ISSN:0975 -3583,0976-2833 VOL 14, ISSUE 03, 2023

Original research article

ASSESSMENT OF ROTATOR INTERVAL AND ITS PATHOLOGIES IN MRI WITH ULTRASONOGRAPHY CORRELATION

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Abstract

Background: This study aims at evaluating normal anatomy of rotator interval and its structures both on ultrasonography and MRI. Secondly to standardise the ultrasonography technique. To validate the efficacy of grey scale ultrasonography in evaluating the normal rotator interval anatomy, its pathologies and to correlate with MRI findings. The following pathologies have been observed coracohumeral ligament tears, long head of biceps tendon tears and dislocation, biceps pulley injuries and Periarthritis of shoulder joint.

Materials and Methods: A Prospective observational Study was done among 30 Patients who were clinically diagnosed / suspicious for rotator interval pathologies in Department of Radio diagnosis, Kamineni Hospitals. L.B. Nagar, Hyderabad for a period of 12 months. Patients with Malignant lesions, Trauma, Massive Rotator Cuff injuries were excluded from the study. Informed consent was obtained from the patients or from the nearest kin of the patients included in this study. A complete history of patient’s present/past illness was taken, and detailed clinical examination was performed in all the cases and findings were recorded in the pre structured questionnaire. Initially MRI was done and the examiner is blind folded to MRI findings, then patients taken for USG examination. Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions. Chi-square test or Fischer Exact test was used as test of significance for qualitative data. Validity of USG was estimated by Sensitivity, Specificity, PPV, and NPV. p value of <0.05 was considered as statistically significant.

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Results: Out of 30 subjects majority were in the age group 51 to 60 years (40%) and majority of them were males (60%). 21 (70%) of subjects had Coracohumeral Ligament Thickening, 4 (13.3%) of subjects had Coracohumeral Ligament Tear, 2 (6.7%) of subjects had Superior glenohumeral ligament tear, 1 (3.3%) of subjects had Long head of biceps tendon - Tear, 2 (6.7%) of subjects had Long head of biceps tendon- Subluxation / Dislocation, 9 (30%) of subjects had associated Tears in Anterior Supraspinatus, 5 (16.7%) of subjects had associated Tears in Superior Subscapularis Tendon, 10 (33.3%) of subjects had as Fluid along Long Head of Biceps Tendon. All the above described Rotator interval pathologies were diagnosed by USG with 100% Sensitivity, Specificity and diagnostic accuracy.

Conclusion: The study concludes that MRI is a useful radiological modality in diagnosis of Rotator interval pathologies as it helps in discriminating between normal anatomy and pathologic changes associated with the Rotator Interval. USG had similar diagnostic accuracy of MRI in diagnosis of RI pathologies such as Coracohumeral ligament thickening, Coracohumeral ligament tear, long head of biceps tendon - tear, long head of biceps tendon- dislocation, Rotator Interval - Inflammation/Fluid, associated tears in anterior Supraspinatus, associated tears in superior Subscapularis tendon and fluid along long head of bicep tendon. Few cases of Superior Gleno Humeral Ligament tears and subcoracoid fat obliteration in case of periarthritis of shoulder could not be evaluated in grey scale ultrasonography.

Keywords: Rotator interval, MRI, USG

Introduction

Rotator Interval (RI) is the triangular musculotendinious defect in the rotator cuff in the anterosuperior aspect. All these structures helps in maintaining the stability of the joint and its biomechanical functioning. The close relationship with the joint capsule and nearby anatomical structures, such as the long head of biceps tendon and Coracohumeral ligament, etc., increases its importance [1].

The RI’s role in biceps tendinopathy, SLAP lesions and glenohumeral instability has been recently popularized in shoulder literature [2]. The Rotator interval (RI) and Rotator Capsule (RC) structures are not visible on plain radiographs. MRI or USG is widely used in the screening of these anatomical structures. The Rotator Capsule can be observed in routine shoulder MRI screening in patients with rotator cuff symptoms in all planes. Some authors state that the abduction, external rotation (ABER) is the best position for viewing the rotator cuff and cable pathologies. This is attributed to the decreased tension of ruptured rotator cuff fibres and avoidance of adherence to adjacent intact cuff tissue [3]. Tamborrini *et al.* [4] reported that musculoskeletal US is another superior technique used to visualize the RI. Pathologies of the anatomic structures within the RI (including tendinosis, tears and capsulitis) can be imaged using USG with a better resolution than any other techniques. With the above background on Rotator interval and its structures and limited literature with respect to pathologies of RI, especially determining the role of USG in diagnosis of RI pathologies in comparison with MRI. This study was conducted with the objectives to correlate various rotator interval pathologies including biceps pulley injuries, periarthritis of shoulder. Comparing USG findings with MRI findings in Rotator interval pathologies and grading of rotator interval tears.

