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Role Of High-Resolution Ultrasound In Evaluation Of Shoulder Impingement. A Comparative Study With MRI

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Abstract

Background: Shoulder impingement is the most common cause of shoulder pain. High-resolution ultrasonography can be utilised to assess different pathological abnormalities encountered in cases of shoulder impingement. MRI, on the other hand, was the gold standard in our study.

Results: Twenty patients complained of shoulder pain and restricted shoulder movement. Grey scale ultrasonography and conventional MRI were used to examine all of the patients. Both modalities' outcomes were recorded and compared. The sensitivity of high-resolution ultrasonography in the identification of shoulder impingement and other disorders affecting the shoulder joint was found as follow: 80 % for rotator cuff tendinopathy, 78.8% and 100% for partial and full-thickness tears of rotator cuff, respectively, 100% for calcific tendinitis and 81.82% for acromiocalvicular osteo-arthritis.

Conclusion: According to our findings, high resolution ultrasonography with dynamic real-time assessment should be employed more frequently as the first line imaging modality in the evaluation and assessment of various disorders causing shoulder impingement.

Keywords: Ultrasound, MRI, Shoulder impingement, Rotator cuff, tears

Introduction

Subacromial impingement is one of most frequent cause of shoulder pain, which accounts for up to 60% of all shoulder symptoms [1]. Impingement syndrome can be caused by a multitude of factors that are divided into structural causes and functional causes. The structural causes include the acromial shape, bursa, humerus; coracoid process, acromion-clavicular joint, and rotator cuff [2].

Rotator cuff pathologies are the most common cause of shoulder pain [3]. Although MRI gives only a static evaluation of the shoulder joint, it was considered the best imaging method for diagnosing subacromial discomfort and rotator cuff disorders. High-resolution ultrasonography combined with a dynamic approach is a useful tool for detecting and evaluating various disorders encountered in cases of shoulder impingement [4].

Clinical examination alone is insufficient in determining the management options of the underlying etiology of shoulder pain. An accurate diagnosis and the severity of the underlying rotator cuff pathology determine whether conservative care or surgical treatment is appropriate [5]. Conventional MRI, MR arthrography, and ultrasound have become the gold standards for diagnosing rotator cuff pathology and can assist clinicians in determining the appropriate treatment plan for each patient [6]. MRI is a sensitive technique, but it is also costly and lone time-consuming. It was not recommended for claustrophobic people; patients had metallic peacemakers, or had cochlear implants [7]. When compared to static MRI, high resolution ultrasonography is less expensive, more available, and less time-consuming procedure. It also has the advantage of being a dynamic form of imaging. As a result, it has become a commonly utilised diagnostic tool for musculoskeletal disorders [3].

Subjects and Methods

Methods

The goal of the study was to assess the efficacy of high-resolution ultrasonography (US) and magnetic resonance imaging (MR) in the diagnosis of subacromial impingement syndrome, as well as to determine the added value by dynamic ultrasound to the static examination, using MRI as a reference standard in our study.

Twenty patients, 12 men and 8 women, ranging in age from 20 to 60 years, participated in the study (mean age 40), who were referred to the radiology department from the Orthopedics surgery department and outpatient clinics at the new Cairo police hospital. All of the patients complained of shoulder pain and/or restricted motion in the afflicted shoulder joint. All patients were subjected to the following:

- Clinical assessment: including history taking and clinical examination.
- Radiological investigations: US and conventional MRI examinations for the painful shoulder.
- The results obtained by both sonographic and MRI examinations were compared. MR was considered as the reference standard in our study.

This study was a prospective study that was conducted between November 2019 and March 2021.

Patients were chosen based on a set of criteria for inclusion and exclusion. Adult patients over 20 years were included in the study. We select patients who complain of painful shoulder and limited shoulder movement in a sequential order, while pregnant women and patients with previous shoulder dislocation or surgical intervention, neoplastic lesions, rheumatoid arthritis, and contraindications to MRI use were excluded. Prior to being included in this study, patients gave their informed oral permission, which included details about the procedure.

Ultrasound examination

All ultrasonographic examinations were performed in real time using a General Electric (GE) LOGIC P9 ultrasound device with a high frequency linear array transducer of 7-12 Mega Hertz (MHz) to diagnose the causes of shoulder movement limitations and to evaluate the rotator cuff tendons. Because rotator cuff tears nearly always affect the supraspinatus tendon, the supraspinatus tendon should be given special attention.

In the static approach, the patient is usually seated in a backless chair, while in the dynamic technique, the patient is supine. While the patient sat in a backless chair, the long head of the biceps brachii tendon, subscapularis, supraspinatus, infraspinatus, and teres minor tendons, acromioclavicular joint, subacromial subdeltoid bursa, were all examined as well as dynamic examination for subacromial impingement. The detailed technique of static and dynamic examinations of shoulder ultrasound was detailed elsewhere [2].

MRI examination

A closed high field system machine with (1.5 Tesla) magnet unit (Philips Achieva) was used to do MR of the shoulder. Prior to the examination, remove any metallic objects from the patient's body or clothing and instruct patients to remain quiet and motionless throughout the examination to avoid motion artifacts.

