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ULTRASONOGRAPHY AND MR ARTHROGRAM IN DETECTION OF SHOULDER JOINT DISORDERS

By

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ABSTRACT

Background: Ultrasonography and Magnetic Resonance Imaging (MRI) are widely used to detect a lot of the shoulder joint pathologies as rotator cuff, labral, and capsular abnormalities.

Objective: to detect role of ultrasonography and MR Arthrogram in detection of shoulder joint disorders in comparison to conventional MRI.

Patients and methods: Thirty patients underwent ultrasound examination, conventional MR imaging of the shoulder and MR shoulder arthrography for clinically suspected labral or rotator cuff abnormalities. This study was done at the Radiodiagnosis Department, Al-Azhar University Hospitals during the period between October 2019 and October 2020.

Results: MR arthrography was found superior over conventional MRI in its sensitivity regarding specifically labral tears Whereas 0% of patients were found positive by conventional MRI, 10% of patients were detected by magnetic resonance arthrography (MRA), followed by bankert lesion being positive in 7% by conventional MRI, whereas 27% were proved positive by MRA, anterior labrum periosteal sleeve avulsion (ALPSA) was negative in 100% of patients who underwent conventional MRI, 3% positive result was detected by Magnetic Resonance Angiogram (MRA), and finally compared to 3% positive superior labral anterior posterior (SLAP) cases detected by conventional MRI, 7% positive cases were proved by MRA.

Conclusion: Ultrasound together with MR arthrography enhanced the accuracy of MR in the evaluation of the glenoid labrum and rotator cuff tendon.

Keywords: Ultrasonography and MR arthrogram, Shoulder joint disorders.

INTRODUCTION

Glenohumeral joint instability is very common. With regard to primary anterior shoulder dislocations, the incidence is between 8.2 and 23.9 per 100 000 person-years, with an estimated prevalence of 1.7%. Whereas these estimates seem high, they actually underestimate the true nature of instability, as they do not include subluxation events or instability in other directions *(Jones et al., 2012)*.

Superior labrum from anterior to posterior tear (SLAP) injury is one of the common causes of glenohumeral instability. Shoulder impingement is a frequent and very painful condition among athletes, particularly those involved in overhead sports such as baseball and swimming it accounts for 44 to 65% of shoulder complaints during physician visits *(Page, 2016)*.

Shoulder impingement has been classified into two main categories: structural and functional. Subacromial impingement can be caused by narrowing of the subacromial space (SAS) resulting from a reduction in the space due to bony growth or soft-tissue inflammation (―structural) or superior migration of the humeral head caused by weakness and/or muscle imbalance (―functional). It is possible that some subacromial impingement results from a combination of both structural and functional factors *(Cools, 2014)*.

Many imaging methods, including ultrasonography, arthrography, CT arthrography, MR arthrography, have been used to image the glenoid labrum and the associated structures of the capsular mechanism *(Oh et al., 2020)*.

Ultrasonography of the shoulder joint is simple, cheap, fast and non-invasive imaging technology for detection of rotator cuff and non-rotator cuff pathologies. MR arthrography allows extensive noninvasive evaluation of the soft tissue details as rotator cuff pathologies including the size of the tear, amount of muscle atrophy and size of the tear that helps in surgical planning *(Farmer and Hughes, 2012)*.

Fluoroscopic control of needle placement during the intra-articular injection of contrast media into the glenohumeral joint is the standard technique. However, injection for MR arthrography can be palpation-directed, ultrasonography-guided or computerized tomography (CT)-guided. Deployment of ionizing radiation is a disadvantage of fluoroscopic and CT- guided shoulder arthrography. As for injection by direct manual palpation, this technique requires experience in musculoskeletal radiologic procedures and is unreliable. In recent years, the US- guided shoulder arthrography technique has been used as an alternative real-time imaging modality *(Ogul et al., 2017)*.

Different approaches to enter the shoulder joint have been known. Although the anterior approach is the most commonly used, the posterior approach has become the preferred technique *(Waldt et al., 2017)*.

MR arthrography is a useful and accurate technique in the diagnosis of SLAP lesions of the shoulder as it is a sensitive modality but it cannot used in patients with claustrophobia *(Jenny et al., 2010)*.

Direct MR arthrography of the glenohumeral joint is a very excellent method to image the shoulder when used in conjunction with ultrasonography. Because of its benefits, which include capsular distention, separation of intra-articular structures and excellent contrast resolution, this technique has higher sensitivity and specificity than routine MR imaging for the detection of abnormalities in the shoulder joint *(Lee et al., 2018)*.

The aim of this study was to detect different shoulder joint pathologies using ultrasonography and MR arthrogram in comparison to conventional MRI.

PATIENTS AND METHODS

Thirty patients underwent ultrasound examination, conventional MR imaging of the shoulder and MR shoulder arthrography for clinically suspected labral or rotator cuff abnormalities. This study was done at the Radiodiagnosis Department, Al-Azhar University Hospitals during the period between October 2019 and October 2020.

Institutional review board approval was obtained before the start of the study.

Inclusion criteria:

- The study was including Patients of any age with clinically evident or suspected shoulder impingement or glenohumeral instability.
- Both sexes were included.

