Original Article

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Assessment of Accuracy of Rotator Cuff Tears on Shoulder Ultrasound with Respect to Magnetic Resonance Imaging

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Abstract

Background: The aim of the study is to assess the accuracy of ultrasound for diagnosis of rotator cuff tears with respect to magnetic resonance imaging, To identify partial thickness rotator cuff tears, full thickness rotator cuff tears and tendinopathic changes; and to evaluate the sensitivity and specificity of US in diagnosing them with respect to magnetic resonance imaging. **Subjects and Methods:** It is a prospective study conducted at the department of Radiodiagnosis in Narayana Medical College and Hospital, Nellore. A total of 30 patients who were suspected of having rotator cuff tear or tendinosis and planning to undergo MRI of shoulder were included in this study. Shoulder ultrasound was performed either before or after the MRI scan on same day. Findings of ultrasound were compared and correlated with findings of MRI. **Results:** Sensitivity (SN), specificity (SP), positive predictive value (PPV), negative predictive value (NPV), and accuracy for diagnosis of rotator cuff tear was 93%, 73%, 77%, 91%, and 83%, respectively. **Conclusion:** (SN) Sensitivity for diagnosis of rotator cuff tear was good and had a higher (NPV) negative predictive value. Consequently, operator of ultrasound even though having a short tenure of experience for performing ultrasound of shoulder had good sensitivity in diagnosing tears; and able to eliminate them with sureness.

Keywords: Rotator Cuff Tears, Ultrasound, Magnetic Resonance Imaging.

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Introduction

Among the multiple causes of shoulder pain, rotator cuff (RTC)pathology is the most common cause in the general population, and there is always a notable morbidity associated with rotator cuff pathology including the (RCT) rotator cuff tears.[1,2,3,4,5]

The other causes of shoulder pain comprise sub acromial and subdeltoid bursitis, adhesive capsulitis, tendinitis, arthritis, and fractures.

Primary imaging modality of choice in workup of shoulder pain is plain radiographs to rule out any bony abnormality and soft tissue calcifications. However, plain radiographs are normal in most cases even when there is an underlying pathology present.

Magnetic resonance imaging (MRI) is a fine modality in diagnosing and (RCT) rotator cuff tears.[6,7]

However, with the speedy development and advancement of technology of ultrasound like 7.5–18 MHz (Megahertz) linear array broad-bandwidth probes, good penetration of beams of ultrasound, and better resolution of ultrasound image; the (SN) sensitivity of ultrasound to evaluate and diagnose (RCT) rotator cuff tears has ameliorated significantly and did level up nearly to that of (MRI) Magnetic resonance imaging.[6,8] But the utmost deciding factor is the skill of operator of ultrasound in performing the scan. In many of the previous studies that were reported and published in the literature, depicting high (SN) sensitivity and (SP) had operators of ultrasound who had a very long tenure of experience in carrying out the ultrasound of shoulder; i.e., almost in several years.[9] There prevails a very ample data regarding, ultrasound operator carrying out the ultrasound of shoulder who had short experience in evaluating and diagnosing (RCT) rotator cuff tears and pathologies of rotator cuff. One of the reported and published studies, demonstrated that good (SN) sensitivity and (SP) specificity in evaluating and diagnosing rotator cuff tears had increased with the experience of operator of ultrasound through the study.[10] This study was based on the evaluation and diagnosis of (RCT) rotator cuff tears and pathologies of rotator cuff with accuracy with respect to magnetic resonance imaging by an ultrasound operator who had short tenure of experience in carrying out the shoulder ultrasound.

Aims and Objectives:

- To assess the accuracy of ultrasound for diagnosis of rotator cuff tears with respect to magnetic resonance imaging.
- To identify partial thickness rotator cuff tears, full thickness rotator cuff tears and tendinopathic changes; and to evaluate the sensitivity and
- Specificity of US in diagnosing them with respect to magnetic resonance imaging.

Subjects and Methods

The prime source of data for this study will be the patients attending the radiodiagnosis department, Narayana Medical College, Nellore.

US of the shoulder was done free of cost for the patients who were planned for the magnetic resonance imaging scan of the same shoulder joint.

