Discrepancy between Fluoroscopic Arthrography and Magnetic Resonance Arthrography in Patients with Arthroscopically Confirmed Supraspinatus Tendon Tears: The Additional Benefit of Cine Fluoroscopic Arthrography Images

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Purpose: To determine the additional diagnostic benefits of fluoroscopic arthrography (FA) in patients with full-thickness supraspinatus tendon (SST) tears by comparing FA images with magnetic resonance arthrography (MRA) images.

Materials and Methods: This study included FA and MRA images of 53 patients who were confirmed to have full-thickness SST tears by arthroscopy. In the FA analysis, the presence of contrast leakage into the subacromial-subdeltoid bursa was recorded. In the MRA analysis, contrast leakage, retraction of a torn tendon, width and length of the tear, and supraspinatus atrophy were evaluated. Patients were divided into the concordant group or the discordant group based on the presence of contrast leakage to compare the characteristics of SST tears. We used Fisher’s exact test and two-sample t-test for the comparison.

Results: Of the 53 patients, 34 were included in the concordant group and 19 were included in the discordant group. In the concordant group, the grades of retraction were higher than those in the discordant group; the width and length of the tears were larger. Muscle atrophy was more severe in the concordant group.

Conclusion: A full-thickness SST tear did not always exhibit contrast leakage on FA, particularly small SST tears or tears with low-grade retraction. FA can provide diagnostic information regarding the severity of full-thickness SST tears by itself.

Index terms
Shoulder
Arthrography
Magnetic Resonance Imaging
Fluoroscopy

INTRODUCTION

Magnetic resonance arthrography (MRA) of the shoulder is widely used despite the pain and discomfort associated with its use, because it provides high sensitivity and specificity for rotator cuff tears (1-4). It can also provide clear discrimination between rotator cuff tears and small anatomical variations (5, 6).

Intra-articular injection into the glenohumeral joint is an important procedure performed prior to shoulder MRA (7). Currently, the use of digital radiology allows the entire procedure of fluoroscopic arthrography (FA) to be recorded as cine images.

Arthrographic findings showing contrast leakage into the subacromial-subdeltoid bursal space can be used to investigate the pathologic condition of supraspinatus tendon (SST) tears,
such as a full-thickness tear. However, in some cases, unexpected discrepancies occur between arthrography and MRA, showing no contrast leakage on arthrography but a full-thickness SST tear on MRA.

To the best of our knowledge, no study has examined the differences between arthrography and MRA for shoulder pathology. The purpose of this study is to determine if there are additional diagnostic benefits of FA in patients with arthroscopically confirmed full-thickness SST tears by comparing FA images with MRA images.

**MATERIALS AND METHODS**

**Patient Selection**

Our retrospective study was approved by the hospital’s Institutional Review Board. From September 2012 to March 2013, we identified 150 patients who underwent arthroscopy for shoulder pain and had an SST tear reported in their arthroscopic operation notes. Ninety-seven patients were excluded because of the following criteria: 1) no available preoperative MRA and FA data, including conventional magnetic resonance image (MRI) without arthrography ($n = 22$), lack of FA ($n = 14$), and magnetic resonance (MR) imaging performed in other hospitals ($n = 57$), and 2) partial-thickness SST tear ($n = 4$). After exclusion, 53 patients (age range, 35–76 years; mean age, 64.3 years) with an arthroscopically confirmed full-thickness SST tear were enrolled in this study. Of them, seven patients had an articular-sided partial thickness tear of the infraspinatus tendon (IST) and two patients had a full thickness tear of the IST. In their operation records, there was no fibrous adhesion at the tear site or in the adjacent area. The mean interval between MR examination and arthroscopic surgery was 32.7 days (range, 27–36 days). Of the patients enrolled, 21 were men (39.6%) and 32 were women (60.4%), and 39 patients (73.6%) affected on the right side and 14 patients (26.4%) affected on the left side were evaluated.