Exclusion criteria:

- Patients with known or diagnosed fracture/dislocation involving the shoulder on plain radiography.
- Patients who had undergone shoulder surgery for any reason.
- Patients with contraindications to arthrography e.g. septic arthritis of the shoulder joint.
- Claustrophobic patients.

All patients were subjected to the following:

- Full history taking and clinical examination.
- Evaluation of previously done radiological studies eg, X-ray, ultrasound, CT or arthroscopic findings.
- Detailed explanation of the imaging procedure.

All patients were conducted to:

- A preliminary ultrasound examination.
- Conventional MRI examination.
- MR Arthrography examination.
- The findings of MR arthrography with be compared to the conventional MRI findings.

Ultrasound examination:

- The image resolution improved as the frequency of the transducer increases, but this was at the expense of depth penetration.
- In general, an ultrasound probe was of at least 10 MHz sufficed.
- For an average-sized patient, a transducer of 12–15 MHz produced detailed images with high resolution, while uncommonly a 9-MHz transducer was required for extremely large patients to allow depth penetration, but this at the expense of lower resolution.
- The transducer was linear (with a flat rather than curved surface) so that the sound beam propagates through the soft tissues in a similar linear fashion.
- The sound beam was directed perpendicular to the tendon fibers and minimized anisotropy, which caused the tendon to appear artifactually hypoechoic.
- The true US characteristics of a normal tendon were only seen when the tendon was imaged perpendicular to the sound beam.
- If the bone cortex under a tendon was clearly defined and hyperechoic, that indicated that the sound beam was perpendicular to the cortex, and also, therefore, perpendicular to the overlying tendon, minimizing anisotropy.

Magnetic Resonance Imaging:

Device: GYROSCAN INTERA 1.5T MAGNET (PHILPS) or SYMPONY 1.5T MAGNET (SIEMENS).

Patient Position: The patient was supine with the head directed towards the scanner bore. The preferred positioning of the leg was neutral with slight internal rotation.

Pre contrast MR Sequences:

- **Imaging planes and pulse sequences:**

  - Preliminary scout localizer in axial, sagittal, coronal.
  - Axial PD FAT SAT FOV 14, matrix 512x256, Nex 2, slice thickness 4 mm intersection gap 0.5 mm, TR 2000-3000 TE 20-40.
  - Coronal oblique STIR FOV 16, matrix 256x192, Nex 2, slice thickness 4 mm intersection gap 0.5 mm, TR 400-800 TE 20-40 TI 150.
  - Coronal oblique T2 FOV 16, matrix 256x192, Nex 1, slice thickness 4 mm intersection gap 1 mm, TR >2000 TE 90-110.
  - Sagittal oblique T2 FOV 14, matrix 256x192, Nex 1, slice thickness 4 mm intersection gap 1 mm, TR >2000 TE 90-110.

MR Arthrography: Direct MR arthrography using CT guidance.

CT guided: Using GE 4 DETECTORS MULTI-SLICE CT.

- **Technique:**

  - The area was prepared and draped in a sterile fashion.
  - The subcutaneous tissue was anesthetized with about 5 mm of lidocaine.
  - CT guided intraarticular placement of 18-20 gauge needle.
  - Gadolinium-based solution is prepared, comprised 0.8 Ml of dimeglumine gadopentetate (Magnevist; Schering, Berlin, Germany; 469 mg/mL) and 100 mL of saline.
  - Immediately after the intra-articular needle placement was confirmed by CT, gentle aspiration was performed to avoid gas bubbles. Between 12 and 18 mL of the gadolinium-based solution was delivered until the joint capsule was appro¬priately distended. The volume of injection was determined according to patient comfort and resistance to the injection.
  - After the injection procedure was completed, a dressing was placed on the skin over the entrance site of the needle.
  - The patients remained seated for several minutes after the procedure and were instructed to move the injected shoulder slowly to allow the contrast material to spread inside the capsule.
  - The patient was scanned with MRI during max. 30 minutes of injection.

Post intra-articular contrast injection MR sequences:

- Imaging planes and pulse sequences.
- Preliminary scout localizer in axial, sagittal, coronal.

- Axial T1 FAT SAT FOV 14, matrix 256x192, Nex 2, slice thickness 3mm intersection gap 0.5 mm, TR 400-800 TE 16.
- Coronal oblique T1 FAT SAT FOV 14, matrix 256x192, Nex 2, slice thickness 3mm intersection gap 0.5 mm, TR 400- 800 TE 16.
- Sagittal oblique T1 FOV 14, matrix 256x192, Nex 1, slice thickness 4 mm intersection gap 1 mm, TR 400-800 TE 16.

Statistical Analysis:

The collected data were revised, coded, tabulated and introduced to a PC using Statistical package for the Social Sciences (SPSS 22). Data were presented. As Mean, Standard deviation (± SD) for numerical data. and Frequency and percentage of categorical data.

Sensitivity, Specificity, PPV, NPV and Accuracy were calculated $p > 0.05$ was considered significant.

RESULTS

A total of 30 patients were included in the study, 23 male patients (77%) and 7 female patients (33%), the mean patient age was 32.5+ 10.5 years, range (15- 61 years).