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Material and Methods

Study Setting: Department of Radio diagnosis, Kamineni Hospitals. L.B. Nagar, Hyderabad.

Study Population: Subjects who were clinically diagnosed / suspicious for rotator interval pathologies

Inclusion criteria

1. Clinically diagnosed / suspicious rotator interval pathologies
2. All subjects undergoing MRI shoulder for pain and restricted movements.

Exclusion criteria

Malignant Lesions, Trauma, Massive Rotator Cuff Injuries, Recurrent Shoulder Dislocations and Patient undergoing MR arthrography were excluded from the study.

Type of Study: Prospective observational Study.

Study Duration: 12 months (June 2018 to May 2019).

Sample Size

Universal sampling was done in the present study i.e. all the patients with pain in shoulder or restricted movements or suspicious to have Rotator interval injury by MRI and USG during the study period were included in the study. In our study during the study period 30 subjects with pain in shoulder and suspicious to have Rotator interval pathology were included in the study for analysis.

Method of Collection of Data

Informed consent was obtained from the patients or from the nearest kin of the patients included in this study. A complete history of patient's present/past illness was taken, and detailed clinical examination was performed in all the cases and findings were recorded in the pre structured questionnaire. Initially MRI was done and the examiner is blind folded to MRI findings, then patients taken for USG examination.

Technique of MRI

All scans were done on Siemens symphony MR Machine with super conducting magnet and field strength of 1.5 tesla using standard spin echo imaging techniques.

Patient placed with arm in adduction and external rotation.

T_1 spin echo sagittal /oblique.

T_2 Medic axial/coronal.

PDFS axial/coronal/sagittal.

Technique of USG

The ultrasound examinations were performed using high resolution (12 MHz) linear probe on Philips IU 22 ultrasound machine. Modified crass position and crass position was used for visualisation of these structures. The rotator interval was imaged in cross

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section at three levels: proximal (as far medially as it could be visualised), mid and distal (at the biceps reflection pulley level). The rotator cable was identified on sagittal images as a linear band running on the under surface of Supraspinatus tendon in continuity with the Coracohumeral ligament anteriorly and with its fibres running perpendicular to direction of Supraspinatus tendon fibres.

External and internal rotation performed to check for instability of the biceps tendon. The Supraspinatus and subscapular tendons were viewed carefully to detect abnormalities such as tears, calcifications, tendinosis, and degeneration. Detailed analysis of rotator interval and Coracohumeral ligament was obtained in short axis are noted in the mid-level or at thickest the visualized stretch of the ligament.

Statistical Analysis [5, 6, 7, 8]

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version **(**IBM SPSS Statistics, Somers NY, USA) software. Categorical data was represented in the form of Frequencies and proportions. Chi-square test or Fischer's exact test was used as test of significance for qualitative data. Validity of USG was measured by estimating Sensitivity, Specificity, Positive predictive value, Negative predictive value and Diagnostic accuracy. p value of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.

Ethical Considerations

Institutional Ethics Committee approval was obtained prior to the start of the study. Informed consent was obtained from all the subjects prior to the inclusion in the study.

Results

In the study 30 subjects with pain in shoulder or restricted movements or suspicious to have Rotator interval injury by MRI and USG were included. Of them majority i.e., 40% were in the age group 51 to 60 years, 18 subjects (68%) were males and 12 subjects (32%) were females. In the study 80% were diagnosed to have periarthritis, 6.7% were normal and 3.3% had Corocohumeral Ligament Tear, and Complete Tear of LHBT.

Table 1: RI pathology USG findings comparison with MRI

USG		MRI				P value
		Yes		No		
Coracohumeral Ligament Thickening	Yes	21	100.0%	0	0.0%	<0.001*
	No	0	0.0%	9	100.0%	
Coracohumeral Ligament Tear	Yes	4	100.0%	0	0.0%	<0.001*
	No	0	0.0%	26	100.0%	
Superior glenohumeral ligament tear	Yes	1	50.0%	0	0.0%	<0.001*
	No	1	50.0%	28	100.0%	
Long head of biceps tendon - Tear	Yes	1	100.0%	0	0.0%	<0.001*
	No	0	0.0%	29	100.0%	
Long head of biceps	Yes	2	100.0%	0	0.0%	<0.001*