**Fluoroscopic Arthrography and Magnetic Resonance Arthrography**

All patients provided written informed consent for the procedure. A 23-gauge needle was inserted into the glenohumeral joint via an anterior approach under pulsed fluoroscopic guidance (Zexira DREX-ZX80, Toshiba Medical Systems Corporation, Otawara, Japan). The injection was performed with the patient supine in a straight anteroposterior position. The injection consisted of approximately 20 cc of the following mixture: 2 cc of ioxitalamic acid (Telebrix 30 Meglumine, Guerbet, Aulnaysous-Bois, France), 0.08 cc gadopentetate dimeglumine (Magnevist, Bayer Schering Pharma AG, Berlin, Germany), and 18 cc normal saline. Standard sterile management was applied in all procedures. Approximately 16–18 cc of contrast mixture was injected into the glenohumeral joint and cine images were obtained during the injection period by FA.

After arthrography, patients were escorted to the MRI room, and a shoulder MRA was performed within 20 minutes. One of the three 3T MRI systems with a dedicated shoulder coil were used (Achieva or Achieva TX, Philips Healthcare, Best, the Netherlands, $n = 25$; Discovery MR 750, GE Healthcare, Milwaukee, WI, USA, $n = 8$; and Trio, Siemens Healthcare, Erlangen, Germany, $n = 20$). Conventional 2D images, including fat saturation T1-weighted axial images (repetition time/echo time, 690/20 ms in Philips, 570/7 ms in Siemens, and 580/10 ms in GE; slice thickness/interslice gap, 3/0.3 mm; field of view, 140 × 140 mm), oblique coronal and oblique sagittal images (repetition time/echo time, 640/10 ms in Philips, 530/7 ms in Siemens, and 580/10 ms in GE; slice thickness/interslice gap, 3/0.3 mm; field of view, 140 × 140 mm), T2-weighted oblique coronal images (repetition time/echo time, 3300/70 ms in Philips, 3500/80 ms in Siemens, and 3300/70 ms in GE; slice thickness/interslice gap, 3/0.3 mm; field of view, 140 × 140 mm), and T1-weighted oblique sagittal images (repetition time/echo time, 690/8 ms in Philips, 620/8 ms in Siemens, and 530/8 ms in GE; slice thickness/interslice gap, 3/1 mm; field of view, 140 × 140 mm), were obtained.

**Imaging Interpretation**

Two musculoskeletal radiologists (one radiologist with more than 8 years of experience in musculoskeletal imaging and one radiologist with musculoskeletal radiology fellowship) independently reviewed both FA images and MRA images in a random order within a two-week time span. They kept a two-week interval between evaluation of each set of FA and MRA images. They were blinded to radiologic reports, arthroscopic findings, and any clinical information. In both FA and MRA analyses, presence of contrast leakage into the subacromial-subdeltoid bursa was checked. We measured the width of tears on fat satu-
ration T1-weighted oblique coronal images, and the length of tears on fat saturation T1-weighted oblique sagittal images. We categorized SST retraction into 3 grades using a published method for determining the Patte score on T2-weighted oblique coronal images: little, humeral head level, and glenoid level (8). We then assessed supraspinatus muscle atrophy using the tangent sign and occupation ratio. We considered that the tangent sign was absent when the superior margin of the supraspinatus muscle was superior to the line tangential to the coracoid and scapular spine (9, 10). Occupation ratio was measured according to the method described by Thomazeau et al. (11) and Khoury et al. (12), which was the ratio between the cross section of the supraspinatus muscle belly and that of its fossa on the T1-weighted oblique sagittal image crossing through the medial border of the coracoid process of the scapula. Lines were drawn as close as possible to the supraspinatus outer margin, inner margins of the coracoid process and scapular spine, and superior limits of the supraspinatus fossa.

We accepted consensus for the presence and grading and considered the average of the two readers’ values for measurements. Finally, we divided the patients into the following two groups: Group 1, concordant group (leakage into the subacromial-subdeltoid bursa on both MRA and FA) and Group 2, discordant group (leakage on MRA, but no leakage on FA). All measurements were performed using a picture archiving and communication system (PACS, Centricity Radiology RA 1000; General Electric Healthcare, Chicago, IL, USA).

**Statistical Analyses**

Fisher’s exact test was used to compare categorical variables, and two-sample *t*-test was used to compare continuous variables between the groups. SPSS software version 20.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses. Findings were considered statistically significant when the *p*-value was less than 0.05.

