI, T2WI, and STIR, and sagittal fat-suppressed proton density, T2WI, and T1WI were all included in our examination protocol. The following were assessed by 10 and 15 years' experienced musculoskeletal radiology consultants. Images were reviewed and both reached a consensus after assessment of the following:

1- The rotator cuff tendons: The subscapularis, supraspinatus, infraspinatus tendons thickness, signal, presence of tear. The tendon was reported as either normal, tendinopathic, partial thickness or full thickness tear.

2- The LHBT was assessed in the rotator interval (RI) and the bicipital groove. Tendon thickness, signal and effusion were evaluated. The tendon was reported as either normal, tendinopathic or torn.

3- The RI was assessed in sagittal oblique images for clear fat, and granulation tissue around the LHBT, CHL thickness was measured (at the thickest visualized part of the ligament).

4- Using T2-weighted coronal images, the width of the axillary joint capsule was measured based on the separation between the outer border of the capsule and high signal fluid.

5- The acromioclavicular joint was assessed for capsular thickening or osteoarthritis features.

Data analysis:

The final diagnoses by clinical, US and MRI have been classified into:

• *Shoulder impingement syndrome:* Clinically, subacromial impingement was diagnosed by the presence of progressive anterosuperior pain and limited abduction, and painful arc test. Subcoracoid impingement was diagnosed by the presence of anterior pain and limited flexion, internal rotation and adduction. Implementing dynamic US, subacromial impingement is diagnosed by pain limiting raising the arm upward or by directly observing bursal fluid or tendon impingement between the greater tuberosity and acromion, while subcoracoid impingement was defined by limitation of shoulder internal rotation and pooling of subcoracoid bursal fluid. At MRI, narrowing of the acromio-humeral or coraco-humeral interval becomes less than 7 and 6mm respectively in the presence of abnormal intervening soft tissues.

• *Rotator cuff tendinopathy:* Clinically diagnosed by pain, weakness, and restriction of shoulder movement with Positive Hawkins and Neer test. By the US; tendon thickening, focal or diffuse hypoechogenicity, loss of the typical fibrillar tendon architecture, and hyperemia on color Doppler were the characteristics that were used to identify it. By MRI, tendon thickening and increased signal that does not extend to the articular or bursal surface with no visible discontinuity of tendon fibers.

• *Rotator cuff tear:* Clinically diagnosed by pain, weakness, and restriction of shoulder motion and positive drop arm test. By US and MRI, direct observation of partial or complete discontinuity of the tendons fibers was the base of diagnosis of partial or full thickness tear respectively.

• *Adhesive capsulitis:* Clinically diagnosed by restriction in both active and passive movement. By US and MRI, it was identified by an increase in CHL thickness >2.4mm, axillary recess capsule thickness >3.5mm, existence of hypoechoic soft tis-

sue in the rotator interval, either on a power Doppler scan with or without hypervascularity **[6].**

The following tests were done:

Test of agreements between clinical, ultrasound, and MRI diagnosis for each pathology:

- Comparison between the clinical and ultrasound diagnosis compared to MRI as a gold standard.
- Evaluations of the diagnostic accuracy indices, such as sensitivity, specificity, and positive and negative predictive values, for every pathology in clinical and ultrasonography settings in comparisonto magnetic resonance imaging (MRI), the gold standard.
- Correlation and test of significance using *p*-value for imaging signs and measurements of adhesive capsulitis in ultrasound and MRI according to active and passive range of movement assessments (painful and painful limited).
- ROC analysis for predictive values of the measurements of adhesive capsulitis.

Statistical methodology:

The 27th edition of SPSS was used for the statistical analysis, and the Chi^2 test was used to compare thecategorical variables that were presented as counts and percentages. After determining normality using the Shapiro-Wilk test, standard deviation and comparison were carried out using the Mann-Whitney U test for quantitative variables presented in the mean.

The Pearson correlation test assessed the linear correlation between quantitative variables. ROC analysis was conducted to detect the cutoff value between patients with adhesive capsulitis and those without affected joints. *p*-value <0.05 was considered significant.

The overall productivity of the parameters and the ideal cut-off value with the detection of sensitivity andspecificity at this cut-off value were found using receiver operating characteristic (ROC) curve analysis.

Using kappa statistics, determine the degree of agreement between the three diagnostic modalities (MRI, ultrasound, and clinical). A kappa of 0.40 to 0.75 is fair to good, 0.40 to 0.75 is excellent, and less than 0.40 is poor.

Sample size:

PASS software was used to determine the minimum sample size needed for the sensitivity and specificity test. Sonographic visualization of CHL at a cut-off value of 0.7mm was found to be accurate (sensitivity 93.1%, specificity 94.4%) for diagnosing adhesive capsulitis, based on the previous report by Tandon et al. **[7].** The percentage of the result is 0.1 when using the Modified Hypergeometric Exact, with an alpha error set at 5% and power at 80%. For the study, a minimum sample size of 51 patients is needed, which takes into account a 10% dropout rate.

Results

Patients' demographic data and clinical examination:

In the present cross-sectional study, 100 patients were included with a total number of 102 shoulders examined. Patients' demographic and clinical history details are listed in (Table 1).

Clinical examination results including inspection, palpation, range of movement assessment and clinical tests are detailed in (Table 2).

Table (1): Patient's demographics and clinical history.