We positioned the shoulder surface coil over the humeral head while the patient was sitting, then requested him to lie down in a supine position with his head directed towards the scanner bore and his arms extended and externally rotated at the side of his abdomen. Preliminary Scout localizer in axial, sagittal, and coronal planes were obtained as:

- T1-weighted and STIR-weighted axial sequences.
- T1-weighted and T2-weighted coronal oblique weighted sequences.
- STIR coronal oblique weighted sequences.
- T2-weighted sagittal oblique sequences.

Statistical analysis

SPSS software (Statistical Package for the Social Sciences, version 26, IBM Corp, and Armonk, NY, USA) was used to code and enter the data. In quantitative data, mean standard deviation, minimum, and maximum were used, while the categorical data was summarized using frequency (count) and relative frequency (percentage) (Tables 1, 2 and3).

Standard diagnostic indices were created and calculated for US exams of various shoulder pathologies, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic efficacy. The Chi-square (2) test was used to compare categorical data. When the anticipated frequency is less than 5, the exact test was utilized instead. Statistical significance was defined as a p value of less than 0.05. To examine agreement between categorical variables, the Kappa measure of agreement was used.

Results

This study included 20 patients, ranging in age from 20 to 60 years (mean age 44 years) and suffering from shoulder pain and/or joint movement limitations, the majority of whom had a clinical diagnosis. In the study population, the frequency and the percentage according to sex were 11 male and 9 female patients, representing 55% and 45 % of the study population respectively. For the side affection, 15 patients suffered from right shoulder pain and 5 patients suffered from left shoulder pain, representing 75% and 25% for the right and left shoulder respectively. Ultrasonography and conventional MRI were used to assess all of the cases and their findings were compared in all cases. Patients under 44 years old (mean age) had a frequent intrinsic factor of impingement resulting in rotator cuff partial-thickness tears, whereas those over 44 years old had a frequent extrinsic factors resulting in rotator cuff full-thickness tears.

The frequency and the percentage of different shoulder pathologies diagnosed by ultrasonography and conventional magnetic resonance imaging (MRI) were determined (table1).

Table 1: The frequency and percentage of different pathological findings in cases of shoulder impingement, detected by ultrasonography and conventional MRI.

	US	**MRI**			
	Count	Percentage%	Count	Percentage%	
Rotator cuff tendinosis	**Positive**	8	40.0%	10	50.0%
	Negative	12	60.0%	10	50.0%
Calcific tendinitis	**Positive**	4	20.0%	4	20.0%
	Negative	16	80.0%	16	80.0%
Rotator cuff partial thickness tear	**Positive**	7	35.0%	9	45.0%
	Negative	13	65.0%	11	55.0%
Rotator cuff full thickness tear	**Positive**	4	20.0%	4	20.0%
	Negative	16	80.0%	16	80.0%
Acromioclavicular osteoarthritis	**Positive**	9	45.0%	11	55.0%
	Negative	11	55.0%	9	45.0%
Biceps Tenosynovitis	**Positive**	4	20.0%	4	20.0%
	Negative	16	80.0%	16	80.0%
Subacromial bursitis	**Positive**	8	40.0%	9	45.0%

	Negative	12	60.0%	11	55.0%
Joint effusion	**Positive**	11	55.0%	12	60.0%
	Negative	9	45.0%	8	40.0%

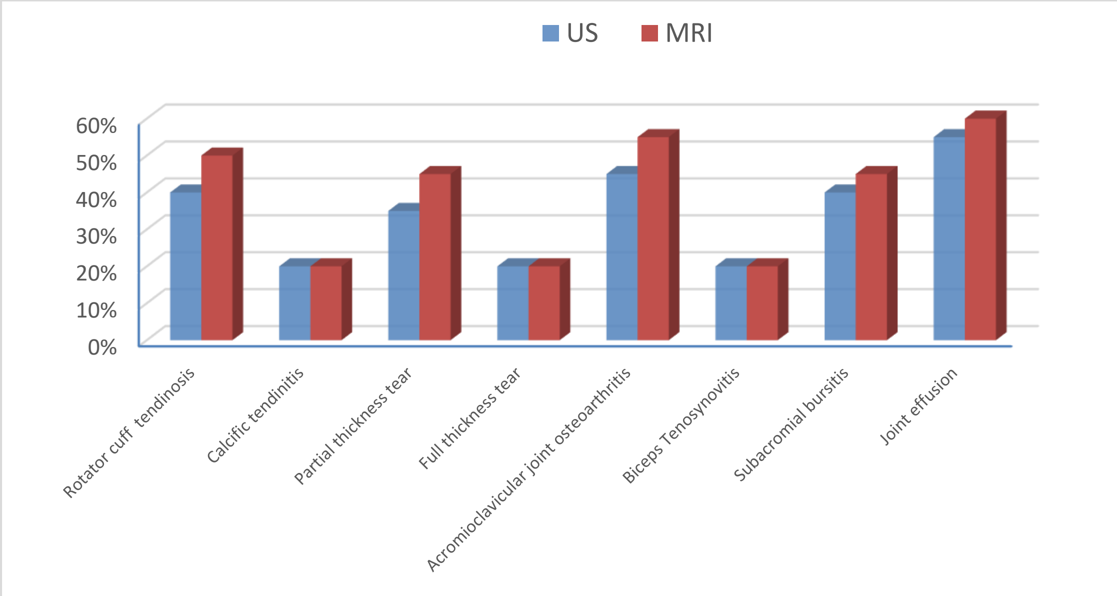


Figure 1. The percentage of different pathological findings encountered in shoulder impingement was detected by ultrasonography and conventional MRI.

