ORIGINAL ARTICLE

The Role of high Resolution Ultrasound in Comparison to Magnetic Resonance Imaging in Evaluation of Painful Shoulder in Adults

Hala M. Maghraby, Yasser M. Fekry, Seham M. E. Shaaban*

Department of Radiodiagnosis, Faculty of Medicine for Girls, Al-Azhar University, Cairo, Egypt

Abstract

Background: ***Shoulder pain is a common complaint that can significantly affect an individual's quality of life and daily activities.***

Aim: ***To assess the role of MRI in the examination and characterization of different etiologies causing shoulder pain and to compare ultrasound accuracy to MRI in the identification of rotator cuff and long head of biceps musculotendinous pathologies.***

Patients and methods: ***This investigation involved 30 cases presented with symptoms of pain of shoulder and some patients have a limitation in their shoulder movement. The study was performed from March 2023 to August 2024. All cases were done at Al-Zahraa University hospital, where ultrasound and MRI examinations were performed in the Radiology Department.***

Results: ***Compared to MRI, ultrasonography showed 100 % sensitivity in detecting rotator cuff tendinosis, 90.91% in detecting partial-thickness supraspinatus tears, and 75 % sensitivity in detecting full-thickness supraspinatus tears. Compared to MRI, ultrasonography showed 100 % sensitivity in detecting Subscapularis tendinopathy and Subscapularis tear. Compared to MRI, ultrasonography showed 50 % sensitivity in detecting Subacromial bursitis and muscle atrophy. It was noticed that ultrasonography sensitivity in detecting biceps tenosynovitis compared to MRI is 66.67 %.***

Conclusion: ***Dynamic ultrasonography showed high sensitivity in the diagnosis of different causative factors encountered in cases of painful shoulder over MRI, especially in dynamic assessment of sub-acromial impingement associated with soft tissue or bursal impingement, narrowed acromio-humeral distance, and biceps subluxation.***

Keywords: High resolution ultrasound; Magnetic Resonance Imaging; Shoulder Pain

1. Introduction

Shoulder pain is a frequent complaint that can significantly affect an individual's quality of life and daily activities. It may arise from various causes, including injuries, overuse, degenerative conditions, inflammatory disorders, and underlying medical conditions. The complexity of the shoulder joint, with its wide range of motion and multiple structures, makes it susceptible to a variety of pain-generating mechanisms.[1]

Many pathological conditions may cause rotator cuff disease, such as trauma (whether chronic or acute), instability, or inflammation. Rotator cuff tendinous pathologies usually affect the supraspinatus tendon and, less frequently, the infraspinatus and subscapularis tendons in the form of tendinopathy that can progress to partial or full-thickness tear. Shoulder impingement is considered a clinical diagnosis, yet imaging of the shoulder joint plays a significant role in detection and assessing the degree of tendon affection. [2]

Ultrasound (US) imaging, also known as sonography, is a widely used diagnostic tool in musculoskeletal medicine, particularly for assessing shoulder pathologies. This non-invasive technique utilizes high-frequency sound waves to produce images of the inside of the body, providing valuable information about muscles, tendons, ligaments, joints, and other soft tissue structures. [3]

Accepted 15 April 2025.
Available online 30 June 2025

* Corresponding author at: Radiodiagnosis, Faculty of Medicine for Girls, Al-Azhar University, Cairo, Egypt.
E-mail address: sehammonier990@gmail.com (S. M. E. Shaaban).

https://doi.org/10.21608/aimj.2025.446600

One of the important advantages of shoulder joint Dynamic ultrasound scanning is that it can be performed in multiple planes with active movement and a focused scan of the area of patient complaint to ensure accurate diagnosis. However, it has a limited role in the assessment of osseous, rotator interval, and labral lesions. [4]

In rotator cuff tendinous tear, factors that impact the tendon repair result are as follows: Chronicity, Tear size, Number of tendons, degree of tendon retraction, Fatty degeneration, and rotator cuff muscle atrophy. [5]