Demographics		
Age (years):		
Mean ± SD	35.7±14.9	
Median	35	
Range	18-60	
	Count (n=100)	%
Sex:		
Male	56	56
Female	44	44
Chronic diseases:		
DM	12	11.8
Rheumatoid	2	2.0
Examined shoulders:		
Right	46	46
Left	54	54
Affected shoulders with restriction:		
Unilateral shoulder	98	98
Bilateral shoulders	2	2
Duration of symptoms (months):		
Mean ± SD	9.3±7.7	
Median	7	
Range	2-24	

Table (2): Clinical examination including inspection, palpation, range of movement assessment and clinical tests.

	Count (n=102)	%
Inspection:		
Prominent sternoclavicular joint	6	5.9
Deformity of clavicle	0	0.0
Prominent acromioclavicular	10	9.8
Deltoid wasting	0	0.0
Joint swelling	0	0.0
Winging of scapula	0	0.0
Palpation:		
Anterolateral aspect of the glenohumeral Joint	92	90.2
Upper humeral shaft and head	98	96.1
Over acromioclavicular joint	72	70.6
Along length of the clavicle	24	23.5
Below acromion	92	90.2

Table (2): Count.

	Count (n=102)	%
Movement assessment:		
Active range of motion:		
Abduction:		
Painful with limitation	94	92.2
Painful without limitation	8	7.8
Adduction:		
Painful with limitation	10	9.8
Painful without limitation	26	25.4
Forward flexion:		
Painful with limitation	74	72.5
Painful without limitation	14	13.7
Backward extension:		
Painful with limitation	74	72.5
Painful without limitation	14	13.7
Horizontal flexion:		
Painful with limitation	70	68.6
Painful without limitation	18	17.6
Internal rotation:		
Painful with limitation	76	74.5
Painful without limitation	24	23.5
External rotation:		
Painful with limitation	80	78.4
Painful without limitation	22	21.5
Passive range of motion:		
Abduction:		
Painful with limitation	0	0.0
Painful without limitation	58	56.8
Adduction:		
Painful with limitation	0	0.0
Painful without limitation	18	17.6
Forward flexion:		
Painful with limitation	0	0.0
Painful without limitation	30	29.4
Backward extension:		
Painful with limitation	0	0.0
Painful without limitation	34	33.3
Horizontal flexion:		
Painful with limitation	0	0.0
Painful without limitation	28	27.5
Internal rotation:		
Painful with limitation	0	0.0
Painful without limitation	58	56.8
External rotation:		
Painful with limitation	0	0.0
Painful without limitation	58	56.8
Rotator cuff muscle tests:		
Hawkins test	98	96.1
The cross-body adduction test	78	76.5
Neer test	84	82.4
Drop arm test	46	45.1
Painful arc test	54	52.9

Among the examined patients, (n=80/102, 78.4%) had painful limited active movement, (n=22/102, 21.6%) had painful non-limited active movement, (n=60/102, 58.8%) had painful non-limited passive movement while none in this study had limited passive movement (Table 3).

Table (3): Active and passive movement assessment.

Active and passive movement assessment	Count (n=102)	%
Active:		
Painful with limitation	80	78.4
Painful without limitation	22	21.6
Passive:		
Painful with limitation	0	0.0
Painful without limitation	60	58.8

Clinical diagnoses (Table 4) were rotator cuff tendinopathy/tendinosis (n=102/102, 100%), rotator cuff tears (n=46/102, 45.1%), shoulder impingement syndrome (n=54/102, 52.9%). Since non-had limited passive movement, there was no clinical diagnosis of adhesive capsulitis based on clinical examination. A combination of more than one clinical diagnosis was also documented (Table 5).

Ultrasound examination:

By ultrasound, (n=46/102, 45.1%) were diagnosed as rotator cuff tendinopathy, (n=32/102, 31.4%) as rotator cuff tear (Figs. 1,2), (n=32/102, 31.4%) as impingement syndrome (Fig. 3) and only two (n=2/102, 2%) shoulders were diagnosed with signs of adhesive capsulitis (Fig. 4) (Table 4). A combination of multiple clinical diagnoses was also documented (Table 5).

MRI:

According to MRI, (n=68/102, 66.7%) were diagnosed as rotator cuff tendinopathy, (n=40/102, 39.2%) as rotator cuff tear (Figs. 5,6), (n=18/102, 17.6%) as shoulder impingement syndrome and (n=28/102, 27.5%) as adhesive capsulitis (Fig. 7) (Table 4). A combination of multiple clinical diagnoses was also documented (Table 5).

Agreement between clinical, ultrasound, and MRI diagnoses:

Statistically, there was fair to good agreement between US and MRI in the diagnosis of rotator cuff tendinopathy, rotator cuff tear and shoulder impingement syndrome with the highest values (*p*-value <0.001, and Kappa 0.74) approaching excellent agreement in rotator cuff tear (Figs. 1,2,5,6). There was poor agreement between clinical and MRI in all the diagnoses and between US and MRI in adhesive capsulitis (Table 6) (Figs. 4,7).

Comparison between clinical, ultrasound, and MRI diagnoses:

When MRI was used as the gold standard, clinical diagnosis accuracy ranged from 67 to 82%, with rotator cuff tears having the highest accuracy. Ultrasound diagnostic accuracy ranged from 65 to 88%, again highest in rotator cuff tears. Both clinical and US had quite close overall diagnostic accuracies except in rotator cuff tendinopathy and tear, US had a higher diagnostic accuracy (Table 7).

