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A comparative study of ultrasonography and magnetic resonance imaging for the evaluation of rotator cuff injuries

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Abstract
Introduction: The Rotator cuff is a group of muscles and tendons which provide strength and stability during shoulder motion and includes Subscapularis, Supraspinatus, Infraspinatus & Teres minor muscles and their tendons.
There are numerous causes of shoulder disability, although Rotator cuff pathologies are most common cause of shoulder disability, Impingement syndrome, Bicipital tendinopathy, Dislocation, Adhesive capsulitis and Glenoid labral tears are other causes that can lead to shoulder pain and restriction of mobility of the shoulder
Objectives
1. To study the spectrum of rotator cuff pathologies encountered on Ultrasound & Magnetic resonance imaging.
2. To correlate Ultrasound and Magnetic resonance imaging findings.

Material and Methods: Present study was a single centric, cross sectional prospective, observational, hospital-based study in which 40 patients underwent ultrasound and MRI of the shoulder and findings of both were compared.
Results: Average age group of the study population was 49.77 years. The gender distribution in our study showed a male preponderance, of 16 males [53.3%] and 14 female [46.7%]. Study showed out of 40 patients, 21 patients (70%) had disease of the shoulder on right side while 9 patients (30%) had disease on left side. All of the patients in our study were right-handed. For partial thickness tears USG had a sensitivity of 92.86%, specificity of 100%. In cases with full thickness tears, 100% sensitivity and 96.3% specificity was achieved.
Conclusion: Based on our findings, USG can be used as a first line modality while investigating a case of shoulder joint pain to rule out rotator cuff tears and MRI should be used as second line non- invasive test to confirm the diagnosis & to rule out associated injuries.
Ultrasound is nearly as efficient as MRI and is practical, well accepted, and accurate non-invasive imaging technique in patients presenting with shoulder pain.

Keywords: Magnetic resonance imaging, painful shoulder, ultrasound

Introduction
The ball and socket diarthrodial gleno-humeral multiaxial joint which is synovial in nature with wide range of movements. Its deluxe design gives a wide range of movements and gives humans the ability for diverse amount of daily activities. The relatively larger head of humerus than the scapula's glenoid fossa although it gives significant range of movements but has a drawback of increased vulnerability to instability. The primary stabilising components of the shoulder joint are glenoid labrum & rotator cuff muscles. Cartilaginous glenoid labrum deepens the glenoid cavity thereby providing more contact area and more stability to glenohumeral joint [1].
The Rotator cuff which is a unit of tendons & muscles which provides strength and stability during shoulder motion and includes, Supraspinatus (superior), Subscapularis (anterior), Teres minor (posterior) & Infraspinatus (postero-superiorly) muscles and their tendons, which envelop the gleno-humeral joint, keeping the humeral head firmly attached in the scapula's glenoid fossa [2].

The supraspinatus, coupled with the deltoid, stabilises the glenohumeral joint and elevates the arm. It is thought to be the upper extremity's strongest abductor and elevator [3]. In fact, it is a component of the gleno-humeral abduction and elevation initiator.

Additionally, the external rotation torque provided by the infraspinatus and teres minor serves to prevent the glenohumeral joint from subluxating posteriorly. The infraspinatus has a biphasic role during abduction and elevation, with the muscles acting as either movers or depressors.

Subscapularis operates as an internal rotational rotator, particularly when the internal rotation is at its maximum. As it turns out, the glenohumeral joint's strongest internal rotator is the arm whether it is abducted or adducted [4].

Because the long head of the biceps acts in tandem with the rotator cuff, it must be taken into account.

To compensate for the poor socket of the glenoid fossa, the labrum offers additional articular surface by covering a larger portion. The glenoid fossa and its labrum work together to strengthen the joint's natural stability. In terms of the relative contribution of the rotator cuff muscles at rest (isometric) or at motion (isokinetic) it, studies have shown that at rest in the neutral position, the subscapularis contributes to about half the strength with the infraspinatus also contributing just over 22% [5]. Isokinetic analysis of the muscles showed the supraspinatus and infraspinatus contributing to half the strength during abduction and external rotation [6].

USG is used to diagnose rotator cuff tendinopathy and shoulder impingements in a fast, dynamic, real-time manner. In the diagnosis of full thickness rotator cuff injuries, USG is as accurate as MRI. According to studies, USG is less accurate in diagnosing partial thickness rotator cuff injuries. USG is a simple, low-cost method that provides immediate similitude with the opposite side. USG accuracy, on the other hand, is highly user-dependent and has a limited role in evaluating the bony and cartilaginous components of the shoulder joint.

