

## Is the Apprehension Test Sufficient for the Diagnosis of Anterior Shoulder Instability in Young Patients without Magnetic Resonance Imaging (MRI)?

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### Abstract

**Introduction:** The purpose of this study is to compare the sensitivities and positive predictive values (PPV) of the anterior apprehension test and magnetic resonance imaging (MRI) in the diagnosis of anterior labral tears in young patients with shoulder instability and to determine if surgery could be carried without this investigation in selected patients. **Materials and Methods:** We undertook a retrospective study of 168 patients aged between 15 and 30 years with a history of shoulder dislocation and compared the sensitivities and the PPV of the apprehension test with both MRI and magnetic resonance arthrograms (MRA) in the diagnosis of a Bankart lesion. The radiological investigations were interpreted by general practice radiologists and specialised musculoskeletal radiologists. All patients had their diagnosis confirmed by shoulder arthroscopy. **Results:** Our results showed that the apprehension test was highly reliable when it was positive with a PPV of 96%. It was more sensitive than MRI in the diagnosis of a Bankart lesion. The clinical test was significantly better when a musculoskeletal radiologist interpreted the MRI. The MRA interpreted by a musculoskeletal radiologist had the highest rates of sensitivity in detecting Bankart lesions. The figure was similar to that for the apprehension test. There was no difference in the PPVs among the clinical test, the MRI and the MRA read by the 2 categories of radiologists. **Conclusion:** We conclude that a routine MRI may be unnecessary in evaluating a young patient with clinically evident anterior shoulder instability if the apprehension test is positive. A MRA that can be interpreted by a musculoskeletal radiologist will be the next best investigation if the clinical test is negative or equivocal.

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**Key words:** Dislocation, Glenohumeral joint, Radiological investigations

### Introduction

A good history and a detailed physical examination is often sufficient to make a diagnosis of a recurrent anterior dislocation of the shoulder, even in the absence of a radiologically documented dislocation of the joint.<sup>1</sup> The anterior apprehension test has recently been supplemented with the relocation, crank, and load and shift tests to increase its accuracy. The advent of computer tomography (CT) arthrogram, magnetic resonance imaging (MRI) and magnetic resonance arthrogram (MRA) have enabled surgeons to predict preoperatively the intra-articular pathology with greater accuracy so as to counsel patients and to obtain informed consent. A small study in 1996<sup>1</sup> has

shown that a physical examination using several tests had a higher sensitivity but a similar specificity in predicting a glenoid labral tear than MRI, although this study has been refuted in a 1997 study by Seeger et al.<sup>2</sup> A more recent study<sup>3</sup> has suggested that the need for routine MRAs may not be as crucial as currently accepted in the management of a clinically unstable shoulder especially in the young patient. However, the MRA showed a sensitivity of 95% and a specificity of 100% for detecting anterior labral tears in a study by Parmar et al.<sup>4</sup> This study suggests that the MRA rather than MRI should be the investigative modality of choice. There is therefore confusion regarding the role of MRI or MRA in shoulder instability. These investigations

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however, have come with additional costs to the patient, both in terms of expense and time delay in obtaining them. In addition, their accuracy has also been challenged.<sup>1</sup> The routine use of these modalities now, needs critical re-evaluation in the face of rising healthcare expenditure.<sup>1,3</sup> Do these investigations provide information that may not be obtained in a routine arthroscopic evaluation of the joint and do any additional findings affect the management plan of the surgeon at the time of arthroscopy?

The hypothesis of this present study is that a well conducted apprehension test is sufficient to make a diagnosis of a recurrent anterior instability of the shoulder and an associated labral tear in the young patient without the need for additional investigations such as the MRI or MRA.

## Materials and Methods

We accessed the Shoulder and Elbow Registry of our institution between the years 2007 and 2013 and identified 230 patients with a history of recurrent anterior dislocation of the shoulder who were eligible for the study.

### Inclusion and Exclusion Criteria

The inclusion criteria were all patients between 15 to 30 years of age with a history of recurrent anterior dislocation of the shoulder and who had undergone arthroscopic surgery at our institution. Only patients with documentation of the anterior apprehension test in the case notes were included. Both positive and negative findings must be indicated in the files before they were included. First time dislocators were excluded as we never operated on this group. Also patients with previous shoulder surgery, multidirectional instability (MDI) or posterior instability were excluded as were patients who had experienced pain on the apprehension test, or excessive pain that prevented the performance of the test or guarding that prevented the apprehension test manoeuvre.

