HIGH-RESOLUTION ULTRASONOGRAPHY OF SHOULDER FOR ROTATOR CUFF TEAR: CORRELATION WITH ARTHROSCOPIC FINDINGS

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ABSTRACT

INTRODUCTION

Rotator cuff disease is the most common cause of shoulder pain. Ultrasonography being non-invasive, widely available, more cost-effective method and is the first choice in imaging of rotator cuff tears. Arthroscopy of shoulder is considered as the gold standard for diagnosis of rotator cuff tears. Objective of this study was to compare the diagnostic accuracy of high-resolution ultrasonography of shoulder for rotator cuff tears with arthroscopy of shoulder.

METHODS

Thirty patients clinically suspected to have rotator cuff tear who underwent ultrasonography and arthroscopy of shoulder were included in the study. Duration of study was for two years. All ultrasonography examinations were conducted in ultrasound machine using GE Voluson 730 PRO high frequency (10-12 MHz) linear array transducer done by two experienced radiologists. Arthroscopies were done by two experienced shoulder arthroscopic surgeons.

RESULTS

Age of the patients with rotator cuff tears ranged from 40 to 80 years. 57% were females and 43% were males among the patients who had rotator cuff tears. 71.43% of the rotator cuff tears were found in the dominant arm. 64.28% of patients with rotator cuff tear had given history of fall or trauma to the corresponding shoulder within 6 months prior to presentation. 39.28% of patients who had rotator cuff tears were known diabetics. Supraspinatus tendon was the most commonly affected tendon, followed by infraspinatus and subscapularis tendons. For overall detection of rotator cuff tears, ultrasonography in comparison with the arthroscopy has sensitivity and specificity of 92.85% and 100%. For detection of full thickness rotator cuff tear, its sensitivity and specificity was 94.73% and 100% and for partial thickness rotator cuff tears 76.92% and 100%. Ultrasonography has 100% sensitivity and specificity for detection of supraspinatus full thickness tear. For supraspinatus partial thickness tear, sensitivity and specificity was 88.89% and 100%, respectively. For detection of infraspinatus full thickness tear, ultrasonography has sensitivity and specificity of 80% and 100%.

CONCLUSION

High-resolution ultrasonography has high sensitivity and specificity for full thickness rotator cuff tear detection, but for detection of partial thickness rotator cuff tear its sensitivity is relatively less.

KEYWORDS

Shoulder Ultrasonography, Shoulder Arthroscopy, Rotator Cuff, Supraspinatus Tear, Infraspinatus Tear.

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INTRODUCTION: Rotator cuff is a complex of four muscles and their tendon. The tendons blend with joint capsule and forms a musculotendinous collar that surrounds the glenohumeral joint.

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It plays a major role in the rotatory movements and stability of shoulder joint. Shoulder pain is the third most common musculoskeletal symptom encountered in medical practice after back and neck pain. Rotator cuff disease is most common cause of shoulder pain.[1] Rotator cuff disorders includes rotator cuff tears, rotator cuff tendinopathy, shoulder impingement syndrome and subacromial subdeltoid bursitis. Compromised shoulder movement due to pain, stiffness or weakness can cause substantial disability and affect a person's ability to carry out daily activities and work.[2]

Average prevalence of rotator cuff tears in asymptomatic adult shoulder is about 23%. Prevalence increases with increasing age. Prevalence in the age group of 50 to 59 years is 13%, in 60 to 69 years is 20%, in 70 to 79 years is 31% and above 80 years of age is about 51%.[3] Factors which aide on to this progress includes age, occupation, trauma, acromion type, acromioclavicular joint degeneration, proximal migration of the humeral head and bony spurs compressing on the tendons. The muscles involved in the formation of rotator cuff are Supraspinatus (SSP), Infraspinatus (ISP), Teres Minor (TM) and Subscapularis (SSC).[4] Rotator cuff muscles generate torque forces to move the humerus while acting in concord to produce balanced compressive forces to stabilise the glenohumeral joint. Being one of the most important stabilisers of shoulder joint, rotator cuff tear can cause major joint dysfunction. In the workup of patients with shoulder pain, role of imaging is to diagnose and to guide treatment decisions. The diagnosis of a rotator cuff tear and its extent, full or partial thickness, can determine whether the patient will be managed conservatively or will need surgery.[5]