MR imaging's greater ability to show both internal structures and soft tissue around the joint, as well as its non-invasive nature, has made it the imaging method of choice in many cases. MRI gives good spatial resolution of bone, cartilaginous, and soft tissue at the shoulder joint, providing anatomical information about the tendon implicated, the size, extent, and position of tendon tears, which is crucial for determining the surgical feasibility and kind of treatment required. Shoulder MR imaging is commonly utilized to assess impingement, instability, and other clinical problems. MRI can show the progression of rotator cuff tendinopathy and partial or full thickness tear [7].

As a result, we will compare the effectiveness of USG against MR imaging in evaluating shoulder pathologies in patients with shoulder pain in this study.

Materials and Methods

Patient Recruitment: Present study was a single centric, cross sectional prospective, observational, hospital-based study in which 40 patients underwent ultrasound and MRI of the shoulder and findings of both were compared.

Ultrasonography of shoulder

Equipment: Philips Affiniti 70G Ultrasound machine, high resolution linear array transducer with frequency 5-12Hz will be used.

Shows protocol and positioning

Steps	Protocol	Positioning
1.	Biceps brachii tendon, long head.	On the lap, place your palm up.
2.	Sub Scapularis and Biceps Brachii Tendon, subluxation/dislocation	On the lap, place your palm up along with external rotation
3.	Supraspinatus and Rotator Interval	Crass position & modified Crass position
4.	ACJ, Subacromial & Subdeltoid bursa and dynamical assessment for sub-acromial impingement.	On the lap, place your palm up.
5.	Posterior labrum, Infraspinatus and teres minor	On the lap, place your palm up.

Magnetic resonance imaging of shoulder

Equipment: MRI will be carried out on Philips 1.5 Tesla Achieva machine, using standard imaging protocol.

Positioning: Every patient will lay supine with the head pointing towards magnet (head first supine), The shoulder is immobilised with sand bags and placed in a tiny semiflexed shoulder coil, with the laser beam localiser centred over the shoulder or in the midline of the shoulder coil.

Imaging of the shoulder joint was performed in all 3 planes (axial, coronal & sagittal) using oblique axis as follows:

MRI protocol for shoulder

Sequences	TR	TE	THK	FOV	NSA
T2 Axial	4300-4310	100	3	120-160	3
T1 SAG	550-560	18	3	120-160	3
T2 COR	4100-4110	90	3	120-160	3
PDW SPIR SAG	3700-3710	30	3	120-160	3
PDW SPIR COR	2500	30	3	120-160	3
STIR AXIAL	2960-2970	30	3	120-160	3

Statistical Analysis: The data were imported into a Microsoft Excel spreadsheet & analysed using the SPSS 22 statistical analysis programme. Frequencies and proportions were used to represent categorical data. The Chi-square test was performed to determine significance. The mean and standard deviation were used to describe continuous data. A p value of 0.05 was considered statistically significant. Validity of USG with MRI was estimated by calculating Sensitivity, Specificity, NPV, PPV and Diagnostic Accuracy. Agreement between two tests was determined by Kappa Coefficient

Results

Distribution according to age and sex

Our study group consisted of 30 patients with a mean age of 49.77 [S.D10.27] years, which corresponds to the average age of 42.28 years found by Worland RL *et al.* [2003]. The gender distribution in our study showed a male preponderance, of 16 males [53.3%] and 14 female [46.7%]. In the study, the youngest patient was 20 years old and the oldest patient was 84 years old.

Based on side of involvement & dominant hand involved

Study showed out of 40 patients, 21 patients (70%) had disease of the shoulder on right side while 9 patients (30%) had disease on left side. All of the patients in our study were

right-handed.

Distribution of rotator cuff tears

Rotator cuff pathologies were the commonest cause of painful shoulder in our study. The pathologies included partial, full thickness tears and tendinosis. Supraspinatus tendon was the commonest tendon to be involved in our study. Where in USG detected 22 patients and MRI detected 26 patients with supraspinatus tendon involvement was present in around 80% of their cases as shown in a previous study done by Matthieu J *et al*. [8].

