Magnetic Resonance Imaging versus Ultrasound in the Diagnosis of Shoulder Rotator Cuff Lesion: Physical Comparison

Hajar H. Singal, Siham Sabah Abdullah, Mohammed B. Hasan, Harith M. Abd Al-Baqi

Department of Physiology and Medical Physics, College of Medicine, Al-Nahrain University, Baghdad, Iraq

Aliraqia University, college of medicine, Baghdad, Iraq

Al-Numan General Teaching Hospital, Baghdad, Iraq

Emails: Hajar33hamad@gmail.com, drsihamsubah66@gmail.com, mohammedbader.12@gmail.com

Abstract

Background: Different diagnostic imaging modalities, such as ultrasonography (US), MRI are commonly used for the characterization of rotator cuff (RC) disorders. Since the most recent systematic reviews on medical imaging, multiple diagnostic studies have been published, most using more advanced technological characteristics.

Objective: Diagnostic accuracy of ultrasound (US) in detection of rotator cuff (RC) lesions and compared to magnetic resonance imaging (MRI).

Patients and methods: This study included 60 patient for (6 months) in Al-Numan General Teaching Hospital with shoulder pain and shoulder movement limitations and cross-sectional data collection 2021. examined by ultrasound and MRI were compared as gold standard.

Results: The comparative imaging characteristics diagnosis of muscular shoulder injury of tendonitis was 30% vs. 33.3% by ultrasound and magnetic resonance imaging respectively. For tenosynovitis, partial tear and complete tear, the comparative imaging characteristics by U/S and MRI were 10% vs. 13.3%, 6.7% vs. 8.3% and 13.3% vs. 15 respectively.

Regarding Bony shoulder injuries, the comparative imaging characteristics for bone marrow lesion for U/S and MRI were (1.7% vs. 18.3%) respectively. For other injuries like Bursa, Effusion, and Labrum were (6.7% vs. 23.3%) (10% vs 18.3%), and (zero% vs. 11.7%) respectively.

Conclusion. Ultrasound and MRI have shown similar diagnostic efficacies for evaluation of the rotator cuff. When clinical findings require rotator cuff evaluation, the choice between MRI and ultrasound is influenced by access to imaging, radiologist experience, referring physician preference, MRI contraindications, and patient choice. In physics using high-wavelength radio waves that reach deeper than ultrasound, and return the waves (echo) in the form of a more .resolution, and clear image.

Keyword: Rotator Cuff lesion, shoulder pain, physics in MRI, physics in ultrasound, Shoulder joint, High resolution, Shoulder impingement.
Introduction:

A magnetic resonance imaging (MRI) scan is a common procedure around the world. MRI uses a strong magnetic field and radio waves to create detailed images of the organs and tissues within the body(1-2). MRI is a non-invasive method of mapping the internal structure and certain aspects of function within the body. It uses nonionizing electromagnetic radiation and appears to be without exposure-related hazard. It employs radio frequency (RF) radiation in the presence of carefully controlled magnetic fields in order to produce high quality cross-sectional images of the body in any plane(3-6).

Ultrasonography (US) is an inexpensive, convenient, and effective tool that can be used to evaluate the shoulder. It does not expose the patient to harmful radiation and can be used to evaluate the musculoskeletal system dynamically. Additionally, US is not subject to metal artifacts when evaluating patients with previously placed hardware. Over the years, US has been found to be reliable and accurate for diagnosing rotator cuff tears (RCTs), despite its operator dependence. The usage of US for diagnosing RCTs in orthopedic practice varies depending on practitioners’ familiarity with the exam and the availability of experienced technicians. The purpose of this article is to review the diagnostic accuracy of US for identifying RCTs(7-11).

Rotator cuff tear (RCT) accounts for 50% of shoulder injuries, leading to chronic pain and disability in the upper extremity (12). The prevalence of RCT increases with advanced age, and more than 50% individuals in their 80s suffer from RCT (13). The initial treatment for most RCT cases is conservative, with physical therapy, analgesics, and possibly corticosteroid. There are a wide variety of surgical options, such as rotator cuff repair, superior capsule reconstruction, as well as reverse shoulder arthroplasty (14-15). However, reinjury rates of RCT range from 11% to 94% after surgical intervention (16-20).