Inclusion criteria:

Study Includes

- Patients with shoulder pain, both acute and chronic.
- Patients having shoulder stiffness
- Patients presenting with restriction of movements at the joint.
- Patents with history of trauma to the shoulder.

Exclusion criteria:

The study excludes

- The patients refusing for the US scan
- Female patients when chaperones are absent.
- Post operative cases
- Patients unable to cooperate because of pain
- Patients with history of claustrophobia
- Patients with history of cardiac pacemakers, metallic implants.

Sample size calculation: 30

Type of study:

- Prospective observational study

Technique:

Ultrasound of shoulder:

Ultrasound machine: PHILIPS HD11XE

Transducer used: High frequency transducer(14MHz)

The study was explained and subjects were made to sit on a rotating chair.

Sequence of evaluation:

- Biceps tendon was assessed first, with elbow flexed at 90 degrees. Patient informed to perform internal rotation & external rotation of arm, in order to evaluate any dislocation of LHBT from bicipital groove.
- Secondly, the subscapularis was assessed, with the arm externally rotated and elbow at 90o flexion.
- Acromio-clavicular joint was assessed to rule out arthritis.
- Impingement was assessed by asking the patient to abduct the arm.
- Supraspinatus and infraspinatus were assessed by asking the asking the patient to internally rotate the arm, such that the dorsum of hand touches the back of the patient.

Ultrasound criteria for rotator cuff pathology 11:

Tendinosis:

Described as a heterogeneous, ill defined, and hypoechoic area within the tendon with a change in the tendon calibre (thinned/ enlarged) without a defect in the tendon.

Partial thickness tendon tear:

Described as a well-defined anechoic or hypoechoic area disrupting the tendon fibres

Interstitial tear: Tear not extending up to the articular or bursal surface

Articular tear: Tear extending till articular surface

Bursal tear: Tear not extending up to the bursal surface

Full thickness tear: Described as a well-defined anechoic or hypoechoic area, disrupting the hyperechoic tendon fibres and extending from articular to the bursal surface of tendon.

MRI of the shoulder:

MRI Scanner-

GE Healthcare DISCOVERY 750W 3T MRI

Study protocol

- PD FS AXIAL
- PD FS SAGITTAL
- PD FS CORONAL
- T2W CORONAL
- T1W CORONAL
- T2W AXIAL
- AXIAL GRE

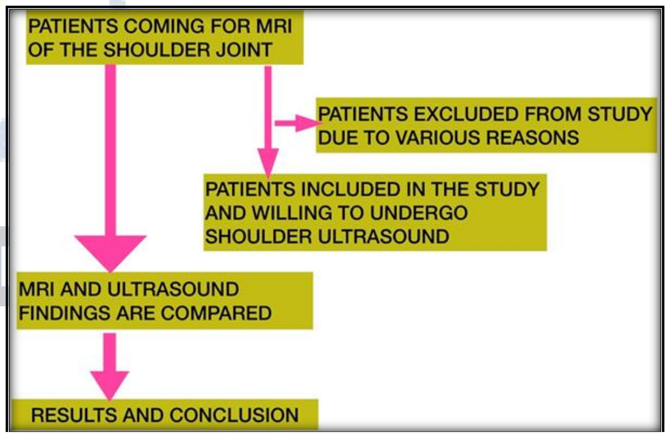

Figure 1: Diagrammatic algorithm of the study

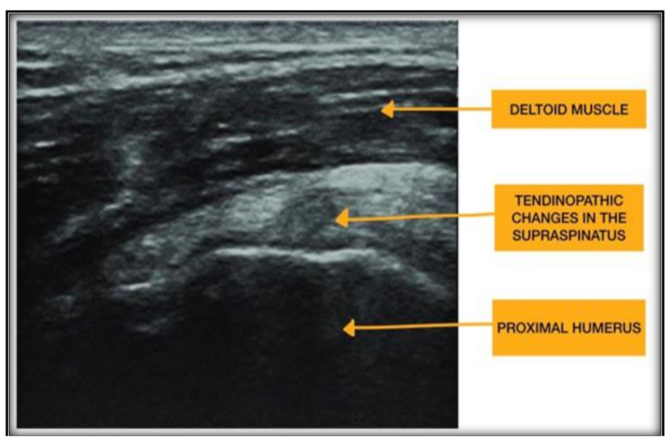

Figure 2a: A 54 year old male with right shoulder pain, diagnosed to have supraspinatus tendinosis. Image - Grayscale ultrasound short axis view showing heterogenous echotexture of the supraspinatus tendon.

