ORIGINAL RESEARCH

The validity and accuracy of ultrasonography in rotator cuff disorders by comparing its findings with those of magnetic resonance imaging

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ABSTRACT
Rotator cuff pathology is one of the most common causes of shoulder pain and dysfunction. In addition to history and physical examination, evaluation of a patient with shoulder pain often involves assessment of the rotator cuff with a diagnostic test such as high-resolution ultrasonography or MRI.
High resolution ultrasound is non-invasive, less expensive and non-ionizing modality with good sensitivity in detecting rotator cuff disorders. It can be used as a focused examination providing rapid and real-time diagnosis. MRI is the gold standard for assessment of soft tissue structures around the shoulder joint. MRI is an excellent modality because of its multiplanar capability and high soft tissue contrast.
Ultrasonography has comparable accuracy with MRI for assessment of rotator cuff disorders, and low cost of ultrasound makes it the most cost-effective screening method for rotator cuff disorders.
40 patients who presented with shoulder joint pain, restriction of movements or clinically suspected rotator cuff disorders, referred to Department of Radiodiagnosis.
MRIhas a high sensitivity, specificity and accuracy for identifying rotator cuff disorders, particularly partial and full thickness tears than tendinosis. Supraspinatous tendon is the most commonly affected tendon, followed by the subscapularis and infraspinatous. Teres minor was not affected in any of the patients. Tears of the rotator cuff tendons are commonly associated with fluid in SA-SD and SC burase, USG had low sensitivity but high specificity for SA-SD bursitis, SC bursitis and acromio-clavicular joint pathologies.
Key words: Rotator cuff pathology, USG, MRI

INTRODUCTION

The shoulder is most mobile joint inhuman body. This mobility provides the upper extremity with tremendous range of motion like adduction, abduction, flexion, extension, internal rotation, external rotationand 360° circumduction in the sagittal plane. Furthermore, the shoulder allowsscapular protraction, retraction, elevation, and depression[1].
In comparison to all other joints in the body, the shoulder joint has the most range of motion, however it is generally stable. A skeletal arch created superiorly by the coracoid process, the acromion, and the extracapsular ligaments, as well as the tendon of the long head of the biceps brachii muscle and the surrounding muscle tendons comprising the rotator cuff, all contribute to the stability of the joint.
The supraspinatus, infraspinatus, subscapularis, and teres minor muscles make comprise the rotator cuff. The joint's superior, anterior, and posterior surfaces

are encircled by a musculotendinous collar made up of these muscles' tendon fibres and joint capsule.

This group of muscles supports and retains the humeral head in the glenoid cavity of the scapula while maintaining the arm's mobility and flexibility. The biceps brachii muscle's long head tendon travels through the joint superiorly and prevents the humeral head from moving upward on the glenoid cavity[2].

One of the most frequent complaints in the orthopaedic department is shoulder pain, which frequently results in significant disability[3]. Most prevalent issues in the shoulder joint are caused by rotator cuff pathologies, and proper care requires a precise diagnosis[4]. A set of lesions that cause shoulder pain include rotator cuff tears, impingement syndrome, and cuff strains. Clinically, it can be challenging to discern between these diagnosis and cuff issues from other disorders including glenohumeral instability. Evaluation of a patient with shoulder discomfort frequently includes evaluation of the rotator cuff using a diagnostic test such high resolution ultrasonography or MRI[5], in addition to the history and physical examination.

High resolution ultrasonography has good sensitivity for both rotator cuff problems and is non-invasive, less costly, and non-ionizing. In desired clinical conditions, it can be used as a concentrated examination that provides a quick, real-time diagnosis[6]. High resolution ultrasonography has been shown to have higher than 90% accuracy, sensitivity, and specificity in identifying any tear, whether partial or full thickness[7]. In shoulder imaging, it plays a complimentary role to MRI.

High resolution ultrasound can also detect additional abnormalities, such as tenosynovitis, tendinosis, calcific tendinitis, subacromial-subdeltoid bursitis, larger tuberosity fracture, etc. that may mimic a rotator cuff tear at clinical examination.[8]

For detecting both subtle and evident internal derangement and evaluating overall joint structure, MRI has emerged as the gold standard. Due to its multiplanar capabilities, MRI is a great modality. It is possible to learn more about rotator cuff disorders using an MRI, including tendinosis, calcific tendinitis, tears, muscle atrophy, and involvement of nearby structures like the rotator interval and long head of the biceps brachii tendon. All of these conditions have an impact on the treatment and prognosis for rotator cuff disorders.