**RESULTS**

Of the 53 patients, 34 (64.2%) were included in the concordant group (Fig. 1), and the remaining 19 (35.8%) were included in the discordant group (Fig. 2, Table 1). None of the patients showed leakage on FA only. The mean values of the width and length of SST were significantly larger in Group 1 than in Group 2 (*p* = 0.01 and 0.02, respectively). With respect to the SST retraction grade, there was a significant difference between the two groups (*p* = 0.03). Both the tangent sign and occupation ratio showed significant differences between the two groups (*p* < 0.01, both).

All patients with tendon retraction at the glenoid level (8/53, 15.1%) belonged to Group 1. There were a total of 16 patients with confirmed massive SST tears. Of them, 15 patients who had massive SST tears (15/53, 28.3%) belonged to Group 1. One patient...
with a massive SST tear who belonged to Group 2 also had a full-thickness subscapularis tendon tear (Fig. 3).

**DISCUSSION**

To evaluate SST tears using shoulder MRA, direct arthrography is a necessary and important procedure for glenohumeral injection. It can be uncomfortable for patients because of pain, time consumption, and radiation if the procedure is performed under fluoroscopic guidance. In general, this intra-articular injection could be regarded as a brief procedural step prior to MRA. However, more information can be obtained from the digitally stored cine FA images. In practice, we usually find concordant results between FA and MRA, but discordant results were observed in some patients. We reviewed the literature and identified the differences between FA and MRA, but we did not find any reports specifically related to this subject. In this study, we tried to determine if there are any differences between FA and MRA findings.

![Fig. 2. A 48-year-old female patient in Group 2 (discordant group).](image)

**Table 1. Comparison between Group 1 and Group 2**

<table>
<thead>
<tr>
<th></th>
<th>Group 1 ($n = 34$)</th>
<th>Group 2 ($n = 19$)</th>
<th>$p$-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td>0.558</td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>22</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>65.5 ± 7.9</td>
<td>63.5 ± 7.9</td>
<td>0.375</td>
</tr>
<tr>
<td><strong>Side</strong></td>
<td></td>
<td></td>
<td>0.748</td>
</tr>
<tr>
<td>Right</td>
<td>24</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Retraction grade</strong></td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Little</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Humeral head level</td>
<td>25</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Glenoid level</td>
<td>8</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Width (mm) of tear</strong></td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>Little</td>
<td>15.4 ± 6.5</td>
<td>16.4 ± 6.5</td>
<td></td>
</tr>
<tr>
<td>Humeral head level</td>
<td>25.1 ± 9.4</td>
<td>16.8 ± 7.3</td>
<td>0.02</td>
</tr>
<tr>
<td>Glenoid level</td>
<td>8</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Tangent sign</strong></td>
<td></td>
<td></td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Yes</td>
<td>21</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>13</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td><strong>Occupational ratio (%)</strong></td>
<td></td>
<td></td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>43.8 ± 15.1</td>
<td>66.6 ± 15.8</td>
<td></td>
</tr>
</tbody>
</table>

*Mean ± standard deviation.
and to observe if there are additional benefits of FA images. We compared the FA and MRA findings between the concordant and discordant groups with respect to confirmed full-thickness SST tears. As mentioned in the results, the concordant group showed not only wider and longer SST tears but also higher grades of SST retraction than the discordant group. Because the dimensions of SST tears and retraction of SST reflect the overall defect size of SST tears, our results indicate that if SST tears are large, the possibility of leakage on FA images is high. The concordant group also had more patients with a positive tangent sign and showed a lower occupation ratio than the discordant group. A positive tangent sign and a low occupation ratio demonstrate atrophy of the supraspinatus, which can be correlated with the chronicity of the tear. We think that patients in the concordant group had more advanced supraspinatus atrophy and it would take longer for detection after the event of a SST tear.

We can explain the difference between the concordant and discordant groups by flap tears or a one-way check valve mechanism. If the SST tear is small, the edge of the torn tendon or fibrosis that develops after the tear can act as a check valve that blocks the flow of injected contrast from the glenohumeral joint cavity into the subacromial-subdeltoid bursa during FA. On the other hand, during preparation for MRA, the physical movement required (e.g., walking, raising the affected arm, or lying down) can cause a change in the pressure gradient between the joint and the bursa. The pressure change allows a greater flow of the contrast into the bursal space; therefore, leakage appears on MRA images. Conversely, if the defect is large, the valve-like action is not sufficient to interrupt the flow. This mechanism can explain the difference between the concordant and discordant groups.