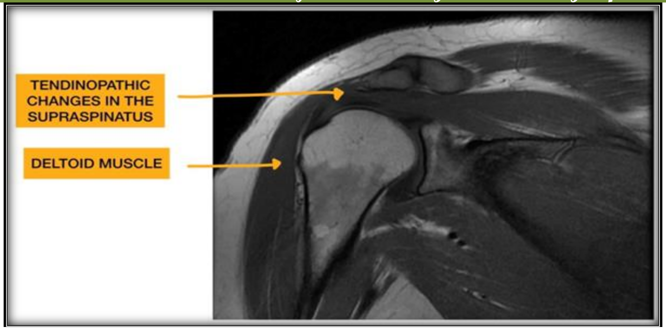

Figure 2b: A 54 year old male with right shoulder pain, diagnosed to have supraspinatus tendinosis. Image -MRI- T1 weighted Image, corona! section showing thickening and hyperintensity of the supraspinatus tendon.

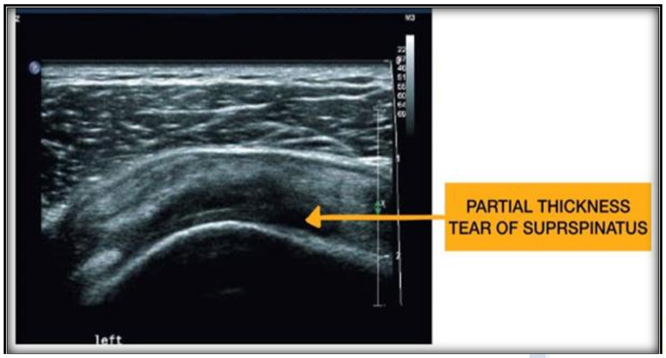

Figure 3a: A 46 year old male with right shoulder pain, diagnosed to have partial thickness tear of supraspinatus tendon. Image - Grayscale ultrasound short axis view showing partial thickness tear of supraspinatus tendon.

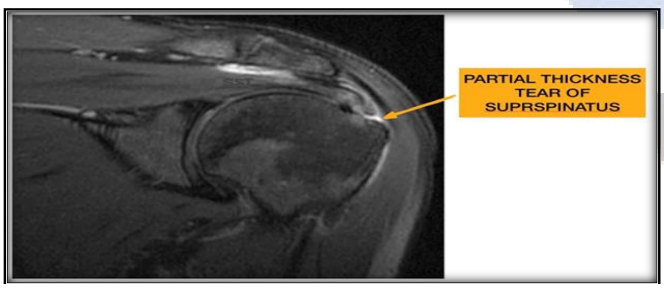

Figure 3b: A 46 year old male with right shoulder pain, diagnosed to have partial thickness tear of supraspinatus tendon. Image - MRI- T2 weighted fat suppressed Image, corona! oblique section showing a partial thickness tear at bursa! surface in supraspinatus tendon distally.

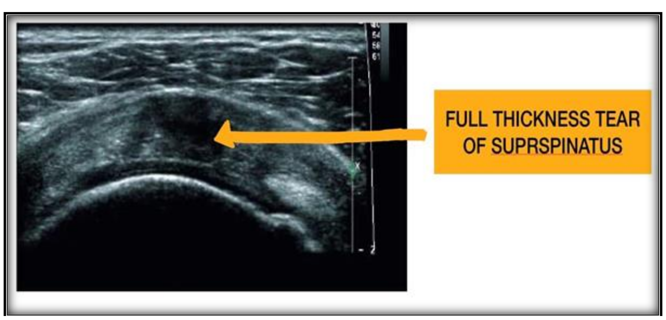

Figure 4a: A 40 year old female with difficulty in lifting her arm, diagnosed to have full thickness tear of supraspinatus tendon. Image - Grayscale ultrasound short axis view showing full thickness tear of supraspinatus tendon with associated heterogenous echotexture of the tendon consistent with tendinopathic changes.