Magnetic Resonance Imaging (MRI) is a sophisticated diagnostic technique extensively used in orthopedics and sports medicine to evaluate shoulder injuries and conditions. It utilizes a powerful magnetic field, computer technology, and radio waves to produce detailed images of the structures within the shoulder, including bones, muscles, tendons, ligaments, and other soft tissues.[6]

MRI is highly effective in diagnosing a wide range of shoulder pathologies, involving rotator cuff tears, impingement syndromes, labral tears, arthritis, and more. It is particularly valued for its ability to differentiate between soft tissue structures and to reveal the extent of injuries. [7]

The preferred imaging modalities for assessment of rotator cuff musculotendinous pathologies are ultrasound and MRI. Each modality has its accuracy, advantages, disadvantages, availability, and cost effectiveness, which are important parameters that guide the process of deciding the best diagnostic imaging modality. [8]

The study aimed to assess ultrasound role to MRI in the examination and characterization different etiologies causing shoulder pain and to compare ultrasound accuracy to MRI in identification of rotator cuff and long head of biceps musculotendinous pathologies.

2. Patients and methods

This investigation involved 30 cases presented with symptoms of pain in the shoulder, and some patients had a limitation in their shoulder movement. The study was performed from March 2023 to August 2024. All cases were done at Al-Zahraa University hospital, where ultrasound and MRI examinations were performed in the Radiology Department.

Inclusion criteria

The study included adult patients aged from 16 to 60 years old and both sexes, complaining of shoulder pain suspected to arise from the Musculotendinous tissue of the shoulder joint, if no contraindications for MRI.

Exclusion criteria: Patients who have shoulder dislocation, patients who have neoplastic lesions, patients with cardiac pacemakers, cochlear implants, or surgical aneurysmal clips, morbid obesity, and claustrophobic patients.

Ethical Considerations:

The study protocol was presented to the local research ethical committee at the Faculty of Medicine, Al-Azhar University for approval. Informed consents were obtained from each participant or from the legal guardians before inclusion in the investigation. Confidentiality of data and the privacy of participants have been guaranteed throughout the investigation.

Methods:

All patients were submitted to the following: Clinical examination, History taking by the physician, and Radiological investigation:

Imaging procedure

Ultrasonography:

Equipment:

Ultrasound and color Doppler were performed by using a linear probe (L 6 - 12 MHZ) using Philips and Toshiba. The color Doppler parameters were applied. The color code map is red, and for motion away from the probe, the code is blue. No specific patient preparation is indicated for the static and dynamic shoulder ultrasound examination; however, the room temperature was set to an optimal level, and the evaluation was carried out with the patient seated in a backless chair. A systematic approach was performed after applying an adequate amount of sterile lubricant coupling gel over the transducer. All sonography and color duplex parameters were adjusted to maximize the machine's sensitivity.

Examination technique

Ultrasound static and dynamic examination were done to all patients, through a systematic approach. During examination, the case seated in a backless chair. The probe held with the firm hand grip and the transducer was then placed after applying an adequate amount of sterile coupling gel.

Magnetic Resonance Imaging

Device: PHILIPS MR Systems Achieva 1.5 Tesla

Patient position:

Patient examined in supine position with head toward scanner bore, patient arm is kept is by his side in neutral position or with slight external rotation by the use of Surface coil around examined shoulder joint.

Imaging planes and pulse sequences:

Axial scout localizer, examination planes in coronal and sagittal planes

3. Results

This investigation involved thirty cases, seventeen were women and thirteen were men, where the female patients' percentage was 56.7 %, compared to 43.3% of the male cases with the age range from 21 years to 65 years with the mean of their ages was 47.4 ± 11.5 years (Table 1)

Table 1. Demographics and baseline characteristics

SEX	FREQUENCY	PERCENTAGE (%)
MALE	13	43.30
FEMALE	17	56.70
TOTAL	30	100
AGE	47.4 ± 11.5	
MEAN ± SD	21	
MINIMUM	65	
MAXIMUM		

Table 2 shows that, there MRI detects subacromial bursitis in 26.7% of cases, while US detects it in a higher percentage (53.3%), Both MRI and US show a high prevalence of AC osteoarthritis (83.3% for MRI vs. 80% for US), MRI detects biceps subluxation in only 3.3% of cases, while US detects it in 10% of cases, MRI detects biceps tenosynovitis in 10% of cases, while US detects it in 16.7% of cases, and MRI detects joint effusion in 56.7% of cases, while US detects no cases of joint effusion.