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tendon Dislocation (Type II Bennett's)	No	0	0.0%	28	100.0%	
Rotator Interval - Inflammation/Fluid	Yes	21	95.5%	0	0.0%	<0.001*
	No	1	4.5%	8	100.0%	
Subcoracoid Fat Obliteration	No	6	100.0%	24	100.0%	-
Associated Tears in Anterior Supraspinatus	Yes	9	100.0%	0	0.0%	<0.001*
	No	0	0.0%	21	100.0%	
Associated Tears in Superior Subscapularis Tendon	Yes	5	100.0%	0	0.0%	<0.001*
	No	0	0.0%	25	100.0%	
Fluid along Long Head of Bicep Tendon	Yes	10	100.0%	0	0.0%	<0.001*
	No	0	0.0%	20	100.0%	

In the study on MRI 21 subjects had Coracohumeral Ligament Thickening, 4 subjects had Coracohumeral Ligament Tear, 2 subjects had Superior glenohumeral ligament tear, 1 subject had Long head of biceps tendon tear, 2 subjects had Long head of biceps tendon Dislocation, 22 subjects had Rotator Interval - Inflammation/Fluid, 6 subjects had Subcoracoid Fat Obliteration, 9 subjects had Associated Tears in Anterior Supraspinatus, 5 subjects had Associated Tears in Superior Subscapularis Tendon and 10 subjects had Fluid along Long Head of Bicep Tendon. All the RI pathologies were diagnosed by USG except for 1 case of Superior glenohumeral ligament tear, 1 case of Rotator Interval - Inflammation/Fluid, 6 cases of Subcoracoid Fat Obliteration compared to USG.

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Table 2: Validity of USG in diagnosing RI pathologies in comparison with MRI

	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Diagnostic Accuracy (95% CI)	Cohen's kappa (95% CI)
Coracohumeral Ligament Thickening	100% (84.54, 100)	100% (70.08, 100)	100% (84.54, 100)	100% (70.08, 100)	100% (88.65, 100)	1 (0.6422 - 1.358)
Coracohumeral Ligament Tear	100% (51.01, 100)	100% (87.13, 100)	100% (51.01, 100)	100% (87.13, 100)	100% (88.65, 100)	1 (0.6422 - 1.358)
Superior glenohumeral ligament tear	50% (9.453, 90.55)	100% (87.94, 100)	100% (20.65, 100)	96.55% (82.8, 99.39)	96.67% (83.3, 99.41)	0.6512 (0.3158 - 0.986)
Long head of biceps tendon - Tear	100% (20.65, 100)	100% (88.3, 100)	100% (20.65, 100)	100% (88.3, 100)	100% (88.65, 100)	1 (0.6422 - 1.358)
Long head of biceps tendon Dislocation	100% (34.24, 100)	100% (87.94, 100)	100% (34.24, 100)	100% (87.94, 100)	100% (88.65, 100)	1 (0.6422 - 1.358)
Rotator Interval - Inflammation/Fluid	95.45% (78.2, 99.19)	100% (67.56, 100)	100% (84.54, 100)	88.89% (56.5, 98.01)	96.67% (83.3, 99.41)	0.918 (0.5614 - 1.275)
Subcoracoid Fat Obliteration	95.45% (78.2, 99.19)	100% (67.56, 100)	100% (84.54, 100)	88.89% (56.5, 98.01)	96.67% (83.3, 99.41)	0.918 (0.5614 - 1.275)
Associated Tears in Anterior Supraspinatus	0% (0.0, 39.03)	100% (86.2, 100)	-	80% (62.69, 90.5)	80% (62.69, 90.5)	-
Associated Tears in Superior Subscapularis Tendon	100% (70.08, 100)	100% (84.54, 100)	100% (70.08, 100)	100% (84.54, 100)	100% (88.65, 100)	1 (0.6422 - 1.358)
Fluid along Long Head of Bicep Tendon	100% (56.55, 100)	100% (86.68, 100)	100% (56.55, 100)	100% (86.68, 100)	100% (88.65, 100)	1 (0.6422 - 1.358)

Sensitivity, Specificity, PPV NPV and Diagnostic accuracy was 100% for USG in comparison with MRI for Coracohumeral Ligament Thickening, Coracohumeral Ligament Tear, Long head of biceps tendon - Tear, Associated Tears in Superior Subscapularis Tendon and Fluid along Long Head of Bicep Tendon.

Table 3: Association between Coracohumeral ligament thickening and periarthritis based on USG and MRI

		Thickening of CHL in USG				Thickening of CHL in MRI			
		<2 mm		>2 mm		<2 mm		>2 mm	
		Count	%	Count	%	Count	%	Count	%
Periarthritis	Present	5	20.8%	19	79.2%	6	25.0%	18	75.0%
	Absent	6	100%	0	0%	6	100%	0	0%
	P value	0.001*				0.003*			

Fisher Exact test *

Among 24 subjects with Periarthritis, 79.2% had Thickening >2 mm in USG and 20.8% had <2 mm thickening. There was significant association between Periarthritis and CHL Thickening >2 mm in USG. Among 24 subjects with Periarthritis, 75% had CHL Thickening >2 mm in MRI and 25% had <2 mm thickening. There was significant association between Periarthritis and CHL Thickening >2 mm in MRI.

