Comparison of MDCTA (16-Slice Multi-Detector Row Computed Tomography Arthrography) and MRA (Magnetic Resonance Arthrography) for Detecting Labral Lesions of the Shoulder

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Purpose: To compare the accuracy of 16-slice multi-detector row computed tomographic arthrography (MDCTA) and magnetic resonance arthrography (MRA) for making the diagnosis and classification of labroligamentous injuries.

Materials and Methods: This study is a prospective series that used MRA and MDCTA to examine 23 patients who complained of shoulder instability. Two radiologists independently analyzed the MRA and MDCTA. The sensitivity, specificity, accuracy, positive and negative predictive values were calculated from the arthrograms and the arthroscopic findings. The images of MDCTA and MRA corresponded with the findings on arthroscopy.

Results: Both imaging modalities had the same sensitivity for detecting Bankart lesions (n=10, 90%) and posterior labral tears (n=2, 50%) on McNemar test (p=1.00). For superior labrum anterior-to-posterior (SLAP) lesions, 6 MRA cases and 4 MDCTA cases corresponded with the arthroscopic findings. The difference between the sensitivities of MDCTA (66.7%) and MRA (100%) was not significant (p=0.09).

Conclusion: We suggest that the sensitivity of diagnosing labral lesions that induce shoulder instability is similar for MDCTA and MRA. MDCTA is effective for diagnosing and evaluating shoulder instability.

Index words: Shoulder
Magnetic resonance (MR)
Arthrography
Tomography
X-Ray Computed

Multi-detector row computed tomographic arthrography (MDCTA) and magnetic resonance arthrography (MRA) are superior to computed tomography (CT) or magnetic resonance imaging (MRI) for evaluating shoulder instability [1, 2]. Previous reports have indicated that MRA is more accurate for evaluating the capsuloligamentous complex, the glenoid labrum, the intracapsular portion of the long head of the biceps tendon, and the rotator cuff than CT arthrography [1, 2]. Therefore, MRA has been a useful technique for diagnosing labral lesions that induce shoulder instability [1-5].

CT shows high accuracy for detecting cortical defect and calcification of tendon and ligament. MDCTA allows multiplanar images of the lesion, and these images
are comparable to MRA. Moreover, MDCTA allows reconstruction images with 1 mm or thinner sectioning in any direction in the target lesion, whereas MRA can show only images with a fixed section thickness. The capability of MDCTA for isotropic data acquisition with high spatial resolution is a precondition for accurate imaging in the anatomically complex shoulder region [1, 3]. Waldt et al. [3] have already demonstrated that MDCTA is as effective as MRA for detecting variants of the superior labrum and labro-bicipital complex.

Because the ability of MDCTA to identify pathologic labral lesions has not yet been demonstrated, we prospectively compared the accuracy of MDCTA and MRA for making the diagnosis and classification of labroligamentous injuries, and we used the arthroscopic findings as the reference standard.

**Materials and Methods**

**Patients**

Twenty-three shoulder joints (21 men and 2 women, mean age: 28 years, age range: 17–52 years) were evaluated between August 2005 and January 2006 for shoulder instability. This study was approved by the ethical committee at our institution.

A contrast agent consisting of a 1:5 mixture of iomeprol (Iomeron 300; Ilsung, Seoul, Korea) and gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) diluted 1:250 in 20 ml of saline solution was prepared for a total volume of 24 mL [1]. The patients underwent fluoroscopic-guided arthrography in the neutral position with the previously mixed iodinated and paramagnetic contrast agents prior to MDCT and MRI. On fluoroscopy, the anterior approaching intra-articular position of the needle (21 gauge spinal needle; Hakko, Nagano-ken, Japan) was confirmed with visualization of the iodinated contrast agent (Iomeron 300) in the joint space. The volume of injected solution ranged from 10 to 24 mL. No side effects were observed. The patients were examined using MRA followed by MDCTA, after obtaining their informed consent for performing one-shot CT-MR arthrography.