METHODOLOGY

SOURCE OF DATA

The source of data for this study were patients referred for ultrasound or MRI examination of the shoulder to the Department of Radio-diagnosis. The study included forty patients who presented with shoulder joint pain, restriction of movements or clinically suspected rotator cuff disorders.

SAMPLE SIZE: 40.

METHOD OF COLLECTION OF DATA

INCLUSION CRITERIA

- History of shoulder pain.
- History of restricted movement of shoulder.
- Clinically suspected to have internal derangements like rotator cuff injury,biceps tendon injury, calcific tendinitis.
- Either gender.
- Age group between 18-75 years of age.

EXCLUSION CRITERIA

- Previous history of prosthesis.
- Patients with any electrically,magnetically or mechanically activated implants (pacemaker, biostimulators, neurostimulators and cochlear implants).
- Patients having claustrophobia.
- Patients who are unwilling for imaging.
- Subjects unable to cooperate due to pain.
- Patients not willing to give written informed consent.

DATA ACQUISITION

A structured pre-prepared case proforma was used to enter the patient details, clinical history and imaging findings who met the inclusion criteria.Ultrasound examination of the shoulder joint was performed in gray scale mode using a high resolution, 7.5-12 MHz, linear array transducer of GE versana balance. Rotator cuff tendons and muscles, ACJ and dynamic assessment for subacromial, subdeltoid and sucoracoid impingement were studied. Magnetic Resonance Imaging of the shoulder joint was performed subsequently. Imaging was done with 1.5 Tesla TOSHIBA MRI machine using shoulder coil, the following sequences were selected as required:

1. Oblique coronal/oblique saggital T1W sequence.
2. Oblique coronal/oblique saggital T2W FSE sequence with or without fat saturation.
3. Axial/oblique coronal/oblique saggital PD weighted FSE sequence with or without fat saturation.
4. Axial T2*W GRE sequence.
5. Axial/oblique saggital STIR sequence Field of view 14-16 cm, slice thickness 3 mm and matrix size and TR/TE kept according to the selected sequence. The high-resolution USG findings were correlated with the MRI findings.

RESULTS

Table 1: USG findings of Rotatorcuff tendons pathology.

Affected Tendon	USG-Findings				
	Tendinosis	Partial thickness tear	Fullthickness tear	Normal	Limited Mobility(LM)
Supraspinatus	11	3	8	15	**3**
Infraspinatus	02	3	4	31	00
TeresMinor	00	01	00	39	00
Subscapularis	07	06	01	25	01
BicepsTendon	02	03	01	34	00

The USG findings of rotator cuff tendons pathology was tested by Manwhiteny U-test, the results found that, the Supraspinatus& infraspinatusis the most commonest and significantly associated with gross pathological finding. The least expression was seen inSubscapularis & Biceps Tendon U test 12.56,p<0.001. In case of Supraspinatus, the tendinosis 11 cases Partial thickness tear were seen in 3 cases full thickness tear 8 cases normal 15 cases andLimited Mobility(LM)was seen in 3 cases respectively. Similarly, in case ofInfraspinatus, only 2 cases wereseen Tendinosis; 3cases were Partial thickness tear; 4 cases were full thickness tear, 31 cases were seen in normal. Further, the teresminor 39 cases were normal,25 cases of normal in Subscapularis and 34 cases normalin Biceps Tendon. Asper the results, the USG findings of rotator-cuff tendons pathological findings were found to be statistically significant at 1% level $p<0.01$.

Table 2:MRI Findings of Rotatorcuff tendons pathology

Affected Tendon	MRI Findings			
	Tendinosis	Partial thickness tear	Full thickness tear	Normal
Supraspinatus	15	13	8	4
Infraspinatus	02	04	04	30
TeresMinor	00	01	00	39
Subscapularis	11	09	01	19
BicepsTendon	3	3	1	33

Of the supraspinatus tendon pathologies, tendinosis was seen in 15 patients and partialtear in 3 patients.Tendinosis changes in the biceps and rotatorcuff tendons were found in total of 31 patients and it was the most commonly identified abnormality in this study. Partial tears of the rotator cuff tendons were found in total of 30 patients involving the supraspinatous, infraspinatous tendons subscapularis, teres minor and biceps tendon,whereas full thickness tear in 14 patients