Table 2. Both percentage and frequency of associated pathological conditions detected by magnetic resonance imaging in comparison to static and dynamic ultrasonography.

	CONVENTIONAL MRI		STATIC & DYNAMIC U/S	
	N	%	N	%
SUBACROMIAL BURSITIS				
NO	22	73.30	14	46.70
YES	8	26.70	16	53.30
AC OSTEOARTHRITIS				
NO	5	16.70	6	20.00
YES	25	83.30	24	80.00
BICEPS SUBLUXATION			N	%
NO	29	96.70	27	90.00
YES	1	3.30	3	10.00
BICEPS TENOSYNOVITIS				
NO	27	90.00	25	83.30
YES	3	10.00	5	16.70
JOINT EFFUSION				
NO	13	43.30	30	100.00
YES	17	56.70	0	0.00

Table 3 demonstrates that a significant agreement has been observed among magnetic resonance imaging and ultrasound with regard to the detection of RC Tendinosis, Calcific Tendinitis, Supraspinatus Full Thickness Tear, Supraspinatus Partial Thickness Tear, Subscapularis Tendinopathy, and Subscapularis Tear.

Table 3. P-values for US detection capability of RC shoulder Pathologies in comparison to MRI (frequency and percentage of patients)

		RC TENDINOSIS (MRI)				CHI-SQUARE TEST VALUE	P-VALUE	SIG.*
		No		Yes				
		N	%	N	%			
RC TENDINOSIS (US)	No	2	25.00	0	0.00	5.89	0.064	NS
	Yes	6	75.00	22	100.00			
		Calcific Tendinitis (MRI)						
		No		Yes				
		N	%	N	%			
CALCIFIC TENDINITIS (US)	No	29	96.70	0	0.00	--	--	--
	Yes	1	3.30	0	0.00			
		Supraspinatus Partial Thickness Tear(MRI)						
		No		Yes				
		N	%	N	%			
SUPRASPINATUS PARTIAL THICKNESS TEAR (US)	No	15	78.90	1	9.10	13.65	<0.001	HS
	Yes	4	21.10	10	90.90			
		Supraspinatus Full Thickness Tear (MRI)						
		No		Yes				
		N	%	N	%			
SUPRASPINATUS FULL THICKNESS TEAR (US)	No	26	100.00	1	25.00	21.67	0.001	HS
	Yes	0	0.00	3	75.00			
		Subscapularis Tendinopathy (MRI)						
		No		Yes				
		N	%	N	%			
SUBSCAPULARIS TENDINOPATHY (US)	No	23	85.20	0	0.00	10.95	0.009	HS
	Yes	4	14.80	3	100.00			
		Subscapularis Tear (MRI)						
		No		Yes				
		N	%	N	%			
SUBSCAPULARIS TEAR (US)	No	28	96.60	0	0.00	14.48	0.067	NS
	Yes	1	3.40	1	100.00			

*P-value Significance: >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

Table 4 demonstrates that a significant agreement has been observed among magnetic resonance imaging and ultrasound with regard to the detection of subacromial bursitis, AC Osteoarthritis, biceps Subluxation, biceps tenosynovitis, joint effusion, and muscle atrophy.

Table 4. P-values for US detection capability of shoulder associated Pathologies in comparison to MRI (frequency and percentage of patients)

