Indirect MR arthrography of the shoulder in detection of rotator cuff ruptures

**Abstract** The aim of this study was to compare the efficacy of indirect MR arthrography images obtained following intravenous contrast injection and conventional MR imaging in the diagnosis of rotator cuff tears. Twenty-four patients with clinically suspected rotator cuff disease were examined. Conventional MR images and post-contrast indirect MR arthrography images were obtained. All images were evaluated in a blinded fashion by two musculoskeletal radiologists. Results were analyzed depending on surgical output. The correlation coefficient (Spearman rank correlation test) and the kappa values for agreement between surgery and imaging techniques were calculated. The correlation coefficients between indirect MR arthrography and surgery for reader 1 and reader 2 were 0.9137 and 0.9773, respectively. Whereas the agreement between conventional MR imaging and surgery was moderate ($\kappa = 0.383–0.571$), the agreement between indirect MR arthrography and surgery was excellent ($\kappa = 0.873–0.936$). We suggest the use of indirect MR arthrography technique when conventional MR images are equivocal in diagnosis of rotator cuff disease.

**Key words** Magnetic resonance imaging · Indirect MR arthrography · Shoulder · Rotator cuff rupture

**Introduction** Shoulder pain is a common clinical problem with numerous causes, including glenohumeral joint instability, subacromial impingement, and rotator cuff tendon failure [1]. These changes can be misdiagnosed clinically. In the absence of a precise diagnosis, treatment may fail to relieve the symptoms, resulting in chronic limitation of motion, atrophy, and persistent pain.

Magnetic resonance imaging has been shown to be accurate in the detection of these shoulder pathologies [2, 3]. Complete rotator cuff tears generally are easily diagnosed on MR images. Nevertheless, in some cases differentiation among complete rotator cuff tears, partial tears, tendinopathy, and degeneration is difficult [4, 5].

In MR imaging of shoulder, diagnostic success requires delineation of complex anatomic structures and demonstration of subtle abnormalities. Magnetic resonance arthrography extends the capabilities of conventional MR imaging because intra-articular contrast material outlines abnormalities. However, direct intra-articular injection of saline or paramagnetic contrast material is invasive and is complicated by the need for fluoroscopic guidance. It has recently been shown that intravenously administered gadopentetate dimeglumine also enhances the joint cavity [6]. This technique was proposed as a practical alternative to direct MR arthrography [7].

The purpose of this study was to prospectively compare the efficacy of conventional MR imaging and indirect MR arthrography in the diagnosis of rotator cuff tears.
Fig. 1 Comparison of paracoronal T1-weighted SE (left) and fat-saturated T1-weighted post-contrast spin-echo (right) images. Anatomic contour delineation is superior on fat-saturated T1-weighted post-contrast image as compared with the image without fat suppression and contrast injection. Note contrast accumulation in subdeltoid bursa and glenoid cavity at right image

Fig. 2 T2-weighted paracoronal MR image (right) obtained prior to contrast injection and T1-weighted fat-saturated paracoronal image (left) at the same level following contrast administration. Note the massif rupture which is more conspicuous on right side but well-delineated on fat-saturated contrast image

Materials and methods

Between August 1997 and June 1998, 24 patients underwent both conventional MR imaging and indirect MR arthrography for clinically suspected labral or rotator cuff abnormalities. Arthroscopy (n = 1) or open surgery (n = 23) were performed in all of these patients. The patients were 16–73 years old (mean age 52 years; 17 women and 7 men). Informed consent was obtained from each patient.

The MR imaging was performed with a 1.0-T superconductive magnet (Magnetom SP 42, Siemens, Erlangen, Germany) and a shoulder surface coil. Firstly, standard unenhanced MR images were obtained. Imaging parameters for axial and paracoronal T1-weighted imaging were as follows: TR/TE = 600/15 ms; 160-mm field of view (FOV); 200 × 256 matrix; 3-mm slice thickness; 0.3-mm gap between slices; three signals averaged. Paracoronal T2-weighted images (TR/TE = 2000/25–70 ms) were obtained with a 160-mm FOV, 140 × 256 matrix, 4-mm slice thickness, 0.4-mm interslice gap, and two signals averaged. Parasagittal T2*-weighted gradient-echo fast imaging with steady-state precession (FISP) images (TR/TE/flip angle = 500/12 ms/15°) were obtained with a 160-mm FOV, a 140 × 256 matrix, 4-mm slice thickness, 0.4-mm interslice gap, and five signals averaged. The total duration of this routine conventional MR examination was approximately 35 min.

After routine MR imaging, each patient was imaged with indirect MR arthrography. In this procedure, 0.1 mmol/kg gadopentetate dimeglumine (Magnevist, Schering, Berlin, Germany) was injected intravenously, and the shoulder was exercised for an average 15 min (range 10–20 min). Following the exercise, spin-echo T1-weighted axial images were obtained once more. In addition, frequency-selective fat-suppressed T1-weighted (TR/TE = 975/22 ms) paracoronal and parasagittal images were obtained. Imaging parameters were: 160-mm FOV; 192 × 256 matrix; 3-mm slice thickness; 0.3-mm interslice gap; and two signals averaged. The total examination time of this indirect MR arthrography was approximately 25 min.

The duration between routine MR imaging and indirect MR arthrography examinations was approximately 11 days (range 0–27 days).

Unenhanced and enhanced images were interpreted independently by two experienced musculoskeletal radiologists without benefit of clinical data. Firstly, routine MR images, and 4 weeks later indirect MR arthograms, were interpreted. Images were evaluated independently for abnormalities of rotator cuff, labrum, and capsular anatomy by using standard criteria established in recent literature.

The duration between indirect MR arthrography examination and surgery was approximately 7 days (range 1–23 days).

Sensitivity, specificity, and accuracy rates were calculated for each technique and reader. The results of MR techniques and surgery were compared using Spearman rank correlation coefficient test. The kappa (κ) values for agreement between surgery and imaging techniques, and between readers, were calculated. The κ values are interpreted as follows: 0.81–1.00, excellent agreement; 0.61–0.80, good agreement; 0.41–0.60, moderate agreement; 0.21–0.40, fair agreement; and 0.00–0.20, poor agreement.

Results

No complications were associated with intravenous injection of the gadopentetate dimeglumine. Exercises of shoulder were well tolerated by all patients, even in painful shoulders. The intravenous administration of gadopentetate dimeglumine produced marked enhancement of the joint cavity in all patients. Intravenously injected paramagnetic contrast material outlined the surface of rotator cuff (Fig. 1). Complete tears were identified by discontinuity of the tendon (Fig. 2). Partial tears were identified by irregularity of the surface of the cuff without actual discontinuity of the cuff tendon.

According to the surgery reports, there were 10 complete tears, 5 partial tears, and 9 rotator cuffs with