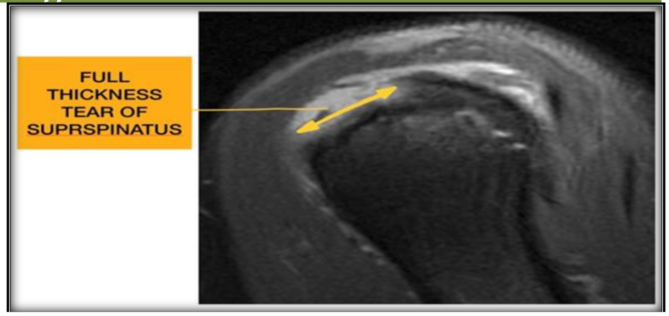

Figure 4b: A 40 year old female with difficulty in lifting her arm, diagnosed to have full thickness tear of supraspinatus tendon. Image - MRI- T2 weighted fat suppressed Image, sagittal section showing a full thickness tear of supraspinatus tendon. Double headed arrow showing the diameter of tear.

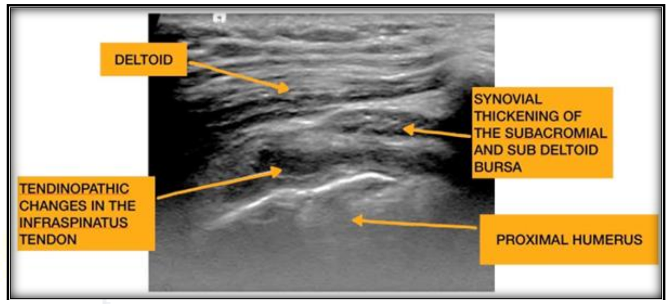

Figure 5a: A 57 year old male with right shoulder pain, diagnosed to have tendinopathic changes of infraspinatus. Image - Grayscale ultrasound long axis view showing tendinopathic changes of infraspinatus associated with synovial thickening of the subacromial and subdeltoid bursa.

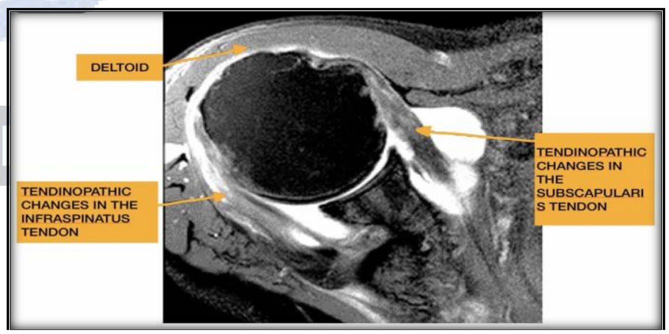

Figure 5b: A 57 year old male with right shoulder pain, diagnosed to have tendinopathic changes of infraspinatus. Image - MRI- Proton Density fat suppressed Image, axial section showing tendinopathic changes of infraspinatus with associated tendinopathic changes in subscapularis tendon.

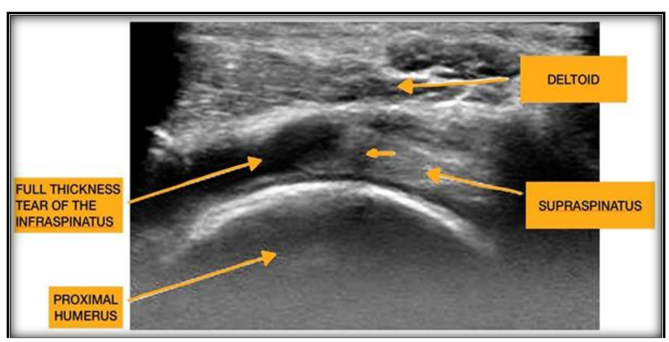

Figure 6a: A 48 year old male with right shoulder pain, diagnosed to have full thickness tear of infraspinatus tendon. Image - Grayscale ultrasound short axis view showing full thickness tear of infraspinatus tendon.

