Accuracy of Abduction-External Rotation MRA Versus Standard MRA in the Diagnosis of Intra-articular Shoulder Pathology

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abstract

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The goal of this study was to compare the accuracy of abduction-external rotation magnetic resonance arthrography (ABERMRA) with standard MRA in the diagnosis of intra-articular shoulder pathology.

One hundred three consecutive patients undergoing preoperative direct MRA and subsequent arthroscopic examination were included in the study. Seventy-eight patients underwent standard MRA and 25 underwent ABERMRA. Specialist-trained musculoskeletal radiologists reported all scans, and attending shoulder surgeons performed all arthroscopies. Arthroscopic assessment revealed 11 partial-thickness rotator cuff tears, 3 full-thickness tears, 64 labral lesions (48 soft tissue and 16 significant bony), and 17 superior labrum anterior-posterior (SLAP) tears. The sensitivity/specificity for standard MRA was 0.56/0.99 for partial-thickness rotator cuff tears, 1.00/1.00 for full-thickness rotator cuff tears, 0.75/0.91 for soft tissue labral tears, 0.58/1.00 for significant bony glenoid lesions, and 0.50/0.91 for SLAP tears. Abduction-external rotation magnetic resonance arthrography increased the sensitivity/specificity to 1.00/0.85 for soft tissue labral tears, 0.75/1.00 for significant bony glenoid lesions, and 1.00/1.00 for SLAP tears, although it missed 2 of 2 partial-thickness rotator cuff tears.

This study suggests that standard MRA is a valuable investigation tool for instability, SLAP tears, and rotator cuff tears, although limitations exist. Additional ABERMRA sequences appear to improve the diagnostic accuracy of soft tissue anterior and posterior labral tears, SLAP tears, and significant bony glenoid lesions and should be routinely requested by shoulder surgeons when ordering MRAs to obtain the maximum benefit from this invasive investigation.

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The accurate diagnosis of intra-articular soft tissue pathology in the shoulder can be challenging, particularly because the clinical findings often have a poor correlation with the final diagnosis.1,2 This is especially true for partial-thickness rotator cuff tears and superior labral anterior-posterior (SLAP) tears.1,3,4 Therefore, diagnostic imaging is an important adjunct in identifying pathology and planning treatment, especially surgical treatment.

Previous studies have investigated the accuracy of magnetic resonance arthrography (MRA) and reported a sensitivity/specificity of 0.94/0.99 for full-thickness rotator cuff tears and 0.86/0.96 for partial-thickness rotator cuff tears,5 0.75-0.88/0.85-0.91 for anterior labral lesions,6,7 and 0.71-0.96/0.84-0.91 for SLAP tears.8,9 The range of reported values is likely due to differences in radiologist experience, scanner specifications, and scanning protocols.6 The addition of the abduction-external rotation (ABER) sequence has been reported to increase the accuracy of MRA by improving delineation of the inferior glenohumeral labroligamentous complex, the anteroinferior aspect of the glenoid labrum, and the undersurface of the rotator cuff tendon,10 although the current indications of when radiologists should perform this sequence are unclear and the sequence is often underused.

The goals of the current study were to (1) report the accuracy of MRA compared with arthroscopic findings for the diagnosis of labral and rotator cuff pathology in a large series of consecutive patients reported by experienced musculoskeletal radiologists; (2) investigate whether additional acquisition of the ABER sequence (ABER-MRA) improves the accuracy compared with standard MRA; and (3) identify for which pathologies it is most useful.

**Materials and Methods**

One hundred four consecutive patients with shoulder pain or instability symptoms who had undergone preoperative direct MRA with standardized sequences and subsequent arthroscopic examination between November 2006 and July 2011 were included in this study. One patient was excluded due to a poor quality scan that could not be reliably reported, leaving 103 patients for analysis. Magnetic resonance arthrography with ABER sequence acquisition was also performed in 25 of 103 patients. The study group comprised 76 men and 27 women with a mean age of 30 years (range, 15-79 years). Preoperative diagnosis was instability in 90 shoulders, SLAP tear in 15, impingement in 7, rotator cuff tear in 6, pain of unknown cause in 3, and unstated in 3. Surgery was considered in patients with shoulder pain refractory to nonoperative treatment and in patients with recurrent instability symptoms.