Ultrasound and magnetic resonance imaging results were obtained for the 20 patients included in this study. On the basis of that imaging finding, the study population was classified into two groups. Group one, rotator cuff pathology including rotator cuff tendinopathy, calcific tendinitis, partial-thickness tears and full-thickness tears (table 2).Group two, non-rotator cuff pathology including acromioclavicular osteo- arthritis, tenosynovitis of long head of biceps brachii tendon, subacromial bursitis and joint effusion (table3).

Among ten cases detected by MRI to have rotator cuff tendinopathy, only eight cases could be detected by ultrasonography and the other two cases were described as normal tendons. Regarding calcific tendinitis, four cases were correctly diagnosed by both MRI and Ultrasonography. Nine patients had partial-thickness tears of the supraspinatus tendon, which were identified by MRI; two of them were misdiagnosed by ultrasonography and described as degenerated tendons. As regards the supraspinatus full-thickness tear, four cases were correctly diagnosed by both MRI and Ultrasonography. Regarding acromioclavicular osteoarthritis, nine patients were diagnosed by ultrasonography, while two extra patients had been diagnosed by MRI. Four cases had been diagnosed with tenosynovitis of long head of biceps tendon by both ultrasonography and MRI. Eight patients had been diagnosed with subacromial bursitis by ultrasonography, while nine patients had detected by MRI. Twelve patients had joint effusion, which were identified by MRI; one of them was missed by ultrasonography.

By comparing the results, ultrasonography outperforms MRI in the dynamic assessment of subacromial impingement, while MRI outperforms ultrasound in the diagnosis of bony lesions, such as acromioclavicular osteoarthritis and the description of acromial shape, which may be a key factor in the incidence of subacromial impingement.

Table 2: Accuracy and agreement of ultrasound in rotator cuff pathology in cases of subacromial impingement.

Statistic	Rotator cuff tendinopathy	Calcific tendinitis	Rotator cuff Partial-thickness tear	Rotator cuff full-thickness tear
Sensitivity	80%	100%	77.78%	100%
Specificity	100%	100%	95%	100%
False-positive rate	0%	0%	0%	0%
False-negative rate	20%	0%	22.22%	0%
Negative Likelihood Ratio	0.20	0.00	0.22	0.00
Disease prevalence	50%	20%	45%	20%
Positive Predictive Value	100%	100%	100%	100%
Negative Predictive Value	83.33%	100%	84.62%	100%
Accuracy	90%	100%	90%	100%
Misclassification	10%	0%	10%	0%
Kappa agreement	80%	100%	79.4%	100%
P-value	0.001	< 0.001	< 0.001	< 0.001

Table 3: Accuracy and agreement of ultrasonography in non-rotator cuff pathology in cases of subacromial impingement.

Statistic	Acromioclavicular joint osteoarthritis	Biceps Tenosynovitis	Subacromial bursitis	Joint effusion
Sensitivity	81.82%	100%	88.89%	91.67%
Specificity	100%	100%	100%	100%
False-positive rate	0%	0%	0%	0%
False-negative rate	18.18%	0%	11.11%	8.33%

Negative Likelihood Ratio	0.18	0.00	0.11	0.08
Disease prevalence	55%	20%	45%	60%
Positive Predictive Value	100%	100%	100%	100%
Negative Predictive Value	81.82%	100%	91.67%	88.89%
Accuracy	90%	100%	95%	95%
Misclassification	10%	0%	5%	5%
Kappa agreement	80.2%	100%	89.8%	89.8%
P value	< 0.001	< 0.001	< 0.001	< 0.001

