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Exploring shoulder joint pain: a comparative analysis of dynamic ultrasonography and magnetic resonance imaging

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ABSTRACT

BACKGROUND: To evaluate shoulder joint pain, the study concentrated on evaluating the diagnostic accuracy of ultrasonography and magnetic resonance imaging.

AIM: By comparing the results from both modalities within the same patient group, the study aimed to identify potential challenges in image interpretation, underscoring the limitations of ultrasonography and magnetic resonance imaging.

MATERIALS AND METHODS: Patients with shoulder joint pain were included through purposive sampling. These patients underwent ultrasonography and magnetic resonance imaging, and the results were correlated. Various shoulder pathologies, including tendon tears, bursitis, degenerative changes, calcifications, and impingement, were analyzed.

RESULTS: The study comprised 35 patients who underwent ultrasonography and magnetic resonance imaging detecting pathologies such as subscapularis and supraspinatus tendon injuries, partial and full-thickness tears, peribicipital tendon fluid, subcoracoid and subacromial-subdeltoid bursitis, acromioclavicular joint degeneration, tendon calcification, and impingement. Comparative analysis showed varying sensitivities, specificities, positive predictive values, negative predictive values, and accuracy for different pathologies.

CONCLUSION: Compared with ultrasonography, magnetic resonance imaging demonstrated greater sensitivity and specificity in identifying conditions causing shoulder pain. Ultrasonography's affordability, real-time capabilities, and ability to compare results with the unaffected side make it a useful first diagnostic step for shoulder pain. Ultrasonography, although a quick and cost-effective initial diagnostic tool, has limitations, including operator dependence and lower sensitivity in certain conditions. In contrast, magnetic resonance imaging is employed as a confirming measure or in instances where diagnosis is challenging. The study emphasized the complementary roles of ultrasonography and magnetic resonance imaging in the diagnosis of shoulder joint pain, with magnetic resonance imaging as the more accurate and complete imaging modality.

Keywords: rotator cuff; shoulder joint; magnetic resonance imaging; ultrasonography; shoulder pain.

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Боли в плечевом суставе: сравнительный анализ данных динамической ультрасонографии и магнитно-резонансной томографии

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АННОТАЦИЯ

Обоснование. При изучении болей в плечевом суставе оценивалась диагностическая точность ультразвукового исследования и магнитно-резонансной томографии.

Цель. Выявить потенциальные проблемы в интерпретации изображений, полученных с помощью ультразвукового исследования и магнитно-резонансной томографии, с указанием их ограничений путём сравнения результатов обоих методов диагностической визуализации в одной и той же группе пациентов.

Материалы и методы. В исследование включены пациенты, жалующиеся на боль в плечевом суставе, которых отбирали методом преднамеренной выборки. Все пациенты прошли ультразвуковое исследование и магнитно-резонансную томографию. Результаты обследования впоследствии сравнивались. В ходе исследования оценивали различные патологии плечевого сустава, включая разрывы сухожилий, бурсит, дегенеративные изменения суставов, кальцификаты, импинджмент-синдром.

Результаты. В исследование включены 35 пациентов, у которых с помощью ультразвукового исследования и магнитно-резонансной томографии были выявлены такие патологии, как повреждения сухожилий подлопаточной и надостной мышцы, частичные и полнослойные разрывы сухожилий, выпот в сухожилии длинной головки двуглавой мышцы плеча, субкоракоидальный и субакромиально-субдельтовидный бурсит, дегенерация акромиально-ключичного сустава, кальцификация сухожилий и импинджмент-синдром. Сравнительный анализ показал различия в чувствительности, специфичности, положительной и отрицательной прогностической ценности, точности обоих методов визуализации при выявлении различных патологий.

Заключение. Сравнение данных показало, что магнитно-резонансная томография обладает большей чувствительностью и специфичностью при выявлении заболеваний, вызывающих боль в плече. Однако благодаря доступности, возможности работы в режиме реального времени и сравнения полученных результатов с данными непоражённой области ультразвуковое исследование считается методом визуализации первой линии при оценке состояния плечевых суставов. Тем не менее ультразвуковое исследование имеет ограничения: зависимость от оператора и более низкую чувствительность при определённых состояниях. Магнитно-резонансную томографию целесообразнее использовать в качестве подтверждающего метода или в случаях, когда диагностика затруднена. Данное исследование подчёркивает взаимодополняющую роль ультразвукового исследования и магнитно-резонансной томографии в диагностике боли в плечевом суставе, при этом магнитно-резонансная томография является более точным и полным методом визуализации.

