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The Role of Ultrasound and Magnetic Resonance Imaging in the Assessment of Musculo-Tendon Pathologies of the Shoulder Joint

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Abstract
Goal:to assess and characterize musculo-tendon pathologies of the shoulder joint using ultrasound (US) and magnetic resonance imaging (MRI). Background and goals: The shoulder joint, being the most mobile and unstable of all joints, is often prone to injury. To compensate for the unstable bone anatomy, the shoulder is protected from the front, back, and top by a capsule and tendons forming the rotator cuff of the shoulder. Ultrasound is often considered the first-line imaging method for evaluating the cuff, as well as for diseases unrelated to the rotator cuff. MRI is important in cases of extensive abnormalities that are often not fully characterized at the initial sonographic examination, as in the case of sonographically inaccessible areas. However, musculoskeletal imaging is indeed a multi-modal approach, and a combination of techniques should be used to identify and characterize the lesion.
Materials and methods: A prospective study was conducted on 75 patients in the radiology department. Patients of all age groups, including both men and women with shoulder pain, presumably arising from the musculoskeletal tissues of the shoulder joint, were taken for the study.
Results: In our study, ultrasound showed 95.2% sensitivity, 88.8% specificity, and a positive prognostic value of 80% for demonstrating full-layer breaks. In the case of incomplete ruptures, ultrasound showed an overall sensitivity of 94.7%, specificity of 85.7% and a positive prognostic value of 90%. The overall accuracy of ultrasound in detecting full-layer and incomplete tears was 91%.
Conclusion: In patients with complaints about the shoulder joint, ultrasound is a reliable method of dynamic diagnosis. It demonstrates high diagnostic accuracy in detecting rotator cuff pathologies, including cuff tears and tendinopathy. However, MRI has always been successful in the overall assessment of joint structure. Its ability to assess the articular lip and various scapular ligaments cannot be replaced by ultrasound.

Keywords: magnetic resonance imaging; rotator cuff; ultrasound.

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INTRODUCTION

The shoulder joint is a ball-shaped synovial joint. It is formed by the articulation of the scapula and head of the humerus. Being the most mobile and unstable of all joints, it is often prone to injuries. To compensate for the unstable bone anatomy, the shoulder is protected from the front, back, and top by a capsule and tendons forming the rotator cuff of the shoulder. The point prevalence of shoulder pain in the general population is 6.9-26%. Various causes of shoulder pain include tendon injuries, adhesive capsulitis, compression of the cervical nerve root, and acute joint inflammation. More than half of shoulder anomalies are associated with damage to the rotator cuff of the shoulder. They are the most common cause of shoulder pain and dysfunction in patients over 40 years of age. Ultrasound (US) has been shown to be a successful imaging technique for the diagnosis of rotator cuffand non-rotator cuff disorders. It is affordable, but it also allows you to perform a dynamic examination of the patient in several scan planes and in certain hand positions. In addition, it allows the researcher to focus on the area of maximum discomfort. It plays an important role in the diagnosis of calcifying deposits, impingement, pathologies of the acromioclavicular joint and targeted therapy. Magnetic resonance imaging (MRI) is currently considered the reference standard for imaging shoulder joint diseases. The power of MRI lies in its ability to assess sonographically inaccessible areas such as the upper lip, deep parts of various ligaments, the capsule, and areas covered by bone. Currently, it is used as the main form of research for recurrent dislocations, lesions of the lips, articular cartilage, synovial diseases, tumors and infections. It also accurately displays associated muscle abnormalities and thus helps in recognizing surgically treatable pathologies. In addition, it can identify other causes of shoulder pain that clinically mimic rotator cuff disease. These days, ultrasound serves as a complement to MRI, and there are potential benefits from using the two methods in combination. Ultrasound is often considered the first-line imaging method for evaluating the cuff, as well as for diseases unrelated to the rotator cuff. It is suitable for the study of localized and mostly superficial disorders. MRI is important in cases of extensive abnormalities that are often not fully characterized at the initial sonographic examination, as in the case of sonographically inaccessible areas. However, musculoskeletal imaging is indeed a multi-modal approach, and a combination of techniques should be used to identify and characterize the lesion.