In our study the Supraspinatus pathologies the USG pick up rate was 73.3%. Subscapularis pathologies the USG pick up rate was 73.3%. Subscapularis tendon pathologies 50% sensitivity, 92.6% specificity, a PPV of 33.33%, a NPV of 96.3%, with an accuracy of 90% and significance of P = 0.051+. The supraspinatus tendon pathologies showed 76.92% sensitivity, 50% specificity, a PPV of 90.91%, a 25% NPV, with an accuracy of 73.33% and a significance of P= 0.257. For partial thickness tears USG had a sensitivity of 92.7%, specificity of 100%. In cases with full thickness tears, 100% sensitivity and 96.3% specificity was achieved.

Discussion

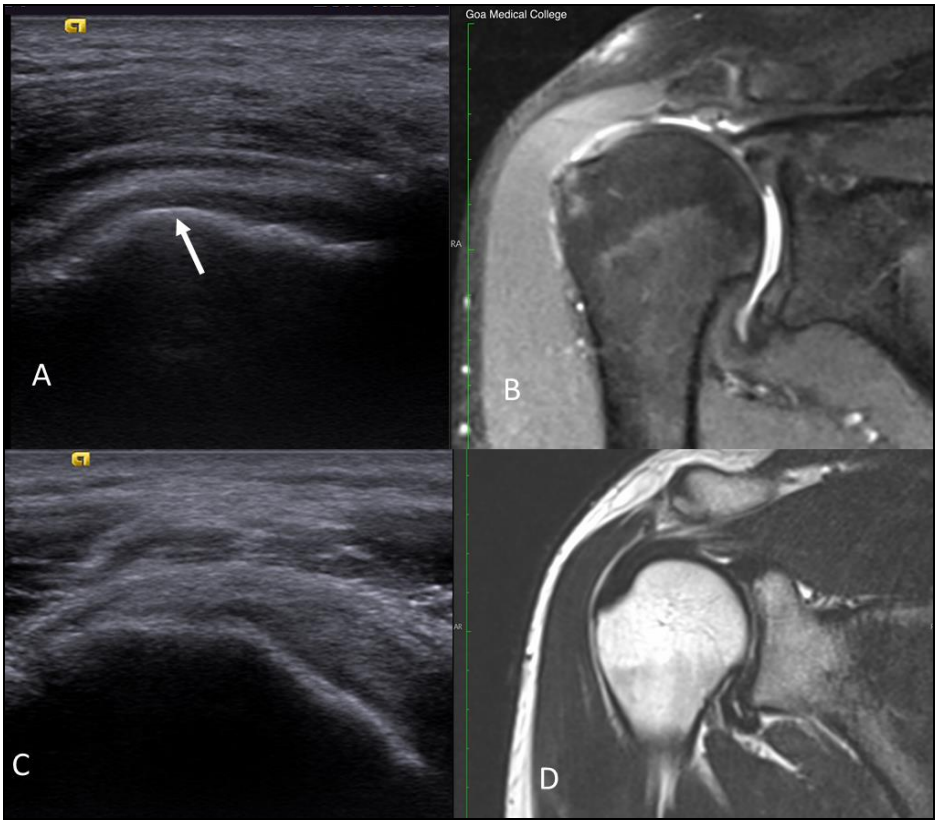
In our total of 40 patients were included in the study. Of these 26 were Male and 14 were female. Bashir S *et al*. [9] found that there were 28 (56%) males and 22 (44%) females in their study. The majority of patients in the research were between the ages of 41 and 50. (60%). Shrestha MS *et al*. [10]. conducted a study. The majority of the patients (66%) were between the ages of 41 and 60. The most common age range was 41-50 years (24 percent), followed by 60-80 years (22 percent), and 51-60 years (21 percent) (20 percent). The patients' average age was 41.6 years.Observations from above-mentioned studies, correlates well with findings of present study that there is maximum incidence of rotator tears between the age of 41-60 years.

Majority of patients (70%) had involvement of the right shoulder. This is consistent with the findings of Bouaziz *et al*, [11] who found that right shoulder involvement is more common (68%) than left shoulder involvement (32 percent).