Discussion

MRI is a practical, well accepted and accurate non-invasive imaging technique in patients presenting with shoulder pain and is imaging modality of choice when clinical examination suspecting the shoulder pathology when plain radiographs are normal or equivocal. The development of MR imaging afforded improved comprehensive visualization of the shoulder joint in a noninvasive manner. We evaluated MR imaging of the shoulder as it is evolving as an important imaging modality for that joint and Rotator interval in particular. Excellent soft tissue contrast and multiplanar acquisition provide optimal assessment of muscle, tendons, hyaline and fibrous cartilage, joint capsules, fat, bursae and bone marrow. In the review by Huri G *et al*., [9] RC and RI structures were not visible on plain radiographs. MRI or USG were widely used in the screening of rotator interval. The RI was observed in routine shoulder MRI screening in patients with rotator cuff symptoms in all planes. Bigoni BJ *et al*., suggested that since the RI is an intra-articular structure, it can only be seen on MRI if synovial fluid is prominent [10]. For this reason, a MR arthrogram is suggested in the presence of any injury of RI structures. The oblique sagittal MRI plane is the most useful sequence in evaluating the RI. On the sagittal plane, the RI capsule lies over the biceps pulley as a hypo-intense band. More medially, the CHL is visualized running from the coracoid process to the humeral head covering the long head of biceps tendon. Conversely, the SGHL is harder to visualize than the other structures of the RI.

In an MRI study by Chung *et al*., the SGHL was not seen at all in all routine MRI views, and the CHL was observed only in 60% of cases [11]. Zappia *et al*., suggested that CHL can also be observed by experienced radiologists as a part of the anterosuperior capsuloligamentous complex [12].

Tamborrini *et al*. [4] in their study reported that musculoskeletal USG is a superior technique used to visualize the RI. Many pathologies of the anatomic structures within the RI (including tendinosis, tears and capsulitis) can be imaged using US with a better

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resolution than any other techniques. The only limiting factor is the decreased visualization while observing the soft tissue beneath any bony structure such as the acromion [13]. Also, USG is dependent on the ability of radiologists' diagnostic experience; decisions on appropriate imaging techniques should be made taking this into consideration.

In the study by S. Doring *et al*. [14] on 50 asymptomatic shoulders, 22 shoulders were from female subjects with ages ranging from 26 years to 52 years and 28 shoulders were from male subjects with ages ranging from 22 years to 59 years were evaluated for rotator cuff interval and rotator cable. The study suggested that Rotator cuff interval and rotator cable play an important role in several shoulder pathologies. A thorough detailed knowledge of the normal ultrasound appearance of rotator cuff interval and rotator cable added to the diagnostic capabilities which in turn could influence the management strategies of shoulder pathologies. Ultrasound is also an easily available imaging modality with many advantages.

Hence the present study and studies by other authors suggested that MRI is an excellent tool in diagnosis of Rotator interval pathologies. MRI provides a unique perspective on the anatomy of the rotator cuff capsule, and radiologists can assess these ligaments on MRI because lesions of the CHL and SGHL explain the occurrence of biceps tendinopathies associated with rotator cuff tears. Routine MSUS imaging of the rotator interval will help in amplifying diagnostic ability in patients with shoulder pain due to rotator interval pathologies and improve the diagnostic accuracy.

Conclusion

The study concludes that MRI is a useful radiological modality in diagnosis of Rotator interval pathologies as it helps in discriminating between normal anatomy and pathologic changes associated with the Rotator Interval. In the present study on MRI, diagnosis was possible in all the lesions of Rotator intervals. MRI was helpful in ruling out pathologies of Superior glenohumeral ligament tears. The study concluded that USG had similar diagnostic accuracy (100%) of MRI in diagnosis of RI pathologies. USG had Sensitivity of 50% in diagnosis of superior Gleno Humeral Ligament tears. USG was poor in the diagnosis of Subcoracoid Fat Obliteration; none of the 6 cases in MRI were detected in USG.

Limitations

1. Sample size estimation was not possible due to limited review of literature on validity of MRI in Rotator interval pathologies. Hence Universal sampling method was followed in the study.
2. MRA (Magnetic resonance arthrography) and Arthroscopy is gold standard for diagnosing rotator interval pathologies were not done in the study to diagnose RI pathologies.

