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Original Article

# Direct shoulder MR arthrography using low field scanner for assessment of labral tears to assess scan reliability in claustrophobic patients



Heba Ibrahim Ali <sup>a,\*</sup>, Hossam Abdelkader <sup>b</sup>

<sup>a</sup> Ain Shams University, Radiology Department, Ramsis Street, Cairo, Egypt

<sup>b</sup> Shaik Zayed Hospital, Orthopedic Department, Egypt

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## ABSTRACT

**Purpose:** Shoulder instability is a common condition that primarily affects young active people. MR arthrography (MRA) has enhanced the capability of conventional MRI in assessing intra articular structures. Claustrophobic patients cannot tolerate scanning by closed magnet machines, so the aim of our study was to assess the labral tears by direct MR arthrography of the shoulder in claustrophobic patients using low field 0.32T machine and to evaluate the reliability of this scanning protocol compared to operative findings.

**Materials and methods:** 40 claustrophobic patients with clinically diagnosed labral tear are included in our study. All are scanned by low field 0.32 Tesla machine. Images are interpreted for changes in the shoulder alignment, labral signal intensity and integrity, glenohumeral ligaments integrity, intraarticular loose bodies and bone marrow signal changes.

**Results:** By MRA, all patients had labral tear, 24 had anterior labral tear, 12 had inferior labral tear and 4 had superior labral tear. MRA of the shoulder using open scanner showed sensitivity of 95.45% and specificity 99.1% for diagnosing tears of the glenoid labrum when correlated with the arthroscopic findings.

**Conclusion:** MRA of the shoulder using low field scanner proved high sensitivity and specificity in detecting labral tears in claustrophobic patients.

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## 1. Introduction

Shoulder instability is a common condition that primarily affects young active people, especially athletes [1]. The labral capsular ligamentous complex is an important component of shoulder stability [2,3].

To correctly diagnose and properly treat shoulder instability, many methods have been used such as routine radiography, conventional arthrography, CT arthrography, and MR imaging [4–7].

On conventional MR images, assessment of the labrum is complicated by pseudo tears caused by hyaline cartilage, which undercuts the labrum and may simulate fluid in a tear, and by the glenohumeral ligaments, which are closely opposed to the labrum and may simulate detached labral fragments [8].

MR arthrography is also an important imaging technique for assessing the labral capsular ligamentous complex of the shoulder joint [9–11].

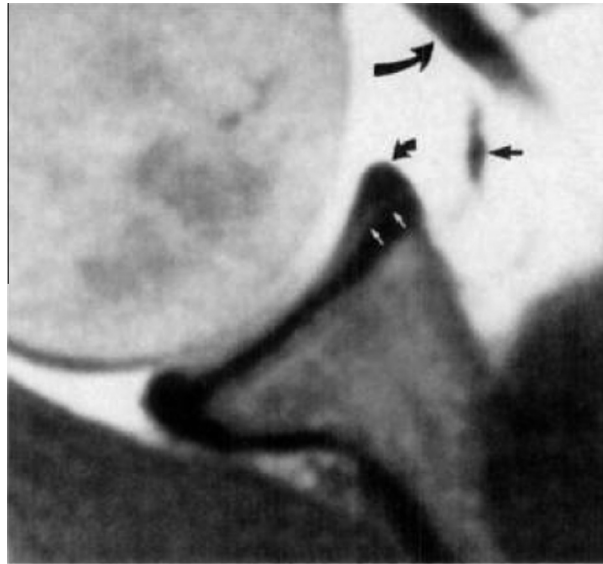
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\* Corresponding author at: 38 Omar Zaafan Street, Nasr City, Cairo, Egypt. Fax: +20 97143442028.

E-mail addresses: [Hebaali\\_m@hotmail.com](mailto:Hebaali_m@hotmail.com) (H.I. Ali), [hossam\\_abdelkader@hotmail.com](mailto:hossam_abdelkader@hotmail.com) (H. Abdelkader).