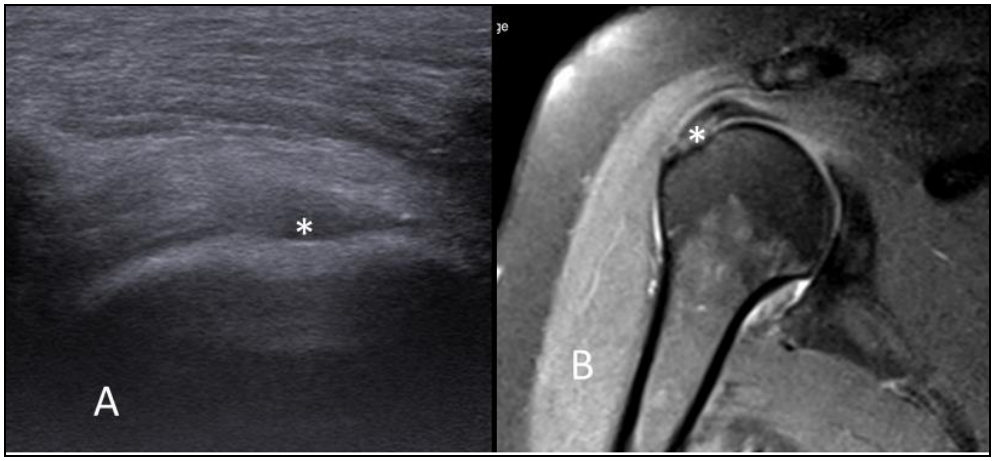
Maximum number of patients had supraspinatus tears (86.7%), followed by subscapularis (6.7%) and infraspinatus (3.3%) tears. Rakesh Vijayvargiya [12] found out that Supraspinatus tendon was the commonest tendon to be involved in his study (90%). Zlatkin M *et al*. [13] had results showing that Supraspinatus tendon involvement was present in maximum numbers of their cases.Similar results are withdrawn in the present study.

Among patients with a tear 72.3% had a tear which was partial in nature while 27.7% had a tear which was complete in nature.A study by Aggarwal J *et al*. [14] also showed that 42 patients were having full thickness tear and 52 patients were having partial thickness tear. Positive corroboration of these results is seen with the present study.

Ultrasound has a high sensitivity of 92.86 percent & specificity of 100 percent for partial tears, & sensitivity of 100 percent & specificity of 96.3 percent for complete tears. In the rotator cuff injuries assessment, USG imaging can be deemed nearly as useful as MRI. In a similar study Aggarwal J *et al*. observed that USG and MRI had a diagnosis accuracy of 97 percent and 97.6 percent, respectively, for full thickness tears and 88 percent and 92 percent, respectively, for partial thickness tears. Therefore MRI and USG were equivalent in their ability to identify full thickness tears, MRI outperformed USG in detecting partial thickness tears.



Case 1: Full thickness supraspinatus tear. (A) (longitudinal USG of the supraspinatus tendon) and (B) (Coronal PD FS image) reveals full thickness tear of the supraspinatus tendon with retraction of the torn tendon, showing bare greater tuberosity sign (white arrow). Fluid is noted in the subdeltoid-subacromial bursa and in the glenohumeral joint space. There is superior migration of the humeral head with reduced acromio-humeral interval. Images (C) and (D) represent corresponding normal USG and MRI appearance of the supraspinatus tendon in a different patient.



Case 2: Partial thickness supraspinatus tear. (A) longitudinal USG of the supraspinatus tendon, shows presence of hypoechoic area (asterisk) along the articular surface of the supraspinatus tendon near its insertion measuring approximately 6 mm in length, suggestive of articular surface partial tear and (B) Coronal PD FS image, confirms the findings of USG with hyperintense signal (asterisk) noted along the articular surface of the supraspinatus tendon near its insertion.

Table 1: Age distribution of patients studied.