The results of our study can be helpful in situations when only shoulder FA is available. Corticosteroid or nonsteroidal anti-inflammatory drug injection into the glenohumeral joint under fluoroscopic guidance is one of these clinically useful instances. Fluoroscopic guidance is generally used for glenohumeral injection and it has several advantages such as a wider view of bony structures or confirmation of successful injection when a mixture with contrast media is used.

There are many conditions that can cause shoulder pain such as osteoarthritis, adhesive capsulitis, rotator cuff disease, and labral pathology (13). Intra-articular corticosteroid injection has shown a short- or medium-term therapeutic effect because corticosteroids are powerful anti-inflammatory drugs (14). If contrast leakage is found in the subacromial-subdeltoid bursa on FA images during injection, we can infer that the patient has a full-thickness rotator cuff tear and it is relatively large. Moreover, we can inform the patient regarding his or her current shoulder status and recommend the appropriate treatment rather than
corticosteroid injection.

However, there are several limitations to this study. First, it was a retrospective study, but all patients had full-thickness tears confirmed by arthroscopic surgery. Second, we focused on only full-thickness SST tears because it is difficult to detect partial-thickness tears with FA images. Third, the injection into the glenohumeral joint consisted of only approximately 16–18 cc of contrast mixture, and the unique case (a case of a massive SST tear in the discordant group) in which leakage was not visible on FA images occurred due to this reason (Fig. 3). The injected contrast mixture leaked into another site of severe injury in this patient; hence, leakage into the subacromial-subdeltoid bursa did not occur. If more amount of the contrast mixture was injected into the joint, the leakage would have been visible on FA images. Fourth, two patients had a full thickness tear of the IST in our study. The situation that contrast leakage occurs into the subacromial-subdeltoid bursa via the IST tear site cannot be excluded. Finally, a small number of variables were used to compare the concordant and discordant groups.

In conclusion, not all full-thickness SST tears showed contrast leakage on FA images, especially small SST tears or tears with low-grade retraction. Because the concordance between FA and MRA is more frequent in patients with larger SST tears and greater worsening of supraspinatus atrophy, FA can provide diagnostic information to determine the severity of full-thickness SST tears by itself and it has the potential to be used as another imaging modality to evaluate these tears.

Acknowledgments

This work was supported by a National Research Foundation (NRF) grant funded by the Korea government, Ministry of Science, ICT & Future Planning (MSIP, 2015R1A2A1A05001887).

REFERENCES

관절경으로 확인된 극상건 파열 환자들에게 있어서 투시 관절 조영술과 자기공명 관절 조영술의 불일치: 영화 투시 관절 조영술의 추가적 이점

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목적: 관절경으로 확인된 극상건 완전 파열 환자들에 대해서 투시 관절 조영술 영상과 자기공명 관절 조영술 영상을 비교함으로써 투시 관절 조영술의 추가적인 진단적 이점을 알고자 하는 것이다.

대상과 방법: 이 연구에는 관절경을 통해 확인된 53명의 극상건 완전 파열 환자들이 포함되었다. 투시 관절 조영술 분석에서는 견봉하-삼각근하 점액낭으로의 누출을 기록하였다. 자기공명 관절 조영술의 분석에서는 견봉하-삼각근하 점액낭으로의 조영제 누출, 파열진의 수축, 파열의 나이비와 같이, 극상근의 위축 등을 평가하였다. 극상건 파열의 특징을 비교하기 위해 환자들을 조영제 누출 유무에 따라 일치군과 불일치군으로 나누었다. 비교를 위해 피셔의 정확검정과 두 표본 t-검정을 사용하였다.

결과: 총 53명의 환자 중 34명이 일치군이었고, 19명이 불일치군이었다. 일치군이 파열진 수축의 정도가 불일치군보다 높았으며, 파열의 나이비와 같이도 일치군이 불일치군보다 컸다. 근육 위축은 일치군에서 더 심했다.

결론: 극상건 완전 파열은 투시 관절 조영술에서 조영제 누출이 항상 보이지 않는데, 특히 극상건 파열이 작거나 파열진 수축이 심하지 않는 경우 보이지 않았다. 투시 관절 조영술은 이 점에서 극상건 완전 파열의 심한 정도에 대해 진단적 정보를 제공할 수 있다.

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