Various imaging modalities are currently available for evaluating shoulder joint particularly the rotator cuff tear including conventional radiography, ultrasonography, computed tomography, arthrography, magnetic resonance imaging, magnetic resonance arthrography and diagnostic arthroscopy.[6] High-resolution ultrasonography (USG) and magnetic resonance imaging have comparable accuracy for identifying and measuring the size of full thickness and partial thickness rotator cuff tears. Sensitivity of high resolution USG for detecting full thickness rotator cuff injury differs from 89% to 100% in different studies.[7,8] In recent studies, it has shown the sensitivity of 100%.[9] The inherent advantages of ultrasonography include wide availability, low cost, quick scan time, multiplanar capability and lack of ionising radiation. Distinct advantages are ability to perform dynamic, real time imaging with contralateral comparison. The quality and consistency of ultrasonography relies on the expertise of the examiners. Hence, operator dependency is a notable drawback.

METHODS: Clinically suspected cases of rotator cuff injury who underwent high-resolution ultrasonography and arthroscopy of shoulder were included in this study. Duration of study was for two years. It was hospital-based prospective study. Sample size was estimated using N masters' software. From the cited study, sensitivity of ultrasonography as compared to arthroscopy for assessing shoulder rotator cuff tear was 77% and precision of 3.25% with desired confidence interval of 95% the required sample size is 28. All the quantitative variables in the present study such as age and sex distribution of rotator cuff tears and subacromial subdeltoid bursa involvement etc. were expressed in terms of frequency and percentage. Sensitivity, specificity, positive predictive value and negative predictive values were calculated for USG findings versus arthroscopy findings. Chi-square test was used to test for difference in proportions. P-value less than 0.05 was considered statistically significant. Patients with pain and restricted shoulder mobility were clinically evaluated.

At the time of clinical evaluation, all patients in our selected group showed signs and symptoms suggestive of rotator cuff tear and therefore examined by using ultrasonography followed arthroscopy within 24 hours. All ultrasonographies were obtained with Voluson 730 PRO GE ultrasound machine using high frequency 10-12 MHz linear array transducer. USG examinations were performed by two experienced radiologists having 5 and 3 years of experience. Patient seated on stool and radiologist seated in front of the patient or was standing behind the patient during the USG examination.

USG Criteria Used to Diagnose the Rotator Cuff Tears (RCTs):

Full Thickness Tears (FTTs):

a. Nonvisualisation or absence of cuff tissue because of complete avulsion and retraction under acromion with approximation of the deltoid muscle to surface of the humeral head.
b. Focal defect in the rotator cuff extending through entire substance of rotator cuff created by a variable degree of retraction of the torn tendon ends.
c. Ability to compress the deltoid muscle by the probe within a defect or against the humeral head.
d. Supraspinatus tears extending 2.5 cm or more posterior to the biceps tendon in the transverse view are regarded as tears extending into the infraspinatus.

Partial Thickness Tears (PTT):

a. Focal hypoechoic or mixed hyper and hypoechoic defect not traversing the entire tendon thickness, involves articular (Articular Surface PTT) or bursal surface (Bursal Surface PTT).
b. A focal hypoechoic zone within the substance of rotator cuff (Mid Substance PTT).
c. Minimal flattening (Loss of Convexity) of bursal side of the rotator cuff (Bursal Surface PTT).

Arthroscopic Examination: Were performed by two experienced orthopedic surgeons with 10 and 8 years of experience. The patient was in beach chair position during arthroscopic procedure. Rotator cuff was approached from the posterior portal and the following anatomical structures were examined, the intra-articular part of the biceps tendon, subscapularis tendon, superior glenohumeral ligament and humeral head of the glenohumeral joint, rotator cuff, the integrity of the labrum and Subacromial Subdeltoid Bursa (SASDB). Findings were noted and the presence or absences of full and partial thickness (Articular or Bursal) rotator cuff tears were recorded.