### Patient Recruitment

Sixty-two patients were removed from the study as they failed to meet the inclusion criteria, leaving 168 patients for the study. Three patients were excluded from the analysis of the MRI/MRA data as the images could not be retrieved, leaving 62 patients with MRI records and 103 with MRA findings.

Ethical approval was obtained from the national Disease Specific Review Board (DSRB).

All clinical assessment was performed by 2 senior fellowship-trained consultant surgeons. A retrospective review of the MRI/MRA films was conducted by 2 fellowship-trained senior musculoskeletal radiologists who

were blinded from the clinical findings and the surgical notes. For the purpose of the study, a musculoskeletal radiologist was defined as someone who was fellowship-trained in musculoskeletal radiology and who had a minimum of 5 years' experience in the subject. The existing reports in the system had been initially interpreted by a general radiologist. For the purpose of this study, a general radiologist was defined as one whose practice was more of a general nature, with no fellowship training in musculoskeletal radiology. A review of the surgical operative notes was conducted and all findings were recorded. All surgeries were performed by 1 of the 2 senior authors (VPK, TCH).

### Anterior Apprehension Test

The test was performed with the patient in a standing position. The examiner stood behind the patient and abducted the arm to 110° with 15° of extension and 15° of external rotation. The examiner observed the patient for apprehension with the aid of a mirror placed in front of the patient (Fig. 1). If no apprehension is elicited, then an anteriorly directed force is applied to the humeral head from behind. The fingers of the examiner are however kept anterior, in order to prevent the humeral head from dislocating.

The presence or absence of apprehension was noted in the file. The test was carried out as described by 2 experienced surgeons who have been performing this test since they started practice. The test was performed by the 2 surgeons on their respective patients.

### Radiological Investigations

All MRI and MRA images were interpreted from the picture archiving and communication system (PACS) system. Imaging was performed using either the Siemens 1.5 Tesla or the GE 1.5 Tesla unit. Arthrography was performed by the radiologist. A radio-opaque marker was



Fig 1. The anterior apprehension test.

used to locate a site over the inferomedial quadrant of the humeral head. After skin preparation, the shoulder was draped and the injection site and soft tissue infiltrated with local anaesthetic (lignocaine 1%).

A 22G spinal needle was inserted into the glenohumeral joint under fluoroscopic guidance and the position confirmed by injection of a small amount of Omnipaque 300 iodinated contrast media. Capsular distension was achieved using 10 mL to 15 mL of diluted gadolinium (0.1 mL gadolinium in 20 mL normal saline). The patient was then sent for the MRA study.

In our study, 2 independent senior fellowship-trained musculoskeletal radiologists retrospectively reviewed all MRI and MRA images, which were previously reported by general radiologists.

When comparing the apprehension test with imaging, paired data was used to ensure a more accurate comparison and to enable calculations of statistical significance. When MRI and MRA were compared, unpaired data was used.

### Arthroscopy

All the surgeries were performed under general anaesthesia. A 30° Karl Storz arthroscope was used via the standard posterior portal for the assessment of the joint. One senior author used a beach chair position, while the other performed the procedure with the patient in the lateral decubitus position. The extent and location of the Bankart lesion and all other findings were recorded in the surgical notes. All patients had the Bankart lesion repaired. Two patients with an engaging Hill-Sach's lesion had a remplissage procedure. All other lesions were too insignificant to be addressed surgically.

### Statistical Study

Comparison of sensitivities and positive predictive values (PPVs) of the clinical tests and the imaging modalities were analysed using McNemar test for paired data and Pearson chi-square test for unpaired data. A value of  $P < 0.05$  was considered to be statistically significant.

## Results

### Apprehension Test

A total of 168 patients had the apprehension test documented in the files (Table 1). The average age was 23 years (range, 17 to 29 years); 150 patients were males. Of the 168 patients, 145 (86%) had a positive test; 139 of this group had a Bankart lesion on arthroscopy, giving a PPV of 96%. Of the total 168 patients, 161 had a Bankart lesion on arthroscopy. The sensitivity of the apprehension test was calculated at 86%. However the specificity was only 14%.

### Imaging

Sixty-two MRIs and 103 MRAs were reviewed by both groups of radiologists (Table 1). Images for 3 other patients could not be retrieved.

The general radiologists identified 28 Bankart lesions on MRI out of 58 identified at arthroscopy, and all 28 were found to have the lesions at surgery, giving a PPV of 100% and a sensitivity of 48%.