Comparison of ultrasound and MRI measurements according to clinical active and passive movement assessment:

The assessed parameters and measurements at US and MRI were not statistically significant in patients with painful limited or non-limited active shoulder movements (*p*-values >0.05) as shown in (Table 8). On the other hand, patients with painful passive shoulder movement had statistically significant thicker rotator interval and axillary recess thickness by US with *p*-values 0.036, and <0.001 respectively (Fig. 4), and statistically significant thicker CHL and axillary capsule by MRI with *p*-values 0.002, and 0.029 respectively (Fig. 7). Also, painful passive movement was associated with a higher frequency and statistically significant rotator interval abnormal soft tissue infiltration, and obliterated subcoracoid fat triangle with *p*-values <0.001, and 0.025 respectively (Table 8) and (Fig. 7).

ROC analysis of the predictability of ultrasound and MRI measurements for adhesive capsulitis:

Ultrasound measurements of rotator Interval Thickness, CHL Thickness, and Axillary Recess Thickness couldn't significantly predict adhesive capsulitis, using a 2.2, 2.6, and 3.6 cutoff, respectively.

MRI measurements of the CHL and axillary joint capsule thickness alone couldn't predict adhesive capsulitis using 2.2 and 3.2mm cut-offs, respectively (Fig. 8).

Table (4): Clinical, US and MRI diagnoses of the examined shoulders.

	Count (n=102)	Percentage (%)	Count (n=102)	Percentage (%)	Count (n=102)	Percentage (%)
Diagnosis:	Clinical		US		MRI	
Rotator cuff tendinopathy	102	100	46	45.1	68	66.7
Rotator cuff tear	46	45.1	32	31.4	40	39.2
Shoulder impingement syndrome	54	52.9	32	31.4	18	17.6
Adhesive capsulitis	0	0.0	2	2	28	27.5

Table (5): Combined clinical, US and MRI diagnoses of the examined shoulders.

	Count (n=102)	Percentage (%)	Count (n=102)	Percentage (%)	Count (n=102)	Percentage (%)
Diagnosis:	Clinical		US		MRI	
Rotator cuff tendinopathy	34	33.3	12	–	22	21.5
Rotator cuff tear	–	–	2	1.9		
Rotator cuff tendinopathy + rotator cuff tear	14	13.7	14	–	14	13.7
Shoulder impingement syndrome			8	7.8	4	3.9
Shoulder impingement + rotator cuff tendinopathy	22	21.5	8	7.8	2	1.9
Shoulder impingement + rotator cuff tear			4	3.9		
Shoulder impingement + rotator cuff tendinopathy + rotator cuff tear	32	31.4	12	11.7	8	7.8
Adhesive capsulitis	–	–	–	–	4	3.9
Adhesive capsulitis + Rotator cuff Tendinopathy	–	–	2	1.9	4	3.9
Adhesive capsulitis + Rotator cuff tendinopathy + Tear	–	–	–	–	14	13.7
Adhesive capsulitis + Shoulder impingement syndrome + Rotator cuff tendinopathy + Tear	–	–	–	–	4	3.9

Table (6): Agreement between (clinical, Ultrasound, and MRI) diagnoses.

	Kappa	Standard error	*p*-value
Rotator cuff tendinopathy:			
Measure of Agreement clinical and MRI	0	0	NA
Measure of Agreement ultrasound and MRI	0.582	0.101	<0.001
Rotator cuff Tear:			
Measure of Agreement clinical and MRI	0	0	NA
Measure of Agreement ultrasound and MRI	0.744	0.097	<0.001
Shoulder impingement syndrome:			
Measure of Agreement clinical and MRI	0.320	0.095	0.002
Measure of Agreement ultrasound and MRI	0.432	0.137	0.001
Adhesive capsulitis:			
Measure of Agreement between clinical and MRI	0	0	NA
Measure of Agreement ultrasound and MRI	0.038	0.036	0.534

Table (7): Comparison between clinical, ultrasound, and MRI diagnoses.

	Diagnostic indices							
	Ratator cuff tendinopathy		Ratator cuff tear		Shoulder impingement		Adhesive capsulitis	
	Clinical	US	Clinical	US	Clinical	US	Clinical	US
Sensitivity	100.0%	67.7%	85.0%	75.0%	48.15%	33.33%	0.0%	0.0%
Specificity	0.0%	100%	79.3%	96.8%	87.50%	100.0%	100.0%	97.3%
PPV	66.7%	100%	73.9%	93.8%	81.25%	100.0%	0.0%	0.0%
NPV	61.11%	60.7%	88.5%	85.7%	60.00%	57.14%	72.5%	72.0%
Diagnostic accuracy	66.7%	78.4%	81.6%	88.2%	66.67%	64.71%	72.5%	70.6%

Table (8): Comparison of ultrasound and MRI measurements according to clinical active and passive movement assessment.

Ultrasound	Movement assessment									
	Active					Passive				
	Painful limited		Painful		*p*-value	Painful		Not painful or limited		*p*-value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Rotator Interval Thickness (mm)	3	0.8	2.4	0.8	0.067	3.1	0.7	2.6	0.8	0.036
Coracohumeral ligament Thickness (mm)	2.4	0.3	2.3	0.3	0.692	2.4	0.4	2.3	0.3	0.312
Axillary Recess Thickness (mm)	3.1	0.8	2.7	0.6	0.165	3.4	0.8	2.6	0.6	<0.001
	Count	%	Count	%	*p*-value	Count	%	Count	%	*p*-value
LHBT sheath effusion:										
No	76	95	22	100	0.449	56	93.3	42	100	0.227
Yes	4	5	0	0		4	6.7	0	0	
MRI										
	Mean	SD	Mean	SD	*p*-value	Mean	SD	Mean	SD	*p*-value
Coracohumeral ligament thickness (mm)	2.6	0.8	2.4	0.6	0.200	2.8	0.8	2.2	0.5	0.002
Axillary joint capsule thickness (mm)	3.3	0.6	3.1	0.4	0.228	3.4	0.6	3.1	0.4	0.029
	Count	%	Count	%	*p*-value	Count	%	Count	%	*p*-value
Rotator interval abnormal soft tissue infiltration:										
No	48	60.0	20	90.9	0.054	28	46.7	40	95.2	<0.001
Yes	32	40.0	2	9.1		32	53.3	2	4.8	
Obliterated subcoracoid fat triangle:										
No	62	77.5	20	90.9	0.321	42	70.0	40	95.2	0.025
Yes	18	22.5	2	9.1		18	30.0	2	4.8	

