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The Diagnostic Accuracy of Shoulder Ultrasound For Rotator Cuff Pathology Compared to Magnetic Resonance Imaging as a Gold Standard

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ABSTRACT

Objective: To assess the diagnostic accuracy of ultrasound in the local population for rotator cuff injury keeping magnetic resonance imaging (MRI) as a gold standard.

Study Design: Diagnostic accuracy cross-sectional study.

Place and Duration of Study: Department of Radiology, Combined Military Hospital, Multan Institute of Medical Sciences-CIMS) Multan, Pakistan, from Apr to Oct 2022.

Methodology: A total of 169 patients with clinically suspected rotator cuff injury were selected by consecutive sampling. Subjects aged 25 to 65 years of either gender presenting with clinically suspected rotator cuff tear were selected for the study. Patients with prosthetic implants, pacemakers and fractures of clavicle, scapula, proximal humerus or having contraindications for MRI were excluded from the study. Ultrasound and MRI were done on each patient by separate operators. Data on diagnoses was collected and analyzed on SPSS v 23.

Results: A total sample of 169 patients with clinically suspected rotator cuff injury were enrolled. The mean age was 37.39± 8.97 years (range 25-65) of which 127(74.15%), were between 25 to 45 years of age. There was a preponderance of males: 120(71%). The diagnostic parameters for ultrasound were sensitivity-92.86%, specificity-90.59%, PPV-90.70%, NPV-92.77% and diagnostic accuracy-91.72%.

Conclusion: The diagnostic accuracy of ultrasound is comparable to that of MRI for detecting rotator cuff tears, suggesting a significant role for ultrasound in assessing rotator cuff tears.

Keywords: Diagnostic Imaging, Rotator Cuff Injuries, Shoulder Injuries, Ultrasonography.

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INTRODUCTION

The prevalence of patients presenting with shoulder pain is variable globally, with a median of 16%.[1] Full thickness tears of the rotator cuff were found in approximately 21% of 683 volunteers in 2010,[2] and 22.1% in 664 volunteers in 2013,[3] increasing with age to 45% in the seventh decade of life. With recent improvements in transducer strength, image resolution, and operator training, ultrasound (US) provides an excellent alternative imaging modality for the diagnosis of rotator cuff tears.[4] Rotator cuff tears may cause pain and shoulder disability and are responsible for 70% of shoulder related physician visits. A systematic review of 2021 showed ultrasound (US) to be equivalent to MRI in terms of diagnostic accuracy for rotator cuff injury.[5] This was also observed in a 2013 Cochrane review (which excluded partial thickness tears) in which sensitivity of US vs MRI was 91% and 98% respectively.[6] This Cochrane analysis included 20 studies of people with suspected rotator cuff tears (1147 shoulders), of which six evaluated MRI and US (252 shoulders), or MRA and US (127 shoulders) in the same people. Magnetic resonance imaging (MRI), magnetic resonance arthrography (MRA) and ultrasound (US) are increasingly being used to assess the presence and size of rotator cuff tears to assist in planning surgical treatment. It is not known whether one imaging method is superior to any of the others. Acute traumatic injury is more common in the younger population while degenerative micro-tears occur in the older segment of the population. Rotator cuff pathology is a progressive and degenerative process, with age being the most common factor and smoking an additional factor.[7] Ease of access and feasibility of US in the point of care setting makes it an attractive option for seamless clinical management.[8]

The rationale of conducting this study is to establish the diagnostic accuracy of US for rotator cuff

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pathology in resource constraint population so as to provide an evidence-based utilization to provide maximum possible and timely patient care in a developing country.

METHODOLOGY

The diagnostic accuracy cross-sectional study design was adopted to answer the study question. Permission from institutional ethics review committee (IRB letter number 13/Trg/dated Jan 2022) was obtained. The study took place in the Radiology Department of Combined Military Hospital, Multan, Pakistan, from Apr to Oct 2022. Sample size was calculated using Open Epi online sample size calculator using a prevalence of rotator cuff injury of 22% [2] taking confidence level of 95%, margin of error of 7% and power of 80%. The estimated sample size was calculated to be 148. A sample of 169 patients was enrolled after informed and written consent, by non-probability consecutive sampling.

Inclusion Criteria: Subjects aged 25 to 65 years of either gender presenting with clinically suspected rotator cuff tear (i.e., symptomatic patients which is defined as a history of shoulder pain (≤ 3-months duration) plus any one or more of the following clinical signs: Snapping of scapula when arms are lifted and positive impingement test.