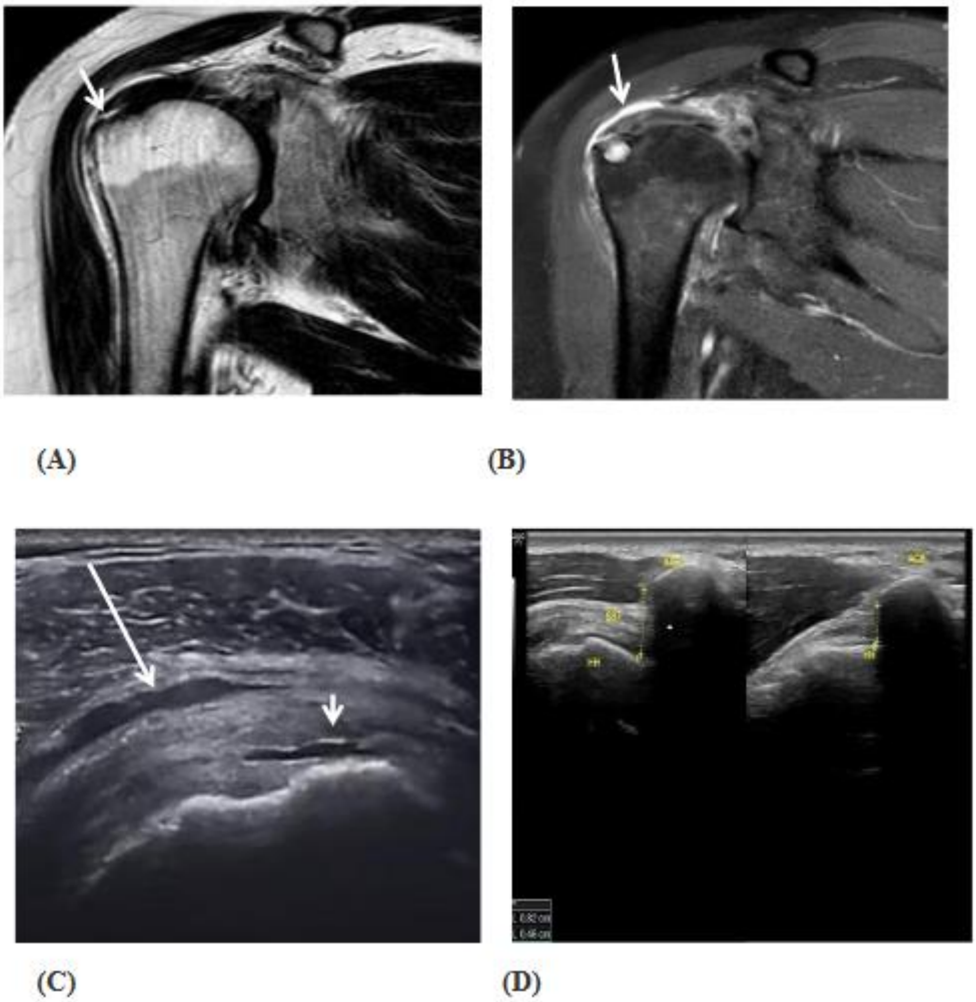


Fig.2 A MRI shoulder coronal T2WI shows intrasubstance bright signal within the supraspinatus tendon (arrow) denoting intrasubstance partial-thickness tear. B MRI STIR WI shows fluid signal within the subacromial subdeltoid bursa (arrow). C Static US shows swollen supraspinatus tendon with intrasubstance linear hypoechoic defect not reaching the articular or bursal surfaces (small arrow). Distended subacromial bursa by hypoechoic fluid (tall arrow). D The subacromial tunnel narrowed in dynamic US, which was increased in the stress position.