The joint was explored, and the superior labrum and labor-bicipital complex were inspected macroscopically as the reference standard. All 23 patients underwent shoulder arthroscopy by one orthopedic surgeon who had 8 years experience. The result for each modality was compared with the intraoperative arthroscopic assessment.

Patients with Bankart variants seen on arthroscopy were excluded (n = 8). Because of their chronic clinical history, their arthroscopic findings may not correspond to the pathologic findings. So, fifteen patients (14 men and 1 woman, mean age: 26 years, age range: 17–52 years) formed the final study group for statistical analysis.

**Imaging protocol**

MRA was performed on a Signa 1.5-T system (GE Medical Systems, Milwaukee, WI, USA). The shoulder joint in the neutral position, was in a dedicated, phased-array, shoulder coil [Quadrature coil; GE Medical Systems]. The T1-weighted spin-echo images (T1WSE) were taken in the transverse and oblique coronal planes [500/10 [repetition time msec/echo time msec, measurement] with a flip angle of 10°, 3-mm-thick sections, 140 × 140 mm field of view (FOV), 1 mm intersection gap, 256 × 192 pixel matrix, and averaging of two signals]. The three-dimensional fat-suppressed spoiled gradient-echo images (3D FSPGR) were obtained in the transverse plane (25/4, 25° flip angle, 3-mm-thick sections, 140 × 140 mm FOV, no intersection gap, 256 × 192 pixel matrix, two signals averaged). The gradient-recalled-echo T2* images (GRE T2*) were taken in the transverse plane (22/600, 20° flip angle, 4-mm-thick sections, 140 × 140 mm FOV, 1 mm intersection gap, 256 × 192 pixel matrix, three signals averaged). The fast spin-echo proton density-weighted images (FSEPD) in the oblique coronal and oblique sagittal planes were used (30/3000, 10 echo train length, 4-mm-thick sections, 140 × 140 mm FOV, 1 mm intersection gap, 256 × 256 pixel matrix, two signals averaged). Fat-suppressed T2-weighted fast spin-echo images (T2W FSE) were also taken in the oblique coronal plane (85/4000, 14 echo train length, 3-mm-thick sections, 140 × 140 mm FOV, 1 mm intersection gap, 256 × 224 pixel matrix, three signals averaged).

MSCTA was performed on a 16-row multislice CT unit (Sensation 16; Siemens Medical Solutions, Erlangen, Germany). The scan parameters used were a tube voltage of 120 kV, a tube current of 150 mA, feed/rotation 9 mm, collimation beam 0.75 mm, effective pitch 0.75, and the FOV at acquisition of 150 mm in the transverse plane. The image data were reconstructed with a 360° interpolation algorithm and a high-resolution kernel [B60s sharp] at a slice thickness of 1 mm, a 0.7 mm reconstruction increment, and a matrix of 512 × 512 pixels. Oblique coronal and oblique sagittal reconstructions were generated on a 3D workstation, with
3-mm-thick sections and a 3-mm reconstruction interval.

**Image analysis**

The MRA and MDCTA were analyzed independently by two musculoskeletal radiologists with 5 and 4 years of specialty experience, respectively. They had access to only the clinical history. The images were interpreted separately with 1 week between the reading sessions. The MRA in the first session and MDCTA in the second session were evaluated individually. Two radiologists analyzed the type of labral lesion that induced the shoulder instability. The types included classic and bony Bankart lesions, Bankart variants (anterior labroligamentous periosteal sleeve avulsion [ALPSA], Perthes lesion), posterior labral tears, superior labrum anterior-to-posterior [SLAP] lesions, anterosuperior labral tears and sublabral recesses. Consensus was finally obtained in the case of initial disagreement.

The criteria for a classic Bankart lesion were a fragment of labrum attached to the anterior band of the inferior glenohumeral ligament with a ruptured scapular periosteum that was “floating” in the anteroinferior aspect of the glenohumeral joint [6]. Combined evidence of an

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**Fig. 1.** Right shoulder of a 19-year-old man who suffered with recurrent shoulder dislocations for 3 years.