Exclusion Criteria: Patients with prosthetic implants, pacemakers and fractures of clavicle, scapula, proximal humerus or having contraindications for MRI were excluded from the study.

Demographic characteristics including age (years) and gender were noted. The shoulder US was performed for all cases by the same Radiologist using Xario 100 ultrasound machine (Canon Medical systems) with a 10-MHz linear transducer. The guidelines of European Society of Musculoskeletal Radiology (ESSR) were used for rotator cuff tear radiological assessment. The US protocol for the anterior shoulder included the following muscle tendons: Biceps, supraspinatus, and subscapularis. For the posterior shoulder, infraspinatus and teres minor muscle tendons were included. The observation of a hypoechoic gap (fluid signal) in the tendon extending from the articular to bursal surface was deemed positive for full-thickness tear. MRI scan was performed at a 1.5 Tesla MRI machine (Canon medical system) using dedicated shoulder MRI protocol. The patients were positioned supine with arms adducted in mid-external rotation. A multi-phased body array coil was used with in plane spatial resolution of ≤0.4 X 0.4 mm, field of view of 120-160 mm and slice thickness of ≤ 3mm. T1 weighted coronal and sagittal oblique, T2 weighted coronal oblique and intermediate weighted fat- saturated sequences in coronal oblique, axial and sagittal oblique images were acquired. Ultrasound and MRI were reported by two separate consultant radiologists, each with more than 5 years' experience. Reports were compiled and tabulated by a designated third person in Statistical Package for Social Sciences version 23 (SPSS v 23) to ensure blinding of the reporting radiologists. A 2x2 contingency table was constructed, taking MRI as reference standard: Sensitivity, specificity, PPV, NPV and accuracy for ultrasound was calculated. The data was stratified for age groups and gender to adjust for confounding variables. Age variable was compiled as means with standard deviation while gender and presence of rotator cuff tear were calculated as frequency and percentages. A *p*-value of <0.05 was considered significant and was calculated using the Pearson Chi Square Test.

RESULTS

A total sample of 169 patients with clinically suspected rotator cuff injury were enrolled. Mean age was 44.4±12.6 years of which 127(75.1%) were between 25 to 45 years of age. There was a preponderance of males: 120(71.0%). Out of 169 patients, ultrasound correctly identified 78 true positives and 77 true negatives, with only 6 false negatives and 8 false positives. This resulted in a high sensitivity of 92.86% and specificity of 90.59%, indicating that ultrasound was highly effective in both detecting and ruling out shoulder pathology compared with MRI. The positive predictive value was 90.70%, and the negative predictive value was 92.77%, reflecting the reliability of ultrasound results in predicting true disease status. The overall diagnostic accuracy was 91.72%, demonstrating that ultrasound correctly classified the majority of patients. Furthermore, the (p<001) showed that statistically significant association between ultrasound and MRI findings, indicating that ultrasound is a reliable diagnostic tool for evaluating shoulder pathology (Table).

DISCUSSION

This analytical cross-sectional study suggested that the diagnostic accuracy of ultrasound is comparable to MRI for detecting rotator cuff tears suggesting a significant role for US in assessment of rotator cuff tears. This study reported that the overall sensitivity, specificity, PPV, NPV and diagnostic

accuracy of ultrasonography for rotator cuff tears was found to be 92.86%, 90.59%, 90.70%, 92.77% and 91.72% respectively.

Table: Diagnostic Parameters for Shoulder Ultrasound Vs Shoulder MRI

Shoulder MRI findings		
	Yes/ Positive	No/ Negative
Shoulder Ultrasound findings		
Yes/ Positive	a =78(46.15%)	b= 08(4.7%)
No/ Negative	c= 06(3.5%)	d= 77(45.5%)
Sensitivity= True Positive/(True Positive +False Negative) = 92.86% Specificity= True Negative / (True Negative +False Positive) = 90.59% Positive Predictive Value= True Positive/ (True Positive+ False Positive) = 90.70% Negative Predictive Value= True Negative/ (True Negative +False Negative) = 92.77% Diagnostic Accuracy= (True Positive +True Negative)/All Patients= 91.72%		
Pearson Chi-Square value-117.710(*p*-value <.oo1)		