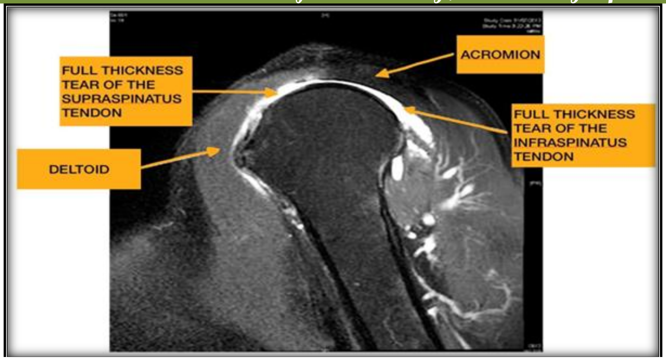

Figure 6b: A 48 year old male with right shoulder pain, diagnosed to have full thickness tear of infraspinatus tendon. Image - MRI- T2 weighted fat suppressed Image, axial section showing full thickness tear.

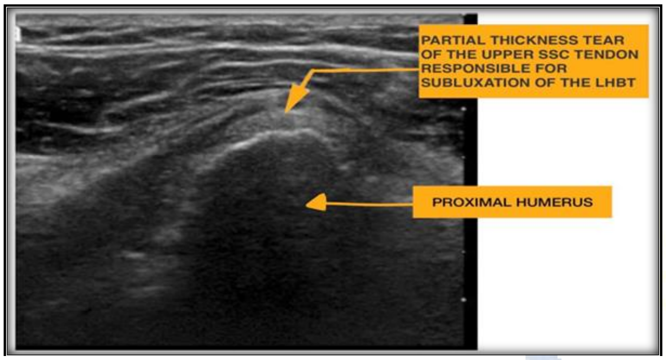

Figure7a: A 36year old male with right shoulder pain, diagnosed to have full thickness tear of subscapularis tendon. Image - Grayscale ultrasound short axis view showing full thickness tear of subscapularis tendon associated with subluxation of long head of biceps tendon.

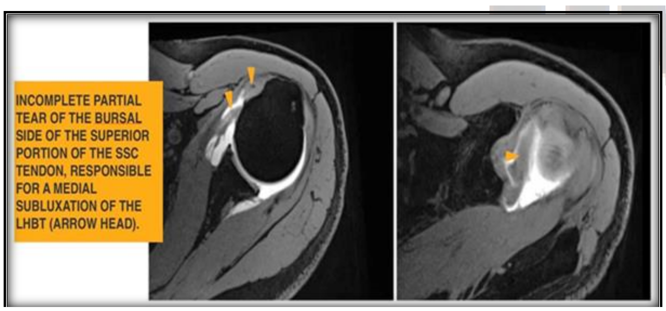

Figure7b: A 36year old male with right shoulder pain, diagnosed to have full thickness tear of subscapularis tendon. Image - MRI- Axial fat suppressed T1 WI and Axial oblique fat suppressed T1 WI, showing an incomplete partial tear at the bursa! side of the subscapularis tendon, which is responsible for subluxation of long head of biceps tendon medially (arrow heads).

Results

30 patients are evaluated in this study for rotator cuff abnormalities who had both magnetic resonance imaging and ultrasound of their shoulder joint; and patients of all age groups are included in this study.
Twenty-three cases were men and seven cases were women
The highest number of cases is found in the age group of 18-30 years, with a total number of 12 cases accounting for 40 %, followed by the age group of 51-60 years with a total number of 7 cases accounting for 23.3%.
Majority of the cases (19 cases) presented with duration of symptoms between one to six months constituting for about 63.3% of all cases.
Very few cases (2) presented with duration of symptoms for more than one year constituting for about 6.7% of all cases.
18 cases were right-handed 60.0% and 12 cases were left-handed constituting for about 40.0%.
Involvement of the dominant hand is seen in 17 cases constituting for about 56.6% and involvement of the non-dominant hand is seen in 13 cases constituting for 43.3%.

Ultrasound in Comparison with Magnetic Resonance Imaging supraspinatus tendon tear (Any tear):
Ultrasound showed sensitivity (SN) of- 100%, specificity (SP) of - (81.8%), positive predictive value (PPV) of -66.6%, and negative predictive value (NPV) of - 100%, and with a diagnostic accuracy of 86.6%.