		SUBACROMIAL BURSITIS (MRI)				CHI-SQUARE TEST VALUE	P-VALUE	SIG.*
		No		Yes				
		N	%	N	%			
SUBACROMIAL BURSITIS (US)	No	13	59.10	1	12.50	5.11	0.039	NS
	Yes	9	40.90	7	87.50			
		AC Osteoarthritis (MRI)						
		No		Yes				
		N	%	N	%			
AC OSTEOARTHRITIS (US)	No	5	100.00	1	4.00	24	<0.001	HS
	Yes	0	0.00	24	96.00			
		Biceps Subluxation (MRI)						
		No		No				
		N	%	N	%			
BICEPS SUBLUXATION (US)	No	27	93.10	0	0.00	9.31	0.1	NS
	Yes	2	6.90	1	100.00			
		Biceps Tenosynovitis (MRI)						
		No		Yes				
		N	%	N	%			
BICEPS TENOSYNOVITIS (US)	No	24	88.90	1	33.30	6	0.064	NS
	Yes	3	11.10	2	66.70			
		Joint Effusion (MRI)						
		No		Yes				
		N	%	N	%			
JOINT EFFUSION (US)	No	13	100.00	17	100.00	--	--	--
	Yes	0	0.00	0	0.00			
		Muscle Atrophy (MRI)						
		No		Yes				
		N	%	N	%			
MUSCLE ATROPHY (US)	No	28	100.00	1	50.00	14.48	0.067	NS
	Yes	0	0.00	1	50.00			

Compared to MRI, ultrasonography showed 100 % sensitivity in detecting rotator cuff tendinosis, 90.91% in detecting partial-thickness supraspinatus tears and 75 % sensitivity in detecting full-thickness supraspinatus tears. Compared to MRI, ultrasonography showed 100 % sensitivity in detecting Subscapularis tendinopathy, Subscapularis tear. Compared to MRI, ultrasonography showed 50 % sensitivity in detecting Sub-acromial bursitis, Muscle atrophy. It was noticed that ultrasonography sensitivity in detecting biceps tenosynovitis compared to MRI is 66.67 % (Table 5)

Table 5. ROC analysis for ultrasound compared to magnetic resonance imaging.

	TP	TN	FP	FN	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
SUPRASPINATUS PARTIAL THICKNESS TEAR	10	15	4	1	90.91%	78.95%	71.43%	93.75%	83.33%
SUPRASPINATUS FULL THICKNESS TEAR	3	26	0	1	75.00%	100.00%	100.00%	96.30%	96.67%
SUBSCAPULARIS TENDINOPATHY	3	23	4	0	100.00%	85.19%	42.86%	100.00%	86.67%
SUBACROMIAL BURSITIS	7	13	9	1	50.00%	59.09%	43.75%	92.86%	66.67%
MUSCLE ATROPHY	1	28	0	1	50.00%	100.00%	100.00%	96.43%	96.55%

Case

Case summary:

women case 49 years old with a history of trauma 2 months ago complaining of movement limitation and pain of right shoulder.

MRI finding:

The supraspinatus tendon partial thickness tear. Subscapularis tear with medial displacement of LHB tendon. Minimal joint effusion. ACJ hypertrophic osteoarthritic changes.

On Ultrasound examination:

The right supraspinatus tendon shows an incomplete full-thickness tear. Mild sub-deltoid bursitis. Full-thickness tear of the subscapularis tendon. The LHB tendon tenosynovitis. On dynamic examination medial subluxation of the biceps tendon.

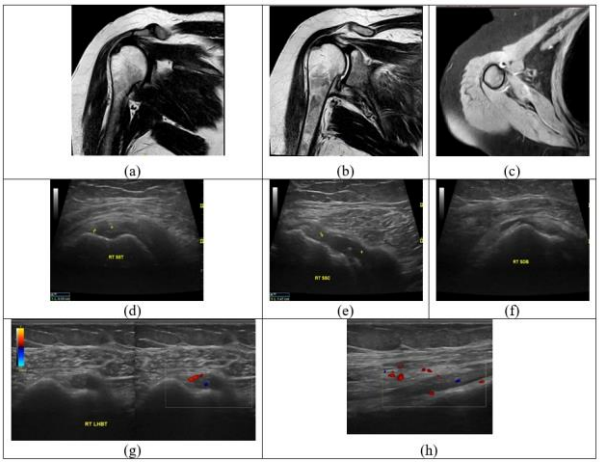

Figure 1. (a) magnetic resonance imaging CORONAL TI, (b) MRI coronal T2 images show supraspinatus tendon intra-substance signal alteration reaching the articular surface denoting degeneration with partial thickness

