The Use of Magnetic Resonance Arthrography to Detect Partial-Thickness Rotator Cuff Tears

By William B. Stetson, MD, Thomas Phillips, MD, and Andrew Deutsch, MD

Introduction

Partial-thickness rotator cuff tears can be caused by trauma or anatomic impingement, or they can be a natural consequence of aging. They may involve either the articular surface, the bursal surface, or both sides of the rotator cuff. They can be asymptomatic or a potential source of shoulder dysfunction. Recent studies have seemed to indicate that partial-thickness cuff tears can progress and do not heal on their own[1]. The articular side of the rotator cuff is hypovascular (Fig. 1), and the collagen bundles on the articular side are thinner and less uniform (Fig. 2), making articular-sided partial-thickness rotator cuff tears two to three times more common than bursal-sided tears[2-8].

Magnetic resonance imaging, although a useful and established technique for detecting full-thickness rotator cuff tears, has been found to be less reliable in detecting partial-thickness tears. With the use of standard magnetic resonance imaging techniques, many partial-thickness rotator cuff tears are missed[9-12]. In 1992, Traughber and Goodwin reported a sensitivity ranging from 56% to 72% and a specificity ranging from 83% to 85% for arthroscopically proven partial-thickness rotator cuff tears[9]. However, in another study, an 83% rate of false-negative results was reported for arthroscopically proven partial-thickness tears[10]. Wright and Cofield found only six definite partial-thickness tears on preoperative magnetic resonance imaging studies in eighteen patients with arthroscopically proven partial-thickness tears[11].

Magnetic resonance arthrography may improve the sensitivity in the detection of partial-thickness rotator cuff tears. Two years ago, we began a prospective study to detect partial-thickness articular-sided rotator cuff tears using an intra-articular injection of gadolinium and magnetic resonance imaging. We hypothesized that this technique would help us in the evaluation and treatment of patients in whom the diagnosis is un-

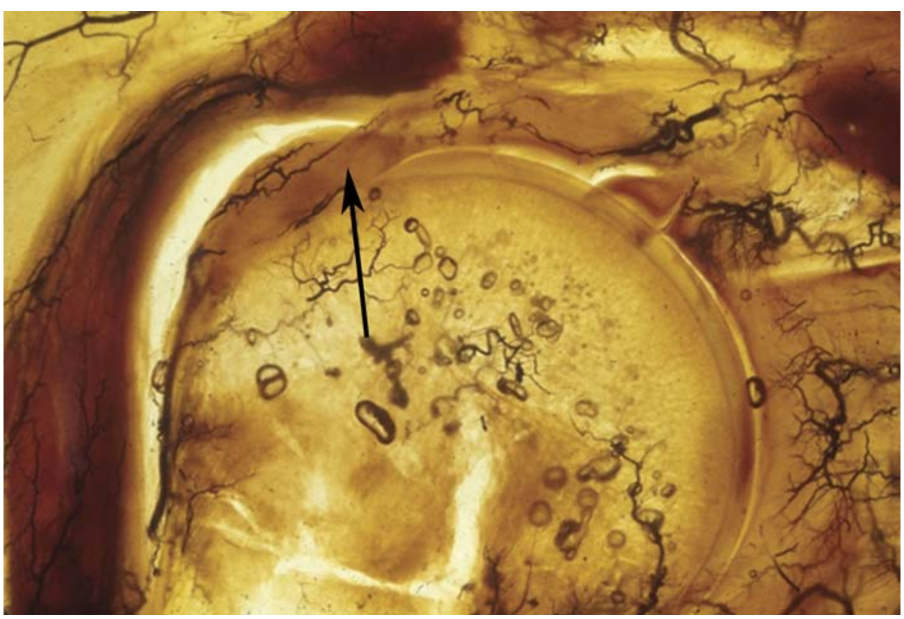

Fig. 1
Coronal photomicrograph of the zone of diminished vascularity of the supraspinatus tendon. The arrow points to the critical zone of hypovascularity of the articular side of the tendon.