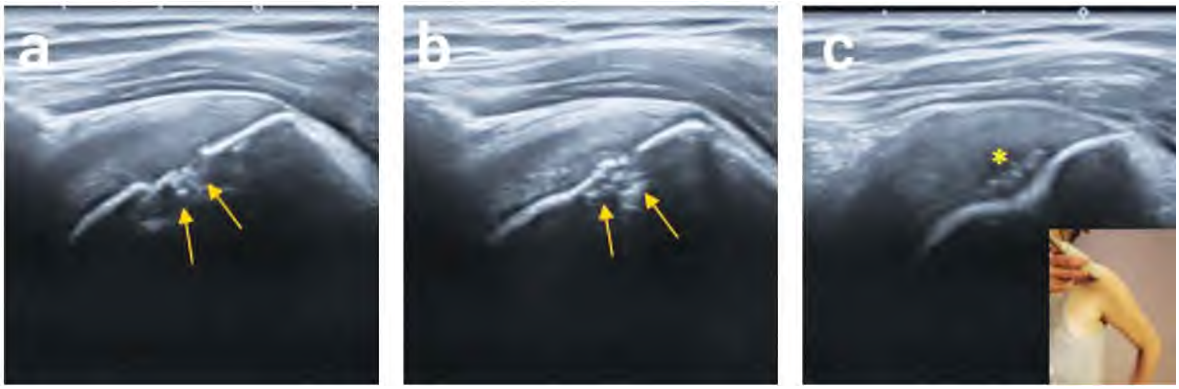

Fig. (1): 60-year-old female patient complaining of right shoulder pain and limitation of movements for 4 months duration. The active movements were painful with limitation and passive movements were painful. The drop arm, Hawkins test, Neer test and Cross-body test were positive. The patient was clinically diagnosed with rotator cuff tendinopathy and tear. B mode assessment of the right supraspinatus tendon in the long axis (a&b): Showed cortical irregularity of greater tuberosity (arrows), and (c) Hypoechoic partial articular surface tear (*) was noted. Probe position image [22].

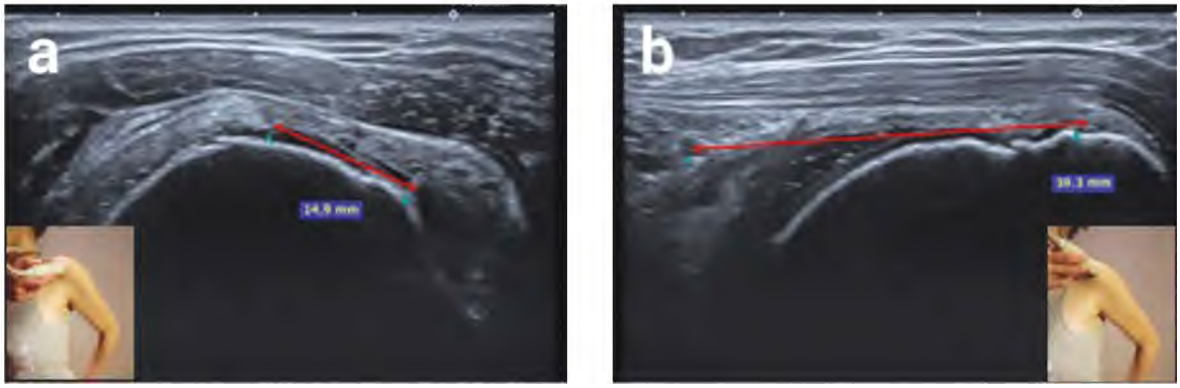

Fig. (2): 55-year-old male patient complaining of shoulder pain and limitation of movements of the right shoulder for 1-year duration. Active movements were painful and limited while passive movements were painful.The drop arm test, Hawkins test, Neer test and Cross-body test were positive. The patient was clinically diagnosed with full-thickness supraspinatus tear. B-mode assessment of the right supraspinatus tendon in the short axis (a) and long axis (b) revealed a retracted, complete tear of the supraspinatus tendon with a gap (TS: 14.9mm and LS: 39.3mm). Probe position image [22].