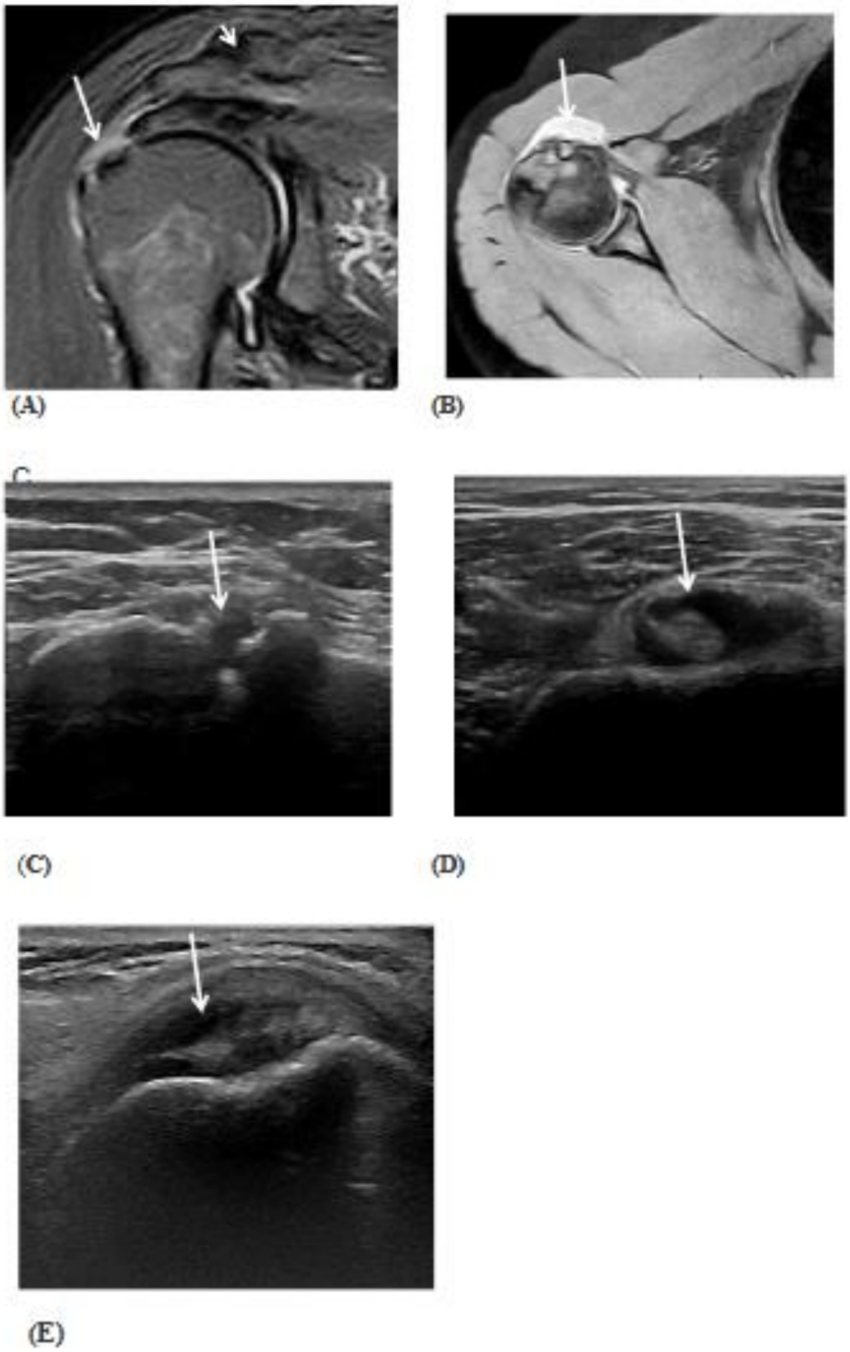
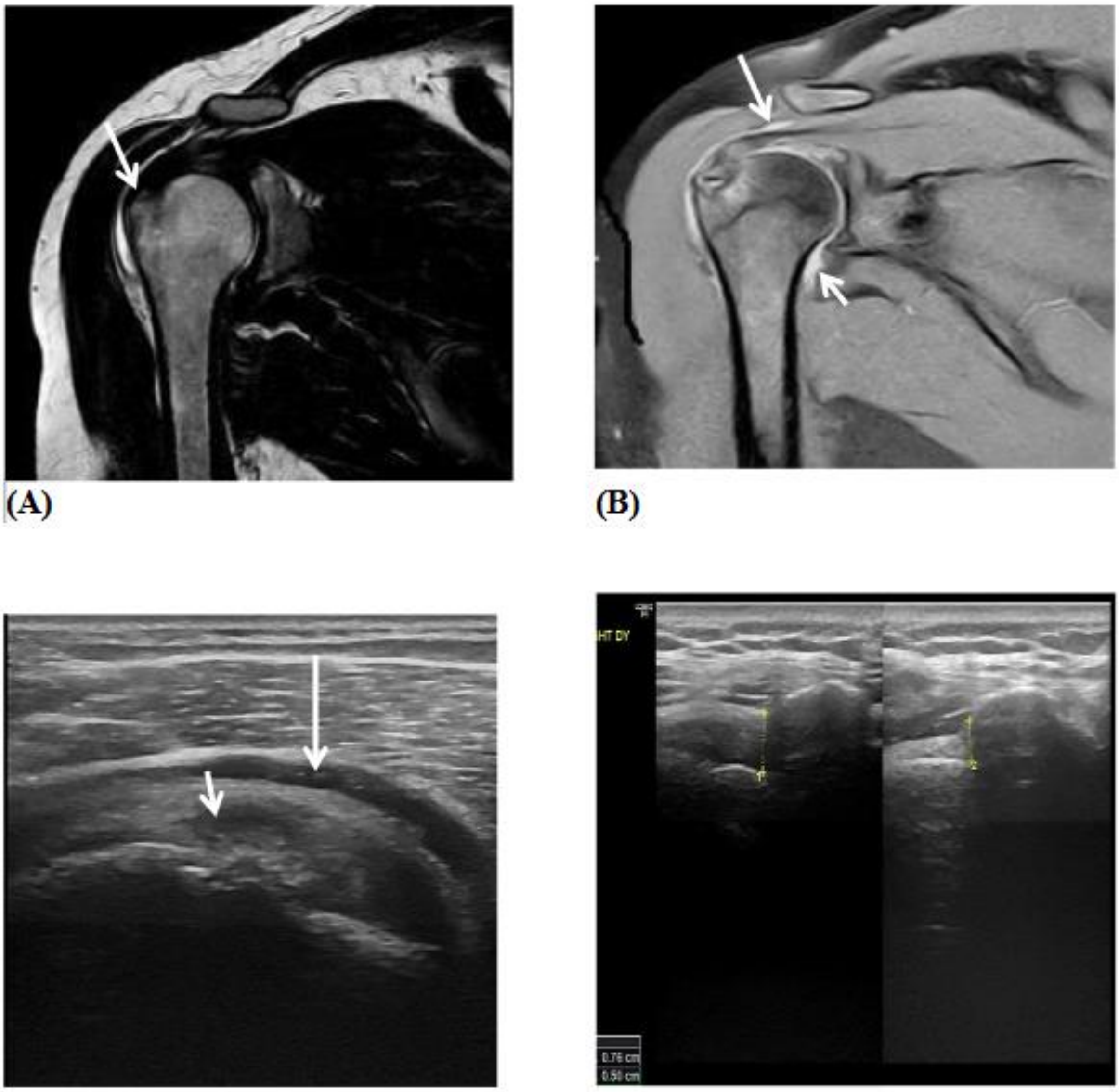


Fig. 3 A MRI, sagittal STIR WI: acromioclavicular osteoarthritis (arrow) with fluid signal filling the gap due to a full-thickness tear of the supraspinatous tendon (tall arrow). Axial T2 WI on B MRI shows a significant hyper intense fluid signal along the sheath of the long head of the biceps tendon (arrow). C static ultrasound: acromioclavicular joint osteoarthritis seen on a static ultrasound. D The long head of the biceps tendon sheath is distended by hypoechoic fluid in a static US (short axis) image (arrow). E a complete thickness tear of the supraspinatus tendon is indicated by a hypoechoic linear defect (gap) interrupting the fibres of the supraspinatus tendon (arrow).

N.B: Dynamic US couldn't be adequately accomplished because of restricted movement of the patient's shoulder.