Ultrasound diagnosis of rotator cuff tears has shown wide variability while MRI has been shown to have a high sensitivity and accuracy, thus being the preferred option despite reduced cost effectiveness and issues of non-availability.[9] Enhanced sonographic capabilities such as higher frequency, linear array, broad-bandwidth transducers having increased image resolution resulted in a significantly improved reliability of US.[10] A study conducted by Chauhan et al., was in relation to both full-thickness tears and partial-thickness tears. For full-thickness tears, US demonstrated high sensitivity (86.7%) and specificity (100%), resulting in a higher diagnostic accuracy (98.4%). In contrast, for partial-thickness tears, US exhibited lower sensitivity (89.7%) and specificity (98.8%), leading to a relatively lower diagnostic accuracy (95.9%). Based on these findings, the study recommended the use of US as the primary diagnostic tool for the initial assessment of rotator cuff tears.[11]

Aminzadeh B *et al*., studied 48 patients referred with clinically diagnosed rotator cuff tendinopathy and found that US demonstrated the highest sensitivity (93.7%) and specificity (100%) when detecting tears that involved the full thickness of the tendon. In these cases, the PPV was 100%, NPV was 96.6%, and the diagnostic accuracy was 97.9%, all indicating excellent diagnostic performance.[13] A study by Saraya *et al*., revealed sensitivity and specificity of US in detecting rotator cuff tear as 88.0% and 89.0% respectively, where the incidence of rotator cuff tears was 45.[14] A study by Prashanth *et al*., reported higher sensitivity, specificity, and diagnostic accuracy were observed for complete tears (86%, 86%, and 91%, respectively), while lower values were found for partial tears (75%, 95%, and 86%, respectively).[15] Additionally Ganesh *et al*., reported that with similar sensitivity and specificity, MRI and USG are useful diagnostic techniques for rotator cuff injuries.[16]

USG is a great screening alternative due to its cost-effectiveness, noninvasiveness, and easy accessibility. However, when it comes to identifying the anatomical regions that need surgical repair, MRI is superior. Madhavi *et al*., explained that ultrasound is a portable, quicker and a cheaper method in addition to being more comfortable for the patient who can even guide the operator to the most affected area of the shoulder. Point of care ultrasound has become a reality for clinicians at the bedside owing to the availability of portable US machines. This strategy may improve care, streamline diagnosis, reduce radiology workload and be more cost effective.[17] In a study by Mohtasib *et al*., shoulder US done by an orthopedic surgeon for symptomatic shoulder patients showed high sensitivity and specificity.[18] Another similar study demonstrated by Zoga *et al*., claimed 88% accuracy for full-thickness and lower for partial-thickness tears detection by US.[19]

The diagnostic performance of shoulder US was evaluated by Naunton *et al*., in a learning curve associated with increased operator experience over time spans may also have contributed to evaluate the accuracy of high resolution ultrasound (USG) and MRI in the diagnosis of rotator cuff tears (RCT) and to determine if high resolution USG compares favorably in sensitivity and specificity to MRI in the diagnosis of rotator cuff injury. The usual care provided by GPs for RCRP in Australia relies on the use of ultrasound and steroid injection thus, endorsing the use of US for rotator cuff injuries is a reliable diagnostic tool.[20] In a study conducted by Toh *et al*., analyzed the use of ultrasound (US) and magnetic resonance imaging (MRI) for rotator cuff injuries, concluding that both are viable first-line options but have different strengths. While MRI is often preferred for its diagnostic detail, especially for partial tears, US offers cost-effectiveness and real-time visualization, particularly for full-thickness tears, and its effectiveness is highly dependent on operator skill.[21] A comparison of US and MRI using arthroscopy as gold standard was done by Hapani *et al*., on 30 patients clinically suspected of having rotator cuff tears, showed a comparable sensitivity and specificity of both modalities. For partial thickness tears ultrasound showed sensitivity and specificity of 91.4% and 100% while MRI had a

sensitivity of 88.2% and specificity of 100%. In cases of full thickness tears the sensitivity and specificity of ultrasound and MRI were 90%/100% vs 100%/100% respectively.[22] This is in conflict with the Cochrane review mentioned above in which the diagnostic accuracy of ultrasound for partial thickness tears was low.

The results of our study are similar, to a significant extent, to studies done in the international and regional scene and suggest a role for shoulder US in the diagnosis of rotator cuff tears. The strength of this study was its sample size and the focus on the local population. The lack of comparison with arthroscopic findings may be considered a limitation as well as the fact that partial and full thickness tears were not studied separately.

CONCLUSION

The findings of this study suggest that the diagnostic accuracy of ultrasound is comparable to MRI for detecting rotator cuff tears suggesting a significant role for US in assessment of rotator cuff tears. This may be in the form of initial imaging or point of care assessment, with MRI being reserved for definitive diagnosis where required. Further research and validation studies are warranted.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SA & FN: Data acquisition, data analysis, critical review, approval of the final version to be published.

SKB & AL: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MS & EAM: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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