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**Fig. 1.** Normal sublabral hyaline cartilage after intra articular injection of gadopentetate dimeglumine, T1-weighted (450/18) axial MR arthrogram shows normal sublabral hyaline cartilage (white arrows). Hyaline cartilage is lower in signal intensity than contrast solution is and therefore is not mistaken for labral pseudo tear. Middle glenohumeral ligament (straight black arrow) is separated from anterior labrum (small curved arrow) as it courses toward subscapularis tendon (large curved arrow) [12].

In MR arthrography, these pseudo tears are not a source of diagnostic difficulty because hyaline cartilage is lower in signal intensity than the contrast solution (Fig. 1), and because the glenohumeral ligaments are separated from the glenoid rim by the distended joint capsule [12].

MR arthrography (MRA) has enhanced the capability of conventional MRI in assessing articular pathology of the shoulder, as the contrast facilitates distension of the joint capsule and assessment of the intra-articular structures [13].

Intraarticular structures are better demonstrated if they are separated by means of capsular distention. Such separation can be achieved with intraarticular injection of contrast material (diluted gadopentetate dimeglumine) or saline or with preexisting joint fluid (joint effusion). The goal is to produce high contrast between the labrum, capsule, capsular recesses, glenohumeral ligaments (GHLs), and articular surface of the rotator cuff [11].

This study attempts to analyze the role of MRA of the shoulder using low tesla open scanner magnet for detecting glenoid labrum pathology in claustrophobic patients who have subsequently undergone arthroscopic shoulder surgery.

## 2. Methods

### 2.1. Study population

Forty claustrophobic patients were enrolled into the study. Twenty-eight patients had shoulder instability, thirty patients had pain, fourteen had shoulder trauma, and twelve cases reported history of repeated shoulder dislocation. The selection of the patients was based on their clinical data as the orthopedic surgeon suspected labral

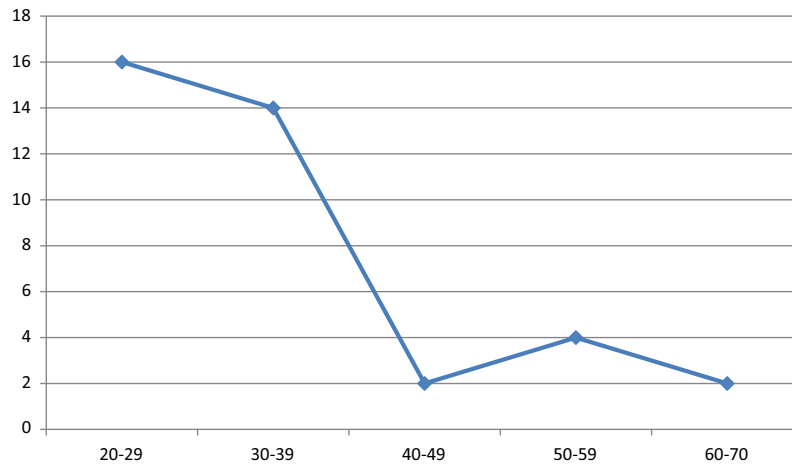
tear, all reported claustrophobia in previous circumstances or they were unable to do the study on the other closed machine in our facility, conventional MR imaging was performed in four patients prior to MRA. The exclusion criteria included patients with other pathologies that cause shoulder symptoms such as cervical disk lesions or postoperative patients, and in general patients in whom MRI is contraindicated or pregnant ladies with prohibited X-ray exposure during fluoroscopic guided contrast injection. The study was approved by the local ethical committee of the institution.