Four patients (13%) were found positive for joint effusion by both conventional MRI and MR Arthrography **(Figure 1)**.

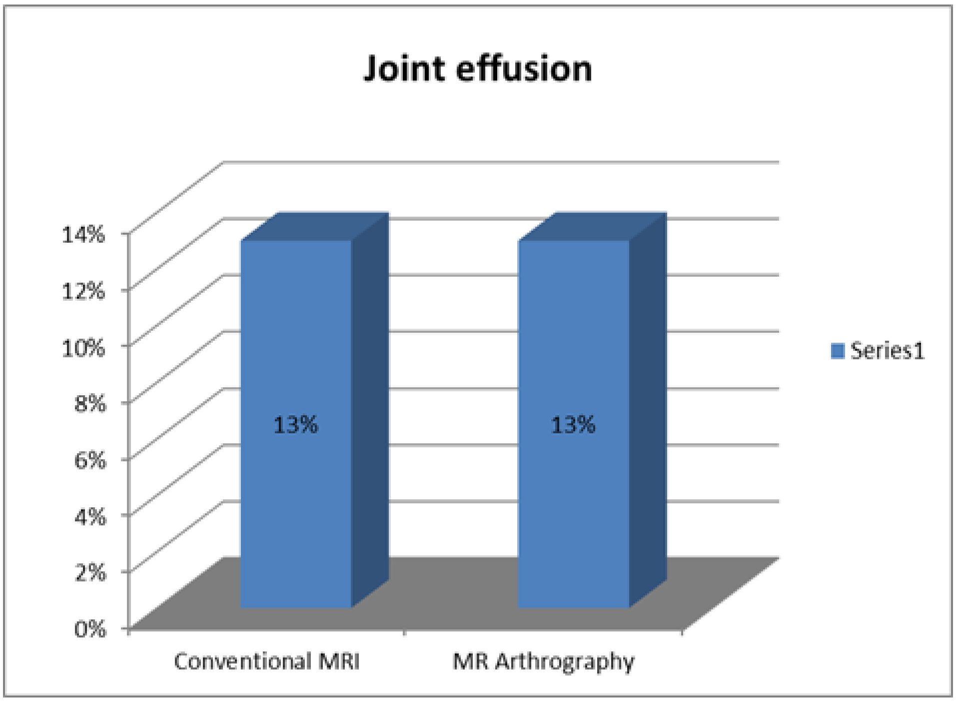

Figure (1): Comparison between conventional MRI and MRI arthrography regarding detection of Joint effusion

One patient (3%) was positive for SLAP by conventional MRI, while 2 patients (7%) were positive by MRA **(Figure 2)**.

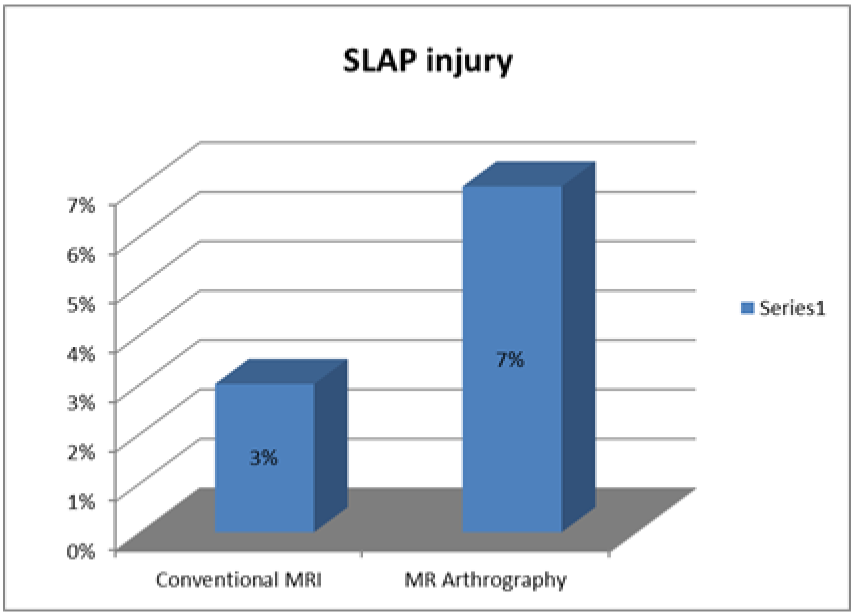

Figure (2): Comparison between conventional MRI and MR arthrography regarding detection of SLAP lesion

Two patients (7%) were found positive for Bankert lesion by conventional MRI, whereas 8 patients (27%) were found positive by MRA **(Figure 3)**.