(A) (B) (C) (D)

Fig 4. A MRI coronal T2 WI: intrasubstance bright signal at the supraspinatus tendon (arrow) yet with preserved fiber continuity. B MRI coronal T2 PD WI: fluid signal at the subacromial subdeltoid bursa (arrow) and minimal joint effusion (short arrow). C Static US shows swollen supraspinatous tendon with reduced echogenicity yet no tears detected (short arrow) and hypoechoic fluid distending the subacromial subdetoid bursa (tall arrow).D narrowed subacromial tunnel in dynamic US that was increased in stress position.

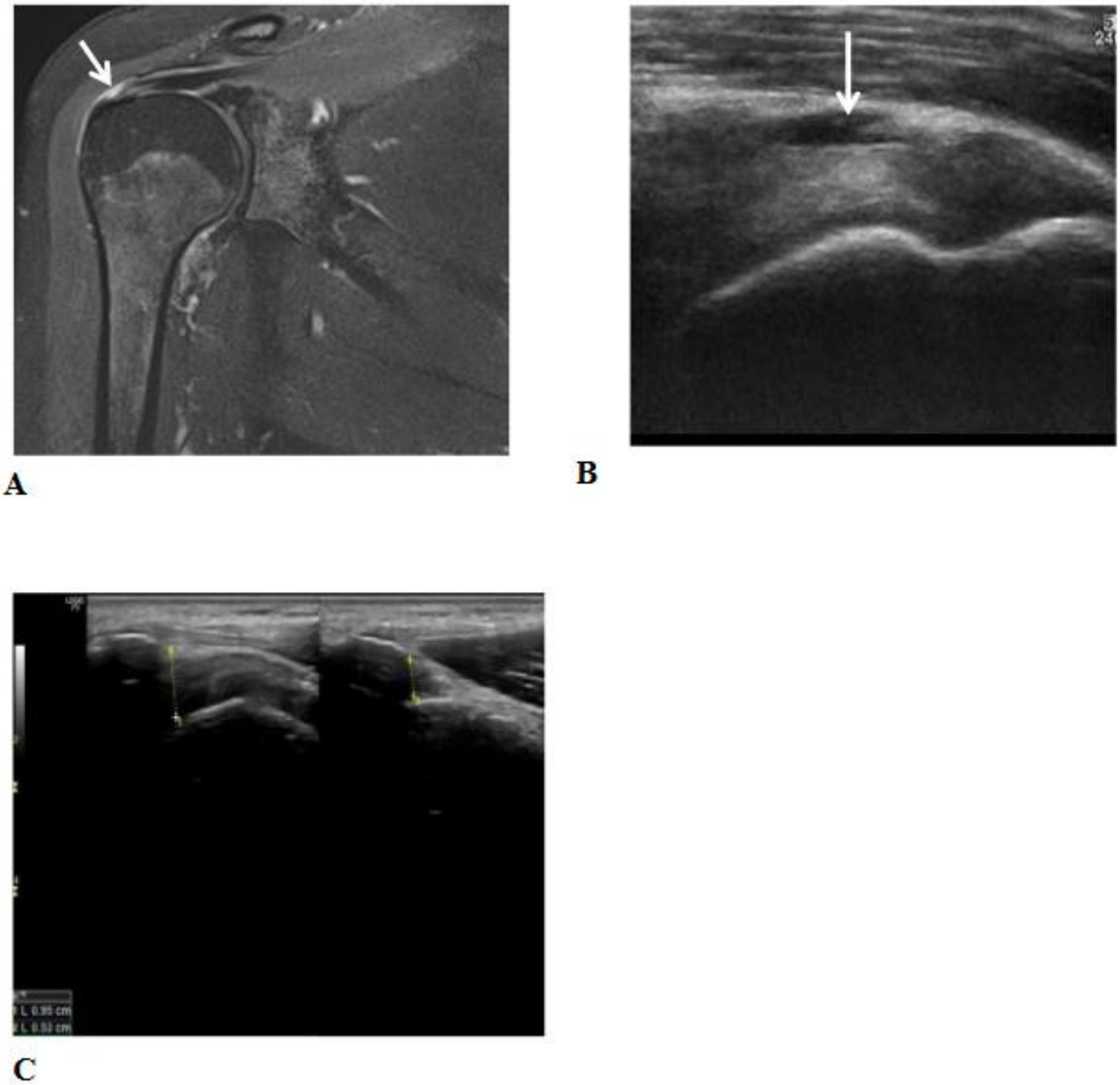


Fig 5. A MRI coronal STIR WI: bright signal intensity in the anterior direct fibers of the supraspinatus tendon denoting bursal surface tear (arrow). B static US shows linear hypoechoic defect involving the anterior direct tendinous fibers of the supraspinatus tendon (arrow).C dynamic US shows narrowing of the subacromial tunnel, which was increased in stress position.