### 2.2. Technique and imaging

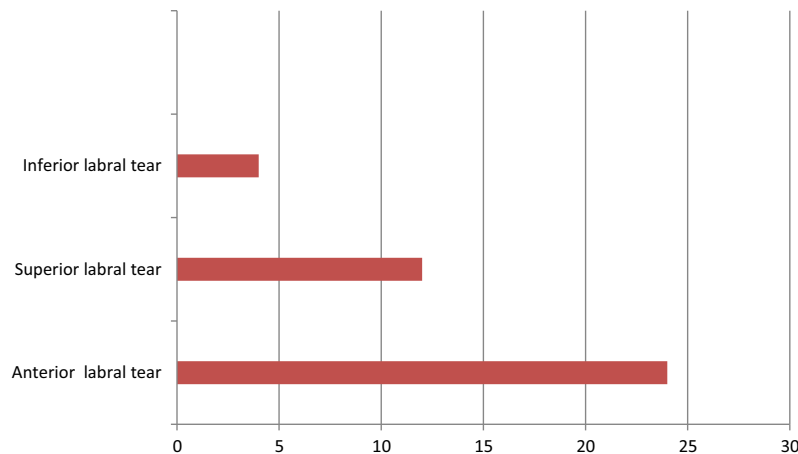
MR arthrography was performed through anterior approach under fluoroscopic guidance, supine positioning of the patient, marking the skin just medial to the humeral head cortex, inserting the needle under fluoroscopic guidance, intraarticular positioning of the needle was confirmed with a small amount of iodinated contrast material (Ultravist 370; Schering, Berlin, Germany). Subsequently, 15–20 mL of a mixed solution was injected, which was composed of 25 mL of saline, 0.1 mmol of gadolinium diethylene triamine pentaacetic acid (Magnevist; Schering), and 0.3 mL of epinephrine (1:1000).

Proper patient and needle positioning as well as accurate confirmation of intra-articular needle placement are critical to a successful and atraumatic shoulder arthrographic examination. Documentation of intraarticular contrast injection was done by plain X-ray acquisition.

A 0.35 T open MR scanner, Magnetom C, Germany, was used utilizing a dedicated shoulder coil. Patients were scanned in the supine position with the arm in a neutral position. The following acquisitions were obtained:



**Chart 1.** Age distribution among the study population.



**Chart 2.** Prevalence of localization of the labral tear among the study population.

T1-weighted spin-echo in axial, sagittal and coronal planes, PD coronal plane and axial images and short tau inversion recovery (STIR), were obtained. The thickness and interval of the slices were 4.0 mm and 0.4 mm, respectively. Patients tolerated the study; no additional pain medication was given. The study time was approximately 40 min. No complications depicted.

### 2.3. Image interpretation

The images were interpreted by two experienced radiologist for changes in the shoulder alignment, labral signal intensity and integrity, glenohumeral ligament integrity, intraarticular loose bodies and bone marrow signal changes.

### 2.4. Statistical analysis

Each radiologist reported the presence or absence of labral tear, its location being anterior, superior or inferior

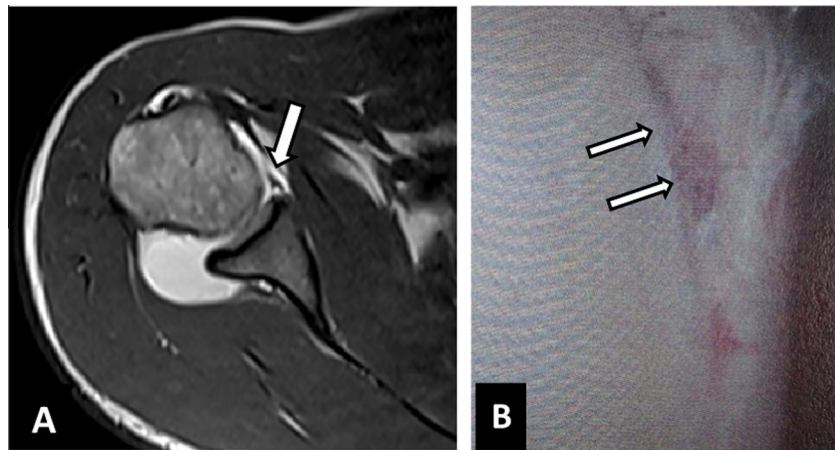
and type of tear in terms of complete thickness or partial thickness labral tear with any associated intraarticular loose bodies. They reported the shoulder subluxation or dislocation if present. The glenohumeral ligaments were analyzed and tear reported in superior, middle or inferior GHL. Finally, any associated findings were reported such as bone marrow edema or rotator cuff tear.