Inclusion Criteria: All clinically suspected cases of rotator cuff tear who undergo USG and arthroscopy.

Exclusion Criteria:

1. Patients who undergo USG, but not arthroscopy.
2. Old cases of rotator cuff repairs.

3. The conditions in which USG and arthroscopy are technically difficult to perform.

RESULTS: Thirty clinically suspected cases of rotator cuff tears were included. Findings in the patients studied were tabulated using Microsoft excel. All statistical analyses were conducted using the SPSS statistical package (Version 17.0). Observations of these 30 patients were compiled and analysed. Age of the patients ranged from 39 to 80 years. Highest numbers of patients were in the age group of 40-59 years (18 patients), which corresponds to 60% of the study population. Mean age of rotator cuff tear was 55.6 years. 56.63% (17) were females and 43.34% (13) were males. Right shoulder was most commonly affected side involving 71.43% (20 out of 28) of rotator cuff tears and left shoulder was affected in 28.57% (08). Among the 28 rotator cuff tears, 71.43% (20) affected the dominant limb and remaining 28.57% (8) affected nondominant limb. All dominant upper limbs were right sided and no left-sided dominance was observed. 64.28% (18 out of 28) of patients with rotator cuff tear had history of trivial trauma to the corresponding shoulder within 6 months of presentation.

35.72% (10 out of 28) patients did not give history of trauma to respective shoulder. 39.28% (11 out of 28) of the patients who had rotator cuff tears were known diabetics on treatment. Among four rotator cuff tendons, one tendon was torn in 64.28% (18 out of 28) cases, two tendons were torn in 32.15% (9 out of 28) and three tendons were involved in 3.57% (1 out of 28) of total rotator cuff tear. Supraspinatus tendon was the most commonly affected tendon among the rotator cuff tears involved in 96.42% (27 out of 28) cases followed by infraspinatus involved in 32.14% (9 out of 28) cases. Third most commonly affected tendon was Subscapularis (SSC), 10.71% (3 out of 28) and Teres Minor (TM) was not involved in any cases.

USG detected 26 Rotator Cuff (RC) tears out of 30 patients and arthroscopy confirmed the presence of 28 tears out of 30 patients examined. USG was negative in 4 cases and arthroscopy was negative in 2 cases (Figure 1). USG shoulder showed over all sensitivity of 92.85%, specificity of 100%, Positive Predictive Value (PPV) of 100% and Negative Predictive Value (NPV) of 50% in comparison with the arthroscopy of the shoulder in detection of the rotator cuff tear with P value of 0.031. USG detected 18 out of 19 Full Thickness Rotator Cuff Tear (FTT-RC) with sensitivity, specificity, PPV and NPV of USG in comparison with the arthroscopy was 94.73%, 100%, 100% and 91.66% respectively with P value of 0.03. USG could not diagnose 1 FTT-RC (Subscapularis FTT) out of 19 arthroscopically proved full thickness rotator cuff tears. USG detected 10 out 13 Partial Thickness Tear (PTT-RC) with sensitivity, specificity, PPV and NPV of USG in comparison with the arthroscopy was 76.92%, 100%, 100% and 85% respectively with P value of 0.04. USG could not diagnose 3 PTT-RC out of 13 arthroscopically-proved partial thickness cuff tears. Total number of supraspinatus tears detected in USG was 26 out of 30 patients examined.