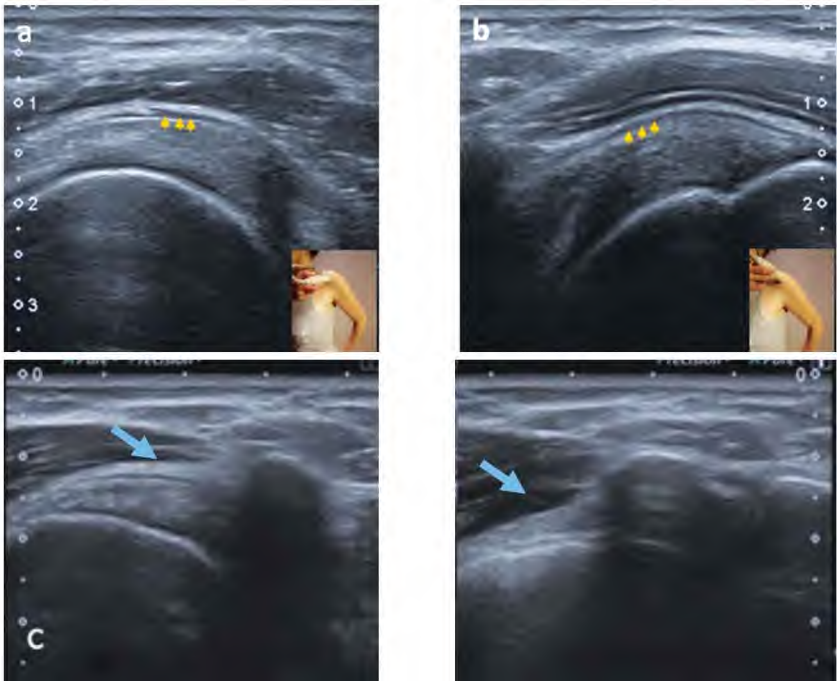

Fig. (3): B mode assessment in the short axis (a) and the long axis (b) shows minimal distended subacromial/subdeltoid bursa (arrowheads) associated with mild supraspinatus tendinosis. Probe position image [22]. (c) Dynamic US Coronal view of the left shoulder with subacromial bursa (arrow) impingement during arm elevation.

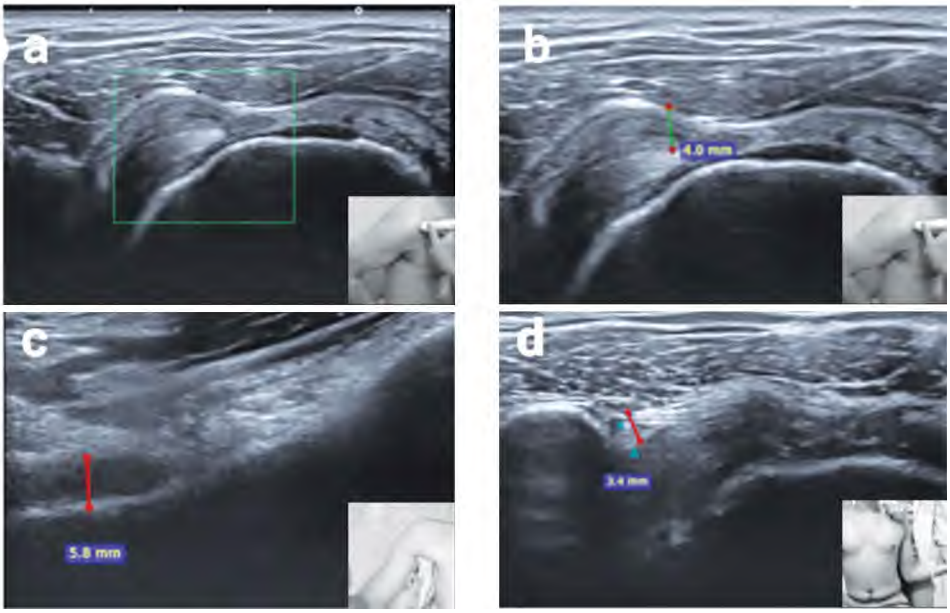

Fig. (4): The same patient as in Fig. (3). Active movements were painful and limited while passive movements were painful. Assessment of RI: (a) RI colour Doppler: No vascularity detected. (b) RI thickness (4mm), (c) AR thickness (5.8mm) (d) CHL thickness (3.4mm. Probe position images [13,21].

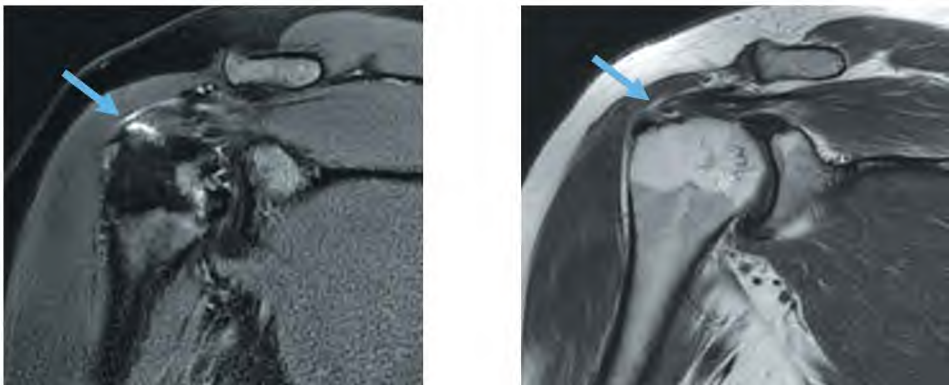

Fig. (5): Same patient in Fig. (1). Coronal STIR T2WI (a) and T2WI (b) MRI scan: Shows supraspinatus partial articular surface tear (arrow) with tendinopathy: There wasan intra-substance increased signal in T2/STIR near the humeral insertion, reaching the articular surface.