Musculoskeletal radiologists identified 43 Bankart lesions on MRI out of 58 found on arthroscopy, and all 43 were identified on arthroscopy, giving them a sensitivity of 74% and a PPV of 100%. The difference in sensitivity between the 2 groups of radiologists was significant with a  $P$  value of 0.001.

Eighty-three out of 103 MRAs were reported positive for Bankart lesions by the general radiologists. Of these, 81 were positive on arthroscopy, giving a PPV of 98%. The sensitivity for MRA by the general radiologist was calculated at 83%.

Musculoskeletal radiologists interpreting MRAs identified 91 out of the 98 Bankart lesions found on arthroscopy, giving them a sensitivity of 93%. The difference in the sensitivities between the 2 groups of radiologists was also found to be statistically significant with a  $P$  value of 0.021. However there was no difference in the PPVs between the 2 categories of radiologists (98% versus 97%).

### Apprehension Test vs Imaging

There were 46 patients with a Bankart lesion on arthroscopy who had both apprehension tests as well as MRIs read by both general practice and musculoskeletal radiologists (Fig. 2). Out of the 46, 21 were correctly identified on MRI by general radiologists giving a sensitivity of 46% but 42 had a positive apprehension test, giving it a sensitivity of 91%. The difference was statistically significant ( $P < 0.001$ ).

The musculoskeletal radiologists identified 32 on MRI out of 46 Bankart lesions, giving them a sensitivity of 70%. The sensitivity of the apprehension test in this group was 91%. The difference was statistically significant with a  $P$  value of 0.021.

Seventy-eight patients with Bankart lesions at surgery had both an apprehension test and MRAs read by both groups of radiologists. Both MRAs read by general practice radiologists and the apprehension tests were positive in 65 out of 78 of the patients giving them equal sensitivities of 83%. The musculoskeletal radiologists, correctly identified Bankart lesions in 71 out of 78 patients giving a sensitivity of 91%. However, there was no statistical difference between this and the figure for the apprehension test (83%), the  $P$  value being 0.18.

Table 1. Details of Arthroscopic Findings and Findings of Clinical Examination and Imaging Studies

|                            |                           | Arthroscopic Findings |                  |       |
|----------------------------|---------------------------|-----------------------|------------------|-------|
|                            |                           | Bankart Positive      | Bankart Negative | Total |
| Anterior apprehension test | Positive                  | 139                   | 6                | 145   |
|                            | Negative                  | 22                    | 1                | 23    |
|                            | Total                     | 161                   | 7                | 168   |
|                            | Sensitivity               |                       | 86%              |       |
|                            | Specificity               |                       | 14%              |       |
|                            | Predictive value          |                       | 96%              |       |
|                            | Negative predictive value |                       | 4%               |       |
| MRI general                | Positive                  | 28                    | 0                | 28    |
|                            | Negative                  | 30                    | 4                | 34    |
|                            | Total                     | 58                    | 4                | 62    |
|                            | Sensitivity               |                       | 48%              |       |
|                            | Specificity               |                       | 100%             |       |
|                            | Positive predictive value |                       | 100%             |       |
|                            | Negative predictive value |                       | 12%              |       |
| MRI by MSK radiologist     | Positive                  | 43                    | 0                | 43    |
|                            | Negative                  | 15                    | 4                | 19    |
|                            | Total                     | 58                    | 4                | 62    |
|                            | Sensitivity               |                       | 74%              |       |
|                            | Specificity               |                       | 100%             |       |
|                            | Positive predictive value |                       | 100%             |       |
|                            | Negative predictive value |                       | 21%              |       |
| MRA general                | Positive                  | 81                    | 2                | 83    |
|                            | Negative                  | 17                    | 3                | 20    |
|                            | Total                     | 98                    | 5                | 103   |
|                            | Sensitivity               |                       | 83%              |       |
|                            | Specificity               |                       | 60%              |       |
|                            | Positive predictive value |                       | 98%              |       |
|                            | Negative predictive value |                       | 15%              |       |
| MRA by MSK radiologist     | Positive                  | 91                    | 3                | 94    |
|                            | Negative                  | 7                     | 2                | 9     |
|                            | Total                     | 98                    | 5                | 103   |
|                            | Sensitivity               |                       | 93%              |       |
|                            | Specificity               |                       | 40%              |       |
|                            | Positive predictive value |                       | 97%              |       |
|                            | Negative predictive value |                       | 22%              |       |