Materials and Methods

A prospective study was conducted with 75 patients in the radiology department for 2 years from July 2019 to September 2021. The study included patients of all age groups, including men and women, with shoulder pain, presumably due to the musculoskeletal tissues of the shoulder joint. Diagnosed cases of any tumor, arthritis, shoulder periarthritis/frozen shoulder, or those who had already undergone shoulder surgery

were excluded from the study. Any patient with a shoulder fracture was excluded based on X-ray examination. Patients with contraindications to MRI, such as patients with a pacemaker, metal implants, or patients with claustrophobia, were also excluded.

Ultrasound examination: Ultrasound examination of the shoulder joint was performed in the patient's sitting position on a chair or bed. Ultrasound examination was performed in a sequential order. First, the biceps and subscapular tendons were examined, then the supraspinatus tendon, and finally the posterior structures, including the subclavian muscle and the posterior shoulder joint, were examined.

MRI examination: The patient was in a supine position with the shoulder and arm placed side by side and parallel to the body, in a neutral or light external rotation. The shoulder was kept as close to the center of the magnet as possible. We found that it was helpful to tuck the patient's arm under the hip so that the shoulder remained stationary. A four-channel flexible coil was used for the study. The technique of abduction-external rotation was used in cases of pronounced suspicion of lip pathology, as well as ruptures of the rotator cuff of the articular surface, which were not clearly visualized using traditional techniques

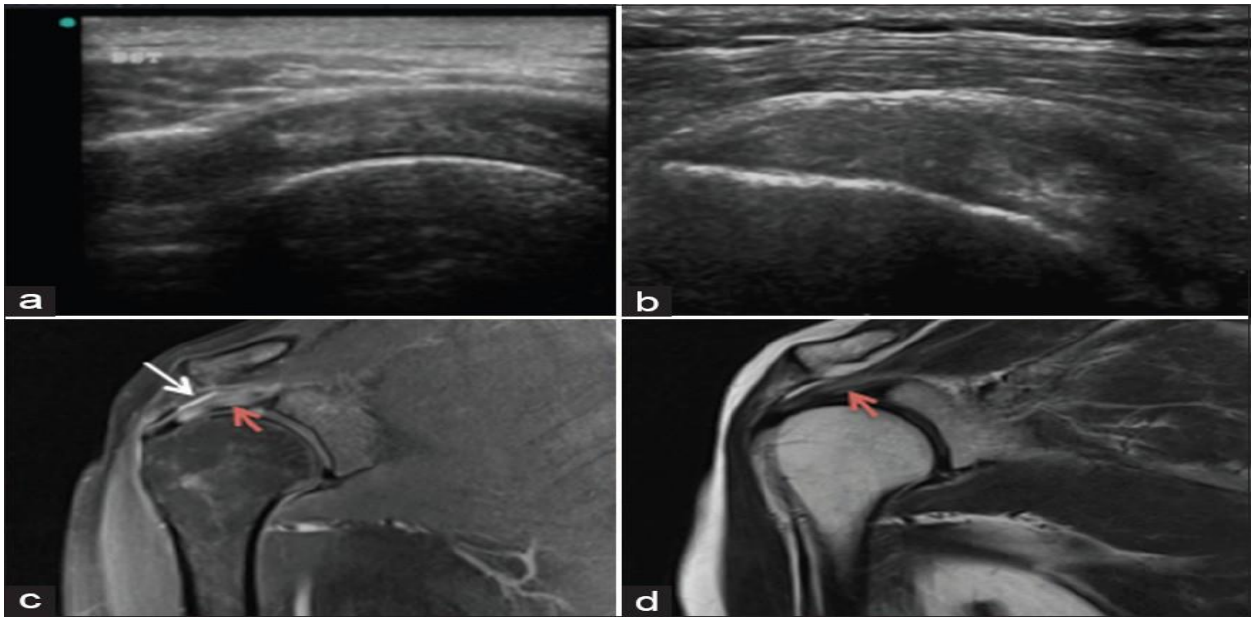


Figure 1: A 50-year-old female patient complaining of right shoulder pain for 2 months. On clinical examination, resistance to abduction caused pain, indicating damage to the supraspinatus muscle. a) transverse; and (b) A longitudinal sonogram of the right supraspinatus tendon showed thickening and heterogeneity of the tendon with loss of the normal fibrillar pattern. There was no focal defect inside the tendon. (c) The coronary oblique Proton density (PD) is saturated with fat. (d) T2-weighted images (T2VI) revealed a hyperintensive signal in the supraspinatus tendon (red arrow) that was not as bright as fluid. Concomitant subacromial-subdeltoid bursitis (white arrow)