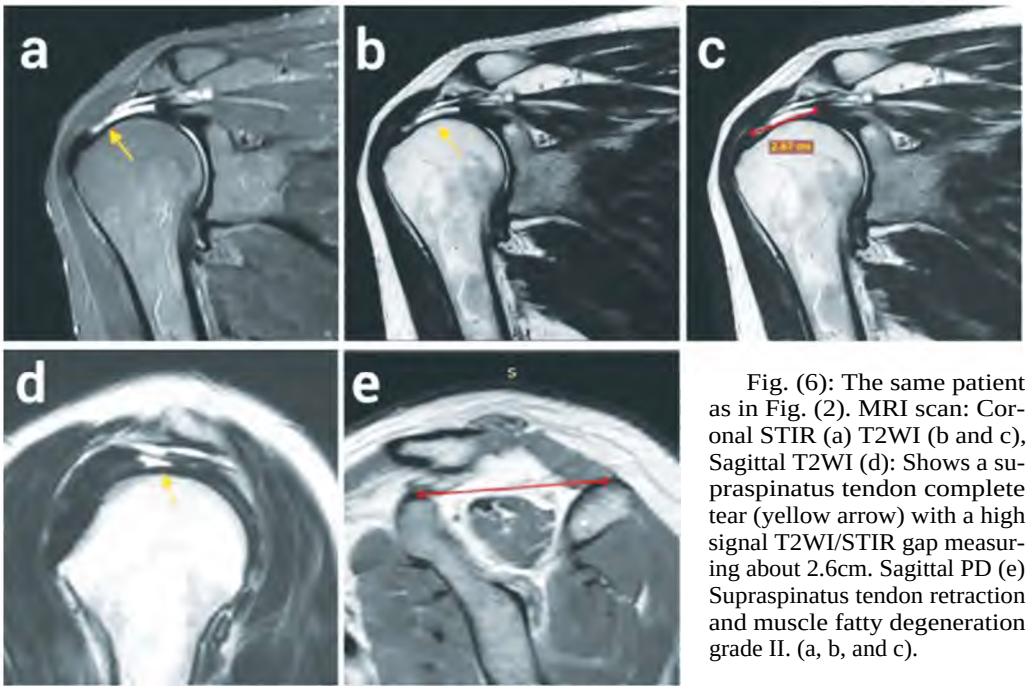

Fig. (6): The same patient as in Fig. (2). MRI scan: Coronal STIR (a) T2WI (b and c), Sagittal T2WI (d): Shows a supraspinatus tendon complete tear (yellow arrow) with a high signal T2WI/STIR gap measuring about 2.6cm. Sagittal PD (e) Supraspinatus tendon retraction and muscle fatty degeneration grade II. (a, b, and c).

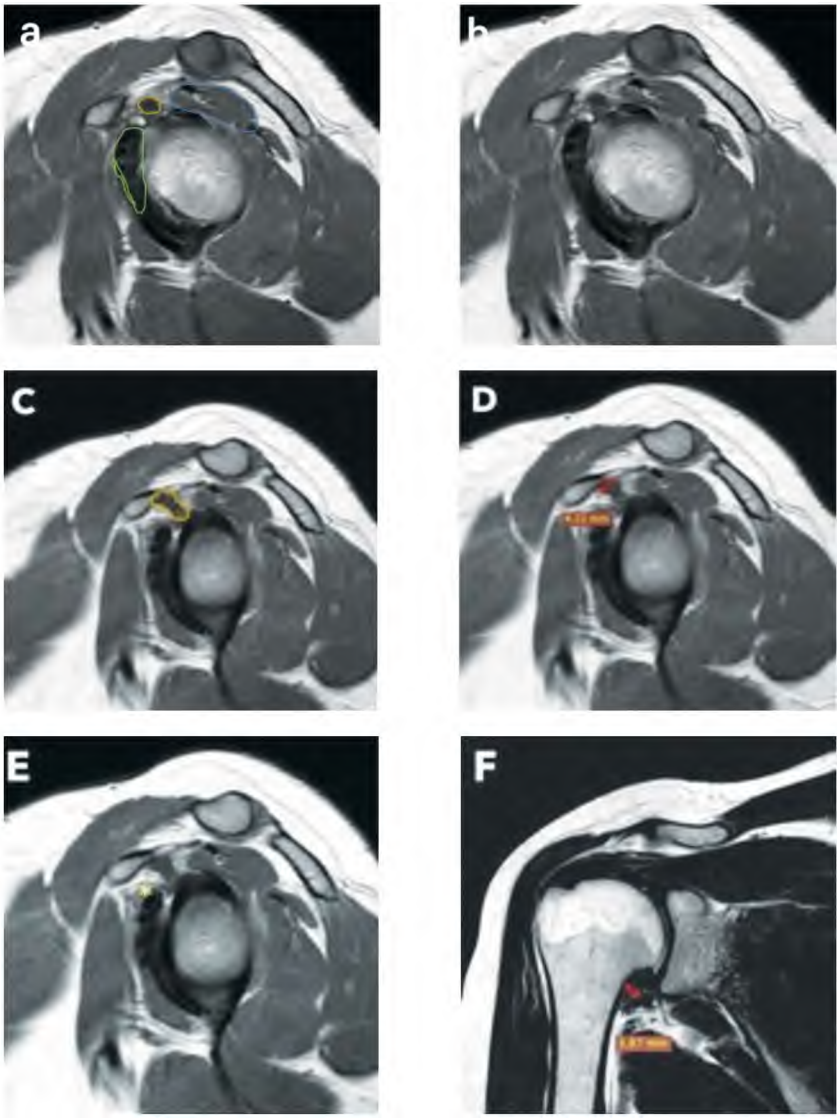

Fig. (7): The same patient as in Fig. (3). Sagittal PD (a) and (b) MRI scan: Shows soft tissue low signal within rotator interval surrounding the long head of biceps (yellow). Sagittal PD (c) and (d) MRI scan: Showed a thickened CHL (yellow) measuring about 4.2mm. Sagittal PD MRI scan: (e) Partial obliteration of the subcoracoid fat triangle (*) Coronal T2WI (f) Measurement of axillary joint capsule thickness (3.8mm).