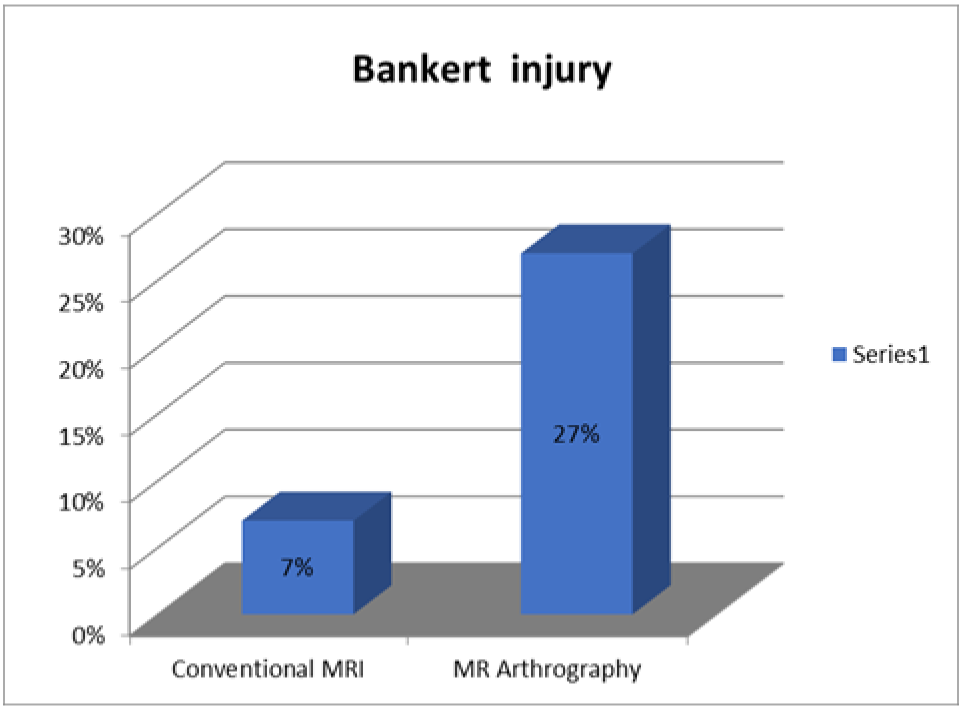

Figure (3): Comparison between conventional MRI and MR arthrography in detection of Bankert injury

No patients (0%) were determinant for ALPSA by conventional MRI, one patient (3%) was confirmed positive for ALPSA by MRA **(Figure 4)**.

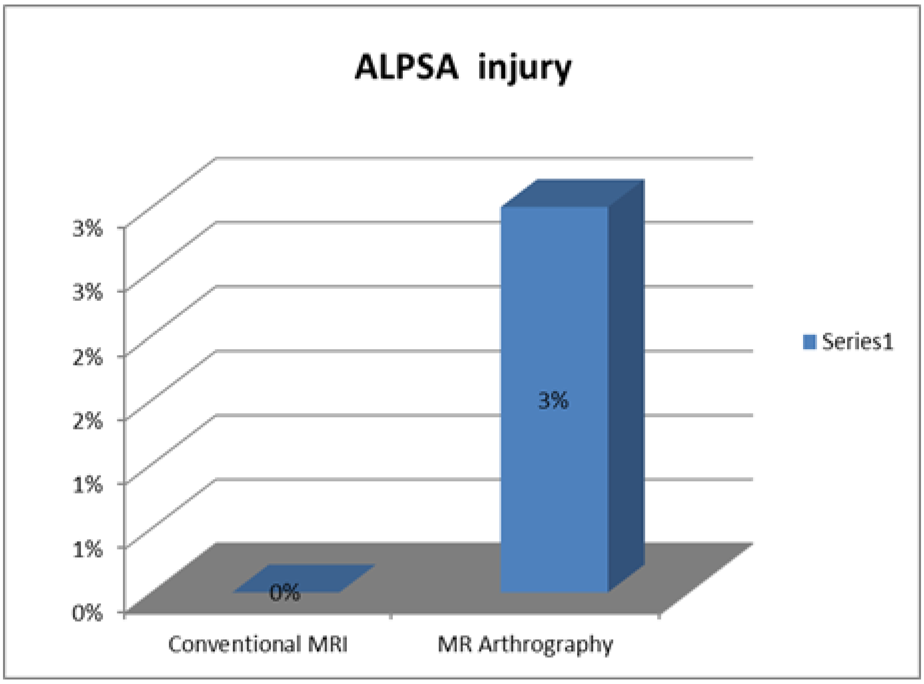

Figure (4): Comparison between conventional MRI and MRI arthrography in detection of ALPSA injury

No patients (0%) were confirmed positive for SLAP by conventional MRI, 2 patients (7%) had suspected signs for SLAP and were referred for MRA, and 28 patients 92% were negative **(Figure 5)**.