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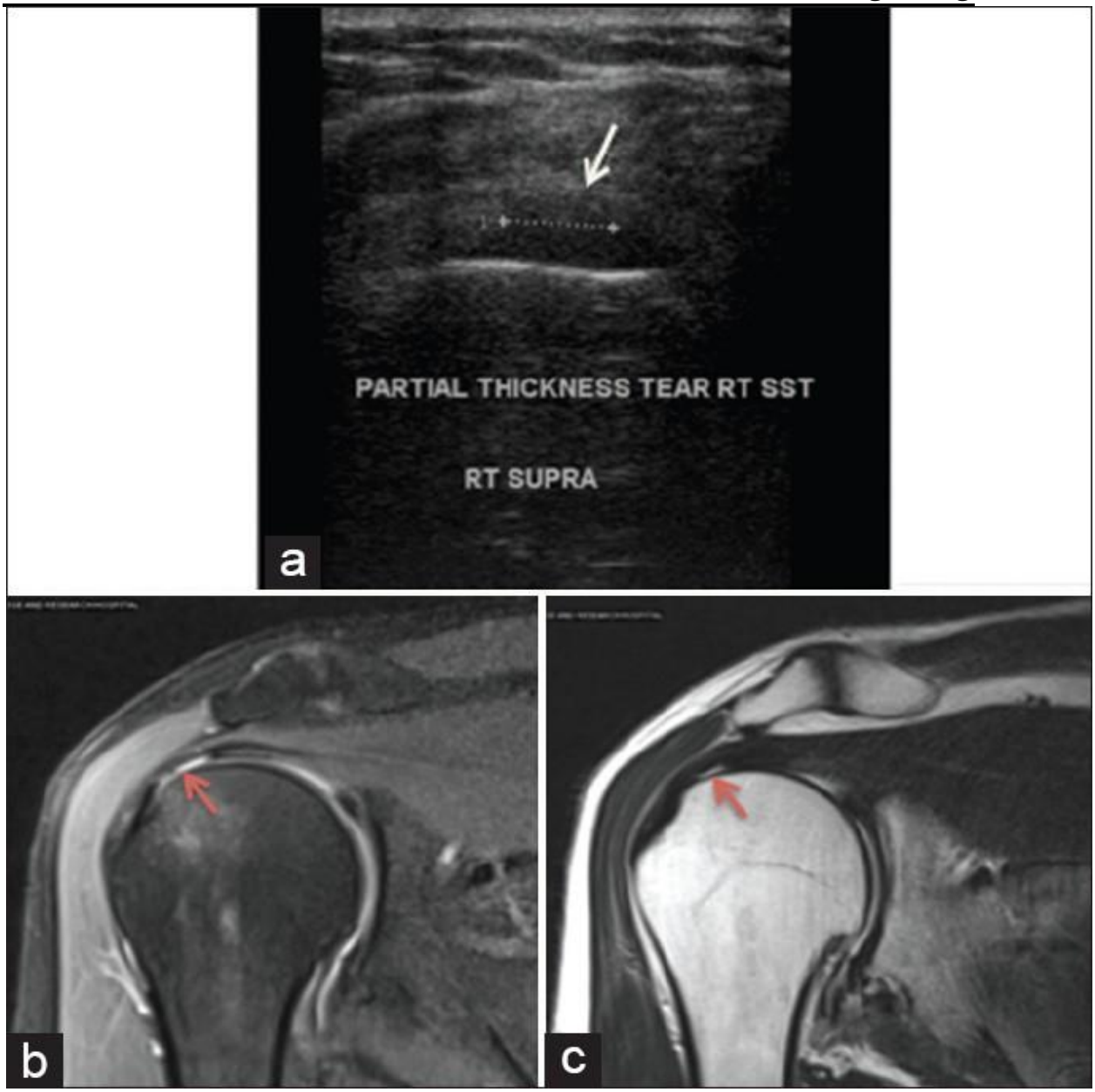


Figure 2: A 57-year-old patient with a history of falling on her right shoulder, after which she was unable to move her arm. On clinical examination, damage to the supraspinatus tendon was suspected. (a) A transverse sonogram showed a hypoechoic defect on the articular surface of the supraspinatus tendon. The overlying surface fibers of the bursa (white arrow) remained intact; and (b) Coronal oblique PD with fat deposition. (c) The T2W images show an incomplete joint surface tear that occupies less than 50% of the tendon thickness (red arrow).