However, arthroscopy detected 27 tear out of 30 shoulders examined (Figure 2 and 3). Among these, 18 were FTT and 8 were PTT, which was detected in the USG against the 18 FTT and 9 PTT detected arthroscopically (Figure 4 and 5). USG shoulder showed sensitivity, specificity, PPV and NPV of 100% in comparison with the arthroscopy of the shoulder in detection of SSP-FTT with P value <0.01. The sensitivity, specificity, PPV and NPV of USG for detection of SSP-PTT was 88.89%, 100%, 100% and 95.45% respectively with P value <0.01. USG detected 4 ISP-FTT and 1 ISP-PTT in comparison with the arthroscopic detection of 5 ISP-FTT and 4 ISP-PTT out of 30 shoulders examined. The sensitivity, specificity, PPV and NPV of USG detection of ISP-FTT and ISP-PTT was 80%, 100%, 100% and 96.15% with P value of 0.005 and 25%, 100%, 100% and 89.65% with P value of 0.428, respectively. USG had not detected any SSC-FTT and detected 1 SSC-PTT, however, arthroscopy detected 1 SSC-FTT and 2 SSC-PTT out 30 shoulders examined in both the modalities. USG detected 1 and arthroscopy detected 2 Long Head of Biceps (LHB) tears out of 30 shoulders examined.

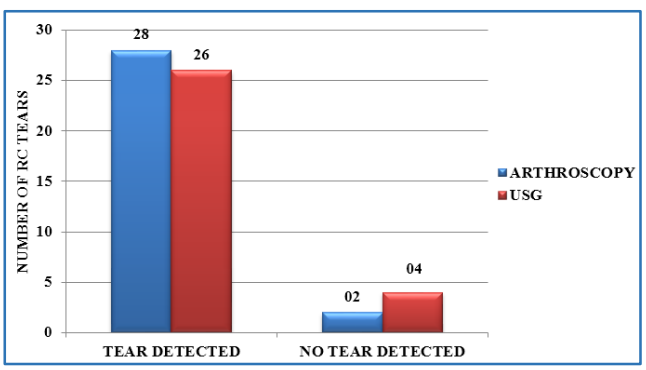

Fig. 1: Comparing the Overall Rotator Cuff Tear Detection in Arthroscopy and USG

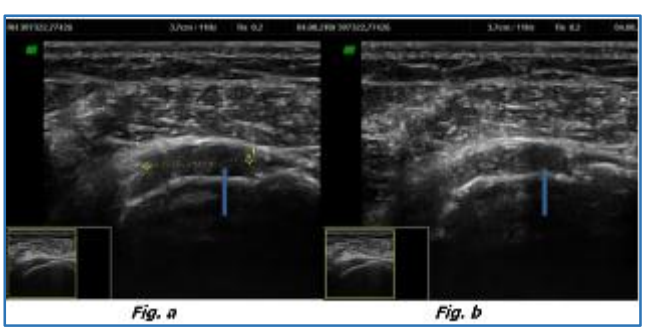

Fig. 2

Fig. 2: *Ultrasonography (USG) Images of Supraspinatus (SSP) Full Thickness Tear. 74-Year-Old Male Patient Presented with Pain and Restricted Right Shoulder Movements Since About 6 Months.* ***(a)*** *Longitudinal* ***(b)*** *Transverse, USG Images Showing Full Thickness Tear of Right SSP Tendon (Arrow) with Retraction of the Tendon Ends. Long and Thin Arrow Represents Torn Supraspinatus Tendon.*

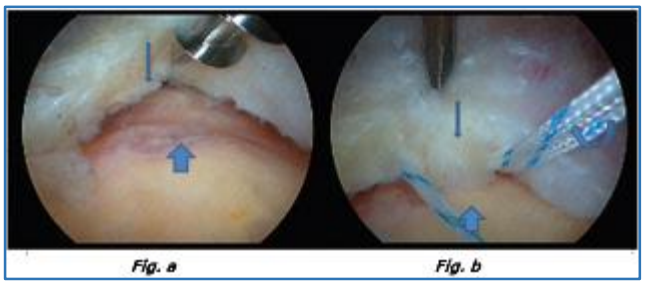

Fig. 3

Fig. 3: *Arthroscopic Images of Supraspinatus (SSP) Full Thickness Tear. Same Patient as in Figure 2 Who Underwent Arthroscopic Examination. Arthroscopic Images* ***(a and b)*** *Showing Full Thickness Tear of Right Supraspinatus Tendon* ***(a)*** *and Tendon Repair with Anchors* ***(b).*** *Long and Thin Arrow Represents Torn Supraspinatus Tendon and Short and Thick Arrow Represents Greater Tuberosity of Humeral Head. Curved Arrow in* ***(b)*** *Represents Anchors, which are used to Repair Tendons.*