Recommendations

The study recommends for the use of MRI in diagnosis of Rotator interval pathologies as it is the better imaging modality available for the diagnosis apart from MR arthroscopy. MRI has the advantage of discriminating between normal anatomy and pathologic changes associated with the Rotator Interval. MRI is extremely sensitive to rotator interval inflammation or fluid that may represent pathology occult to plain radiography or USG of shoulder. The study also recommends for Use of USG in diagnosis of Rotator interval pathologies by the expert sinologists as it has shown diagnostic accuracy equivalent to MRI in diagnosis of all rotator interval pathologies except for Rotator Interval - Inflammation/Fluid and Subcoracoid Fat Obliteration.

Conflict of Interest: None.

Funding Support: Nil.

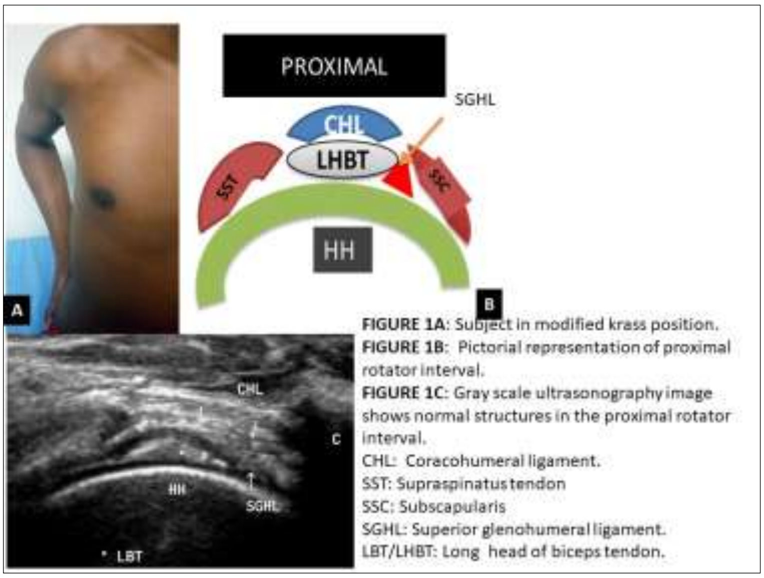

FIGURE 1A: Subject in modified krass position.
FIGURE 1B: Pictorial representation of proximal rotator interval.
FIGURE 1C: Gray scale ultrasonography image shows normal structures in the proximal rotator interval.
CHL: Coracohumeral ligament.
SST: Supraspinatus tendon
SSC: Subscapularis
SGHL: Superior glenohumeral ligament.
LBT/LHBT: Long head of biceps tendon.

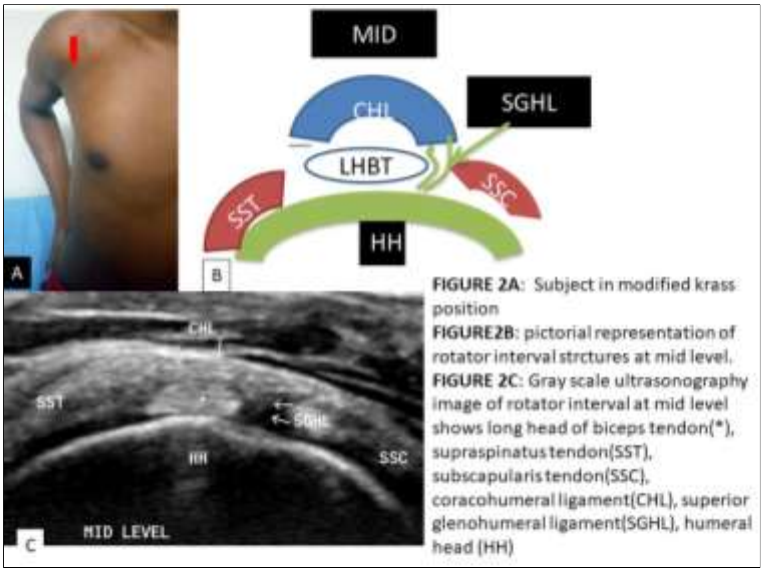

FIGURE 2A: Subject in modified krass position
FIGURE2B: pictorial representation of rotator interval strctures at mid level.
FIGURE 2C: Gray scale ultrasonography image of rotator interval at mid level shows long head of biceps tendon(*), supraspinatus tendon(SST), subscapularis tendon(SSC), coracohumeral ligament(CHL), superior glenohumeral ligament(SGHL), humeral head (HH)