Ключевые слова: вращательная манжета; плечевой сустав; магнитно-резонансная томография; ультрасонография; боль в плече.

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ЭКО•ВЕКТОР

BACKGROUND

The scapula and humerus form the ball-and-socket glenohumeral (GH) or shoulder joint. It is a major joint that connects the upper limb to the trunk and has a wide range of movements across various planes. The scapula, clavicle, and humerus make up the shoulder complex. This system is made up of four ingeniously formed joints, namely, the acromioclavicular (AC), GH, sternoclavicular (SC), and a "floating joint" called the scapulothoracic (ST) joint. The upper extremities are joined to the axial skeleton at the thorax via the GH, AC, and SC joints. The scapula may easily follow the curves of the posterior thoracic wall because of the ST joint. Normal shoulder-girdle movements are accomplished by the combined action of these four joints. To offset the unstable bony anatomy, the rotator cuff tendons and a capsule protect the shoulder anteriorly, posteriorly, and superiorly. The tendon may experience "wear and tear" from daily activity. Shoulder pain can arise from various etiologies, including acute trauma and a range of degenerative illnesses associated with impingement syndrome. Shoulder pain is one of the most common complaints in orthopedics, often leading to substantial impairment. Clinical evaluation has lower accuracy than arthroscopy, although many clinical studies have used this to diagnose painful shoulders and are thought to be reliable in locating the site of the periarticular lesions, which are the most prevalent causes of shoulder pain [1, 2]. Shoulder pain is frequently caused by rotator cuff pathologies, particularly tears. Clinical examination has limited usefulness in establishing the management of the underlying cause. The severity of the underlying rotator cuff injury and an appropriate diagnosis determine whether to proceed with conservative therapy or surgery [3, 4]. The excellent accuracy of diagnosing rotator cuff pathology can be attributed to advancements in ultrasonography (USG) resolution, redefined techniques, and a better understanding of pathology. High-resolution USG and magnetic resonance imaging (MRI) are the recommended when evaluating suspected rotator cuff tears. Each technique has advantages and disadvantages. Several crucial factors influence the selection of the optimal modality, including skills, cost-effectiveness, availability, and accuracy [5]. To identify rotator cuff and nonrotator cuff pathologies, USG is a highly sensitive, harmless, less expensive, and non-ionizing approach [6]. It is a supplementary tool for shoulder MRI. High-resolution USG demonstrated >90% sensitivity, accuracy, and specificity in identifying tears of any size, full or partial thickness. High-resolution USG can detect abnormalities that may resemble a rotator cuff rupture, such as tendinosis, tenosynovitis, subacromial-subdeltoid bursitis, calcific tendinosis, and fracture of the greater tuberosity. MRI and USG are now of greater use than arthrography for determining the integrity of the rotator cuff. At this point, MRI is regarded as the "gold standard" for assessing the overall joint structure and detecting internal derangements [6]. MR arthrography is utilized to detect instability [7]. Thus, this study aimed to analyze the quality of USG with MRI in evaluating shoulder joint pain in the same patient and to identify image interpretation pitfalls and limitations for both USG and MRI.

Aim — to evaluate a patient with shoulder joint pain in terms of assessment by USG as the first line of imaging modality as compared with MRI.

MATERIALS AND METHODS

Research design

Patients with pain in their shoulder joints who were sent to our department for investigations underwent a year-long study. Purposive sampling was used.

Conformity criteria

The study included patients with a history of shoulder joint pain in any setting, regardless of age or sex, and those who had a clinical suspicion of rotator cuff injuries or disorders that affect the shoulder joints. Individuals with a medical history of metallic implants, cardiac pacemakers, foreign bodies, previous shoulder surgeries, or prosthetics, and those who had previously experienced claustrophobia were excluded.

Research facilities

The study was conducted in the Department of Radiodiagnosis, Saveetha Medical College and Hospital, Chennai, Tamil Nadu. Patients referred for investigational procedures to the Department of Radiodiagnosis, Saveetha Medical College and Hospital found to have shoulder joint pain were examined.