## 3. Results

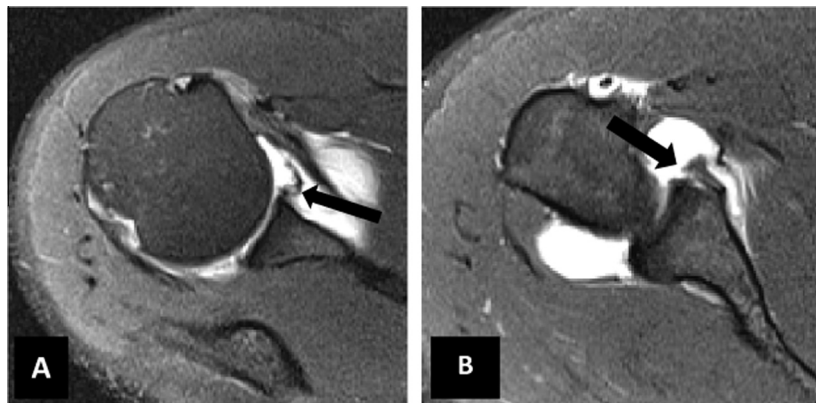
A total of 40 claustrophobic patients with clinically diagnosed labral tear were enrolled in the study, including 28 (70%) males and 12 (30%) females, aged 24–63, with a mean age of 43.5 [Chart 1](#).

By MRA, all patients had labral tear, 24 patients (60%) had anterior labral tear, 12 patients (30%) had inferior labral tear and 4 patients (10%) had superior labral tear [Chart 2](#).

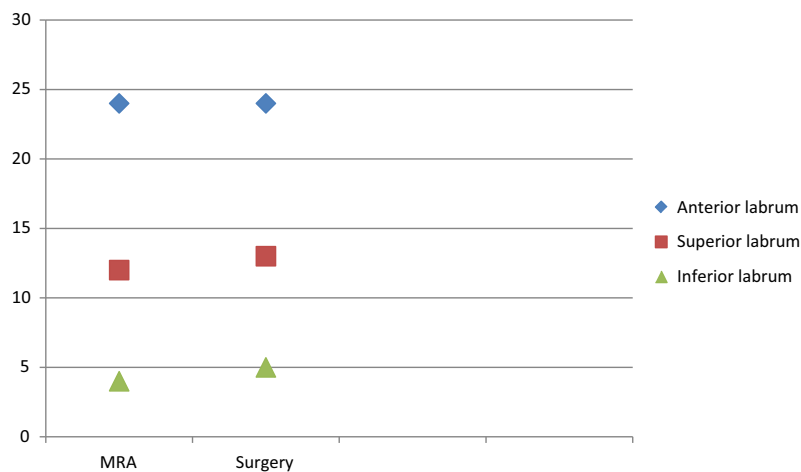
From 24 patients diagnosed with anterior labral tear, 18 patients (75%) were diagnosed as cartilaginous Bankart



**Fig. 2.** 26 year old male with anterior labral tear, axial T1 image after intraarticular contrast injection showing linear defect of the anterior labrum with detached labral fragment (arrow) (A). The corresponding intraoperative image (B) showing the anterior labral tear (arrows).