A. MDCTA in the transverse plane shows contrast medium interposition (arrow) between the glenoid rim and the detached capsulolabral complex.

B. T1WSE (TR/TE, 500/10) of MRA in the transverse plane shows a detached anterior labrum (arrow).

C. Arthroscopy confirmed the Bankart lesion (arrows).

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**Fig. 2.** Left shoulder of a 23-year-old man who suffered with anterior shoulder instability for 2 years after falling during a soccer game.

A. MDCTA in the transverse plane shows a slightly thickened, partially detached anterior labrum without displacement (arrow).

B. T1WSE (TR/TE, 500/10) of MRA in the transverse plane shows a fragmented anterior labrum with an intact periosteum (arrow).

C. Arthroscopy confirmed the Perthes lesion (arrows).
osseous lesion led to the diagnosis of a bony Bankart lesion rather than a classic Bankart lesion (4, 6). ALPSA was seen as a tear of the anteroinferior labrum without rupture of the anterior scapular periosteum, stripped and medially displaced inferior glenohumeral ligament, labrum and periosteum (7). A Perthes lesion was also defined as a labroligamentous avulsion, but with a medially stripped intact periosteum (7). A posterior labral tear consisted of posterior labral, capsular and glenoid rim injury that was secondary to posterior dislocation or subluxation of the shoulder joint (6). The criteria for a SLAP lesion were extension of a labral tear into the superior labrum with the lateral or superior portion (3). An anterosuperior labral tear was a tear limited to the anterosuperior aspect of the labrum, with or without associated lesions in the superior and middle portions of the glenohumeral joint (4). A sublabral recess was defined as a sulcus with smooth borders and a medial extension between the superior labrum and bony glenoid (3, 8). A tear of the glenoid labrum was diagnosed when the normal cross-sectional appearance was disrupted or when an abnormal signal intensity was noted. The signal intensity on MRA was compared to that of the nearby muscles or circumferential labrum (9).

**Statistical analysis**

The sensitivity, specificity, accuracy, positive and negative predictive values were calculated for detecting labral lesions from the imaging and gross arthroscopic findings. Statistically significant differences were calculated using the McNemar test. Statistical significance was set at $p<0.05$. All statistical operations were processed using Stata statistical software (version 9.0; Stata, College Station, TX, U.S.A.).

**Results**

**Macroscopic assessment of the two modalities (MRA and MDCTA)**

On arthroscopy, ten Bankart lesions ($n=8$ classic Bankart lesions, $n=2$ bony Bankart lesions), two posterior labral tears and 6 SLAP lesions were visualized in the 18 shoulder joints. Three shoulders with SLAP lesion had another lesion, including a classic Bankart lesion, bony Bankart lesion and posterior labral tear. No anterosuperior labral tears or sublabral recesses were detected on arthroscopy.

The diagnoses, based on MDCTA and MRA, were the same for 16 of the 18 labral lesions; the exceptions were two SLAP lesions. The arthroscopic and imaging findings corresponded to nine Bankart lesions and one posterior labral lesion. One bony Bankart lesion was incorrectly diagnosed as ALPSA on both imaging modalities. For the SLAP lesions, six cases on MRA and four cases on MDCTA matched the arthroscopic findings. Two missed SLAP lesions on MDCTA were in fact sublabral recesses (Table 1).

For the eight Bankart variants ($n=7$ ALPSA, $n=1$ Perthes lesion), MRA correctly diagnosed two cases and MDCTA made three correct diagnoses. The intact periosteum of the Bankart variants on arthroscopy appeared as a tear on MRA and MDCTA.

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**Fig. 3.** Right shoulder of a 46-year-old man who suffered with chronic anterior shoulder dislocation for 10 years after an injury playing volleyball.

**A.** MDCTA in the coronal oblique plane reveals contrast medium interposed within the superior portion of the labrum (arrow).