Table 3: Percentage distribution of TEARS-N/P/F/T v/s USG findingsof Rotator cuff tendons pathology

Affected TendonUSG	Supraspinatus		Infraspinatus		Teres minor		Subscapularis		BicepsTendon	
	No	%	No	%	No	%	No	%	No	%
Tendinosis	11	27.5	2	5	0	0	7	17.5	2	5
Partial thickness tear	3	7.5	3	7.5	1	2.5	6	15	3	7.5
Full thickness tear	8	20	4	10	0	0	1	2.5	1	2.5
Normal	15	37.5	31	77.5	39	97.5	25	62.5	34	85
Limited Mobility	3	7.5	0	0	0	0	1	2.5	0	0

The pathology descriptive of USG percentage correlation of Rotator cuff tendons pathology was tested by Manwhiteny U-test, the results found that, the Supraspinatus & infraspinatusis the most commonest and significant association with gross pathological finding.

Table 4:Percentage distribution of MRI Findings of Rotatorcuff tendons pathology

Affected Tendon	MRIFindings									
	Supraspinatus		Infraspinatus		Teres Minor		Subscapularis		Biceps Tendon	
	No	%	No	%	No	%	No	%	No	%
Normal	4	10	30	75	39	97.5	19	47.5	33	82.5
Tendinosis	15	37.5	2	5	0	0	11	27.5	3	7.5
Partial thickness	13	32.5	4	10	1	2.5	9	22.5	3	7.5
Full thickness	8	20	4	10	0	0	1	2.5	1	2.5
LM	0	0	0	0	0	0	0	0	0	0
Total	40	100	40	100	40	100	40	100	40	100

Parentage distribution of MRI Findings of Rotator cuff tendons pathology was positively associated $p<0.01$, chi-square was 12.85.

Table 5: Observation of USG and MRI Findings

Affected Tendon	Statistics	USG/MRI	Tendinosis	Partial thickness tear	Full thickness tear	Normal	LM
Supraspinatus		**USG**	11	3	8	15	3
	Specificity (%)		88	77	74	65	45
	Sensitivity (%)		75	65	57	58	55
	PPV		65	55	65	63	53
	NPV		56	47	63	55	52
		MRI	15	13	8	4	0
	Specificity (%)		95	89	84	98	-
	Sensitivity (%)		88	82	88	74	-
	PPV		64	85	68	67	-
	NPV		51	74	70	77	-
Infraspinatus		**USG**	**2**	**3**	**4**	**31**	**0**
	Specificity (%)		68	70	65	84	-
	Sensitivity (%)		74	62	45	80	-
	PPV		56	68	54	69	-
	NPV		66	55	63	74	-
		MRI	**2**	**4**	**4**	**30**	**0**
	Specificity (%)		84	78	98	96	-
	Sensitivity (%)		90	83	74	99	-
	PPV		65	80	69	87	-
	NPV		74	68	77	85	-
TeresMinor		**USG**	**0**	**1**	**0**	**39**	**0**
	Specificity (%)		-	-	-	88	-
	Sensitivity (%)		-	-	-	83	-
	PPV		-	-	-	65	-
	NPV		-	-	-	78	-
		MRI	**0**	**1**	**0**	**39**	**0**
	Specificity (%)		-	-	-	88	-
	Sensitivity (%)		-	-	-	83	-
	PPV		-	-	-	65	-
	NPV		-	-	-	78	-
Subscapularis		**USG**	**7**	**6**	**1**	**25**	**1**
	Specificity (%)		84	74	-	74	-
	Sensitivity (%)		82	65	-	63	-
	PPV		74	69	-	54	-
	NPV		65	54	-	41	-
		MRI	11	9	1	19	0
	Specificity (%)		92	87	-	90	-
	Sensitivity (%)		85	78	-	87	-
	PPV		86	65	-	83	-
	NPV		65	56	-	70	-
BicepsTendon		**USG**	2	3	1	34	0
	Specificity (%)		65	87	-	87	
	Sensitivity (%)		58	63	-	65	-
	PPV		45	58	-	47	-
	NPV		38	54	-	65	-
		MRI	3	3	1	33	0
	Specificity (%)		74	64	-	98	-
	Sensitivity (%)		68	89	-	92	-
	PPV		54	85	-	74	-
	NPV		35	55	-	88	-

Observation of USG and MRI findings. Asper the results MRI is the best findings as compared with USG.