tear. ACJ hypertrophic osteoarthritic changes. (C) MRI axial T2 images show subscapularis tear with medial displacement of LHB tendon. (d) US image show right supraspinatus tendon full-thickness incomplete tear measuring about 0.59 cm. (e) US image show subscapularis tendon full-thickness tear with a fluid-filled gap measuring about 1.47 cm in length. (f) US images show sub-deltoid bursitis (g-h) US images show The LHB tendon sheath shows mild fluid collection, synovial thickening, and increased vascularity on color Doppler denoting tenosynovitis with medial subluxation of the biceps tendon.

4. Discussion

This investigation involved thirty cases, seventeen were women and thirteen were men, where the female was 56.7 %, compared to 43.3% of the male patients. The age range from 21 years to 65 years with the mean of their ages was 47.4 ± 11.5 years.

In agreement with our research, Abdelzaher et al.[9] conducted a cross-sectional, observational investigation to determine the diagnostic accuracy of ultrasound in the detection of shoulder joint pathologies in rheumatoid arthritis, with magnetic resonance imaging (MRI) serving as the gold standard. It was conducted on thirty case, with a mean age of 41.73 ± 11.5 years, and a higher occurance of female (83.3 percent) than men (16.7 percent).

As a consequence of classifying the different rotator cuff abnormalities, among the 30 patients, 22 patients were diagnosed with rotator cuff tendinosis by MRI, while six patients were additionally diagnosed by U/S Regarding the calcific tendinitis, none was reported by MRI, with only one case spotted by US.

Tuite and Small[10] conducted an analysis of the evidence to determine the most beneficial radiographic views and the optimal imaging test following radiographs for various clinical presentations of chronic shoulder pain, in accordance with the previous ultrasound outcomes. They discovered that ultrasound is generally preferred over magnetic resonance imaging for the assessment of chronic rotator cuff pain. At the same time, MR arthrography is the most precise method for imaging chronic symptoms associated with a suspected labral tear or instability, particularly when abducted and externally rotated images are used.

Regarding supraspinatus tendon tear, 11 patients and 4 cases have been diagnosed by magnetic resonance imaging as supraspinatus partial and full thickness tear, respectively in which 3 were additionally diagnosed by U/S as supraspinatus partial thickness tear and only one patient with supraspinatus full thickness tear was missed.

Three patients were identified as subscapularis tendinopathy by MRI, wherein the ultrasound spotted 4 additional patients. While only a single patient was diagnosed as subscapularis tear by MRI, with an additional patient was also identified by U/S, giving the total of 2.

On the other hand, Wengert et al.[11] demonstrated that the examination of a wide range of shoulder joint pathologies by both ultrasound and magnetic resonance imaging modalities resulted in a moderate to nearly perfect agreement. Consistency has been observed in the supraspinatus tendon (71.64 percent), subscapularis tendon (83.58 percent), infraspinatus tendon (95.52 percent), and teres minor tendon (98.51 percent) of the rotator cuff.

Muscle atrophy was established in 2 cases by MRI, in which on one could be detected by US. We sorted other pathologies found apart from the rotator cuff abnormalities, for starters, among the same 30 patients, 8 patients have been diagnosed as sub-acromial bursitis by magnetic resonance imaging while additional 8 patients were diagnosed by US.

In this study, for acromio-clavicular osteoarthritis, 25 cases were spotted by MRI, yet only 24 cases were identified in the U/S examination. This is comparable with Refaat et al.[12] who found that, out of twenty-one cases diagnosed by magnetic resonance imaging to have acromio-clavicular osteoarthritis, nineteen cases were correctly diagnosed by ultrasound, with subsequent ultrasound sensitivity, specificity, and accuracy of 90.5 percent, 100 percent, and 93.3 percent, correspondingly.

Biceps subluxation and biceps Tenosynovitis were also spotted in 1 and 3 patients, respectively by MRI where additional 2 in each pathology were made out by U/S, given the U/S spotted cases a total of 3 and 5 cases, respectively.