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Figure 3: A 66-year-old male complained of gradual restriction of movement in his right shoulder. I had a history of falling on my right shoulder 1 year ago. (a) A transverse sonogram of the right supraspinatus muscle revealed a full-layered hypoechoic defect with a normal location of the supraspinatus tendon (white arrows). Fluid is visible inside the defect, spreading from the articular surface to the bursal surface. The torn edge of the retracted supraspinatus tendon is visible (S); and (b) A transverse sonogram of the right subscapular muscle showed a full-thickness tendon tear.

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Figure 4: Multi-tendon rotator cuff tears. (a) Coronal oblique PD fat scan of the right shoulder revealed a full-layer rupture of the supraspinatus tendon (double arrow shows the largest size) with medial retraction of the tendon edge. Minimal articular effusion is noted. In the deltoid muscle, a change in signal intensity with loss of volume was noted; and (b) axial PD fat imaging showed a U-shaped rupture of the supraspinatus tendon. (c) Sagittal oblique T2WI image shows the extension of the tear to the rotator interval and the subscapular tendon forward (large white arrow).

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Figure 5: A 19-year-old patient presented with a history of recurrent anterior dislocation of the left shoulder for 5 months. Radiographs in the anteroposterior projection (a) and (b) in the Stryker's projection of the left shoulder notch showed a sphenoid defect in the posterior-upper part of the humerus head

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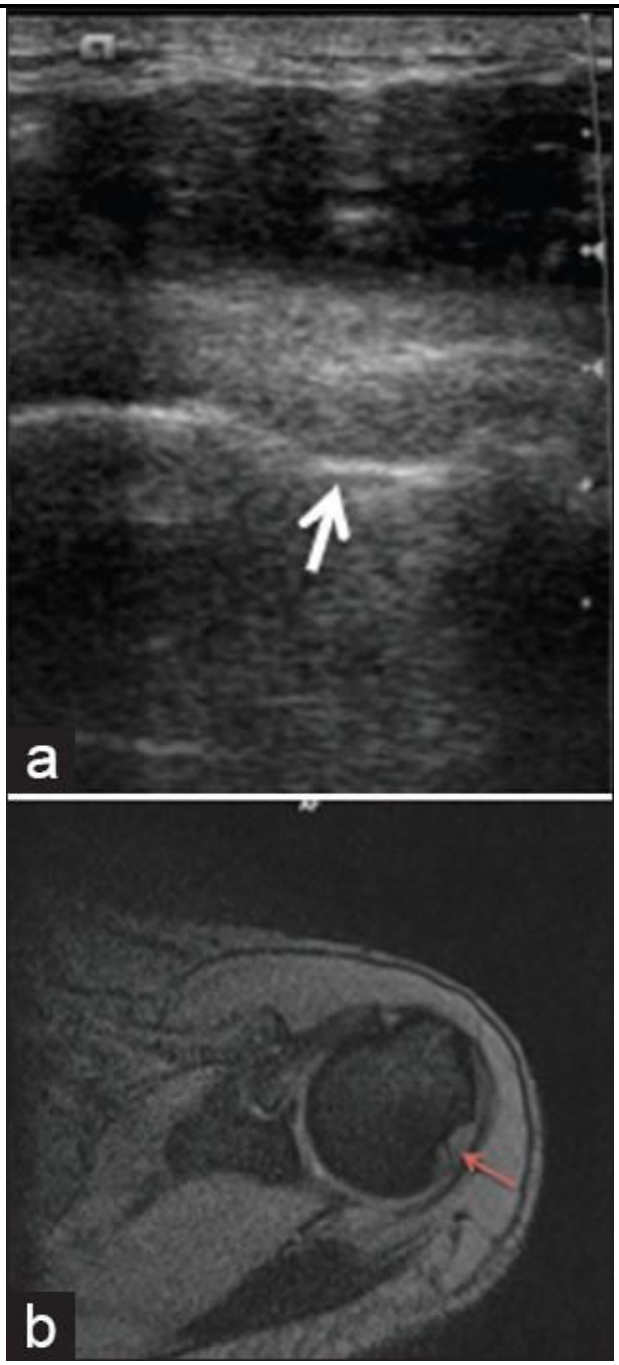