Table 6: Evaluation of USG and MRI Findings

Findings	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
Supraspinatus	85.0	56.28	91.85	38	74.85	<0.01
Infraspinatus	65	100	100	92.58	86.20	<0.01
TeresMinor	-	100	-	100	100	-
Subscapularis	65.74	85.8	76.0	81.11	98	<0.01
BicepsTendon	-	92.50	0.0	100	96.85	-
Subacromial-subdeltoidbursitis	41.88	91.40	80.2	75.68	68.22	0.001
Sub-coracoidBursitis	21.77	100	100	65.0	86.22	0.001
BicepsTendonSheathFluid	20.85	98	51	76	74.58	0.58
ACJPathology	20.23	100	100	51.25	50.85	0.28

(PPV-PositivePredictiveValue;NPV-NegativePredictiveValue)

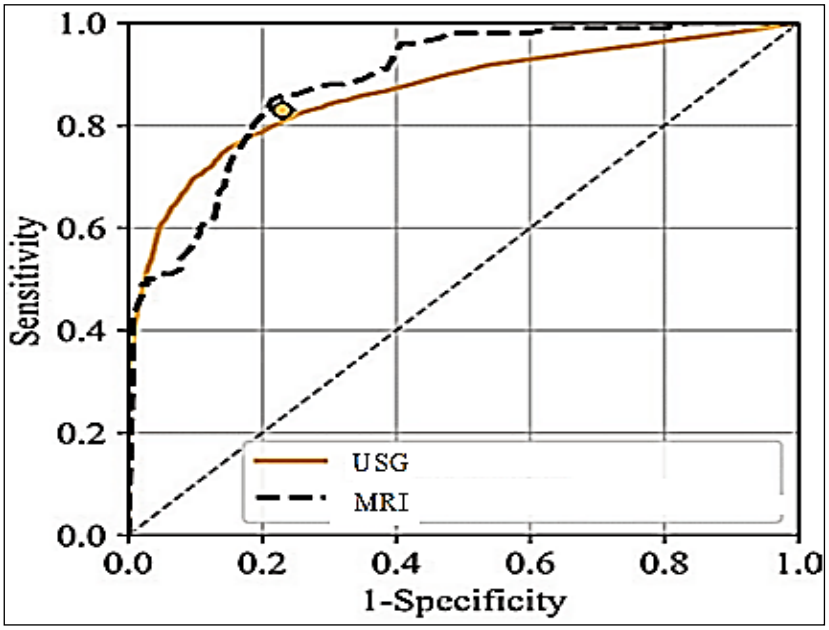

Figure 1:Correlation between AUSG and MRI

For supraspinatous tendon pathologies USG had sensitivity of 85%, specificity of 56.28 %, PPV of 91%, NPV of 38% and accuracy of 78.85% with ap-value of<0.01.For subscapularis tendon pathologies, sensitivity of 65.70%, specificity of 85.88%, PPV of 76%, NPV of 81% and accuracy of 68.22% were obtained with a p-value of <0.01.Infraspinatous tendon pathologies had a sensitivity of 65%, specificity and PPV 100%, NPV of 92.58% and accuracyof 38.0% with ap-value of <0.01.p-value was not obtained for teresminor tendon evaluation as no abnormality was found by USG and MRI in all 40 patients. Biceps tendon had a specificity of 92.50% and NPV of 100%,p-value not obtained as MRI showed no abnormality in all 40patients. Detection of SA-SD bursitis, subcoracoid bursitis, biceps tendon sheath fluid and ACJ pathologies had alow sensitivity.

DISCUSSION

In thepresent study,Of the subscapularis tendon pathologies, tendinosis was seen in 15 patients and partial tear in13 patients. Tendinopathy changes in the rotatorcuff tendons were found in 20patients and it was the most commonly identified abnormality in this study. Partial tears of the rotator cuff tendons were found in 15 patients and were found involving the supraspinatous, subscapularis and infraspinatous tendons. MRI Findings of Rotatorcuff tendons pathology waspositively associated$p$<0.01, chi-square was 12.85.Fluid in the biceps tendon sheath seen as hyperintensity surrounding the biceps tendon in theSA-SD wasfoundin8patients(20%)as comparedto SC 3Cases foundpositive p<0.01 and alsoMRI detection of JEwaspositively seen in 8 cases, theresultsfoundto besignificant p<0.01.Similarreports findings by (Papatheodorou*et al.*, 2006) [9].TheAcromio-clavicular joint pathologies were found in 10patients (25%) by MRI as compared to only 10%(2patients) by USG. Pathologies that were detected by MRI include joint space narrowing and irregularity, degenerative changes such as osteophytes and joint effusion. Type II acromion (flat type) was