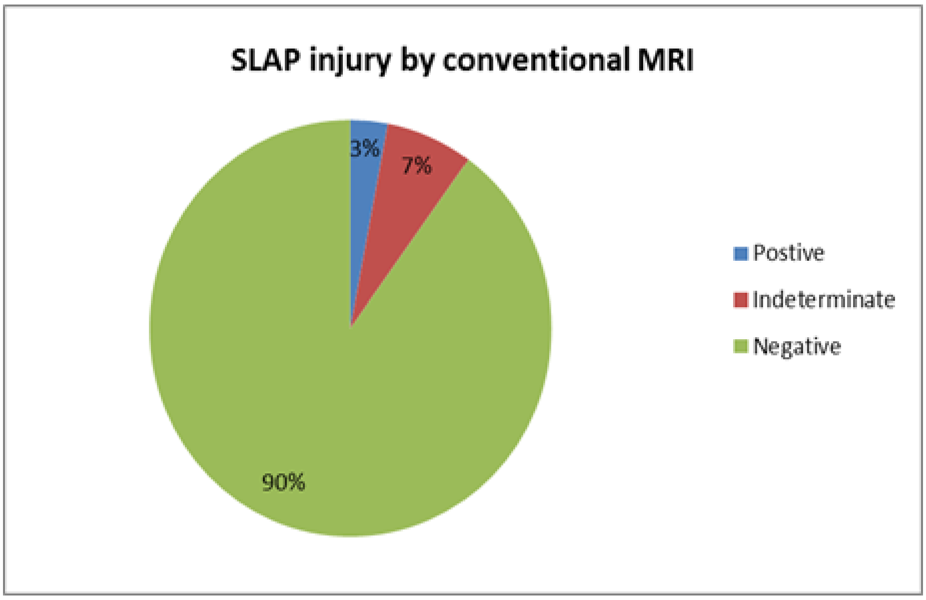

Figure (5): Percentage of SLAP injury by conventional MRI.

Two patients (7%) were found positive for bankert lesion by conventional MRI, 10 patients (33%) were in determinant (had suspicious signs), and 18 patients (60%) were negative **(Figure 6)**.

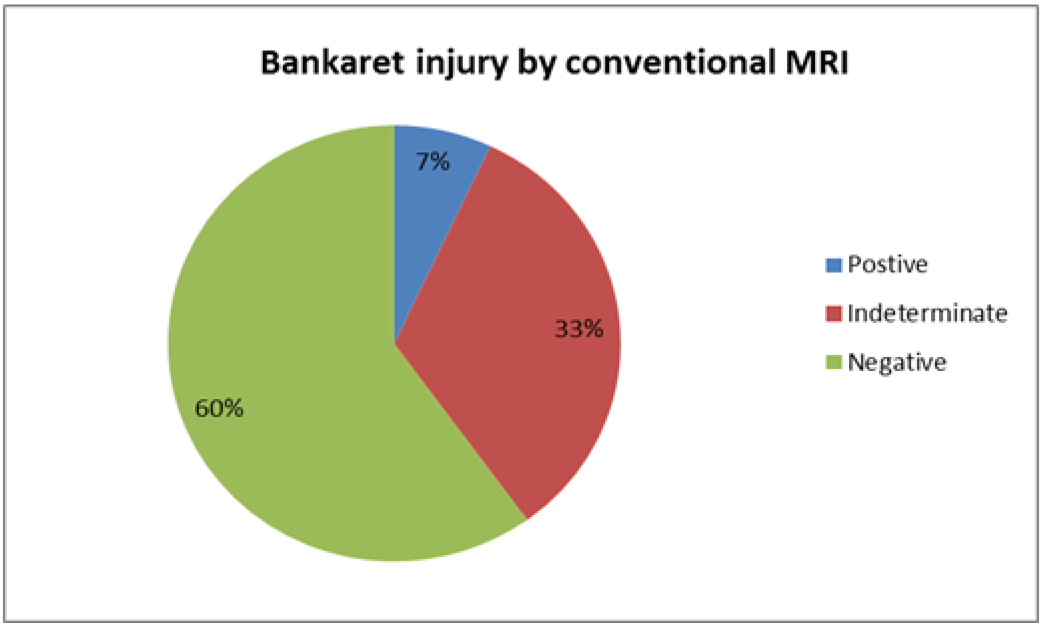

Figure (6): Percentage of Bankert injury by conventional MRI.

Two patients (7%) were found positive for bankert lesion by conventional MRI, 10 patients (33%) were indeterminant (had suspicious signs) and 18 patients (60%) were negative **(Figure 7)**.

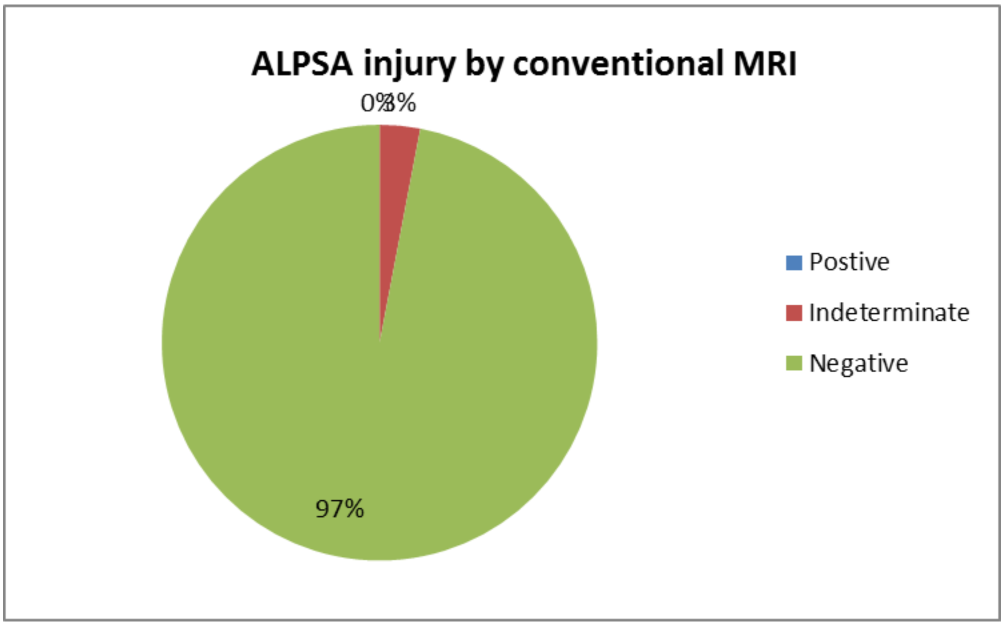

Figure (7): Percentage of ALPSA injury by conventional MRI.