Medical procedure description

Magnetic resonance imaging protocol

The MR procedure was first explained to selected patients. A thorough medical history was obtained. Written informed consent and prior medical records were acquired. Then, patients were positioned and checked for metallic objects. A correlation analysis was performed between the USG and MRI results.

For MRI, a Philips Multiva 1.5 Tesla MRI with an 8-channel SENSE MSK surface coil was used, and the patient was placed in a supine position, focusing on the injured shoulder. The sequences used were proton density images (SPAIR) with 3-mm slice thickness in the axial, coronal oblique, and sagittal planes, T1-weighted imaging in the coronal oblique plane with a 3-mm slice thickness and T2-weighted imaging in the same plane and T2-weighted gradient imaging in the coronal oblique and oblique sagittal planes with a slice thickness of 3 mm. Board-certified radiologists with at least 5 years of expertise in musculoskeletal imaging interpreted the MRI results.

Ultrasound examination of the shoulder

Using a 5–12 MHZ high-frequency linear transducer, a Philips Affinity 70 ultrasound machine was used to assess the affected shoulder. The rotator cuff muscles and tendons, posterior side of the joint, and acromioclavicular joint (ACJ) were evaluated in various positions. In addition, a comparison of the contralateral shoulder was made. USG examinations were conducted by experienced sonographers specializing in musculoskeletal imaging, each with a minimum of 5 years of practice in the field. To maintain consistency, all USG examinations were conducted within 1 day of MRI, minimizing potential variations caused by temporal factors.

Ethical review

The study was approved by Saveetha Medical College Institutional Ethics Committee (No. SMC/IEC/2018/12/002(B) on 11/12/2018). Consent to participate in the study/publication of data for research and educational purposes was obtained.

RESULTS

The study group comprised 35 patients aged >40 (40–81) years. There were 19 male (54.29%) and 16 female (45.71%) patients, indicating minor male majority. The affected side was the right shoulder in 24 (68.57%) patients and the left shoulder in 11 (31.43%). Thirty-three patients were right-hand dominant, and only two were left-hand dominant. Six patients (17.14%) had a history of shoulder trauma.

USG detected subscapularis pathologies in 8.57% of cases, whereas MRI detected this pathology in 11.4%. For supraspinatus pathologies, the USG pickup rate was 71.43%, whereas the MRI pickup rate was 82.85% (Fig. 1, 2). The detection of subscapularis tendon pathologies had 75% sensitivity, 93.55% specificity, 100% positive predictive value (PPV), 96.877% negative predictive value (NPV), 97.14% accuracy, and a *P*-value of 0.005 (significant). For supraspinatus tendon pathologies, USG had 82.76% sensitivity, 83.33% specificity, 96.00% PPV, 50.00% NPV, 82.86% accuracy, and a *P*-value of 0.001 (significant) (Fig. 3).

USG had a pickup rate of 34.29% for partial-thickness supraspinatous tears compared with MRI's pickup rate of 37.14% (Fig. 2). USG demonstrated 78.57% sensitivity, 90.47% specificity, 84.61% PPV, 86.36% NPV, 85.71% accuracy, and a *P*-value of <0.001 (significant).

The pickup rate of full-thickness supraspinatous tears by USG was 17.14% compared with the 17.14% pickup rate of MRI (Fig. 2). USG exhibited 100% sensitivity, 100% specificity, 100% PPV, 100% NPV, 100% accuracy, and *P*-value of <0.001 (significant).

The pickup rate of peri-bicipital tendon fluid by USG was 37.14%, compared with the 80% pickup rate of MRI (Table 1). USG had 42.86% sensitivity, 85.71% specificity, 92.31% PPV, 27.27% NPV, 51.43% accuracy, and P-value of 0.16 (not significant) (Table 2).

The pickup rates for subcoracoid bursitis and subacromial-subdeltoid bursitis by USG were 17.14% and 37.14%, respectively, compared with the pickup rates of 57.14% and 77.14% by MRI (Table 1). For subcoracoid bursitis, USG had 30.00% sensitivity, 100% specificity, 100% PPV, 57.72% NPV, 60% accuracy, and *P*-value of 0.019 (significant). For subacromial-subdeltoid bursitis, USG had 44.4% sensitivity, 87.50% specificity, 92.31% PPV, and 31.82% NPV, 54.29% accuracy, and *P*-value of 0.10 (not significant) (Table 2).