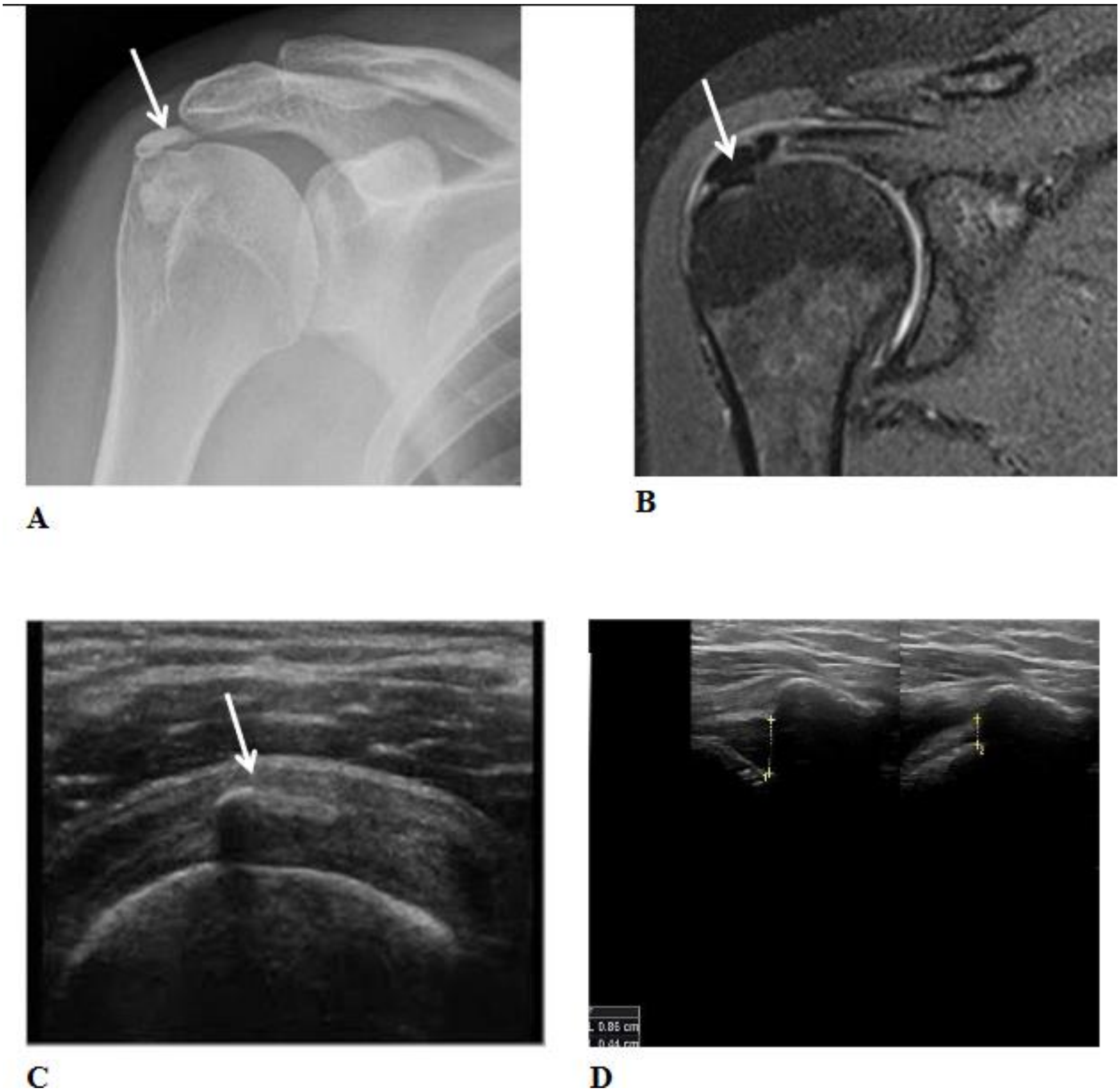


Fig 6. A Digital Radiography revealed dense calcific focus at region of supraspinatous tendon (arrow) .B MRI coronal STIR WI shows abnormal intrinsic (dark) low signal intensity near the humeral insertion of the supraspinatus tendon (arrow).C Static US shows swollen supraspinatus tendon with ill- defined areas of reduced echogensity and hyperechoic foci within its fibers denoting calcific tendinopathy (arrow).Ddynamic US shows relative narrowing of the sub acromial tunnel that was increased in stress position.

Discussion

In this study, we have confirmed the fact that MR examination "in cases of subacromial impingement" is a useful diagnostic tool that provides the anatomical details and the data required for determining the causes of subacromial pain as the acromial shape, subacromial bursa abnormalities, rotator cuff abnormalities such as tears and tendinosis. However, it has several drawbacks, such as being a static examination, in addition to its high cost, time consuming, patient fear, questionable availability added to the overall contraindications of MRI use. On other hand, ultrasonography with dynamic technique can assess the relationship between the acromion, subacromial bursa, supraspinatus tendon and the humeral head during active shoulder movement.

In the current study, eight cases were diagnosed as rotator cuff tendinosis by ultrasonography; however ten cases were detected by MRI. The misdiagnosed cases by US were reported as normal rotator cuff tendons.

In Our study, the US sensitivity, specificity, and accuracy for diagnosis of rotator cuff tendinosis, was found to be 80%, 100%, and 90%, respectively.

Our results agreed and similarly consistent with the findings obtained by El –Shewi et al. [1] and Roy et al. [9], who demonstrated US sensitivity and specificity of 83.3 % and 100% respectively, for the diagnosis of supraspinatus tendinosis.

In the present study, Both MRI and ultrasonography diagnosed a full-thickness tear of supraspinatustendon in four cases, with US sensitivity and specificity of 100 % for each.

This agreed with the studies published by Melanie et al. [10], Teefey et al. [2] and Naganna et al. [12], who reported 100% sensitivity and accuracy of ultrasonography in identifying full-thickness tears of the rotator cuff.

Our findings disagreed with the study carried out by Nicolao et al. [13], who found that US has 100% specificity and 46.2 % sensitivity, for diagnosing full-thickness tears and reported that US may not capture all tears or the exact size of the tear.