Figure 6: (a) A longitudinal sonogram at the level of the subacute muscle shows a step defect in the posterior-upper part of the humerus head (white arrow); and (b) an axial gradient image shows a wedge-shaped defect in the posterolateral part of the humerus head (red arrow) above the level of the coracoid process.

Results

The study was conducted in 75 patients. Of these, 54 are men and 21 are women. Age ranged from 15 to 77 years, with an average age of 46 years. Most of the patients were in the age group of 41-50 years. Based on the medical history and clinical examination, patients were divided into three categories:

- Rotator cuff tears
- Conflict
- Recurrent dislocation or instability.

General rotator cuff pathology, including tear and impaction, has been found to be the main cause of shoulder pain. Pathology of the rotator cuff was suspectedin 66 out of 75 patients. Among all cases with suspected rotator cuff involvement, nine patients did not have any pathology detected by ultrasound. In the remaining 66 patients, the most frequent findings were supraspinatus muscle lesions (75%), followed by pathologies of the biceps tendon. Articular effusion and subacromial-subdeltoid bursitis were quite frequent findings. They were detected in almost 77 and 73% of patients, respectively. Bicepital tendosynovitis was the most common pathology involving the biceps tendon. Damage to the supraspinatus tendon was observed more frequently than to the subacute or subscapular tendon. We found that an incomplete tear was the most common lesion of the supraspinatus and subaspinatus tendons, followed by tendinopathy. Ruptures of the scapular tendon were found in only three patients. Of these, one case was associated with a dislocated biceps tendon, and the other case was associated with a torn biceps tendon. A total of nine patients were found to have intra-tendinous echogenic foci with a posterior acoustic shadow, which indicated calcifying tendinitis. Tendon calcification was better defined on ultrasound than on conventional radiographs, especially in cases of subscapular calcifying tendonitis, where calcification foci were often hidden by underlying bones. Ultrasound successfully detected Hill-Sachs damage in five of the seven patients with recurrent shoulder dislocation. However, no lip tears were detected on ultrasound. Subsequently, they were identified during an MRI examination. MRI was performed in all patients, and the results were evaluated independently of the ultrasound results. Later, the results of ultrasound and MRI were compared. Compared to ultrasound, only six patients showed no lesion. Ultrasound missed supraspinatus pathology in two patients. The third patient had minimal articular effusion without rotator cuff pathology. As with ultrasound, the most common pathology detected on MRI was pathology of the supraspinatus tendon. In both modalities, the same number of pathologies of the biceps tendon was diagnosed, including biceps tendosynovitis. Joint effusion was detected in a larger number of patients with MRI (86%) compared to ultrasound (77%). Bone changes detected on MRI included acromioclavicular arthropathy, Hill-Sachs lesion, and Bankart bone lesion. Damage to the articular lip and shoulder ligaments was detected on MRI in 15 and 4% of patients, respectively. Thickening of the scapular ligament,

especially the inferior scapular ligament,was detected in three cases. Incomplete rupture was the most common pathology in the rotator cuff arm group. Among the pathologies of the supraspinatus muscle, two new cases of incomplete rupture were diagnosed on MRI. In another patient, an MRI scan revealed a full-layer tear instead of a massive partial tear. The ultrasound also missed three full-layer tears and one incomplete tear of the subclavian muscle. Pathologies of the subscapular muscle were well defined on both ultrasound and MRI. In the case of incomplete ruptures, ultrasound showed an overall sensitivity of 94.7%, specificity of 85.7% and a positive prognostic value of 90%. The overall accuracy of ultrasound in detecting full-layer and incomplete tears was 91%.