The pickup rate of ACJ degenerative changes by USG was 11.4% compared with the pickup rate of 51.4% by MRI (Table 1). USG had 22.222% sensitivity, 100% specificity, 100% PPV, 54.844% NPV, 60% accuracy, and *P*-value of 0.038 (significant) (Table 2).

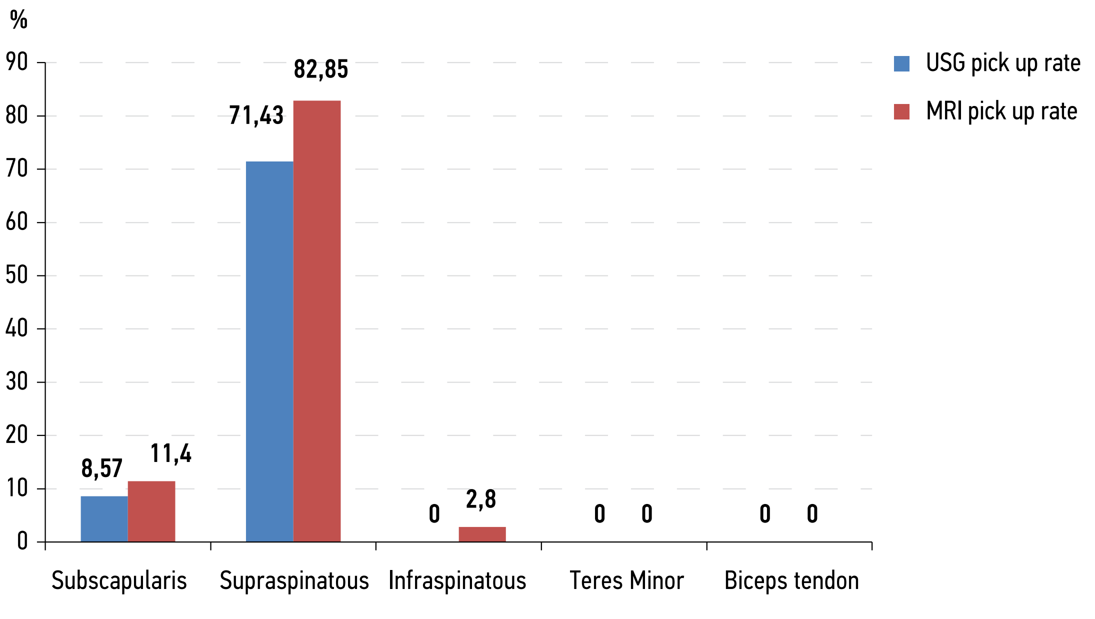

Fig. 1. Correlation of USG findings with MRI findings — pathology (tear): an observation.
Note (here and in fig. 2, 3). USG — ultrasonography, MRI — Magnetic resonance imaging.

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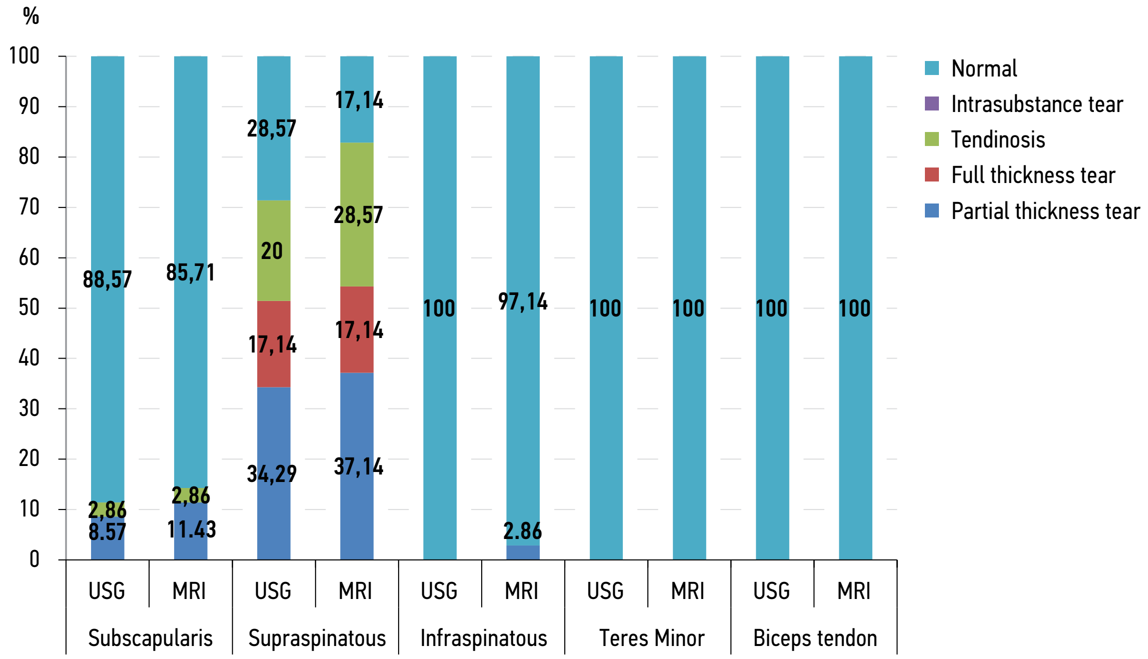