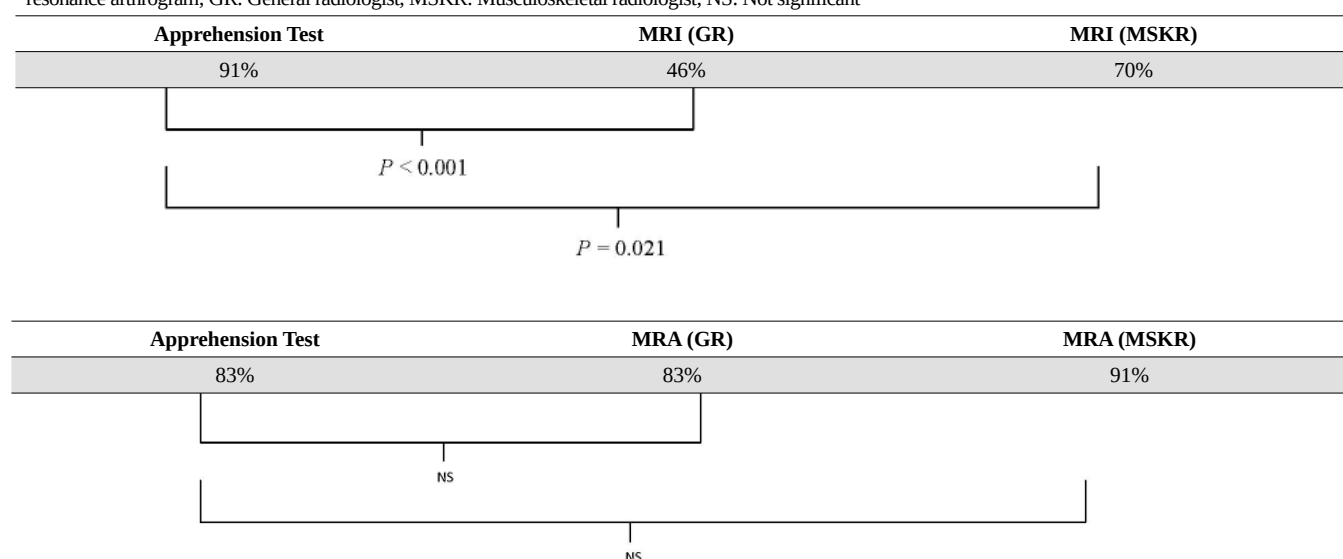
MRA: Magnetic resonance arthrogram; MRI: Magnetic resonance imaging; MSK: Musculoskeletal

### MRI vs MRAs

When comparing MRIs and MRAs, we had 58 patients with a Bankart lesion on arthroscopy that had an MRI done and 98 patients with Bankart lesions that had an MRA done. Both the radiological investigations were reported by both groups of radiologists. MRI interpreted

by the general radiologists had a sensitivity of 48% and MRA a sensitivity of 83% with a *P* value of <0.001. With musculoskeletal radiologists interpreting the images, the sensitivity of MRI was 74% and sensitivity of MRA was 93% and this difference was also statistically significant (*P* = 0.001).

Fig. 2. Image depicting the comparison of the sensitivities of the apprehension test, the MRI and MRA. MRI: Magnetic resonance imaging; MRA: Magnetic resonance arthrogram; GR: General radiologist; MSKR: Musculoskeletal radiologist; NS: Not significant



### Other Lesions

Besides labral tears, 75 Hill-Sachs's lesions, 12 superior labrum, anterior to posterior (SLAP) tears, 1 bony Bankart and 3 partial thickness rotator cuff tears were identified at arthroscopy (Table 2). The majority of the lesions were identified on MRA. There were no HAGL lesions in this series.

### Discussion

This study was initiated to critically compare the apprehension test with an MRI/MRA in confirming an anterior labral tear in the young patient with recurrent anterior instability of the shoulder. For the clinical examination, we chose the anterior apprehension test as it was the earliest test described, easy to perform, reproducible and more predictable in our hands than the load and shift test, the relocation test or the surprise/release test. Hegedus et al<sup>5</sup> in his systemic review of various shoulder physical examination tests showed that the apprehension test had a

positive likelihood ratio of 17.21 and a negative likelihood ratio of 0.39 for the diagnosis of anterior instability. It was the most sensitive (65%) and specific (95.4%) test compared to all other tests including the relocation test and the load and shift manoeuvre. Only the 2 experienced fellowship-trained shoulder surgeons carried out the anterior apprehension test on their respective patients in our study and this ensured the consistency of the test through the study period. Although in clinical practice, surgeons may use more than 1 test to establish the diagnosis and indeed this was observed in this study in some patients, we decided to look at only the apprehension test for the purpose of this investigation.