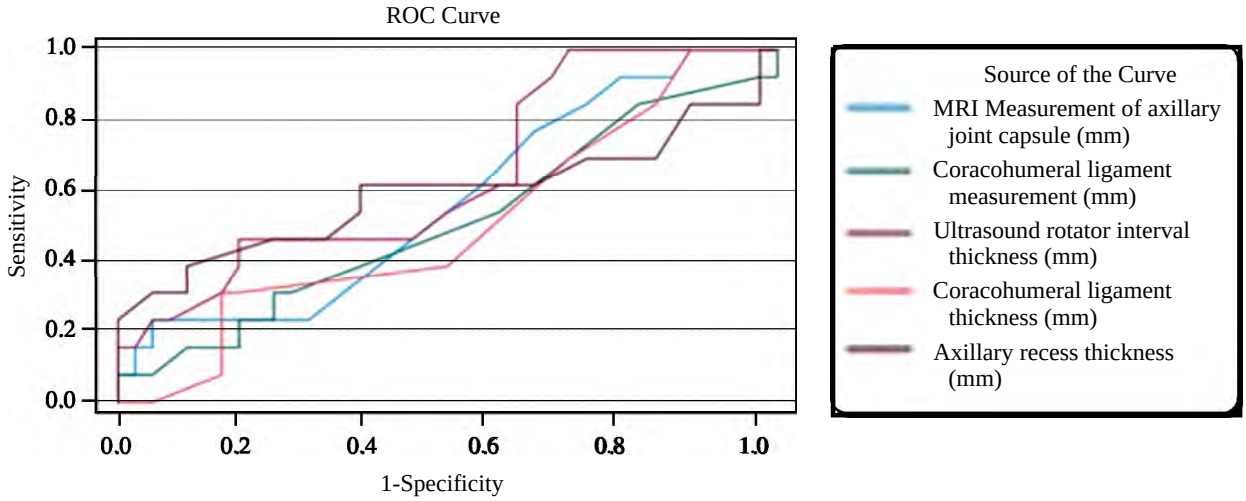

Fig. (8): ROC curve showing the predictability of ultrasound and MRI measurements for adhesive capsulitis.

Discussion

In patients with a limited range of motion in their shoulders, this study examined the relationships between clinical characteristics, static and dynamic US findings, and MRI findings.

The 100 patients presented with restricted ROM were classified into four groups of pathologies: (Adhesive capsulitis), shoulder impingement syndrome, rotator cuff tendinopathy, and tear. However, none of the cases were clinically diagnosed with frozen shoulder, as the limited ROM was observed only during the active movement assessment.

In our study, the agreement between clinical, ultrasound, and MRI diagnosis was evaluated using the Kappa coefficient. There was greater significance in the agreement between MRI and ultrasound.

Our results showed fair to good agreement between US and MRI in the diagnosis of rotator cuff tendinopathy, rotator cuff tear and shoulder impingement syndrome with the highest values approaching excellent agreement in rotator cuff tear.

The results for rotator cuff (RC) tendinopathy were marginally lower than those of studies by *[8,9]*, which found high agreement between US and MRI (Kappa = 0.71-0.72); however, our results for RC tears were comparable to those of studies by *[10,11]*, which found high agreement with Kappa 0.63 and 0.79 respectively.

Regarding shoulder impingement syndrome, the results differed from those of *[8,12]* who reported good agreement between MRI and ultrasound with Kappa 0.79, and 0.80 respectively.

There was poor agreement between clinical and MRI in all the diagnoses and between US and MRI in adhesive capsulitis.

This may be explained by the fact that adhesive capsulitis is less common than rotator cuff tears and subacromial impingement syndrome and that sometimes it can be challenging to distinguish between the two based only on clinical presentation *[13]*.

However, *[6]* noted that several illnesses, such as glenohumeral or acromioclavicular arthritis, and full- and partial-thickness rotator cuff tears, can present with symptoms resembling those of adhesive capsulitis. Consequently, when adhesive capsulitis is diagnosed in its early stages or when clinical features are unusual, radiologic findings may be crucial.

Among 28 patients who showed imaging signs of adhesive capsulitis by MRI, rotator cuff tears were diagnosed by MRI in 18 out of 28, of which 8 were full-thickness tears. This may be consistent with the findings of *[13]*, who reported that a secondary frozen shoulder may occur in patients with rotator cuff tears, particularly full-thickness tears. Therefore, to accurately diagnose adhesive capsulitis and determine the best course of treatment, it is crucial to investigate some distinctive imaging findings.

With MRI acting as the gold standard, the diagnostic accuracy of clinical diagnosis alone ranged from 67 to 82%, with rotator cuff tears having the highest accuracy. Diagnostic accuracy of ultrasounds varied from 65 to 88%, with rotator cuff tears having the highest accuracy.

Our results were compared to those of *[2]*, who discovered that MRI results with high sensitivity and accuracy (89.66% and 56.03%, respectively) when diagnosing rotator cuff tears were comparable to clinical evaluation using characteristic tests. Studies by *[15,16]* that demonstrated high sensitivity and specificity in detecting RC tears by ultrasound compared to MRI corroborated our findings.

Patients in this study who experienced pain during passive shoulder movement hadstatistically significant thicker axillary recess and rotator interval by US, and statistically significant thicker axillary capsule and CHL by MRI. These results are consistent with a study by *[17]*, which discovered that a thicker CHL ligament is a strong indicator of adhesive capsulitis.