Fig. 2. Detailed correlation of USG findings with MRI findings: pathology (tears).

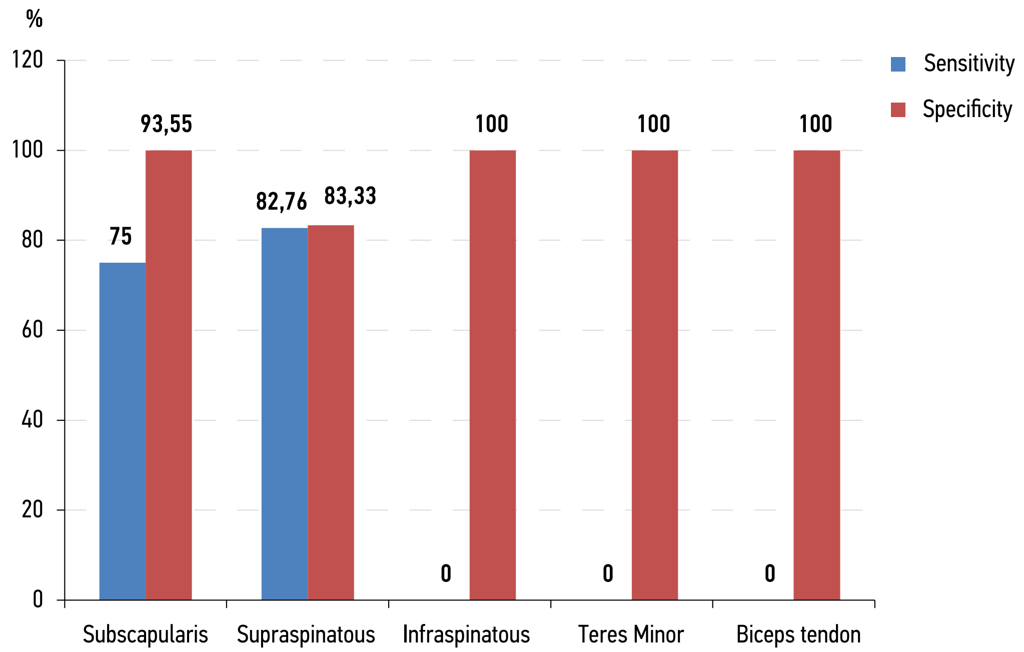

Fig. 3. Correlation of USG findings with MRI findings — pathology (tears): an evaluation.

Table 1. Correlation of USG findings with MRI findings — pathology (others): an observation

Findings	TP	FP	TN	FN	USG pickup rate	MRI pickup rate	Total
Peribicipital tendon fluid	12	1	6	16	37.14	80.00	35
Subcoracoid bursa	6	0	15	14	17.14	57.14	35
Subacromial-subdeltoid bursa	12	1	7	15	37.14	77.14	35
ACJ degeneration	4	0	17	14	11.4	51.4	35
Calcification	4	1	170	0	2.8	2.2	175
Impingement	2	0	66	2	2.6	5.3	70

Note. USG — ultrasonography, MRI — magnetic resonance imaging, TP — true positive, FP — false positive, TN — true negative, FN — false negative, ACJ — acromioclavicular joint.