the commonest acromion type seen in this study, accounting for 50% of the patients. Type III acromion 27.50% was seen in only 3 cases foundin IV patients(7.50%) with14 (35%) Significantly augmentedwith Impingement.Of the supraspinatous tendon pathologies, 11 patientsfound to have tendinosis in USG hadtendinosis in MRI, 15cases of the patients who were found to have tendinosis in USG were found to have partial tear in MRI. 11& 2 patients who had IS,Subscapularis 11 MRI& 3 Cases foundinBiceps Tendon. Normal sonographic appearance of supraspinatous tendon had tendinosis in MRI. All four partial thickness tears diagnosed by ultrasound had partial thickness tears in MRI also. One full thickness tear detected by USG was found to be a partial thickness tear in MRI.Asper the results MRI is the best findings as comparedwith USG.

In ourstudy,for supraspinatous tendon pathologies USG had sensitivity of 85%, specificity of 56.28%, PPV of 91%, NPV of 38% and accuracy of 78.85% with ap-valueof < 0.01.For subscapularis tendon pathologies, sensitivity of 65.70%,specificity of 85.88%, PPV of76%, NPV of 81% and accuracy of 68.22% were obtained with a p-value of <0.01.Infraspinatous tendon pathologies had a sensitivity of 65%, specificity and PPV100%, NPV of 92.58% and accuracy of 38.0% with ap-value of <0.01.p-value was not obtained or teresminor tendon evaluation as no abnormality was found by USG and MRI in all 40 patients. Biceps tendon had a specificity of 92.50 % and NPV of 100%, p-value not obtained as MRI showed no abnormality in all 40 patients. Detection of SA-SD bursitis, subcoracoidbursit is, biceps tendon sheath fluid and ACJ pathologies had alow sensitivity. Main additional findings correlation was testedby logisticregression it wasfoundto bestatistically significant p<0.01. Correlation ofarthroscopy wastestedby un pairedt test, 36 cases were foundgoodcorrelationwith arthroscopy p<0.01. TheArthroscopy wasbestcorrelativetoolto infertherelation betweenUSGandMRI.Aspertheresultedfindings, theMRIispositively associatedascompared withUSGwithspecificityandsensitivityis good(Specificity=95%; sensitivity88%, PPV=74 %andNPVwas 65%).In astudy reportedby (SondipanBiswas*et al*. 2020) [10],The usual sensitivity and specificity of ultrasonography (USG) for diagnosing full thickness tear was 100% each and for MRI was 88% and 100% respectively. For subacromial impingement USG had sensitivity of 66.67%, specificity of 94.12%, positive predictive value of 50% and negative predictive value of 88.89%. For rotator cuff tear USG had sensitivity of 92.86%, specificity of 50%, positive predictive value of 81.25% and negative predictive value of 75% considering shoulder arthroscopy as gold standard. Theabovestudy proved USG and MRI both are sensitive techniques for diagnosing of rotator cuff pathologies. USG has high accuracy in diagnosing partial thickness tears as compare to MRI. MRI proved to be superior in estimation of site and extentoftear.Consideringshoulderarthroscopyasgoldsta ndard,itcanbereservedforpatientswithsuspiciousof USG/MRI findings or those who may need surgical intervention simultaneously. Therehavebeenfewstudiescomparingclinical examinationwithimagingandarthroscopicfindings. Norregaard*et al*.,hasshownapoorcorrelationbetween clinicalexaminationcomparingwithUSGand arthroscopy.Our study has found that impingement that were diagnosed with clinical signs have high accuracy in diagnosis in imaging as well as arthroscopically.

CONCLUSION

MRI can be used as a problem-solving tool in problematic cases or in cases of doubtful diagnosis on USG. MRI is a versatile investigation tool for studying all internal derangements of shoulder affording great soft tissue contrast and multi-planar imaging. With the benefit of being cost effective tool USG is comparable to MRI in detection of full thickness tears of rotator cuff tendons. But MRI is better than USG for detection of partial thickness tears of rotator cuff tendons. MRI is an efficient tool in evaluation of shoulder instability with high sensitivity even without arthrography. It can be served as a clinical guideforradiologistsaswell assurgical experts.

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