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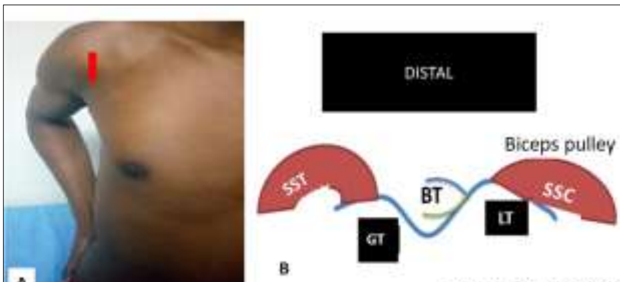

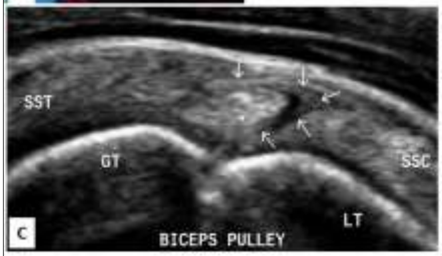

FIGURE 3A : subject in modified krass position.
FIGURE 3B: Pictorial depiction of distal rotator interval.
FIGURE 3C: Gray scale ultrasonography at distal rotator interval shows biceps pulley(white arrows), long head of biceps tendon(star).
GT: Greater tubercle
LT : Lesser tubercule
SST: Supraspinatus tendon
SSC: Subscapularis tendon.

FIGURE 4A : Sagittal T2W image shows normal structures in the rotator interval, coracohumeral ligament(black arrow),long head of biceps tendon(curved arrow),humeral head(star), coracoid process(c)

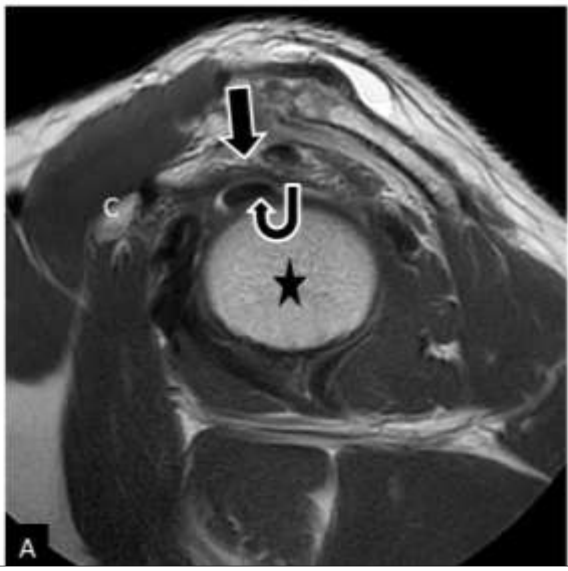

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FIG 4B: Sagittal T2W image shows lateral band of Coracohumeral ligament(arrow) continues as rotator cable (curved arrow) underneath the supraspinatus tendon

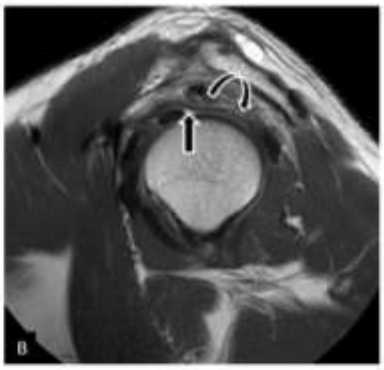

FIGURE 4C: Sagittal PDFS image shows biceps pulley(arrow heads) and long head of biceps tendon

FIGURE 5A: patient came with history of fall, ultrasonography of shoulder shows partial tear of supraspinatus tendon(arrow), altered echogenicity of the lateral band of coracohumeral ligament(Yellow arrows), long head of biceps tendon(star). SSP= supraspinatus tendon, SSC= subscapularis tendon

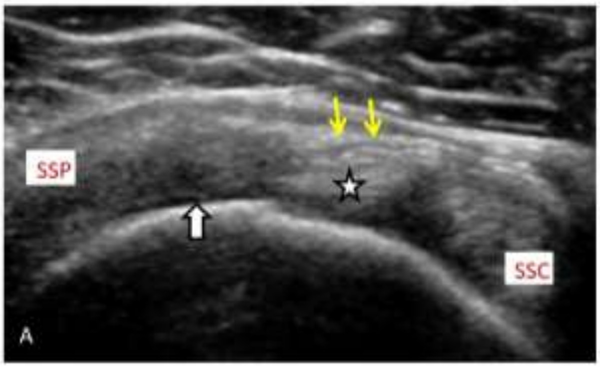

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FIGURE 5B: Sagittal PDFS image shows hyper intensity in the lateral band of Coracohumeral ligament(Yellow arrows), Long head of biceps tendon(black arrow)and distal supraspinatus tendon(red arrow)

FIGURE 5C: Sagittal PDFS image shows hyperintensity in the lateral band of Coracohumeral ligament(yellow arow) which is continuing as rotator cable underneath the distal supraspinatus tendon(red arrow)