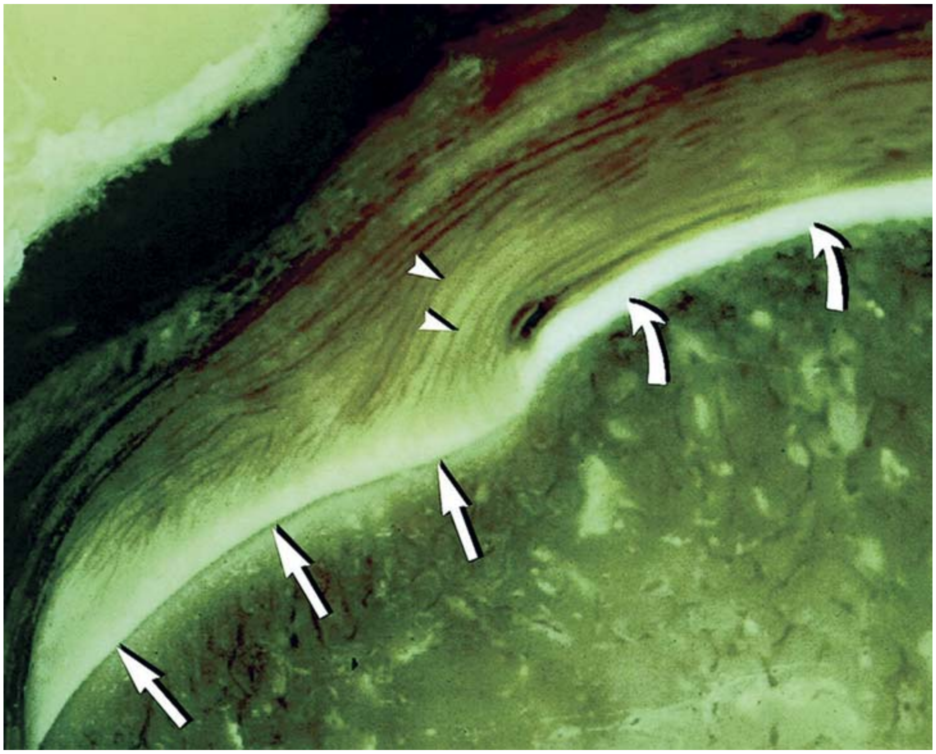

Fig. 2
Coronal photomicrograph of the tendinous insertion of the supraspinatus tendon. The arrowheads point to the thinner, less uniform collagen bundles of the articular side of the supraspinatus tendon. The larger arrows below point to the tendinous insertion to the humeral head. The curved arrows on the right point to the articular surface of the humeral head.

clear. The purpose of this study was to determine whether the use of magnetic resonance arthrography is useful in detecting partial-thickness articular-sided rotator cuff tears.

Materials and Methods

A prospective, nonrandomized study of fifty patients with chronic shoulder pain who were suspected of having a rotator cuff abnormality underwent magnetic resonance arthrography with use of an intra-articular injection of gadolinium.

The technique involves injecting 1.5 mL of gadolinium with normal saline solution intra-articularly into the glenohumeral joint under fluoroscopic control. Following the injection, magnetic resonance imaging was performed with a 1.5-T scanner (Horizon LX; General Electrical Medical Systems, Milwaukee, Wisconsin) with use of the following sequences: axial proton-density-weighted image with fat suppression, oblique coronal proton-density-weighted image, oblique coronal T2-weighted with fat suppression, oblique sagittal T1-weighted, and oblique sagittal proton-density-weighted image with fat suppression. In addition, axial T1-weighted with fat suppression, oblique coronal T1-weighted with fat suppression, and abduction and external rotation images were also acquired. All scans were acquired at the same imaging center and were read by the same fellowship-trained

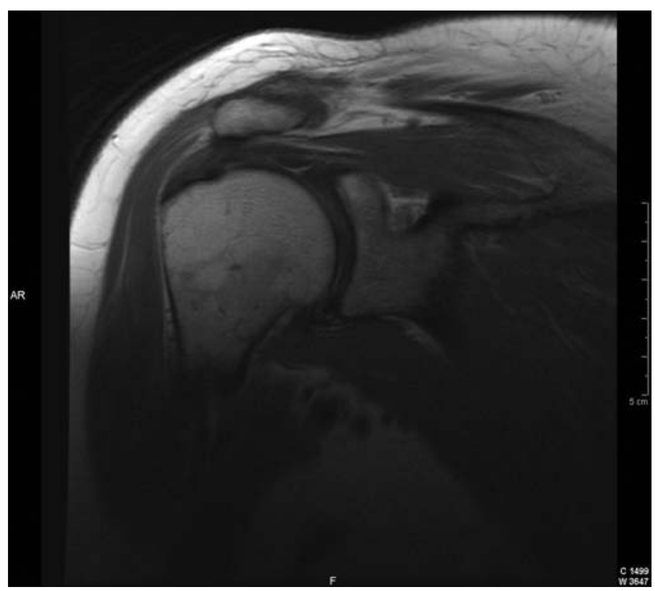

Fig. 3-A
Figs. 3-A through 3-D Case 1, a thirty-eight-year-old man with a partial-thickness rotator cuff tear. **Fig. 3-A** A coronal oblique T1-weighted magnetic resonance image without intra-articular gadolinium shows normal findings.