Table 2. Correlation of USG findings with MRI findings — pathology (others): an evaluation

Findings	Sensitivity	Specificity	PPV	NPV	Accuracy	*P*-value
Peribicipital tendon fluid	42.86	85.71	92.31	27.27	51.43	0.16
Subcoracoid bursa	30.00	100.00	100.00	57.72	60.00	0.019
Subacromial-subdeltoid bursa	44.44	87.50	92.31	31.82	54.29	0.10
ACJ degeneration	22.22	100	100	54.84	60	0.038
Calcification	100.00	99.42	80.00	100.00	99.43	<0.0001
Impingement	50.00	100.00	100	97.06	97.14	<0.0001

Note. USG — ultrasonography, MRI — magnetic resonance imaging, PPV — positive predictive value, NPV — negative predictive value, ACJ — acromioclavicular joint.

The pickup rate of tendon calcification by USG was 2.8% compared with the pickup rate of 2.2% by MRI (Table 1). USG had 100% sensitivity, 99.42% specificity, 80% PPV, 100% NPV, 99.43% accuracy, and *P*-value of <0.0001 (significant) (Table 2).

The pickup rate of impingement by USG was 2.6% compared with the pickup rate of 5.3% by MRI (Table 1). USG had 50% sensitivity, 100% specificity, 100% PPV, 97.06% NPV, 97.14% accuracy, and *P*-value of <0.0001 (significant) (Table 2).

DISCUSSION

Patients with shoulder pain are evaluated using various methods, such as clinical examination, radiography, USG, CT, MRI, arthrography, and arthroscopy. With MR arthrography, accuracy is at its highest. However, traditional MRI, which is sensitive and particular, cannot be a starting point of inquiry. Nonetheless, USG is a helpful and harmless method that is cost-effective.

According to our analysis, shoulder pain was most frequently caused by rotator cuff issues. Among the diseases were tendinosis and full and partial-thickness tears. In this study, the supraspinatus tendon was the most commonly affected tendon, and conditions associated with this tendon were found in 25 and 29 patients by USG and MRI, respectively. This is similar to the study by Zlatkin et al. [8]. Other pathologies causing shoulder joint pain in our study group included peribicipital tendon fluid, subcoracoid bursitis, subacromial-subdeltoid bursitis, ACJ degeneration, tendon calcifications, and subacromial and subcoracoid impingement.

To assess shoulder joint disorders, USG and MRI are frequently utilized and effectively replace the necessity for traditional arthrography. The 1979 publication on the use of USG in rotator cuff assessment by Seltzer S.E., Finberg H.J., and Weissman B.N. [9] was followed in 1986 by the study by Kneeland J.B., Carrera G.F., and Middleton W.D. [10] regarding MRI. These two techniques have matured as a result of technological advancements and discoveries in the anatomical and pathologic properties of the rotator cuff.

In 2001, Martin-Hervas C. et al. used MRIs and USGs to evaluate every patient who reported shoulder pain. According to their findings, full-thickness tear diagnosis was precise on both imaging modalities (100% for USG and 97.1% for MRI) but not sensitive (67.9% for USG and 75.5% for MRI). Because of its specificity, they believe that USG should be a promising imaging method for the initial evaluation of all shoulder joints that cause pain. However, because of the low sensitivity, an additional MRI is required [11].

Bryant L. et al. (2002) examined the ability to use clinical estimation, diagnostic USG, MRI, and arthroscopy to determine the size of rotator cuff tears. The results of open surgery were compared with estimates of the rotator cuff tears in 33 consecutive individuals suspected of having one. The best association was found between the estimated size of the rotator cuff tear from arthroscopy and the actual size of the tear (Pearson correlation coefficient, $r=0.92$; $p<0.001$). MRI ($r=0.74$; $p<0.001$) was comparable to USG ($r=0.73$; $p<0.001$) [12].

Ostlere S. (2003) stated that plain radiographs are helpful as a first screening tool for patients with shoulder joint pain. USG and MRI are the best methods for identifying rotator cuff illness. USG is ideal for providing flexible access to instant-access clinics. MR or CT arthrography is required to investigate instabilities [13].

Martinoli et al. (2003) suggested that USG is noninvasive, quick, and cheap, allowing for greater resolution and the capacity to analyze tissues in both dynamic and static states with the patient in different positions. This warrants the broader use of USG in evaluating nonrotator cuff pathologies [14].