Direct MRA was performed using a standardized protocol in all patients, with insertion of a needle into the glenohumeral joint under fluoroscopic guidance and confirmation with Omnipaque (GE Healthcare, Inc, Princeton, New Jersey). The joint was then injected with 10 mL of diluted 1/200 gadolinium contrast, and image sequences were performed with a 3.0-T scanner (Discovery MR750; General Electric, Fairfield, Connecticut). The standard sequences with the shoulder in external rotation and adduction (standard MRA) included axial T1-weighted spin-echo with fat saturation, oblique coronal T1-weighted spin-echo with fat saturation, oblique coronal short tau inversion recovery, oblique coronal T2-weighted fast spin-echo with fat saturation, oblique sagittal T1-weighted spin-echo with fat saturation, oblique sagittal T1-weighted fast spin-echo, and oblique sagittal T2-weighted fast spin-echo with fat saturation.

The radiologist (S.B.R.) requested additional T1-weighted fast spin-echo fat-suppressed ABER sequences, to be performed by the radiographer when the clinical request form stated a possible diagnosis of shoulder instability or SLAP tear. No standard MRA images were available to the radiologist prior to making this decision. The ability of the radiographer to perform the additional ABER sequencing was limited in some cases by difficulties with positioning the patient in the ABER position due to body habitus and discomfort, combined with the scanner’s large inflexible 3.0-T coil, limitations in the time available for scanning, and not appreciating the significance of performing the additional sequence. A team of 3 specialist-trained musculoskeletal radiologists (S.B.R.) reported all scans.

All arthroscopic procedures were performed by or under the direct supervision of 2 consultant shoulder surgeons (S.J.D.) while the patient was in the beach-chair position. Standard posterior, anterior, and lateral portals were used. The presence or absence of full-thickness rotator cuff tears, partial-thickness rotator cuff tears (including bursal and articular sided), anterior and posterior labral tears (including significant bony glenoid lesions), and SLAP tears was recorded. Glenoid bone loss greater than 25% of the width of the glenoid was classified as a significant bony lesion.11,12 All findings from the MRA and arthroscopic assessments were entered into a database to allow direct comparison. The patients were divided into 2 groups for analysis: standard MRA (n=78) and ABERMRA (n=25). Table 1 shows that the baseline characteristics of the groups were similar, thus allowing a fair comparison. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for the detection of rotator cuff tears and labral pathology with 95% confidence intervals, with the MRA diagnosis compared with the gold standard arthroscopic diagnosis.

**Results**

Arthroscopic assessment of 103 shoulders revealed 11 partial-thickness rotator cuff tears (10 articular sided and 1 bursal), 3 full-thickness rotator cuff tears, and 89...
intact rotator cuffs. Also found were 64 anterior and posterior labral lesions (48 soft tissue and 16 significant bony glenoid lesions) and 17 SLAP tears (Tables 2-4).

Standard MRA (n=78) correctly diagnosted all 3 full-thickness rotator cuff tears, 5 of 9 partial-thickness rotator cuff tears (4/8 articular and 1/1 bursal), and 65 of 66 intact rotator cuffs. Thirty-four of 48 labral lesions (27/36 soft tissue and 7/12 significant bony glenoid lesions), 29 of 30 intact labra, and 7 of 14 SLAP tears were correctly diagnosed. The analysis for rotator cuff tears was performed first by considering only articular-sided partial tears as true positives, then all partial-thickness rotator cuff tears as true positives, then any tear as a true positive (Table 5). The analysis for labral tears was performed separately for soft tissue and significant bony lesions and by combining both as true positives.