**B.** T1WSE (TR/TE, 500/10) of MRA in the coronal plane demonstrates an irregularity and pooling of contrast material within the superior labrum (arrow), with no evidence indicating complete extension of the lesion throughout the superior labral substance.

**C.** The arthroscopic view was diagnosed as a SLAP tear (arrows).
Statistical comparison

The respective sensitivity, specificity, accuracy, positive and negative predictive values for detecting Bankart lesion were 90%, 100%, 93.3%, 100% and 83.3% for both MRA and MDCTA (Table 1). The respective results for detecting posterior labral tears were same on both imaging modalities: 50%, 100%, 93.3%, 100% and 92.9%. MDCTA and MRA had the same sensitivities for detecting Bankart lesions and posterior labral tears \( (p=1.00) \). For SLAP lesions, the sensitivity, specificity, accuracy, positive predictive and negative predictive values for MRA were all 100% and those for MDCTA were 66.7%, 100%, 86.7%, 100% and 81.8%, respectively. The difference in the sensitivity between the two groups for detecting SLAP lesions was not significant \( (p=0.09) \); Table 1 on McNemar test.

Discussion

The discrepancy in size between the small glenoid fossa and the large humeral head gives the glenohumeral joint great mobility, but it also makes the shoulder joint particularly vulnerable to dislocation [4]. Anteroinferior dislocation is the most frequent cause of anterior glenohumeral instability and produces a constellation of lesions [classic and bony Bankart lesions, Bankart variants, ALPSA and Perthes lesions and anterosuperior labral tears]. A posterior labral tear may occur during posterior dislocation of the shoulder joint. SLAP lesions involve the superior part of the labrum with varying degrees of biceps tendon involvement [4, 10, 11]. It is important to differentiate a SLAP lesion from a sublabral recess of the superior glenoid labrum to avoid unnecessary surgery [2, 8, 12]. Therefore, radiologically assessing instability of the glenohumeral joint is indispensable for surgical planning and selecting the appropriate treatment [13].

MRA and CT arthrography are highly efficient imaging techniques for diagnosing labral lesions, based on the high contrast resolution from the intra-articular diluted paramagnetic contrast or iodinated agent, and the distension of the joint capsule [1, 2]. Of the two modalities, MRA has been considered the reference standard for the workup of patients with shoulder instability, and MRA has significantly higher sensitivity and specificity [2, 13, 15]. For labral lesions in 28 patients, Chandnani et al. [14] reported a sensitivity of 96% for MRA compared to 93% and 73% for MRI and CT arthrography, respectively. Spiral single-detector row CT did not have sufficient sensitivity for detecting labral lesions. The spiral four-detector row CT that was available in 1998 improved the performance by a factor of eight, and this was the result of combining multiple rows of detectors and faster gantry rotation with narrow collimation. In 2002, 16-slice row CT scanners were introduced, with a further reduction of section collimation and scan time [16]. The advantages of CT arthrography for detecting the calcification of tendon and ligament, and the damage of cortical bone are already acknowledged [1]. In particular, MDCTA allows multiplanar images of the lesions, the same as with MRA. MDCTA even makes reconstruction images with sections that are less than 1 mm thick in any direction, whereas MRA can show only images of a fixed section thickness. Owing to the higher spatial resolution of MDCTA, even small sections of sublabral recesses anterior or posterior to the biceps insertion were better delineated with MDCTA than with MRA [3]. Contrast media extension posterior to the