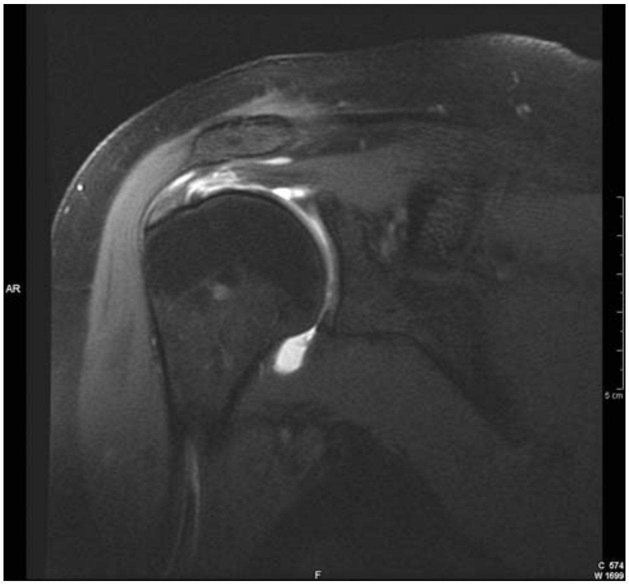

Fig. 3-B

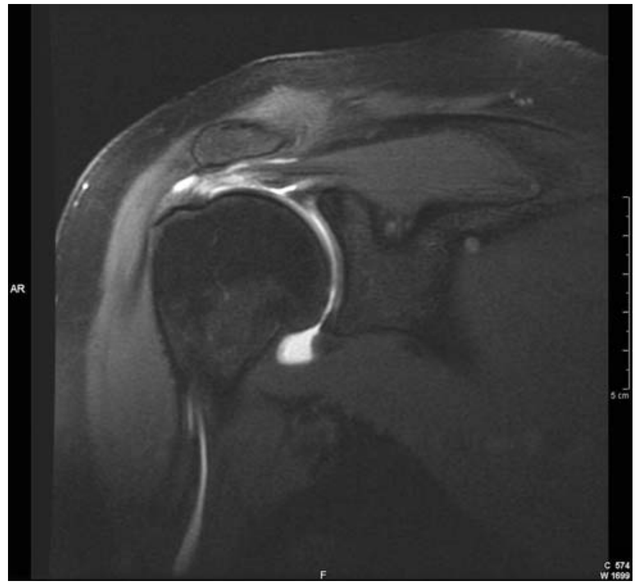

Fig. 3-C

Figs. 3-B and 3-C Coronal oblique T2-weighted magnetic resonance arthrograms after intra-articular injection of gadolinium shows a partial-thickness articular-sided tear of the supraspinatus tendon.

musculoskeletal radiologist (A.D.). The depth and extent of any rotator cuff tear were recorded.

All fifty patients were eventually taken to surgery and underwent a complete 15-point glenohumeral arthroscopic examination by the senior author (W.B.S.). The presence or absence of articular-sided rotator cuff tears was recorded and compared with the findings on magnetic resonance arthrography.

Results

A partial-thickness articular-sided rotator cuff tear was correctly diagnosed with magnetic resonance arthrography (a true-positive result) in twenty-one patients and was verified at the time of shoulder arthroscopy. Twenty-three patients were correctly diagnosed as having normal rotator cuffs (a true-negative result). Four patients were incorrectly diagnosed with magnetic resonance arthrography, as having a full-thickness tear, but, at the time of shoulder arthroscopy, they had large partial-thickness articular-sided tears (a false-positive result). Two patients were diagnosed as having a normal rotator cuff on magnetic resonance arthrography, but they had a partial-thickness articular-sided tear at the time of arthroscopy (a false-negative result).

The sensitivity of magnetic resonance arthrography in detecting partial-thickness articular-sided tears was 91% with a specificity of 85%, a positive predictive value of 84%, and a false-negative rate of 9%.

Case Reports

Case 1. A thirty-eight-year-old right-hand dominant man reported a two-year history of pain in the right shoulder. He had been an avid volleyball player since the age of sixteen. He did not recall any particular injury or accident, but the pain started insidiously and had increased in severity. He continued to play volleyball until six months prior to the evaluation, when the pain had become so severe he had to stop playing. He rested the shoulder for three months, but the pain persisted. A magnetic resonance imaging scan was done by his primary care physician and was read as normal. He completed two months of physical therapy, but the symptoms persisted. He sought alternative care, including chiropractic intervention, acupuncture, faith healing, and herbal remedies, all of which failed to relieve the symptoms.