These findings align with those of *[18]*, who found a connection between the thickness of the joint capsule in the axillary pouch and the discomfort and limited range of motion experienced by patients with adhesive capsulitis. On the other hand, *[19]* discovered no association between the thickness of the capsule and the range of motion.

An obliterated subcoracoid fat triangle, abnormal soft tissue infiltration at the rotator interval, and a higher frequency of these findings were associated in our study with a painful passive movement. Past research *[20,21]* indicated that CHL thickening and subcoracoid fat triangle obliteration are critical indicators of adhesive capsulitis.

Using 2.2, 2.6, and 3.6 cutoffs, respectively, ultrasound measurements of rotator interval thickness, CHL thickness, and axillary recess thickness were not able to significantly predict adhesive capsulitis.

The results of the study by *[17]* which discovered that a thicker CHL strongly suggests the presence of adhesive capsulitis, did not correlate with thesefindings. However, *[19]* found that there was no correlation between the removal of fat from the subcoracoid triangle and clinical dysfunction, nor was there any relationship found between the thickness of the capsule and the range of motion.

With 2.2 and 3.2mm cut-offs, respectively, adhesive capsulitis could not be predicted solely by MRI measurements of the CHL and axillary joint capsule thickness.

Our results also disagreed with the **[22]** study, which compared the axillary recess capsule thickness in patients with adhesive capsulitis that was clinically proven to exist between US and MRI measurements. Their investigation showed a relationship between these measurements, indicating that the MRI mean thickness was 8.9mm and the ultrasound mean thickness was 4.4mm.

Limitations:

The first limitation of the study was that none of the subjects had restricted passive movement or a clinical diagnosis of adhesive capsulitis. Second, we cannot obtain more conclusive results from the small number of patients who show imaging evidence of early adhesive capsulitis and they had no follow-up. Lastly, the dynamic ultrasound assessment was difficult due to the anatomic variability and limited scanning position brought on by shoulder pain and limited range of motion.

Conclusions:

We concluded that the US can still be used to diagnose a variety of shoulder conditions, even in cases where the patient's range of motion was limited. MRI is better than other techniques for identifying adhesive capsulitis in its early stages because it exhibited a strong correlation with the clinical assessment of passive ROM. This knowledge in patient assessment and management has a positive effect on the entire care process.

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الارتباطات بين الفحص الدورى والتصوير بالموجات فوق الصوتية ونتائج التصوير بالرنين المغناطيسى فى أسباب مختلفة من مجموعة مؤلمة أو محدودة من الحركة فى مفصل الكتف

لا يزال انخفاض حركة الكتف مع سبب غير واضح يمثل مشكلة كبيرة في الكشف الدورى. تعرف هذه الحالة باسم التهاب المحفظة اللاصق عندما يكون نطاق الحركة محدودا تماماً. يجب أن تؤخذ فى الاعتبار حالات أخرى مثل اعتلال أوتار الكفة المدورة أو التمزق.

الهدف من الدراسة: تقييم مساهمة التصوير بالرنين المغناطيسى والموجات فوق الصوتية فى تشخيص مختلف قيود نطاق حركة مفصل الكتف.

كان هناك ١٠٠ مريض فى الدراسة ، مجموعه ١٠٢ كتف مع حركات الكتف المؤلمة والمقيدة. وكانت هناك ٥٦ حالة من الذكور (٥٦ فى المائة) و ٤٤ حالة للإناث (٤٤ فى المائة). خضع كل مريض للفحص الدورى والفحص بالموجات فوق الصوتية والرنين المغناطيسى.

اعتلال أوتار الكفة المدورة، متلازمة اصطدام الكتف والتهاب المحفظة اللاصق كانت من المسببات المختلفة للحركات المقيدة للكتف. أظهرت تشخيصات تمزق الكفة المدورة واعتلال الأوتار اتفاقاً معتدلاً ومرتفعاً، على التوالى، بين التصوير بالرنين المغناطيسى والموجات فوق الصوتية. ومع ذلك، من حيث التهاب المحفظة اللاصق، كان هناك اتفاق ضئيل بين الفحص الدورى والتصوير بالرنين المغناطيسى والموجات فوق الصوتية. بالإضافة. تم الاتفاق على تشخيص متلازمة اصطدام الكتف عن طريق التصوير بالرنين المغناطيسى والتقييمات السريرية والموجات فوق الصوتية بشكل جيد إلى حد ما.

كانت دقة التشخيص فى الموجات فوق الصوتية أعلى من الفحص الدورى فى اعتلال أوتار الكفة المدورة والتمزق بنسبة ٧٨,٤٪ و ٨٨,٢٪ على التوالى.

الخلاصة: توصلنا إلى استنتاج مفاده أنه على الرغم من تقييد نطاق حركة المرضى، لا يزال من الممكن استخدام الموجات فوق الصوتية لتشخيص مجموعة متنوعة من حالات الكتف بأعلى أداء في اعتلال أوتار الكفة المدورة والتمزق. نظراً لأن التصوير بالرنين المغناطيسى أظهر ارتباطا قوياً بالتقييم السلبى المؤلم، فقد توصلنا أيضا إلى أن التصوير بالرنين المغناطيسى يتفوق على الطرق الاخرى لتشخيص التهاب المحفظة اللاصق فى مراحله المبكرة قبل أن تصبح الحركة السلبية محدودة. تتأثر عملية الرعاية الدورية بأكملها بشكل إيجابى بهذا التقدم فى تقييم المرضى وإدارتهم.