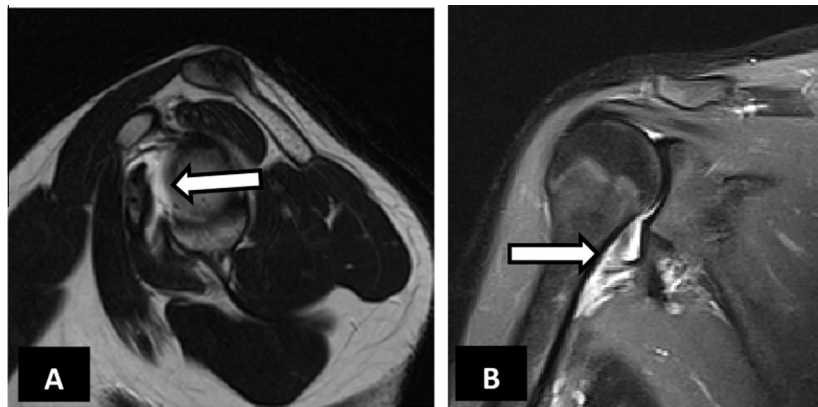
**Fig. 3.** 37 year old male with anterior labral tear, axial image after intraarticular contrast injection showing tear and detachment of the anterior labrum (arrow) (A). A more distal slice (B) showing periosteal sleeve (arrow).



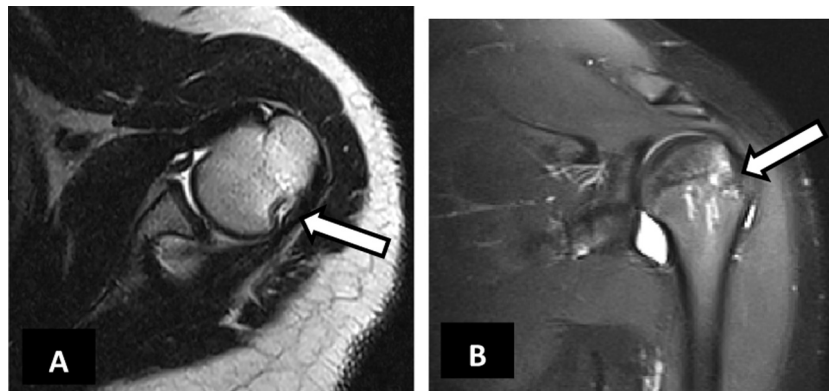
**Chart 3.** Correlation between specificity of shoulder MRA and surgical findings in anterior, superior and inferior labral tears.

lesion associated with Hill Sachs injury on top of repeated anterior shoulder dislocation. 8 patients (20%) had glenohumeral ligament rupture. All cases of anterior labral tear

showed concordant findings with the surgical correlation Fig. 2. Shoulder MRA underdiagnosed one superior and one inferior tear, and it showed partial thickness interrup-



**Fig. 4.** Two different patients showing interrupted glenohumeral ligaments in shoulder MRA. In (A), there is torn middle glenohumeral ligaments with its location filled with intraarticular contrast (arrow). In (B), there is interruption of the humeral attachment of the inferior glenohumeral ligament (arrow) with contrast leak into the axillary recess.



**Fig. 5.** 20 year old male with Bankart lesion and Hill Sachs injury showing the marrow edema and cortical interruption at the superior posterior lateral aspect of the humeral head (arrows) in axial T2 (A) and coronal STIR (B).

tion of the labral while by arthroscopy they were completely torn [Chart 3](#).

When compared with the arthroscopic findings, MRA showed overall sensitivity of 95.45% and specificity of 99.1% for diagnosing tears of the glenoid labrum in the term of its type either complete thickness or partial thickness; this included all kinds of tear, an accuracy of 98.76%.

For individual types of labral tears, MRA was concordant with Arthroscopy in all anterior labral tears, with sensitivity and specificity of 100%. For inferior labral tear, MRA showed sensitivity of 98% and specificity of 99%. For superior labral tear, MRA showed sensitivity of 94% and specificity of 97%.

Positive predictive value 100% and negative predictive value 98.33%, estimated  $P$  value  $< 0.05$ . [Figs. 3–5](#) are demonstrating examples of labral tear with associated findings.

#### 4. Discussion

Shoulder injuries are a common source of pain and disability [14]. Shoulder joint pain due to anterior microin-

stability is not an unusual complaint of young active individuals [15].