Patients and methods

The study included 60 patient for (6months) in Al-Numan General Teaching Hospital, with shoulder pain and shoulder movement limitations and cross-sectional data collection 2021 examined by ultrasound and MRI were compared as gold standard. Inclusion: The research conducted on patients with shoulder pain and shoulder movement limitations (18-70) years old. Exclusion: Pregnant women, Children and a patient with a metal implanted with a body. All patients had standardized bilateral Ultrasound of the shoulder. US were obtained in real time using a high frequency linear array transducer (3-12MHz). US evaluation was done according to both transverse and longitudinal scan. The subscapular is, supraspinatus, infraspinatus and teres minor tendons were examined. include the subcutaneous fat at the top and the humeral head at the bottom. The MRI protocol included coronal T1 and T2, coronal T2-fat suppressed, sagittal T2-proton density and axial T2 and coronal T1 –contrast.
**Statistical analysis:** All data were collected, tabulated and statistically analyzed using Kappa test agreement (k) was used to detect the degree of agreement between each two techniques and its analysis was according to its value. The Validity of the screening test (US and MRI) were assessed in the terms of sensitivity, specificity, predictive value positive, predictive value negative and accuracy. All tests were two sided. P-value < 0.05 was considered significant.

**Results and Discussion:**

A total of 60 patients were collected and investigated as study sample after inclusion and exclusion criteria. The patients’ age was approximately normally distributed and ranged from 18 to 70 years with a mean of 44.45 ± 1.43 years old. The majority of study sample were male gender (55%). However, the site of shoulder injury was dominant at right site more than at left (56.7% vs. 43.3). (Table 1)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Description</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Mean ± SD</td>
<td>44.45 ± 1.43</td>
</tr>
<tr>
<td></td>
<td>Range (min-max)</td>
<td>52 (18-70)</td>
</tr>
<tr>
<td>Gender</td>
<td>Female</td>
<td>27 (45.0)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>33 (55.0)</td>
</tr>
<tr>
<td>Site of Injury</td>
<td>Right</td>
<td>34 (56.7)</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>26 (43.3)</td>
</tr>
</tbody>
</table>

Furthermore, the comparative imaging characteristics diagnosis of muscular shoulder injury of tendonitis was 30% vs. 33.3% by ultrasound and magnetic resonance imaging respectively. For tenosynovitis, partial tear and complete tear, the comparative imaging characteristics by U/S and MRI were (10% vs. 13.3%) (6.7% vs. 8.3%) and (13.3% vs. 15) respectively. (Figure 1)

Regarding Bony shoulder injuries, the comparative imaging characteristics for bone marrow lesion for U/S and MRI were (1.7% vs. 18.3%) respectively. For other injuries like Bursa, Effusion, and Labrum were (6.7% vs. 23.3%) (10% vs 18.3%), and (zero% vs. 11.7%) respectively. (Figure 2)
Figure 1 Baseline comparative imaging diagnosis of muscular shoulder injury by U/S and MRI (n=60)
Figure 2 Baseline distribution of imaging characteristics of bony shoulder injury by U/S and MRI (n=60)

Table 2 Comparative imaging diagnosis of muscular shoulder injury

<table>
<thead>
<tr>
<th>Validity of Ultrasonography (%)</th>
<th>Tendonitis</th>
<th>Tenosynovitis</th>
<th>Partial tear</th>
<th>Complete tear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (Sn)</td>
<td>70.0</td>
<td>75.0</td>
<td>60.0</td>
<td>88.9</td>
</tr>
<tr>
<td>Specificity (Sp)</td>
<td>90.0</td>
<td>100</td>
<td>98.2</td>
<td>100</td>
</tr>
<tr>
<td>Positive predictive value (PPV)</td>
<td>77.8</td>
<td>100</td>
<td>75.0</td>
<td>100</td>
</tr>
<tr>
<td>Negative predictive value (NPV)</td>
<td>85.7</td>
<td>96.3</td>
<td>96.4</td>
<td>98.1</td>
</tr>
<tr>
<td>Accuracy</td>
<td>83.3</td>
<td>96.7</td>
<td>95.0</td>
<td>98.3</td>
</tr>
<tr>
<td>Area Under the curve (AUC)</td>
<td>80.0</td>
<td>87.5</td>
<td>79.1</td>
<td>94.4</td>
</tr>
<tr>
<td>Kappa</td>
<td>0.615</td>
<td>0.839</td>
<td>0.640</td>
<td>0.932</td>
</tr>
<tr>
<td>Significancy (P-value)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Values are significant $p<0.05$
we compared the muscular shoulder tendonitis in MRI and US (Figure 3)