Middleton et al. (2004) examined 108 cases of shoulder joint pain with a clinically suspected rotator cuff injury. After USG and MRI, the patients completed satisfaction questionnaires. The satisfaction levels were greater for 54 patients in USG, 13 in MRI, and both in 50 patients ($p<0.001$). Ten patients were not willing to have an MRI ($p=0.002$), whereas all patients were willing to have repeat USG. Eight patients preferred MRI, 93 preferred sonography, and 17 patients had no preference. The study found that most shoulder pain patients preferred USG over MRI [15].

Vlychou M. et al. (2009) evaluated 56 individuals with symptomatic impingement syndrome; all patients had USG scans and MRIs before surgery. The two imaging modalities identified 44 instances of partial supraspinatus tendon injuries. Results for USG imaging showed 95.6% sensitivity, 70% specificity, 91% accuracy, and 93.6% positive predictive accuracy. For MRI, the corresponding figures were 91.7%, 63.6%, 91%, and 97.7%, respectively. They concluded that USG, which focuses mainly on the supraspinatus tendon, is nearly as valuable as MRI in identifying partial rotator cuff injuries. When surgical intervention is required before placing nearby structures, MRI may be saved for uncertain or complicated instances [16].

Zlatkin M.B. et al. conducted MRI studies on painful shoulders and reported that rotator cuff tears in 51% of patients are associated with type 3 acromia, os acromiale, or anteroinferior bone spurs. By employing traditional MRI, they ascertained that the sensitivity, specificity, and accuracy of rotator cuff injuries, whether partial or total, were 91%, 88%, and 89%, respectively [8].

The study's focus remains on evaluating the diagnostic accuracy of MRI and USG in identifying various shoulder pathologies associated with joint pains. Comparative analysis revealed the superiority of MRI in accuracy, sensitivity, and specificity, particularly in identifying full-thickness tears, bursitis, and ACJ degenerative changes. Conversely, USG demonstrated value in diagnosing partial-thickness tears, exhibiting comparable sensitivity and specificity to MRI. The discussion underscores the complementary roles of both modalities, with MRI providing detailed anatomical insights and USG offering real-time assessment with minimal patient preparation. Acknowledging study limitations, including potential operator-dependent variability in USG and the need for further research to validate findings across diverse patient populations, emphasizes the need for future investigations to address remaining gaps in knowledge comprehensively. Ultimately, the study underscores the importance of leveraging the strengths of MRI and USG to optimize diagnostic accuracy and facilitate tailored treatment strategies for patients presenting with shoulder pain.

CONCLUSION

In assessing labral and capsular conditions, USG is less sensitive than MRI. USG has a high sensitivity of 78.57% and specificity of 90.47% for partial-thickness tears and sensitivity of 100.0% and specificity of 100% for complete-thickness tears. The most precise and sensitive diagnostic method for shoulder pain is MRI. It can be employed in troublesome cases with an uncertain USG diagnosis. USG can be nearly as practical as MRI when assessing rotator cuff injuries. A well-performed USG is a quick and inexpensive primary diagnostic technique that can adequately screen all bothersome shoulder joints; however, it is operator dependent. Because MRI has a lesser chance of artifacts and gives more information on the extent of tendons, it is used.

ADDITIONAL INFO

Author contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work. S. Varma — study design, collection of data, data analysis, and writing of the manuscript; P.K. Sharma — writing of the manuscript, sourcing and editing of clinical images, critical review, and investigation results; A. Faizal — sourcing and editing clinical images, investigation results, critical review and revision; A. Lucas — investigation results, critical review and revision.

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Competing interests. The authors declare that they have no competing interests.

ДОПОЛНИТЕЛЬНО

Вклад авторов. Все авторы подтверждают соответствие своего авторства международным критериям ICMJE (все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией). Наибольший вклад распределён следующим образом: С. Варма — дизайн исследования, сбор и анализ данных и написание рукописи; П.К. Шарма — написание рукописи, поиск и редактирование клинических изображений, критический обзор и результаты исследований; А. Файзал — поиск и редактирование клинических изображений, результаты исследований, критический обзор и доработка статьи; А. Лукас — результаты исследования, критический обзор и доработка статьи.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования и подготовке публикации.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с проведённым исследованием и публикацией настоящей статьи.

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