Four patients (13%) were positive for tendon tear by conventional MRI, 1 patient (3%) was indeterminant (had suspicious signs), and 25 patients (84%) were negative **(Figure 8)**.

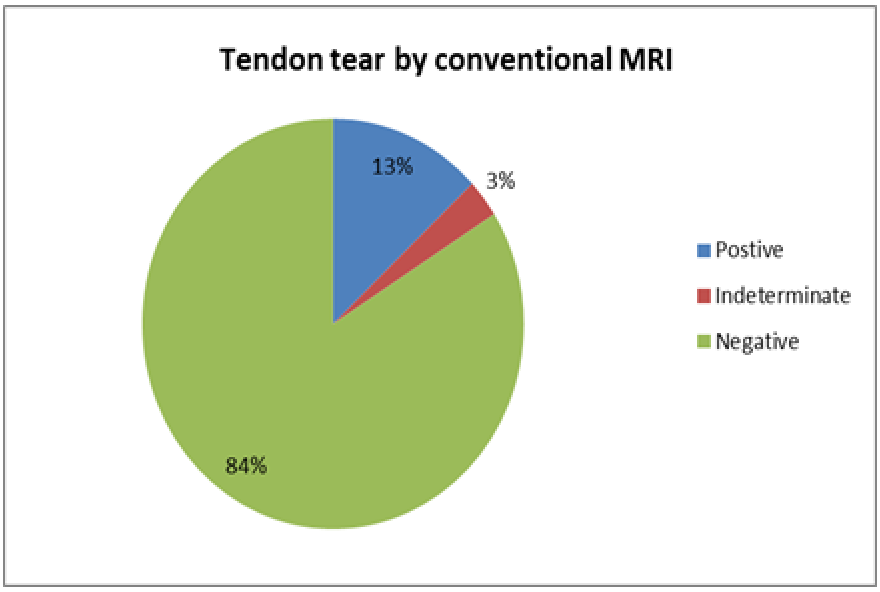

Figure (8): Percentage of tendon tear by conventional MRI.

No patients (0%) confirmed positive for labral tear by conventional MRI, 2 patients (7%) were indeterminant (had suspicious signs), and 28 patients (93%) were negative **(Figure 9)**.

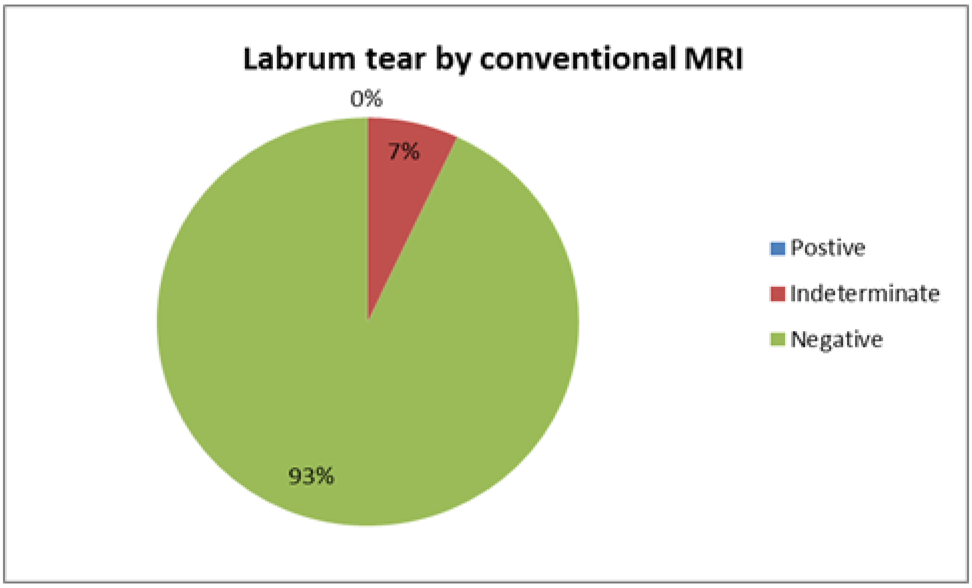

Figure (9): Percentage of Labrum tear by conventional MRI.

Statistically non-significant correlation between conventional MRI and MRA in diagnosis of SLAP, ALPSA, Hill sachs, bursitis, tendon tear, tendenopathy, cysts and joint effusion with P values: 0.28, 0.162, 0.5, 0.5, 0.5, 0.5, 0.5 and 0.5 respectively. However, statistically significant correlation between conventional MRI and MRA in diagnosis of Bankert lesion with P value 0.028 and labral tears with P value 0.021 **(Table 1)**.