Table 1: Diagnostic accuracy of USG in comparison with MRI – supraspinatus tear

		MRI		Total
		Positive	**Negative**	
Ultrasound	Positive	8	4	12
	Negative	0	18	18
Total		8	22	
Chi square test = 15.81, p=<0.0001*, Statistically significant				

Sensitivity	100.000%	63.058% to 100.000%
Specificity	81.818%	59.715% to 94.813%
AUC	0.909	0.747 to 0.983
Positive Likelihood Ratio	5.500	2.267 to 13.346
Negative Likelihood Ratio	0.000	
Disease prevalence	26.667%	12.279% to 45.889%
Positive Predictive Value	66.667%	45.183% to 82.915%
Negative Predictive Value	100.000%	
Accuracy	86.667%	69.278% to 96.245%

INFRASPINATUS TENDON TEAR (Any tear):
Ultrasound showed a specificity (SP) of - (100%), sensitivity (SN) of-50%, positive predictive value (PPV) of -100%, good negative predictive value (NPV) of- 96.5%, and with diagnostic accuracy of 96.6%.

Table 2: Diagnostic accuracy of USG with MRI -infraspinatus tear

		MRI		Total
		Positive	**Negative**	
Ultrasound	Positive	1	0	1
	Negative	1	28	29
Total		2	28	30
Chi square test = 14.0, p=<0.0001*, Statistically significant				

Sensitivity	50.000%	1.258% to 98.742%
Specificity	100.000%	87.656% to 100.000%
AUC	0.750	0.559 to 0.889
Positive Likelihood Ratio		
Negative Likelihood Ratio	0.500	0.125 to 1.999
Disease prevalence	6.667%	0.818% to 22.074%
Positive Predictive Value	100.000%	
Negative Predictive Value	96.552%	87.504% to 99.115%
Accuracy	96.667%	82.783% to 99.916%

SUBSCAPULRIS TENDON TEAR (Any tear):
Ultrasound showed a sensitivity (SN) of- 100%, specificity (SP) of- (100%), positive predictive value (PPV) of-100%, negative predictive value (NPV) of- 100%, and with a diagnostic accuracy of 100%.

Table 3: Diagnostic Accuracy of USG with MRI – Subscapularis tear

		MRI		Total
		Positive	Negative	
Ultrasound	Positive	5	0	5
	Negative	0	25	25
Total		5	25	30
Chi square test = 29, p=<0.0001*, Statistically significant				

Sensitivity	100.000%	47.818% to 100.000%
Specificity	100.000%	86.281% to 100.000%
AUC	1.000	0.884 to 1.000
Positive Likelihood Ratio		
Negative Likelihood Ratio	0.000	
Disease prevalence	16.667%	5.642% to 34.721%
Positive Predictive Value	100.000%	
Negative Predictive Value	100.000%	
Accuracy	100.000%	88.430% to 100.000%

ANY TEAR:

Ultrasound showed a sensitivity of (SN)- 93.3%, specificity (SP) of - (73.3%), positive predictive value (PPV) of -77.7%, negative predictive value (NPV) of - 91.6%, and with a diagnostic accuracy of 83.3%.

Table 4: Diagnostic Accuracy of USG with MRI – Any tear

		MRI		Total
		Positive	Negative	
Ultrasound	Positive	14	4	18
	Negative	1	11	12
Total		15	15	30
Chi square test =13.42, p=<0.0001*, Statistically significant				

Sensitivity	93.333%	68.052% to 99.831%
Specificity	73.333%	44.900% to 92.213%
AUC	0.833	0.653 to 0.944
Positive Likelihood Ratio	3.500	1.496 to 8.189
Negative Likelihood Ratio	0.091	0.013 to 0.619
Disease prevalence	50.000%	31.297% to 68.703%
Positive Predictive Value	77.778%	59.934% to 89.118%
Negative Predictive Value	91.667%	61.773% to 98.682%
Accuracy	83.333%	65.279% to 94.358%

Subacromial and Sub Deltoid Bursitis

Ultrasound showed a sensitivity (SN) of – 66.6 % - specificity (SP) of - (100%), positive predictive value (PPV)-100%, negative predictive value of (NPV)- 81.8%, and with a diagnostic accuracy of 86.6%.