Imaging plays an important role in the assessment of labral injuries and includes conventional radiography and computed tomography (CT) or magnetic resonance (MR) arthrography [16,17].

Several imaging methods have been used to evaluate the glenoid labrum, ligaments, and joint capsule. Although MR imaging has been used in the examination of the glenoid labrum, there are some difficulties with the technique [18–21]. Hajek et al. [22] were the first to perform MR arthrography with the injection of a mixture of saline solution and gadopentetate dimeglumine into the joint space; they found that many anatomic structures were better delineated because of capsular distention.

Patients presenting with shoulder pain often undergo magnetic resonance imaging (MRI) to determine the type and extent of their underlying shoulder pathology, claustrophobic patients represent diagnostic difficulty and they either do MRI under sedation or undergo open MRI using low field magnet. When a glenoid labrum tear is suspected clinically and there are no contraindications, the patient will

receive an intra-articular injection of gadolinium contrast prior to undergoing the MRI (MR arthrogram). However, if rotator cuff pathology is suspected or the underlying pathology is unclear clinically, a routine MRI is typically performed. In cases of shoulder pain, clinical findings and presentation are often complex and patients will have multiple sites of pathology which makes choosing the correct radiologic study challenging and important [22–25].

Traditionally, contrast is injected via an anterior approach under fluoroscopic guidance, although other methods such as ultrasound and MR-guided techniques have been described. A posterior approach to injection has also been described. This has been found to be well tolerated by patients as well as avoiding the interpretative difficulties that may arise from extra capsular contrast extravasation when evaluating the anterior joint structures [26].

While it is well documented that an MR arthrography is superior to routine MRI without contrast for evaluating labral pathology (Routine MR imaging sensitivities range from 44% [7] to 95% [23] compared with MR arthrography with sensitivities of 93–96% [11], and often a patient with unsuspected labral pathology will undergo a routine shoulder MRI. In our study and based on the literature review, we found that MRA done by low field magnet can show high sensitivity of 95.45% for detecting labral tears, and specificity 99.1% for diagnosing type of tears.

In comparison with the rotator cuff, decreased accuracy for identifying pathology of the glenoid labrum is not isolated to low-field MRIs. Mid- and high-field MRIs without arthrogram also showed varied results when evaluating labral lesions (sensitivity, 44–95%; specificity, 63–91%) [27–29].

Our study agreed with Smith et al. [30] that MRA appeared superior to MRI for the detection of glenohumeral labral lesions. According to Lee et al. [31], SLAP lesions were poorly identified using low-field scanner and when compared to our study, there was one case of superior labral tear that was underdiagnosed by MRA.

Low- and standard high-field MRIs have shown promise in better identifying lesions of the anterior (sensitivity, 83–89%; specificity, 100%), posterior (sensitivity, 84–86%; specificity, 100%), and superior labrum (sensitivity, 83–90%; specificity, 99–100%) [32,33]. To the best of our knowledge; few studies were done on low field scanner MRA. Our study agreed with Kreitner et al. that stated despite a minor image quality in comparison with high-field imaging, low-field MR arthrography of the shoulder allows for sufficient evaluation of intra- and extra-articular structures in the detection of major abnormalities such as glenohumeral instability or rotator cuff disease [34].

The limitations of this study include low number of the study population which opens gates to more big scale study and the lack of enough number comparison between the conventional MRI and MRA as our study included only 4 patients who did both examinations.

## 5. Conclusion

As the results show, MRA shoulder protocol is more reliable than conventional MRI for prospectively diagnos-

ing glenoid labrum lesions, open scanner low field magnet approved high sensitivity and specificity in assessment of labral tear and it can be used as a reliable test in a claustrophobic patients for preoperative evaluation of the labral lesions.

Many factors can influence the results such as differences in the quality of each exam, radiologist experience and expertise, the presence or absence of a joint effusion and clinical presentation.

## Conflict of interest

No conflict of interest.

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