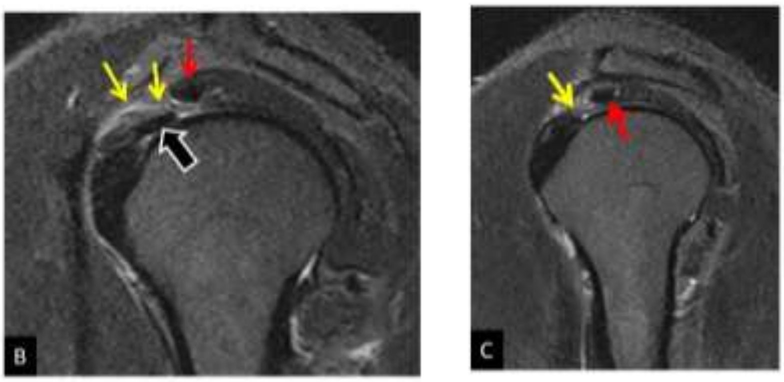

FIGURE 6A: Patient came with pain in the shoulder joint, history of trauma ultrasonography of the shoulder reveal full thickness tear of intra articular portion of long head of biceps tendon(white arrows).

FIGURE 6B: Gray scale ultrasonography of a subject shows normal insertion of the biceps tendon(LBT) at the superior glenoid(G)

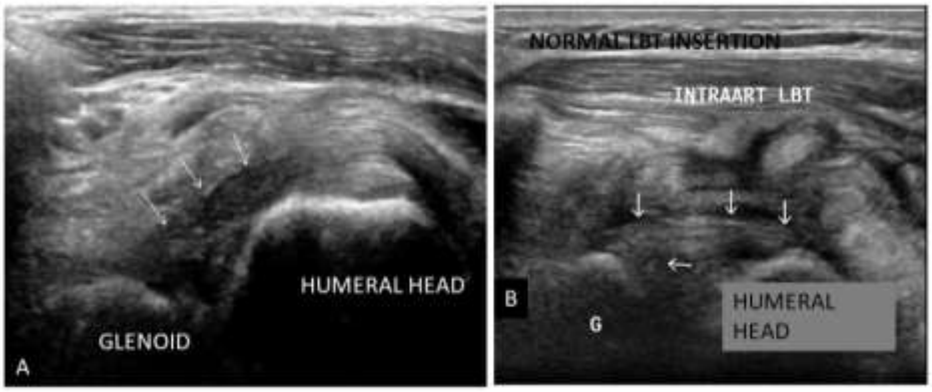

FIGURE 6C: T2W coronal image shows full thickness tear of intra articular portion long head of biceps tendon with retraction of the tendon(yellow arrow). DESS 3D sequence shows retracted long head of biceps tendon(yellow arrow).

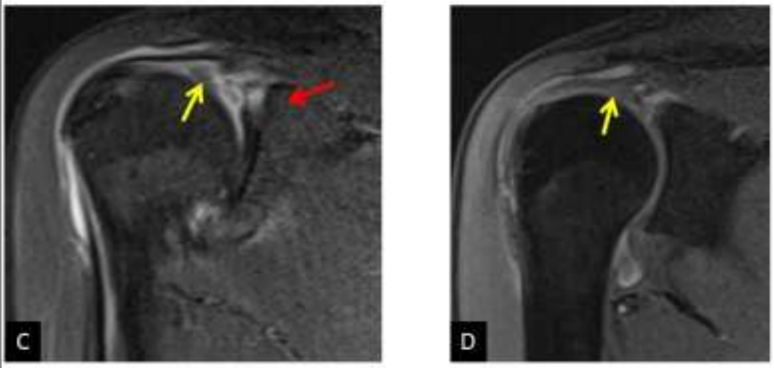

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FIGURE 7A: Patient came with history of trauma ultrasonography reveals subluxation of long head of biceps tendon (arrow) anterior to the intact subscapularis tendon. Tear of medial band of coracohumeral ligament and superior glenohumeral ligament(arrow head) is seen.SSC= Subscapularis tendon.