Table (1): Table of significance correlation between conventional MRI and MRA in diagnosis of Bankert lesion

Variables	P-value
SLAP	0.28
Bankert	0.028
ALPSA	0.162
Hill sachs	0.5
Bursitis	0.5
Tendon tear	0.5
Labrum tear	0.021
Tendenopathy	0.5
Cysts	0.5
Joint effusion	0.5

The sensitivity of conventional MRI compared to MRI arthrogram in diagnosis of bankert lesion was 50%. The specificity of conventional MRI compared to MRI arthrogram was 91.67% **(Table 2)**.

Table (2): Sensetivity, specificity, positive predictive value, negative predictive value and accuracy of conventional MRI compared to MR arthrography in diagnosis of banker lesion

Sensitivity	Specificity	PPV	NPV	Accuracy
50%	91.67%	80%	73.3%	75%

The sensitivity of conventional MRI compared to MRI arthrogram in diagnosis of bankert lesion was 50%. The specificity of conventional MRI compared to MRI arthrogram was 100% **(Table 3)**.

Table (3): Sensetivity, specificity, positive predictive value, negative predictive value and accuracy of conventional MRI compared to MR arthrography in diagnosis of labral tear

Sensitivity	Specificity	PPV	NPV	Accuracy
50%	100%	100%	90%	90.91%

DISCUSSION

The results showed sensitivity of conventional MRI and that of MR arthrography were almost equal regarding joint effusion, tendon tears and hill sachs in 13% of patients, bursitis in 27% of patients, tendinopathy in 23% of patients and cysts in 7% of patients. However, MR arthrography was found superior over conventional MRI in its sensitivity regarding specifically labral tears, whereas 0% of patients were found positive by conventional MRI, 10% of patients were detected by MRA followed by bankert lesion being positive in 7% by conventional MRI, whereas 27% were proved positive by MRA, ALPSA was negative in 100% of patients who underwent conventional MRI, while 3% positive result was detected by MRA, and finally compared to 3% positive SLAP cases detected by conventional MRI, 7% positive cases were proved by MRA.

Our results agreed with *Ferrari et al. (2014)* where twenty-three patients underwent both conventional MRI and MRI shoulder Arthrography for clinically suspected labral or rotator cuff abnormalities. Results were correlated with surgical findings in all patients, nine patients had surgically proved labral tears, all nine of the labral abnormalities detected at surgery were diagnosed with MR arthrography. Six of these tears were missed with conventional MR imaging. In these patients there was not enough native joint fluid to allow definition of the cartilage morphology. Loose joint bodies in two patients and a partial biceps tendon tear in another were detected with MR arthrography and not detected with conventional MR imaging.

Fourteen patients had surgically proved rotator cuff tears. Eleven of these tears were detected with MR arthrography; nine of these tears were complete. No complete tears were missed; however, three partial tears of the bursal surface of the rotator cuff were missed because contrast material did not leak into the tear. Nine of the 14 cuff tears were diagnosed with conventional MR imaging. Seven complete tears were diagnosed, and two were missed because no native joint fluid filled the tear and subacromial bursa. Three partial cuff tears that involved the undersurface of the rotator cuff were missed because no native joint fluid filled the tear.

To sum up, nine of 23 patients in their series had labral tears, which were accurately diagnosed with MR arthrography in all patients, whereas six of nine tears were missed with MR imaging. When evaluating their efficacy in detecting the presence of a tear, results showed that MR imaging and MR arthrography, had sensitivities of 93% and 96%, respectively. Of the nine rotator cuff tears diagnosed with conventional MR, all were believed to be delineated better with MR arthrography, which allowed assessment of the tendon ends and the actual size of the tear. suggested that MR arthrography might be a useful technique for accurately depicting labral lesions.

However, in our study, we lacked surgical or arthroscopic correlation of our data. *Ogul et al. (2017)* considered MRI arthrography as the 100% sensitive Standard for evaluating conventional MRI sensitivity as 50% regarding labral and bankert lesions, moreover, They contained exclusively labral and rotaor cuff abnormalities for evaluation, however including other disorders in our study as joint effusion, tendinopathies and cysts produced satistically nonsignificant correlation between conventional MRI and MRA. Finally discrepancy in our results regarding rotator cuff tears is attributed to the small number of patients with tendon tears included in our study where only four patients (13%) found to be positive by both conventional MRI and MRA.

We also agreed with *Waldt et al. (2017)* who stated MR arthrography is accurate in enabling classification of acute and chronic antero inferior labroligamentous injuries. In his study, Retrospective evaluation of the accuracy of magnetic resonance (MR) arthrography in the classification of anteroinferior labroligamentous injuries by using arthroscopy as the reference standard showed that at arthroscopy, 104 anteroinferior labroligamentous lesions were diagnosed, 44 Bankart lesions, 22 ALPSA lesions, 12 Perthes lesions, and three GLAD lesions.