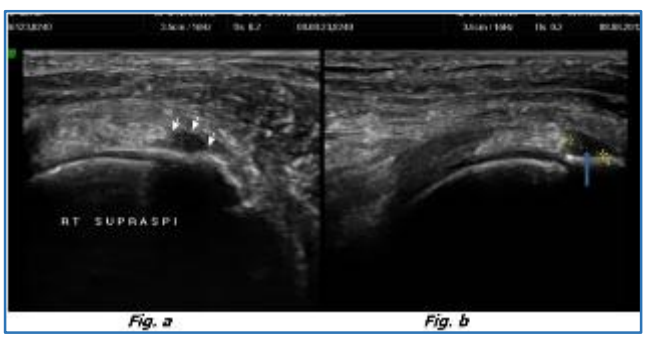

Fig. 4

Fig. 4: *USG Images of Supraspinatus Partial Thickness (Articular) Tear. 60 Years Old Female with Alleged History of Fall on Right Shoulder about 1 Month Back, had Pain and Restricted Shoulder Movements. USG Shoulder a). Longitudinal (Short Arrows) b). Transverse Images (Long Arrow) Shows Partial Thickness Rotator Cuff Tear (Articular Side) of the Right Supraspinatus Tendon.*

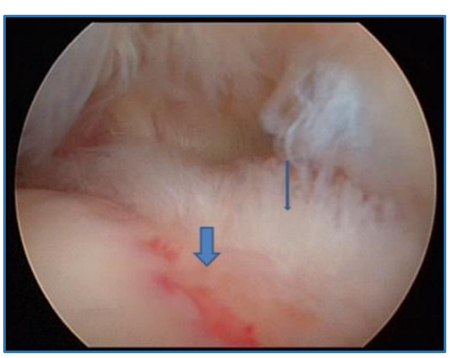

Fig. 5

Fig. 5: *Same Patient as in Figure 4 Who Underwent Arthroscopic Examination. Arthroscopic Image shows Articular Surface Partial Thickness Tear. Short and Thick Arrow Represents Greater Tuberosity and Thin Arrow Represents Partial Thickness Articular Surface Supraspinatus Tear.*

DISCUSSION: High-resolution ultrasonography has been widely used for evaluation of shoulder mainly for rotator cuff pathology. Developments in technology improvements in scanning techniques as well as better knowledge of anatomy and pathology make this examination one of the most useful in exploration of the shoulder. About 70% of rotator cuff tears were found in the 40-70 years age range. This was in concordance with the study by Milgrom et al,[10] which showed that prevalence of rotator cuff tears increases after age of 40 years due to age-related degeneration of rotator cuff tendons.[11] Present study shows 57% of females and 43% of males had rotator cuff tears, slight female predominance, which is statistically not significant. Study by Milgrom et al among 90 patients, which showed no statistically significant differences in incidence of rotator cuff lesions related to gender.[10] In present study, 71.43% of rotator cuff tears were found in dominant arm and all dominant arms were right sided. Study by Yamamoto A et al showed that rotator cuff were common in dominant arms.[12]

In this study, 64.28% of patients with rotator cuff tear had given history of fall and trauma to the corresponding shoulder within 6 months of presentation, but not associated with dislocation of the shoulder. Various studies have found an incidence of rotator cuff tear of 14% to 63% of patients after traumatic dislocation.[13] Full thickness rotator cuff tears after trauma are more common in older patients suggesting that older more degenerated tendons are weaker and tear more easily.[13] In this study, 39% of the rotator cuff tears were found in known diabetics. It is in concordance with various other studies showed that higher prevalence of rotator cuff tears and of degenerative phenomena in diabetics.[14] Study by Sharlene A. Teefey et al[8] in 100 consecutive shoulders, USG detected 65 arthroscopically proved FTT-RC with sensitivity, specificity, PPV and NPV of 100%, 85%, 96% and 100%, respectively.