Discussion:

General pathology of the rotator cuff, including rupture and impingement of the rotator cuff, was the most common reason for contacting the radiologist, accounting for almost 88% of our cases. This is consistent with a study conducted by Hawkins et al., who found that more than 60% of shoulder joint abnormalities связаны с заболеванare associated with rotator cuff disease. Of all the lesions found on both ultrasound and MRI, the supraspinatus tendon was affected more often than the subacute or subscapular tendon. This is comparable to the study conducted by Zlatkin et al., and they found involvement of the supraspinatus tendon in about 80% of cases. The probable cause is the characteristic anatomical location of the supraspinatus tendon. It is located between the large tubercle and the acromial process, which leads to repeated friction when the shoulder is withdrawn above the head. Ruptures of the scapular tendon have always been considered rare. We found only three patients (4%) with torn scapular tendon. All patients had a coexisting rupture of the supraspinatus and / or subspinatus muscle. One in three patients had a dislocated biceps tendon. These results are consistent with data from Codman, who reported scapular tendon damage in less than 3.5% of patients in a series of 200 rotator cuffs shoulder ruptures.More recent studies have shown a significant association of scapular muscle tears with injuries to other componentsof the rotator cuff of the shoulder. In our study, there is a very high association of rotator cuff ruptures with effusion into the articular fissure, biceps tendon sheath, and subacromial sac. High specificity of effusion in cuff tears was alsoobserved by Van Holsbeeck and his colleagues, who found that it is 90% specific. Despite the fact that MRI was considered a reference method, by itself it could not detect calcifying tendinitis. Calcifications were evaluated only retrospectively after comparing the results of ultrasound. In cases of repeated dislocation of the shoulder and instability, ultrasound revealed only the Hill-Sachs defect. No lip tears or glenoid abnormalities were detected. MRI successfully demonstrated lip involvement in all cases of recurrent dislocation. Hill-Sachs defect, Bancart's cartilage and bone lesions were alsodiagnosed in six of the seven patients. Compared with MRI, ultrasound

showed a sensitivity of 95.2% and a specificity of 88.8% for full-layer breaks and a sensitivity of 94.7% and a specificity of 85.7% for incomplete breaks. The overall accuracy of ultrasound in detecting ruptures was 91%. The results of our study are consistent with many others, which indicate a high level of sensitivity andspecificity of full-layer fractures. Naredoe and his team conducted a comparative ultrasound and MRI study of 36 patients with shoulder pain. MRI results were considered the gold standard. Ultrasound showed high sensitivity, specificity and positive and negative prognostic values (range: 85.7-100%) in the diagnosis of tendinitis and partial and complete rupture of the rotator cuff of the shoulder. These results correlate well with our results. Joseph and his team in 2009 compared the diagnostic accuracy of MRI, MR arthrography, and ultrasound to detect rotator cuff tears through a meta-analysis of 65 studies published in the literature. They found no statistically significant difference between the sensitivity and specificity of ultrasound and MRI in the diagnosis of full-or partial-thickness tears. In 2010, Mathieu and colleagues conducted a similar study to assess the need for an additional MRI exam after ultrasound in patients with shoulder pain and / or disability. The results of imaging methods were compared with the results of surgical intervention. The accuracy of ultrasound in the diagnosis of full-layer and incomplete tears was 94 and 81%, respectively.

Conclusion:

Ultrasound is a reliable dynamic diagnostic tool for patients with shoulder complaints. It demonstrates high diagnostic accuracy in detecting rotator cuff pathologies, including cuff tears and tendinopathy. Given the fact that more than half of the complaints are related to these lesions, ultrasound in most cases eliminates the need for additional imaging. However, MRI has always been successful in the overall assessment of joint structure. Its ability to assess the articular lip and various shoulderligaments cannot be replaced by ultrasound. Although our study showed results consistent with the recently published medical literature, it has several limitations. Operator dependence and the limited number of study participants are among the few. The main disadvantage of our study was the lack of correlation with surgical data. Although MRI is widely used as the method of choice for detecting shoulder joint diseases, it does not provide 100% accuracy as a reference standard. Our study would be of great benefit if surgical intervention were considered as a reference point. The inclusion of other methods, such as MR arthrography, would lead to more accurate detection of lip pathologies.

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