As regarding partial-thickness tears of the supraspinatus tendon, MRI discovered 9 cases, but ultrasonography misread two cases and described them as degenerated tendons. The two misdiagnosed cases by ultrasonography had a small partial-thickness tear that can be missed, according to Lenza et al. [14]. Finally, the dimensions of partial-thickness tears must be determined to avoid misdiagnosis of tears.

According to our study, the US has sensitivity and specificity of 77.78% and 100 %, respectively, for diagnosing partial-thickness tears.

Our results agreed and matched the results obtained by Cullen et al. [15], who reported US sensitivity of 79 % and a specificity of 94 % in the detection of partial-thickness tears.

Our results disagreed with the results obtained by Melanie et al. [10], Nathalie et al. [16] and Geoff Hide et al. [17], who reported US sensitivity of 93 % and specificity of 94 % in detecting partial-thickness rotator cuff tears. This means that reduced tendon echogenicity due to anisotropic artefact may be misinterpreted as abnormal, leading to a tear misdiagnosis.

Also, this disagreed with the results obtained by Bashir et al. [18], who found that US sensitivity was 60% in the diagnosis of partial-thickness tears and attributed that frequency of transducer affects the image quality and accuracy because slight mistakes in transducer angulation and orientation can easily mask smallareas of normal variation, leading to false-positive and false-negative readings.

In the current study, four cases show calcific tendinitis diagnosed by both ultrasonography and MRI. Complementary plain radiographs were also taken in the patients to confirm the diagnosis.

Our results proved that ultrasonography has the same sensitivity and specificity (100% for each) as MRI in the detection of calcific tendinitis.

This agreed with the results obtained by El-shewi et al. [1] and Roa et al. [7], who found that ultrasonography had a high accuracy (100%) in detecting calcific tendinitis.

As regarding osteoarthritis of the acromioclavicular joint, eleven patients were diagnosed by MRI and nine cases were diagnosed via US. US has a sensitivity of 81.82%, specificity of 95% and accuracy of 90% in the evaluation of such degenerative process compared to MRI, keeping in consideration the value added by dynamic US in the evaluation of the rotator cuff tendon injury by such degenerative process during repetitive movements of shoulder.

This is agreed with the study of **Roa** el al. [7], who conducted a research on sixty patients and found that US had a sensitivity of 80% and specificity of 95% in the detection of acromioclavicular joint degenerative changes.

The current study revealed that ultrasonography had a high and valuable sensitivity in the detection of fluid in both joint space and bursa, namely the sub acromial bursa that is a common finding in cases of subacromial impingement.

In this study, Ultrasonography revealed eight cases of subacromial bursitis (distended bursa by fluid), whereas MRI revealed 9 cases, giving the US sensitivity and specificity of 88.89% and 100%, respectively. The cases ignored by the US were found to have minimal bursal effusion.

Regarding joint effusion, there were twelve cases of joint effusion detected by MRI, one of which was missed by ultrasonography, with US sensitivity and specificity of 91.67 % and 100 %, respectively. This means that ultrasonography has a relative lower sensitivity than MRI in the detection of very small amounts of fluid, despite its ability to detect the synovial thickening and differentiating the synovium from fluid by using the compression test.

Our results agreed with the results obtained by Melanie et al. [10] and (El-Shewi et al. [1]**,** who reported US sensitivity 93.3 % and specificity 100%, for subacromial bursitis, and sensitivity 94.2 % and specificity 100 % for joint effusion.

This is disagreed with the results obtained by Roa el al. [7], who reported that ultrasonography had a sensitivity of 44.4 % in detecting subacromial bursitis.

In the current study, there were four cases of biceps teno-synovitis found by both ultrasonography and MRI, indicating that ultrasonography has a similar sensitivity (100%) to MRI in detecting biceps teno- synovitis, which includes synovial effusion, synovial thickness, and tendinous altered echogenicity.

This is agreed with the studies conducted by Nathalie et al. [16], Roa el al. [7], and El-shewi et al. [1], who reported that ultrasonography has a high diagnostic value, with 100 % sensitivity and specificity, in the detection of biceps tenosynovitis when compared to MRI.

Conclusion

In terms of sensitivity and specificity, ultrasound and MRI are comparable. Our findings show that ultrasonography with dynamic examination is the first-line imaging modality in the assessment of shoulder impingement and rotator cuff disorders; however, MRI is reserved for cases with suspected labral injuries (e.g. shoulder dislocation), suspected neoplastic, or marrow infiltrative lesions; this will eventually aid in the selection of the best treatment option for the patient as well as the final surgical decision.

Ultrasonography may be the most effective imaging approach for assessing shoulder impingement syndrome and rotator cuff diseases since it is non-invasive, non-ionizing, widely available, low-cost, and has the advantage of dynamic real-time assessment.

Abbreviations

AC: Acromion; ACJ: Acromio-clavicular joint; AHD: Acromio-humeral distance; AP: Antero-posterior; PA: Postero-anterior; CL: Clavicle; Del: Deltoid muscle; Fig: Figure; GT: Greater tuberosity; HH: Humeral head; LHB: Long head of biceps; LT: Lesser tuberosity; MRI: Magnetic resonance imaging; RC: Rotator cuff; TS: Transverse section; US: Ultrasound

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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