Twenty-three labral lesions were nonclassifiable at arthroscopy, all of which occurred after a history of chronic instability, and 83% were also nonclassifiable at MR arthrography. With arthroscopy used as the reference standard, labroligamentous lesions were detected and correctly classified at MR arthrography with sensitivities of 88% and 77%, specificities of 91% and 91%, and accuracies of 89% and 84%, respectively. Bankart, ALPSA, and Perthes lesions were correctly classified in 80%, 77%, and 50% of cases, respectively. The three GLAD lesions were all correctly assessed.

Still the difference in our study was the lack of an arthroscopy as the gold standard and the wide scale of patients included by *Waldt et al. (2017)*.

On the other side, our study did not support the results *Rao et al. (2013)* who found that 27% of their patients with normal shoulders had intralabral signal that extended through the labrum Another potential pitfall concerns the close apposition of the glenohumeral ligaments to the anterior part of the labrum. The labrum may vary in size or have a rounded or blunted shape, as others have described, and given the absence of joint distension, the glenohumeral ligaments may be mistaken for a tear, this is because our study did not include cases that were proven false positive by MRA after conventional MRI.

The limitation of this study include the disadvantages of MR arthrography including the necessity for fluoroscopy, which may not be available at some MR facilities; the longer examination time, and the conversion of the examination from a noninvasive to an invasive examination, which patients may find less tolerable.

The lack of A pathologic proof as a gold standard like surgical data or arthroscopic findings for assessment of the statistical significance of radiologic results did not allow the accurate estimation of the sensitivity and specificity of MR arthrogram as a radiologic diagnostic tool. However, superior to conventional MRI with the results showing conventional MRI as 50% sensitive 91% specific and 75% accurate in diagnosis of labral tears, 50% sensitive 100% specific and 90% accurate in diagnosis of bankert lesions taking MRA arthrography as the 100% standard.

CONCLUSION

Ultrasound together with MR arthrography enhances the accuracy of MR in the evaluation of the glenoid labrum and rotator cuff tendon.

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التصوير بالموجات فوق الصوتية والتصوير المفصلي بالصبغة بواسطة الرنين المغناطيسى للكشف عن إضطرابات مفصل الكتف

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خلفية البحث: يستخدم التصوير بالموجات فوق الصوتية والتصوير بالرنين المغناطيسي على نطاق واسع للكشف عن الكثير من أمراض مفصل الكتف، مثل تشوهات الكفة المدورة، والشفا، والكبسولة.

الهدف من البحث: بحث دور الموجات فوق الصوتية وتصوير المفاصل بالرنين المغناطيسي في الكشف عن إضطرابات مفصل الكتف بالمقارنة مع التصوير بالرنين المغناطيسي التقليدي.

المرضى وطرق البحث: خضع ثلاثون مريضا لفحص الموجات فوق الصوتية والتصوير التقليدي بالرنين المغناطيسي للكتف وتصوير مفصل الكتف بالرنين المغناطيسي للاشتباه سريريا في تشوهات الكفة الشفاوية أو الكفة المدورة وقد أجريت هذه الدراسة في قسم التشخيص الإشعاعي بمستشفيات جامعة الأزهر في الفترة ما بين أكتوبر 2019 وأكتوبر 2020.

نتائج البحث: كان التصوير بالرنين المغناطيسي متفوقًا على التصوير بالرنين المغناطيسي التقليدي في حساسيته فيما يتعلق بتمزق الشفا على وجه التحديد، بينما وجد 0٪ من المرضى إيجابيين بواسطة التصوير بالرنين المغناطيسي التقليدي، وتم اكتشاف 10٪ من المرضى بواسطة التصوير بالرنين المغناطيسي، تليها آفة البنك التي كانت إيجابية في 7٪ عن طريق التصوير بالرنين المغناطيسي التقليدي ، حيث ثبت أن 27٪ كانت إيجابية عن طريق تصوير المفاصل بالرنين المغناطيسي، وكان قلع الكم السمحاقي الأمامي سالبًا في 100٪ من المرضى

الـــذين خضـــعوا للتصـــوير بـــالرنين المغناطيســـي التقليـــدي، بينمـــا تـــم الكشـــف عـــن 3٪ نتيجـــة إيجابيـــة عـــن طريـــق تصـــوير المفاصـــل بـــالرنين المغناطيســـي، وأخيـــرًا تمـــت مقارنتهـــا إلـــى 3 ٪ مـــن الحـــالات الإيجابيـــة للشـــفاه الأمـــامي الخلفـــي التـــي تـــم الكشـــف عنهـــا بواســـطة التصـــوير بـــالرنين المغناطيســـي التقليـــدي، تـــم إثبـــات 7 ٪ مـــن الحـــالات الإيجابية عن طريق تصوير المفاصل بالرنين المغناطيسي.

الاســـتنتاج: أن الموجـــات فـــوق الصـــوتية جنبًـــا إلـــى جنـــب مـــع تصـــوير المفاصـــل بـــالرنين المغناطيســـي يعـــززان مـــن دقـــة الـــرنين المغناطيســـي فـــي تقيـــيم الـــوتر الحقـــاني والكفـــة المدورة.

الكلمـــات الدالـــة: التصـــوير بالموجـــات فـــوق الصـــوتية والتصـــوير المفصـــلي بالصـــبغة، إضطرابات مفصل الكتف.