MRI was absolute superior in 17 cases reporting the present of variable degrees of intra-articular joint effusion, which was hard to assess by U/S thus no cases where reported.

US scan have advantage over MRI examination in in dynamic assessment of Sub-acromial impingement associated with soft tissue or bursal impingement as well as narrowed acromio-humeral distance and Biceps subluxation and Color-Doppler scan which help in detection of increased synovial vascularity with additive value in diagnosis of biceps Tenosynovitis.

The role of dynamic ultrasound versus magnetic resonance imaging in the detection and evaluation of shoulder impingement syndrome has been examined by El-Shewi et al.[13]. The outcomes of their study indicated that the

inclusion of dynamic ultrasound examination in the diagnosis of the painful shoulder resulted in the highest sensitivity in the assessment of impingement syndrome and the detection of various abnormalities affecting the shoulder joint (such as 85.7 percent for rotator cuff partial-thickness tear and 90 percent for rotator cuff full-thickness tear).

Compared to MRI, ultrasonography showed 100% sensitivity in detecting rotator cuff tendinosis, 90.91% in detecting partial-thickness supraspinatus tears, and 75 % sensitivity in detecting full-thickness supraspinatus tears.

The efficacy of ultrasound and magnetic resonance imaging in the diagnosis of shoulder impingement has been compared in an investigation conducted by Refaat et al.[12] Their findings indicated that the ultrasound demonstrated a sensitivity, specificity, PPV, NPV, and accuracy of one hunderd percent for each of the following in the diagnosis of a full-thickness supraspinatus tendon injury when Magnetic resonance imaging has been used as a reference. The sensitivity was 80 percent, the specificity was 95 percent, the PPV was 88.9 percent, the NPV was 90.5 percent, and the accuracy was 90 percent for partial thickness tears.

Regarding acromio-clavicular osteoarthritis 96 % was the sensitivity of U/S compared to MRI. Compared to MRI, ultrasonography showed 100 % sensitivity in detecting Subscapularis tendinopathy, Subscapularis tear.

Nineteen cases have been correctly diagnosed with acromio-clavicular osteoarthritis using ultrasound, with subsequent ultrasound sensitivity, specificity, and accuracy of 90.5 percent, 100 percent, and 93.3 percent, correspondingly, in agreement with us. Refaat et al. [12]

Compared to MRI, ultrasonography showed 50 % sensitivity in detecting Subacromial bursitis and muscle atrophy. It was noticed that US sensitivity in detecting biceps tenosynovitis compared to MRI is 66.67%.

In contrast, Refaat et al.[12] reported that the ultrasound correctly diagnosed twelve of the thirteen cases of subacromial bursitis that had been diagnosed by magnetic resonance imaging; they also identified an additional case of bursitis that was negative by magnetic resonance imaging, resulting in a sensitivity, specificity, and accuracy of 92.3 percent, 94.1 percent, and 93.3 percent, correspondingly.

Abdelzaher et al.[9] conducted a study to ascertain the diagnostic accuracy of ultrasound in the detection of shoulder joint pathologies in rheumatoid arthritis, with magnetic resonance imaging serving as the gold standard. This investigation aligns with the majority of our previous outcomes. They stated that ultrasound demonstrated high accuracy in the following conditions: supraspinatus tendinopathy (Sn 96.6 percent; Sp 93.3 percent), biceps tenosynovitis (Sn 87.5 percent; Sp 97.6 percent), subacromial-subdeltoid bursitis (Sn 72.7 percent; Sp 95.7 percent), humeral erosions (Sn 90.5 percent; Sp 97.3 percent), and acromioclavicular osteoarthritis (Sn 85.7 percent; Sp 95.7 percent).

Limitations: This study has no full coverage of the shoulder constituents that adhere to the painful shoulder in adults, missing the labral, ligamental injuries and it is limited with small sample size, short period of follow up and single center.