<table>
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<tr>
<th>Labral lesion finding</th>
<th>Op. Modality</th>
<th>True-positive</th>
<th>True-negative</th>
<th>False-positive</th>
<th>False-negative</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Accuracy (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
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<tr>
<td>Bankart lesion</td>
<td>MDCTA 9</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>90</td>
<td>100</td>
<td>93.3</td>
<td>100</td>
<td>83.8</td>
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<tr>
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<td>MRA 9</td>
<td>5</td>
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<tr>
<td>Posterior labral tear</td>
<td>MDCTA 1</td>
<td>13</td>
<td>0</td>
<td>1</td>
<td>50</td>
<td>100</td>
<td>93.3</td>
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<td>MRA 1</td>
<td>13</td>
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<td>1</td>
<td>50</td>
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<td>93.3</td>
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<td>92.9</td>
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<tr>
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<td>MDCTA 4</td>
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<td>0</td>
<td>2</td>
<td>66.7</td>
<td>100</td>
<td>86.7</td>
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<tr>
<td>SLAP lesion</td>
<td>MRA 6</td>
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Note: * MDCTA = 16-slice multi-detector row computed tomographic arthrography, MRA = Magnetic resonance arthrography
†18 lesions on intra-operative arthroscopy (Op. findings) in 15 shoulder joints
Statistical analysis by McNemar test
biceps anchor during MRA should not be regarded as a reliable criterion for a SLAP lesion [3]. However, MDCTA is appropriate for a patient with a metallic object in the shoulder and is cheaper than MRA.

In some patients who have a chronic history of shoulder instability, a Perthes lesion detected on MRA may be indistinguishable from a normal labrum seen on arthroscopy. Based on intraoperative arthroscopy, the Bankart variants may be indistinguishable from the other classification of labral lesions and the reliability of the surgical findings may be diminished [7]. Therefore, we didn’t include Bankart variants in the statistical analysis of our study.

This prospective study demonstrated that MDCTA and MRA have almost equal sensitivity for labral lesions. No statistically significant differences between the two imaging modalities were found on McNemar test. Therefore, any comparison of our results with other published results differs according to the diagnostic performance of the two modalities for detecting labral lesions [1]. Our results revealed that both MRA and MDCTA are useful techniques for diagnosing labral lesions that induce shoulder instability. MDCTA can help evaluate the presence, degree and classification of a labral tear. This modality can also be used in patients with a metallic object in the shoulder. Conversely, considering MRA as a possible next step after performing MDCTA is an interesting diagnostic option in selected cases. Additional studies will help to further evaluate the performance and applications of this modality.

This study has several limitations. First, only a small number of shoulders were evaluated. We presumed that the sensitivity of CT for detecting calcifications and bone injuries was greater, while MR was more sensitive for diagnosing soft tissue abnormalities, as based on the optimal MR contrast resolution. Nevertheless, in this study, MDCTA was not superior to MRA for detecting the bony defects of bony Bankart lesions. An additional study with a large number of cases should help to clarify the statistical results in this study. One of two bony Bankart lesions was missed on both MDCTA and MRA, resulting in the same sensitivity of 50% for both modalities, but this was too few cases to draw any final conclusion. We also expect a study focusing on a large number of SLAP lesions will show higher detectability on MRA than that on MDCTA. This is because one limitation of MDCTA includes the difficulty in evaluating a SLAP lesion that presents as abnormal signal intensity on MRA.

Second, mixed contrast material was used in this study. The stability of the mixture of gadolinium chelates and iodinated contrast agents has already been reported on, and its clinical safety was manifest for performing CTA and MRA of the ankle and wrist as a one-shot CTA-MRA exam [1, 17]. Nevertheless, a decrease in the signal intensity on MRA was seen due to the dilution of the gadolinium chelate mixed with the iodinated contrast agent [1]. This might have reduced the sensitivity of MRA for Bankart variants in this study, as compared to previous studies [1, 3, 4, 7, 13]. So, the MRA protocol included one T1-weighted and five PD/T2/T2*-weighted pulse sequences.

In conclusion, the sensitivity of detecting labral lesions that induce shoulder instability was almost equal for MDCTA and MRA in this prospective study. The capability of MDCTA for isotropic data acquisition with high spatial resolution appears to be a promising precondition for the accurate diagnosis and classification of labral lesions. MDCTA is very effective for the diagnosis and evaluation of shoulder instability.

References