Abduction-external rotation MRA (n=25) correctly diagnosed 12 of 12 soft tissue labral tears, 3 of 4 significant bony glenoid lesions, and 8 of 9 intact shoulders. For SLAP tears, ABERMRA correctly diagnosted 3 of 3 tears and 22 of 22 intact shoulders. Although ABERMRA correctly diagnosed 23 of 24 intact rotator cuffs, both articular-sided partial-thickness rotator cuff tears were misdiagnosed as being intact. These tears were less than 50% thickness and were treated with debridement. No full-thickness rotator cuff tears existed in the ABERMRA group. The analysis was limited for rotator cuff tears due to the low prevalence in the ABERMRA group (Table 5).

**DISCUSSION**

This study involved a large series of consecutive patients undergoing preoperative direct MRA with standardized protocols with subsequent shoulder arthroscopic assessment as the referenced standard in all patients. Specialist musculoskeletal radiologists reported all scans, and consultant shoulder surgeons performed all arthroscopic assessments. The study demonstrated that standard MRA is a useful preoperative investigation for the diagnosis of intra-articular pathology in the shoulder. The sensitivity/specificity was 0.75/0.91 for soft tissue labral lesions, 0.58/1.00 for significant bony glenoid lesions, 0.77/0.97 for soft tissue or significant bony lesions, and 0.97/0.77 for an intact labrum. The poor sensitivity for significant bony lesions was due to 3 being misdiagnosed as soft tissue lesions and 2 as intact labra. For the diagnosis of SLAP tears, the specificity was shown to be good at 0.91, but sensitivity was poor at 0.50 because 7 of 14 were missed. Although a high specificity of 0.99 was seen for the diagnosis of rotator cuff tears, the sensitivity was poor at 0.50 for articular-sided partial tears, 0.56 for all partial-thickness rotator cuff tears, and 0.67 for any type of tear, largely due to 4 of 8 articular-sided partial tears being misdiagnosed as intact. However, the sensitivity/specificity for full-thickness rotator cuff tears was 1.00.

Additional imaging sequences with the arm in the ABER position were performed in 25 patients. Analysis of the ABERMRA group demonstrated an increase in sensitivity from 0.75 to 1.00 for soft tissue labral tears but a decrease in specificity from 0.91 to 0.85 (1 tear found to be intact and another found to be a significant bony lesion at arthroscopy) (Table 5). The sensitivity for significant bony glenoid lesions increased from 0.58 to 0.75 when considering them alone and from 0.77 to 1.00 when considering both soft tissue and significant bony lesions as true positives. Perfect correlation was seen for SLAP tears (sensitivity/specificity 1.00/1.00) because all 3 were correctly diagnosed, although the low prevalence of tears present limits this find-
The analysis for rotator cuff tears was not as useful because only 2 articular-sided partial-thickness rotator cuff tears were found at arthroscopy, both of which were missed by ABERMRA, and 1 intact cuff was misdiagnosed as a tear. However, the specificity was high at 0.96 and comparable to the standard MRA results.

The current results are comparable with those in the literature and demonstrate that standard MRA is reliable for diagnosing soft tissue labral tears but less so for ruling them out. It may miss up to 25% of tears, which is similar to the percentage reported by Kalson et al., although all patients underwent ABERMRA in their series. It is reliable for diagnosing significant bony injuries to the glenoid associated with instability but poor at ruling them out, with many being underestimated as pure soft tissue lesions. This is important because it may necessitate initial arthroscopic assessment to estimate glenoid bone loss followed by conversion to open surgery, either at the same sitting or a later date, to address the bony deficiency. Studies suggest that computed tomography (CT) or CT arthrography may be more reliable to detect this pathology, although this involves a significant radiation dose. The current results for partial-thickness rotator cuff tears and SLAP tears (sensitivity, 0.56 and 0.50, respectively) were poor compared with those in the literature (reported values up to 0.865 and 0.969, respectively). This is likely to reflect the low prevalence of these lesions in our sample because only 14 SLAP tears and 9 partial-thickness rotator cuff tears existed in the standard MRA group and 3 and 2, respectively, existed in the ABERMRA group. Another important consideration is that most patients clinically diagnosed with a rotator cuff tear are investigated noninvasively by standard magnetic resonance imaging or ultrasound in the authors’ institution.