4. Conclusion

Dynamic ultrasonography showed high sensitivity in the diagnosis of different causative factors encountered in cases of painful shoulder over MRI, especially in the dynamic assessment of sub-acromial impingement associated with soft tissue or bursal impingement, narrowed acromio-humeral distance, and biceps subluxation. Our patients had a higher percentage of rotator cuff tendinosis than the other rotator cuff abnormalities, followed by supraspinatus partial thickness tear, and then full thickness tear. Meanwhile, in the case of non-related rotator cuff abnormalities, acromioclavicular joint osteoarthritis shows the highest prevalence among the rest.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

References

1. Imagama S, Ando K, Kobayashi K, et al. Shoulder pain has most impact on poor quality of life among various types of musculoskeletal pain in middle-aged and elderly people: Yakumo study. Mod Rheumatol. 2020;30(3):568-572. doi:10.1080/14397595.2019.1623364
2. Saraya S, El Bakry R. Ultrasound: can it replace MRI in the evaluation of the rotator cuff tears?. The Egyptian Journal of Radiology and Nuclear Medicine. 2016 Mar 1;47(1):193-201. DOI: https://doi.org/10.1016/j.ejrnm.2015.11.010
3. Serpi F, Albano D, Rapisarda S, Chianca V, Sconfienza LM, Messina C. Shoulder ultrasound: current concepts and future perspectives. J Ultrason. 2021;21(85):e154-e161. doi:10.15557/JoU.2021.0025

4. Singh A, Thukral CL, Gupta K, Singh MI, Lata S, Arora RK. Role and Correlation of High Resolution Ultrasound and Magnetic Resonance Imaging in Evaluation of Patients with Shoulder Pain. Pol J Radiol. 2017;82:410-417. Published 2017 Jul 28. doi:10.12659/PJR.901540
5. Elfaal MW. Shoulder ultrasonography accuracy compared with magnetic resonance imaging in the detection of rotator cuff injuries. Hamdan Medical Journal. 2018 Jan 1;11(1):13-6. DOI: 10.7707/hmj.737
6. Nayak KS, Lim Y, Campbell-Washburn AE, Steeden J. Real-Time Magnetic Resonance Imaging. J Magn Reson Imaging. 2022;55(1):81-99. doi:10.1002/jmri.27411
7. Kumar N, Prashanth S. Accuracy of MRI in diagnosing rotator cuff and labral tears of shoulder. International Journal of Orthopaedics. 2020;6(2):01-4. DOI: https://doi.org/10.22271/ortho.2020.v6.i2a.2008
8. Singh A, Thukral CL, Gupta K, Singh MI, Lata S, Arora RK. Role and Correlation of High Resolution Ultrasound and Magnetic Resonance Imaging in Evaluation of Patients with Shoulder Pain. Pol J Radiol. 2017;82:410-417. Published 2017 Jul 28. doi:10.12659/PJR.901540
9. Abdelzaher MG, Tharwat S, AbdElkhalek A, Abdelsalam A. Ultrasound versus magnetic resonance imaging in the evaluation of shoulder joint pathologies in a cohort of rheumatoid arthritis patients. Int J Rheum Dis. 2019;22(12):2158-2164. doi:10.1111/1756-185X.13728
10. Tuite MJ, Small KM. Imaging Evaluation of Nonacute Shoulder Pain. AJR Am J Roentgenol. 2017;209(3):525-533. doi:10.2214/AJR.17.18085
11. Wengert GJ, Schmutzer M, Bickel H, et al. Reliability of high-resolution ultrasound and magnetic resonance arthrography of the shoulder in patients with sports-related shoulder injuries. PLoS One. 2019;14(9):e0222783. Published 2019 Sep 23. doi:10.1371/journal.pone.0222783
12. Refaat M, Torky A, Salah El Deen W, Soliman S. Comparing Efficacy of Shoulder Ultrasound and Magnetic Resonance Imaging in Shoulder Impingement. Benha Medical Journal. 2021 Mar 1;38(special issue (Radiology)):112-27. DOI: 10.21608/bmfj.2020.130630
13. El-Shewi IE, El Azizy HM, Gadalla AA. Role of dynamic ultrasound versus MRI in diagnosis and assessment of shoulder impingement syndrome. Egyptian Journal of Radiology and Nuclear Medicine. 2019 Dec;50:1-7. DOI: https://doi.org/10.1186/s43055-019-0107-7