Table 5: Diagnostic Accuracy of USG with MRI- SASD Bursal collection

		MRI		Total
		Positive	Negative	
Ultrasound	Positive	8	0	8
	Negative	4	18	22
Total		12	18	30
Chi square test =15.81, p=<0.0001*, Statistically significant				

Sensitivity	66.667%	34.888% to 90.075%
Specificity	100.000%	81.470% to 100.000%
AUC	0.833	0.653 to 0.944
Positive Likelihood Ratio		
Negative Likelihood Ratio	0.333	0.150 to 0.742
Disease prevalence	40.000%	22.656% to 59.397%
Positive Predictive Value	100.000%	
Negative Predictive Value	81.818%	66.905% to 90.923%
Accuracy	86.667%	69.278% to 96.245%

Joint effusion:

Ultrasound showed a sensitivity of (SN)- 100%, specificity (SP) of- (95.6%), positive predictive value (PPV)-87.5%, negative predictive value (NPV) of - 100%, and with a diagnostic accuracy of 100%.

Table 6: Diagnostic Accuracy of USG with MRI – Joint effusion

		MRI		Total
		Positive	Negative	
Ultrasound	Positive	7	1	8
	Negative	0	22	22
Total		7	23	30
Chi square test =24.27, p=<0.0001*, Statistically significant				

Sensitivity	100.000%	59.038% to 100.000%
Specificity	95.652%	78.051% to 99.890%
AUC	0.978	0.846 to 1.000
Positive Likelihood Ratio	23.000	3.382 to 156.399
Negative Likelihood Ratio	0.000	
Disease prevalence	23.333%	9.934% to 42.284%
Positive Predictive Value	87.500%	50.725% to 97.942%
Negative Predictive Value	100.000%	
Accuracy	96.667%	82.783% to 99.916%

Discussion

As of now, there prevails a finite data regarding the total ultrasound scans needed for an ultrasound operator in order to evaluate and diagnose the (RCT) rotator cuff tear with utmost sureness.

Research which included assessment of two ultrasound operators, proposed that a minimum of hundred ultrasound scans of shoulder joint are required for operators of ultrasound to get to a plateau in their skills to evaluate and diagnose tears of supraspinatus tendon with confidence.[12]

This study which included, the operator of ultrasound who had a short tenure of experience in carrying out the ultrasound of shoulder joint (2 normal subjects [4 shoulders] and 20 patients [40 shoulder]) could evaluate and diagnose any tear of rotator cuff with sensitivity (SN) of 93.3%, specificity (SP) of 73.3%, positive predictive value (PPV) of 77.7%, negative predictive value (NPV) of 91.6%, and with a diagnostic accuracy of 83.3%.

Tendinosis & tears involving the subscapularis tendon were missed very often.

This could be due to the pattern of subscapularis tendon which is normally striated and result of anisotropy, which is an artifact that is manifested when the transducer is not placed properly, parallel to that of the axis of tendon.[13]

The ensuing intra-tendinous hypoechoic pattern may be mis constructed to a pathological tendinosis/ tendon tear. A novice operator of ultrasound would overrate or underrate, true pathology as a result of this.

(SN) Sensitivity for diagnosis of rotator cuff tear was good and had a higher (NPV) negative predictive value. This denotes that, operator of ultrasound even though having a short tenure of experience for performing ultrasound of shoulder can exclude a tear involving the rotator cuff tendons with more sureness than evaluating and diagnosing them.

In this study, case selection was a confounding issue. All of the research participants in this study had a significant pretest probability for tears of rotator cuff tendons (confounding factor is always almost present in majority of the research in hospital setup). This might result in spurious rise of the estimates for (SN) sensitivity & (PPV) positive predictive values. The sensitivity of the test may be reduced if the same operator performed shoulder ultrasonography in a broad population with a lower pretest likelihood. In this instance, however, the (NPV) negative predictive values would be larger than those calculated in this study.

As a result, the study's final conclusion remains the same: an ultrasound operator with minimal expertise carrying out the shoulder ultrasonography may more accurately exclude tears of rotator cuff or than diagnose them.