Age in years	No. of patients	%
40-50	18	60
51-60	8	26.7
>60	4	13.3
Total	30	100

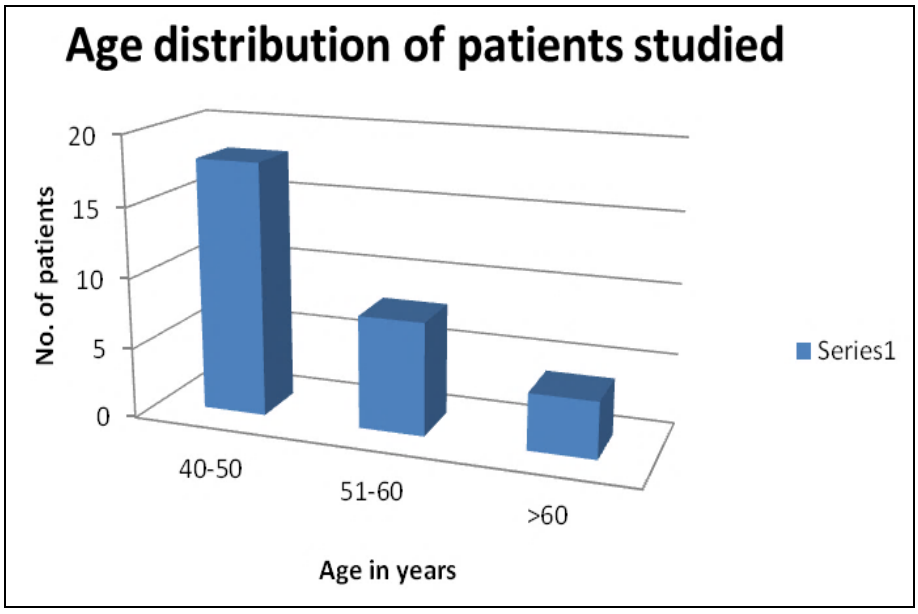


Fig 1: Bar graph representing the ages of patients

Table 2: Representation of cases in accordance with sex

Gender	No. of patients	%
Male	16	53.3
Female	14	46.7
Total	30	100.0

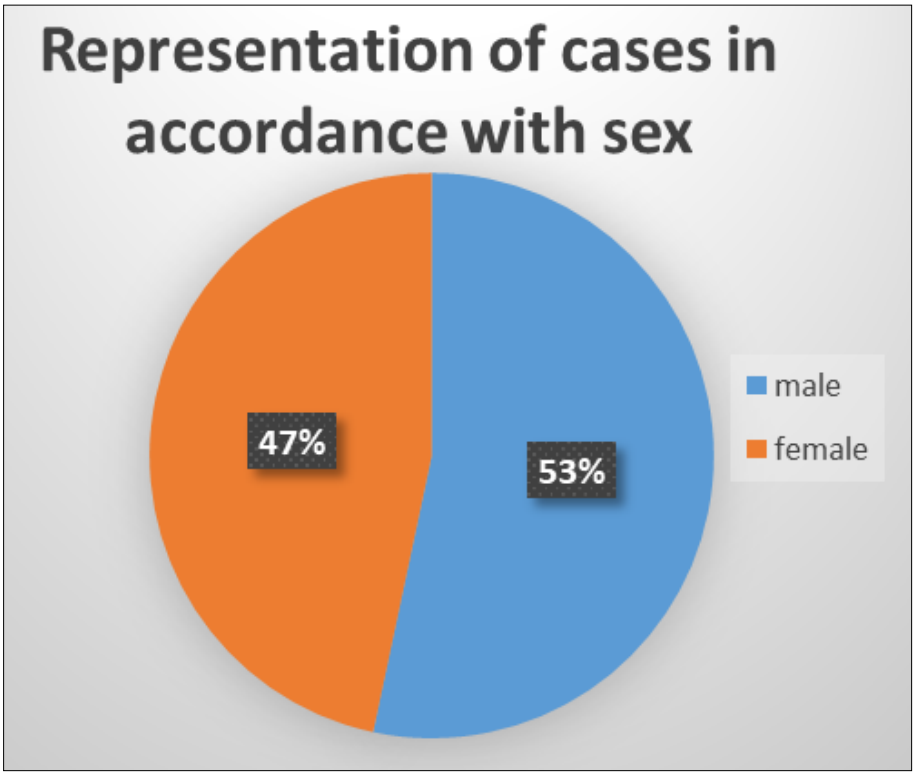


Fig 2: Pie chart showing gender distribution

Table 3: Affected shoulder

Affected shoulder	No. of patients	%
Left	9	30.0
Right	21	70.0
Total	30	100.0

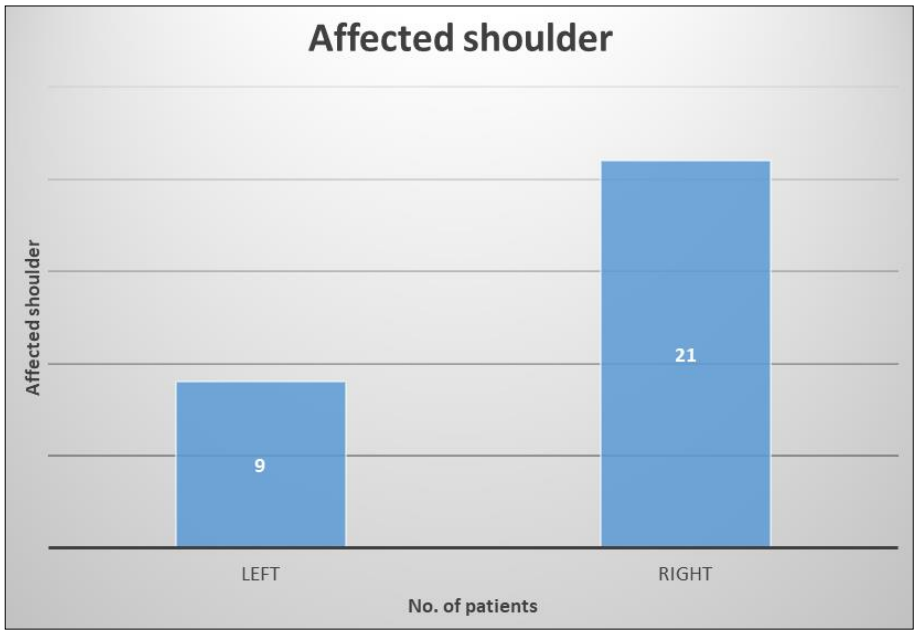


Fig 3: Pie chart showing affected shoulder distribution

Table 4: Evaluation of USG and MRI findings on thickness tears

Findings	Sensitivity	Specificity	PPV	NPV	Accuracy	P value
1. Partial thickness	92.86	100	100	94.12	96.67	<0.001
2. Full thickness	100	96.3	75	100	96.67	<0.001

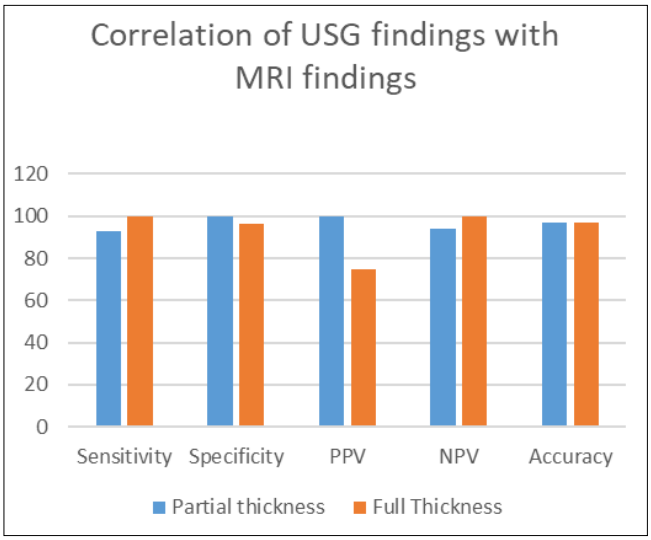


Fig 4: Graphical representation of sensitivity & specificity of partial & full thickness tears

Conclusion

The chronic shoulder pain is most common in dominant hand. The commonest pathology causing shoulder pain is rotator cuff pathology, like full thickness or partial tears & the next common pathology is ACJ type.

The key to a successful study depends on the set protocol of examination and the experience of the sonologist.

Although USG is known to more patient friendly, a considerable degree of shoulder manipulation is needed to achieve adequate visualization of specific sections of the tendon, to pull them into view from under bony impediments which restrict USG penetration. This dependence results in suboptimal scans in patients with restricted shoulder movement, one of the top two presenting complains for rotator cuff pathology. US is less consistent with MRI in individuals with limited range of movement, particularly external rotation.

Rotator cuff tear presentation may range from asymptomatic/mild pain in shoulder to frank inability of shoulder movement. Modern advances in accessibility to surgical treatment makes recognition and early identification of tears in the rotator cuff crucial to decrease morbidity and promoting good health with return to normal/near normal activity status. As a result, both USG and MRI imaging play important roles in the identification and therapy of rotator cuff injuries.

Hence USG can be used as a first line modality while investigating a case of shoulder joint pain to rule out rotator cuff tears and MRI should be used as second line non-invasive test to confirm the diagnosis & to rule out associated injuries. Ultrasound is nearly as efficient as MRI and is practical, well accepted, and accurate non-invasive imaging technique in patients presenting with shoulder pain

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