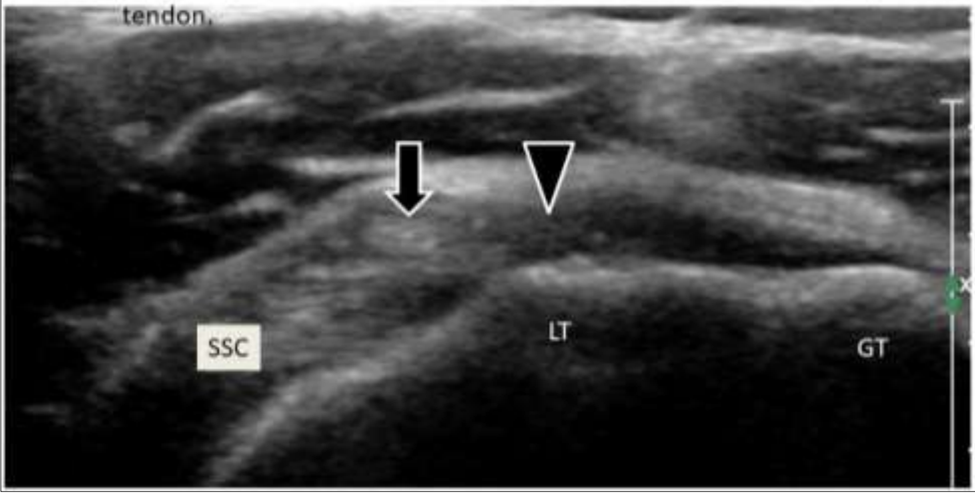


FIGURE 7B: Axial T2 MEDIC sequence shows long head of biceps tendon(arrow) dislocated and seen anterior to subscapularis tendon(star), bicipital groove is empty(curved arrow)

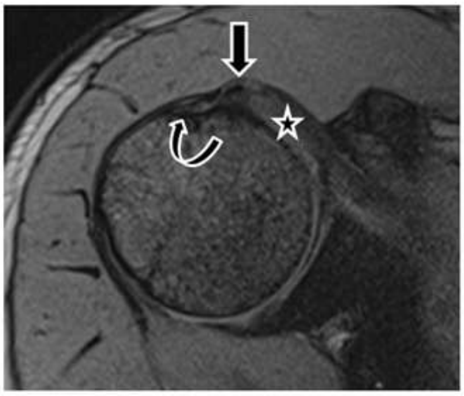


FIGURE 8A: Patient came with complains restriction of movement of the shoulder joint, ultrasonography reveals thickened coracohumeral ligament(between the calipers), long head of biceps tendon(arrow head).8B: Gray scale ultrasonography of both shoulder joints to the right is normal glenohumeral joint capsule(white arrows), to the left thickened glenohumeral joint capsule.(HH=Humeral head;G=glenoid; gh jt capsule=glenohumeral joint capsule)

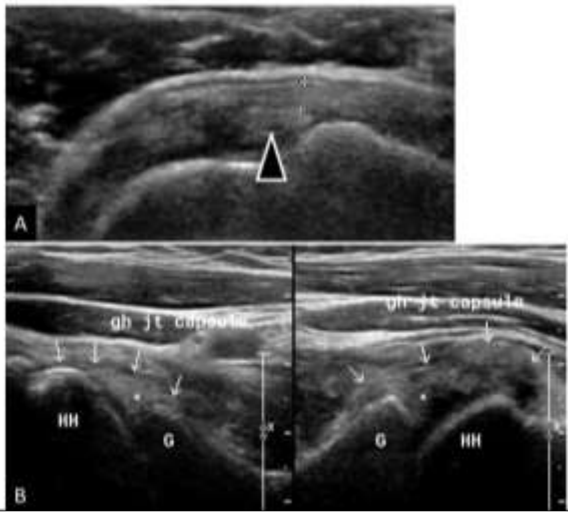
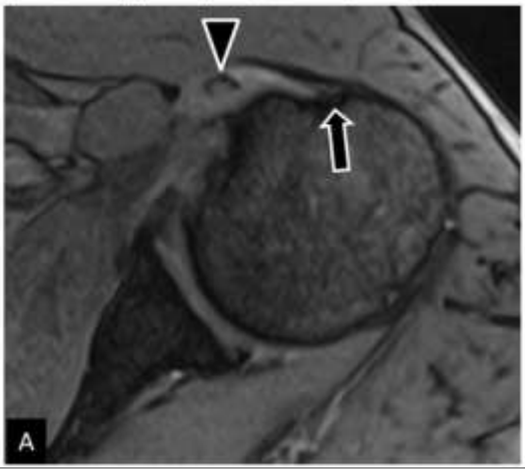


FIGURE 8C: sagittal PDFS images show thickened coracohumeral ligament(arrow), long head of biceps tendon(curved arrow), supraspinatus tendon(arrow head),subscapularis tendon (star)

FIGURE 8D: Coronal PDFS image shows thickened and hyperintensity in the axillary pouch(white arrows).

FIGURE 9A: Axial T2W MEDIC sequence shows dislocated long head of biceps tendon(arrow head) with empty bicipital groove (arrow).



ISSN:0975 -3583,0976-2833 VOL 14, ISSUE 03, 2023

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