Conclusion

(SN) Sensitivity for diagnosis of rotator cuff tear was good and had a higher (NPV) negative predictive value. Consequently, operator of ultrasound even though having a short tenure of experience for performing ultrasound of shoulder had good sensitivity in diagnosing tears; and able to eliminate them with sureness.

Limitations

This study is hampered by the presence of only one operator of ultrasound; thus, we have no idea how many operators of ultrasonography with minimal expertise would perform in identifying rotator cuff tear.

Acknowledgment

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References

1. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, Shitara H, Kobayashi T. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg. 2010;19(1):116-20. doi: 10.1016/j.jse.2009.04.006.
2. Abate M, Schiavone C, Di Carlo L, Salini V. Prevalence of and risk factors for asymptomatic rotator cuff tears in postmenopausal women. Menopause. 2014;21(3):275-80. doi: 10.1097/GME.0b013e31829638e3.
3. Akbar M, Balean G, Brunner M, Seyler TM, Bruckner T, Munzinger J, Grieser T, Gerner HJ, Loew M. Prevalence of rotator cuff tear in paraplegic patients compared with controls. J Bone Joint Surg Am. 2010;92(1):23-30. doi: 10.2106/JBJS.H.01373.
4. Valkering KP, Stokman RD, Bijlsma TS, Brohet RM, van Noort A. Prevalence of symptomatic rotator cuff ruptures after shoulder trauma: a prospective cohort study. Eur J Emerg Med. 2014;21(5):349-53. doi: 10.1097/MEJ.0000000000000097.
5. Nakajima D, Yamamoto A, Kobayashi T, Osawa T, Shitara H, Ichinose T, Takasawa E, Takagishi K. The effects of rotator cuff tears, including shoulders without pain, on activities of daily living in the general population. J Orthop Sci. 2012;17(2):136-40. doi: 10.1007/s00776-011-0186-4.
6. Teefey SA, Middleton WD, Payne WT, Yamaguchi K. Detection and measurement of rotator cuff tears with sonography: analysis of diagnostic errors. AJR Am J Roentgenol. 2005;184(6):1768-73. doi: 10.2214/ajr.184.6.01841768.
7. Della Sala SW, Bianchini G. Magnetic resonance in the study of the painful shoulder. The surgical comparison in 30 consecutive cases. Radiol Med. 1996;91(4):348-55.
8. Liu F, Dong J, Shen WJ, Kang Q, Zhou D, Xiong F. Detecting Rotator Cuff Tears: A Network Meta-analysis of 144 Diagnostic Studies. Orthop J Sports Med. 2020;8(2):2325967119900356. doi: 10.1177/2325967119900356.
9. Lenza M, Buchbinder R, Takwoingi Y, Johnston RV, Hanchard NC, Faloppa F. Magnetic resonance imaging, magnetic resonance arthrography and ultrasonography for assessing rotator cuff tears in people with shoulder pain for whom surgery is being considered. Cochrane Database Syst Rev. 2013;2013(9):CD009020. doi: 10.1002/14651858.CD009020.pub2.
10. Rutten MJ, Jager GJ, Kiemeney LA. Ultrasound detection of rotator cuff tears: observer agreement related to increasing experience. AJR Am J Roentgenol. 2010;195(6):W440-6. doi: 10.2214/AJR.10.4526.
11. Nwawka OK. Update in Musculoskeletal Ultrasound Research. Sports Health. 2016;8(5):429-37. doi: 10.1177/1941738116664326.
12. Alavekios DA, Dionysian E, Sodl J, Contreras R, Cho Y, Yian EH. Longitudinal analysis of effects of operator experience on accuracy for ultrasound detection of supraspinatus tears. J Shoulder Elbow Surg. 2013;22(3):375-80. doi: 10.1016/j.jse.2012.09.017.
13. Narasimhan R, Shamse K, Nash C, Dhingra D, Kennedy S. Prevalence of subscapularis tears and accuracy of shoulder ultrasound in pre-operative diagnosis. Int Orthop. 2016;40(5):975-9. doi: 10.1007/s00264-015-3043-9.

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