![ROC Curve of tendonitis shoulder injury diagnosed by U/S vs. MRI](image)

**Figure 3** ROC Curve of tendonitis shoulder injury diagnosed by U/S vs. MRI

we compared the muscular shoulder tenosynovitis (Figure 4)
Figure 4 ROC Curve of tenosynovitis shoulder injury diagnosed by U/S

we compared the muscular shoulder partial tear (Figure 5)
Figure 5 ROC Curve of partial tear shoulder injury diagnosed by U/S

the comparative diagnosis of complete tear (Figure 6)
...Ultrasound  ...MRI

(Figure 6) ROC Curve of complete tear shoulder injury diagnosed by U/S

(Figure 7) Comparative imaging of bone marrow lesion

Table 3 Comparative imaging diagnosis of muscular shoulder injury

<table>
<thead>
<tr>
<th>Validity of Ultrasonography (%)</th>
<th>of</th>
<th>Mascular shoulder Injury</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bone Lesion</td>
<td>Marrow</td>
</tr>
<tr>
<td>Sensitivity (Sn)</td>
<td></td>
<td>9.1</td>
<td>21.4</td>
</tr>
<tr>
<td>Specificity (Sp)</td>
<td></td>
<td>100</td>
<td>97.8</td>
</tr>
<tr>
<td>Positive value (PPV)</td>
<td></td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>Negative value (NPV)</td>
<td></td>
<td>83.1</td>
<td>80.4</td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td>83.3</td>
<td>80</td>
</tr>
<tr>
<td>Area Under the curve (AUC)</td>
<td></td>
<td>54.5</td>
<td>59.6</td>
</tr>
<tr>
<td>Kappa</td>
<td></td>
<td>0.140</td>
<td>0.256</td>
</tr>
<tr>
<td>Significancy (P-value)</td>
<td></td>
<td>0.033</td>
<td>0.011</td>
</tr>
</tbody>
</table>
Values are significant $p < 0.05$

...Ultrasound ...MRI

Figure 7 ROC Curve of bone marrow lesion of bony shoulder injury diagnosis by U/S

Comparative imaging diagnosis of bursa (Figure 8)
Figure 8 ROC Curve of bursa of bony shoulder injury diagnosed by U/S

Finally Comparative imaging diagnosis of effusion (Figure 9)
Figure 9 ROC Curve of effusion of bony shoulder injury diagnosed by U/S

In the figure(10) below is a picture of the magnetic resonance imaging and ultrasound examination of a patient suffering from partial tendon rupture.
Figure 10: Patient with partial tear and small amount of fluid seen at the distal part of the tendon, small subacromion bursa seen, hyperintensity seen at supraspinatus tendon (MRI+US).

In the figure 11(A, B) below, images of magnetic resonance imaging with contrast and ultrasound of a patient suffering from tendinitis (before the operation).
Figure 11( A)
Figuer 11(B):

Figuer A&B the patient has history of shoulder surgery

A note has been made about abnormal signal intensity lesion involve the humeral head and extended to deltoid muscle and surrounded by bone and soft tissue edema, the lesion measured about 32*27*15 mm the lesion shows enhancement after administration of I.V Contrast. (MRI+US)

The patient was followed up after the operation and the inflammation was removed, and the MRI and ultrasound were examined after the operation in figure 12
Conclusion in diagnostic: MRI is indicated when there is question of an abnormality related to the labrum, articular cartilage, bone marrow, or deep soft tissues. Ultrasound has advantages over MRI when imaging around hardware, for detecting foreign bodies, when there is need to perform a dynamic maneuver to elicit pathology, and for guiding procedures. Ultrasound is indicated also if the patient has a pacemaker, has a non-MRI-compatible metal implant, child and pregnancy. Overweight, or is claustrophobic. Ultrasound and MRI have shown similar diagnostic efficacies for evaluation of the rotator cuff. When clinical findings require rotator cuff evaluation, the choice between MRI and ultrasound is influenced by access to imaging, radiologist experience, referring physician preference, MRI contraindications, and patient choice. In physics Using high-wavelength
radio waves that reach deeper than ultrasound, and return the waves (echo) in the form of a more resolution, and clear image.

References