Our study showed that the apprehension test was very reliable with a PPV of 96%. We are not aware of a similar study analysing the reliability of any other described tests for shoulder instability. Liu et al<sup>1</sup> used several tests including the load and shift and crank tests and was able to show a better sensitivity than an MRI in diagnosing labral tears. However, they were unable to establish the superiority of any 1 clinical test. Jonas et al<sup>3</sup> identified 83 labral tears in

Table 2. Additional Findings

|              | MRI<br>Other Findings by<br>General Radiologist | MRI<br>Other Findings by<br>MSK Radiologist | MRA<br>Other Findings by<br>General Radiologist | MRA<br>Other Findings by<br>MSK Radiologist | Arthroscopy<br>Other Findings |
|--------------|-------------------------------------------------|---------------------------------------------|-------------------------------------------------|---------------------------------------------|-------------------------------|
| Hill Sachs   | 34                                              | 38                                          | 72                                              | 83                                          | 75                            |
| SLAP tear    | 4                                               | 4                                           | 10                                              | 5                                           | 12                            |
| Bony Bankart | -                                               | -                                           | -                                               | -                                           | 1                             |
| Cuff tear    | 1                                               | 1                                           | 7                                               | 2                                           | 3                             |
| Total        | 39                                              | 43                                          | 89                                              | 90                                          | 91                            |

MRA: Magnetic resonance arthrogram; MRI: Magnetic resonance imaging; MSK: Musculoskeletal; SLAP: Superior labrum, anterior to posterior

90 patients with a positive anterior apprehension test giving a PPV of 92%. Only 54 were correctly identified on MRAs (sensitivity 65%). Our, and previous other studies<sup>1,3</sup> just point to the importance of a clinical examination rather than investigations when making a diagnosis. Investigations may perhaps be indicated when clinical examinations are negative or equivocal.

In our institute, as is possibly the practice worldwide, an MRI or MRA is routinely ordered after the standard X-rays to confirm the intra-articular pathology. Of the 2, MRIs have gained favour as they are faster to perform, non-invasive, less expensive and is preferred by patients. Also, the complications with arthrography are avoided.<sup>6</sup> However, concerns regarding its reliability in detecting labral lesions<sup>1</sup> have led to the use of the MRA as a preferred investigation of choice, by radiologists, for patients with shoulder instability. In our study, MRI or MRA was decided by the treating surgeon in consultation with the patient.

The present study expands on the previous works by Liu et al<sup>1</sup> and Jonas et al<sup>3</sup> to compare an established clinical examination (apprehension test) with the MRI and the MRA for the diagnosis in shoulder instability and to establish the preferred investigation for patients with equivocal clinical findings. The study also compares the interpretation of the radiological investigations by the general radiologist with those by the specialised musculoskeletal radiologist. We felt this study was an important one, as a study by Theodoropoulos et al<sup>7</sup> found that hospital-based subspecialised radiologists performed better than community-based general radiologists in the diagnosis of labral lesions, rotator cuff tears, Hill-Sachs lesions and biceps tendon pathologies.

Our initial study premise was to show that clinical testing in the form of the apprehension test was sufficient for the diagnosis and there was perhaps no indication for routine MRIs in young patients with shoulder instability. The sensitivity of the MRI by both the general and the musculoskeletal radiologist was inferior to the apprehension test (Fig. 2). Liu et al<sup>1</sup> reported a sensitivity of 59% with MRIs in detecting labral tears. They did not specify the experience of the radiologist reading the MRIs. Physical examination on the other hand using several different techniques including the apprehension test had a sensitivity of 90%, similar to our finding (Fig. 2). Others<sup>8</sup> demonstrated a sensitivity of 95% with the MRI for diagnosing arthroscopically proven anterior labral tears. That study focused on demonstrating the inaccuracy of MRIs in demonstrating posterior labral tears but again failed to mention the experience of the radiologists interpreting the MRIs. As the study was from a radiology department from a naval hospital, we may assume that the readings were by specialised radiologists dealing with young patients with shoulder instability. It is

apparent that even with experienced radiologists, accuracy in diagnosing labral tears with MRIs varied from centre to centre. On the balance our study and those of others<sup>1</sup> have shown the limited value of routine MRIs in young patients with anterior shoulder instability.