And, also USG detected 10 out of 15 PTT-RC with sensitivity, specificity, PPV and NPV of 67%, 85%, 77% and 77%, respectively. Meta-analysis by Joseph O. de Jesus showed sensitivity and specificity of USG in comparison with arthroscopy for detection of RC-FTT was 95.4% and 98.9% and for RC-PTT was 85.9% and 96%, respectively.[15] The present study found that ultrasonography was highly accurate for detecting full-thickness rotator cuff tears as mentioned in literature. Our ability to detect partial-thickness rotator cuff tears with ultrasonography was limited. Study done by Sharlene A. Teefey and Brenneke and Morgan also reported a low sensitivity of USG for the detection of partial thickness tears.[8,16] This study showed that supraspinatus tendon was the most commonly affected tendon. This is consistent with the study conducted by Jerosch et al on dissected specimen of shoulder joints of 122 patients. That study found that isolated supraspinatus tendon tear occurred in 78% of cases. De Palma et al examined 96 cadaver shoulders and showed similar finding of supraspinatus as the commonly affected tendon. USG detected all Supraspinatus (SSP), full thickness tears and detected 8 out of 9 SSP-Partial Thickness Tears (PPT).

In SSP-PTT, 66.60% (6 out of 9) were articular side and 33.4% (3 out of 9) were bursal side. In a study by Kiran Singisetti and Andreas Hinsche in 96 shoulders, ultrasonography in comparison with arthroscopy showed sensitivity, specificity, PPV and NPR of 89%, 43%, 76% and 100% for SSP tear detection.[7] Study by Jon A. Jacobson et al, 15 patients with partial thickness tear demonstrated that 66.66% were articular surface and 33.33% were bursal surface. USG detected 4 out of 5 Infraspinatus (ISP), Fullthickness Tears (FTT) and 1 out of 4 ISP Partial Thickness Tears (PTT). According to our study, USG was just 25% sensitive to detection of ISP-PTT and P value also not significant. In present study, USG did not detect any tear in one arthroscopically proved Subscapularis (SSC), Fullthickness Tear (FTT) and detected 1 out of 2 SSC-PTT.

Study by Farin P and Jaroma H of 1,640 patients who underwent USG shoulder, 17 were surgically proved to have SSC tear; out of whom 14 were full thickness and 3 were partial thickness tears. Ultrasonography demonstrated 86% sensitivity (12 of 14) in detection of full thickness tears and 67% sensitivity (2 of 3) in detection of partial thickness tears. In our study, sensitivity of USG for SSC-PTT was 50%, but P value not significant (0.954) and not detected any SSC-FTT. However, sample size of arthroscopically proved SSC tear was very small in our study. USG had detected all the 11 distended Subacromial Subdeltoid Bursa (SASDB), which were proved arthroscopically. Study by Hollister et al done on 97 patients with surgery-proven rotator cuff tear, 52% had fluid in the joint, bursa or both.

CONCLUSION: High-resolution ultrasonography of shoulder is the first imaging modality of choice in evaluation of suspected rotator cuff tear. USG is noninvasive, widely available, portable, more cost-effective method. It is better tolerated by patients. USG allows comparison with the normal side and has the benefit of being a dynamic form of imaging as compared to the static MRI. It has high sensitivity and specificity for full thickness rotator cuff tear detection compared to partial thickness tears. It is highly sensitive and specific for full thickness tear of supraspinatus tendon, as supraspinatus is the most commonly affected rotator cuff tendon, ultrasonography's utility is more appreciated. It is sensitive and specific for detection of supraspinatus partial thickness and infraspinatus full thickness tears. But, for detection of infraspinatus partial thickness tears and subscapularis tears, its sensitivity is significantly less.

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