The additional ABER sequence in MRA has been reported to increase the accuracy of diagnosis of rotator cuff tears by detensioning the cuff and allowing contrast to flow into the defect, increasing tension in the inferior glenohumeral ligament for labral injuries and by reproducing the peel-back mechanism for SLAP tears. Although limited by a small sample size in the ABERMRA group, the current study suggests that the accuracy of the diagnosis of labral injuries (soft tissue and significant bony lesions) and SLAP tears increases when compared with standard MRA. The results for partial-thickness rotator cuff tears are disappointing because both articular-sided tears were missed. However, these lesions are notoriously difficult to diagnose accurately, and MRA is still reported to be more reliable than ultrasound or magnetic resonance imaging.

The additional ABERMRA sequence was performed in only 25 of 103 patients in the current study. Given that the pretest clinical diagnoses were instability and SLAP tears in most shoulders, one would have expected that a higher proportion would have had the additional sequence to improve the accuracy of the investigation and provide a more reliable preoperative diagnosis. The experience in the authors’ institution is that radiographers often do not perform the ABER sequence due to difficulties with patient positioning and discomfort, time restraints, and some-
times not considering it necessary. This represents a pragmatic approach and is likely to occur in many other institutions.

Achieving an accurate preoperative diagnosis is vital when planning surgical approach and type of surgery, ensuring the correct equipment is available, and discussing the treatment plan with the patient in the clinic, especially the potential time off work and rehabilitation period. Although the evidence in the literature and in this study suggests that the ABERMRA view should be performed in all MRA imaging sequences, its use has not been ubiquitous due to concerns about the additional scanning time and difficulty with patient positioning and discomfort with the arm in this position.  However, Saleem et al. discussed the practical aspects of acquiring the ABER sequence and reported that it was possible to perform in 95% of their series of 415 MRAs with the use of intra-articular local anesthetic to improve patient comfort, with a total additional time for positioning and scanning of only 5 minutes. Therefore, it is feasible, with appropriate education and training, including the use of intra-articular local anesthetic when performing the MRA, that all MRA scans ordered by the shoulder surgeon for the investigation of instability, SLAP tears, and rotator cuff tears should clearly state, either on the request form or by close discussion with the radiologist, the necessity to include additional ABER sequences to maximize the accuracy and obtain the most reliable preoperative diagnosis.

### CONCLUSION

This study suggests that the accuracy of diagnosis of soft tissue anterior and posterior labral tears, SLAP tears, and significant bony glenoid lesions increases with the addition of the ABER sequence during direct MRA. Therefore, it should be routinely performed, where possible, when choosing to investigate patients with instability and suspected SLAP tears with MRA to maximize the accuracy of this invasive test. However, the study also demonstrated that the use of ABERMRA is still poor, and the au-

### Table 5

Analysis of Accuracy of Standard MRA and ABERMRA

<table>
<thead>
<tr>
<th>Tear</th>
<th>Standard MRA*</th>
<th>ABERMRA*</th>
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<tr>
<td></td>
<td>Sensitivity</td>
<td>Specificity</td>
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<td>Rotator cuff</td>
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<tr>
<td>FT</td>
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<td>0.99</td>
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<tr>
<td>AS</td>
<td>0.50</td>
<td>0.99</td>
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<td>0.99</td>
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<tr>
<td>PT, FT</td>
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<td>0.99</td>
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<tr>
<td>Intact</td>
<td>0.99</td>
<td>0.67</td>
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<tr>
<td>Labrum (anterior &amp; posterior)</td>
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<tr>
<td>Soft tissue</td>
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<td>0.91</td>
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<tr>
<td>Bonyb</td>
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<tr>
<td>Soft tissue, bonyb</td>
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<td>SLAP</td>
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*Numbers in parentheses represent 95% confidence intervals.

**All bony lesions represent significant (>25%) anterior glenoid bone loss.
thors suspect that this is similar in other institutions. The additional sequence, with the routine use of local anesthetic to reduce patient discomfort, should be specifically requested by the shoulder surgeon to obtain a more reliable preoperative diagnosis.

**REFERENCES**