The sensitivity of the apprehension test was similar to those of MRAs read by both groups of radiologists (Fig. 2). These findings show that the MRA is probably a much more powerful investigative tool when compared to MRI whether in the hands of general or musculoskeletal radiologists for identifying Bankart lesions even if it came with the disadvantages of increased cost, increased time to perform and being an invasive procedure besides the risks of well documented complications.<sup>6</sup> Fotiadou et al<sup>9</sup> also showed that MR arthrography had a sensitivity of 96% and a specificity of 80% for the overall detection of anteroinferior labral abnormalities. Ricchetti et al<sup>10</sup> reported a sensitivity of 83.3% with MRA in identifying glenoid labral tears. However, Jonas et al<sup>3</sup> revealed a sensitivity of only 65% with MRAs. Smith et al<sup>11</sup> in a meta-analysis reported a sensitivity of 88% with MRAs. The latter 4 studies suffered from the fact that the MRA interpretation was performed by a number of different radiologists of varying experience. In a study of 43 adolescent patients, Eisner et al<sup>12</sup> reported that although the MRA had a sensitivity of 100%, it failed to identify the extent of labral pathology noted at the time of arthroscopy. Our study also showed a significantly higher sensitivity in detecting labral tears with MRAs than MRIs regardless of the experience of the radiologists. In conclusion, an MRA would be the investigation of choice if indeed the surgeon desired any additional investigations for a patient with shoulder instability and equivocal clinical findings.

The MRI or MRA may be requested by surgeons to identify other lesions that may need to be addressed at the time of arthroscopy. In this study, except for 2 Hill-Sachs lesions which required attention, all other lesions were too insignificant to require surgical management. A bony Bankart is another lesion that may need to be addressed and was found in only 1 patient in this study. We conclude that it is uncommon in patients with recurrent instability to have a clinically significant bony defect. The benefits of MRI therefore appear to be minimal.

We caution that our study is confined to the young patient with shoulder instability where the primary lesion would be a Bankart lesion. By limiting the review population to the 15 to 30 year age group, we hope to exclude a good many degenerative conditions, thus making our study conclusions more robust.

## Limitations

The study has some limitations. It was retrospective.

Although this may be seen as a crucial drawback of the study, we felt that the findings were still valid as all the investigators, senior surgeons performing the test, and original radiologists were to all intents and purposes “blinded”. All radiological investigations were performed after the clinical examination. The subsequent interpretation by the musculoskeletal radiologists was also blinded. This study truly reflects how these individuals would perform in a busy everyday clinical practice. A prospective study with well informed investigators may introduce a bias that may not truly reflect everyday practice.

The apprehension test showed a very poor specificity in our series (14%) when compared to other studies.<sup>1</sup> This was probably due to the fact that all our patients were identified from the Shoulder and Elbow Registry and were essentially patients who have had surgery. Hence, the chance of identifying true negatives would be less likely. However as we were primarily interested in the sensitivities, we chose not to perform a statistical analysis on the specificities, as the numbers of true negatives were low.

Ten different radiologists with varying degrees of experience performed the initial reporting. This may have influenced the findings by this category of radiologists. There were no controls. Since all cases listed for arthroscopy were those who were clinically symptomatic and likely to have labral lesions, the chances of finding the lesion was theoretically higher. The final limitation is that different numbers of patients had different tests. This will be an inherent shortfall in such a study.

The strengths of the study are several. To our knowledge, this is the first study to compare the apprehension test alone directly to MRI and MRA and to cross verify the findings with arthroscopy. Previous studies tended to compare either of the 2 variables and used various physical examination tests rather than just the apprehension test.<sup>1</sup> Our study also has the largest reported number of patients studied (168 cases).

It is our hope that this study will be able to decrease the surgeon’s dependence on MRI scans for evaluating shoulder instability in the young patient. The data would suggest that it would be acceptable to rely on the apprehension test alone unless the history and physical examination are inconclusive. If at all the surgeon feels compelled to have imaging, MR arthrogram interpreted by a musculoskeletal radiologist should be the modality of choice.

## Conclusion

The anterior apprehension test, if positive, may be sufficient to confirm the presence of an anterior labral tear in young patients with recurrent dislocations of the shoulder. If the test is negative or equivocal, an MRA read by a musculoskeletal radiologist will be the investigation of choice.

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