He then sought orthopaedic consultation in our office. At

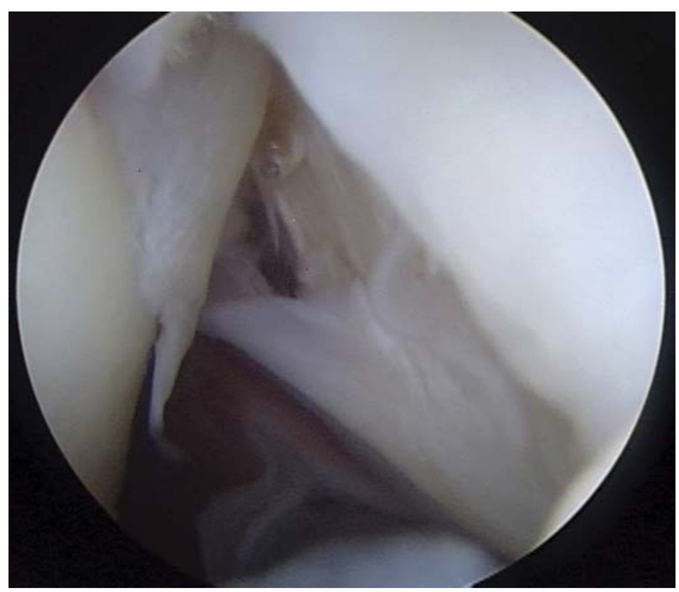

Fig. 3-D

Arthroscopic image looking from the posterior portal anteriorly at the supraspinatus tendon showing the partial-thickness articular-sided tear.

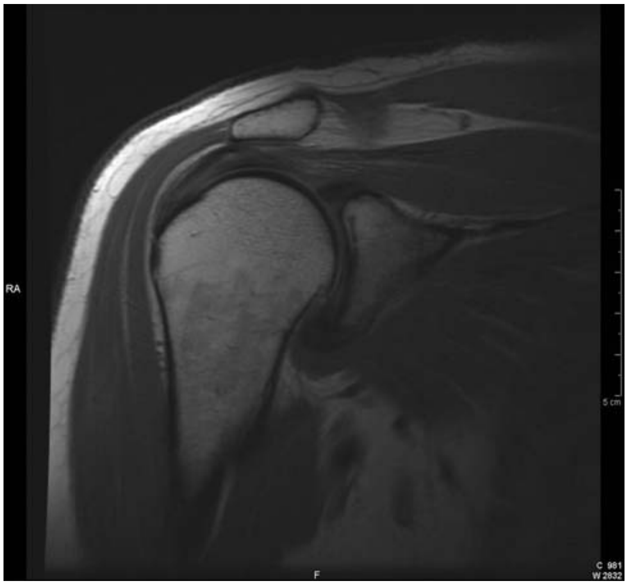

Fig. 4-A

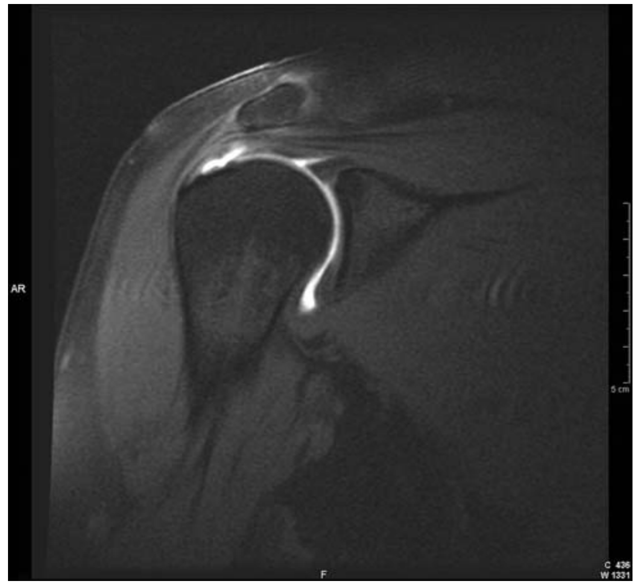

Fig. 4-B

Figs. 4-A through 4-F Case 2, a forty-five-year-old man with a partial-thickness tear of the supraspinatus tendon. **Fig. 4-A** Coronal oblique T1-weighted magnetic resonance image that was read as tendinosis of the supraspinatus tendon. **Fig. 4-B** Coronal oblique T2-weighted magnetic resonance arthrogram showing the partial-thickness undersurface tear of the supraspinatus tendon.

his initial presentation, he reported night pain and pain with overhead activities. On physical examination, he had a full range of motion of the right shoulder without limitation; he had a mildly positive test for the Neer impingement sign and a negative test for the Hawkins sign. He had 5/5 motor strength on supraspinatus testing accompanied by pain. He had a negative apprehension test and no evidence of any anterior, posterior, or multidirectional instability. A repeat magnetic resonance imaging scan had normal findings (Fig. 3-A). The scan was then repeated with intra-articular gadolinium, which showed the partial-thickness articular-sided tear of the supraspinatus tendon (Figs. 3-B and 3-C). Shoulder arthroscopy was then performed where the partial tear of the supraspinatus tendon was found (Fig. 3-D). The tear was débrided and converted to a full-thickness tear, and an arthroscopic rotator cuff repair was performed with use of suture anchors.

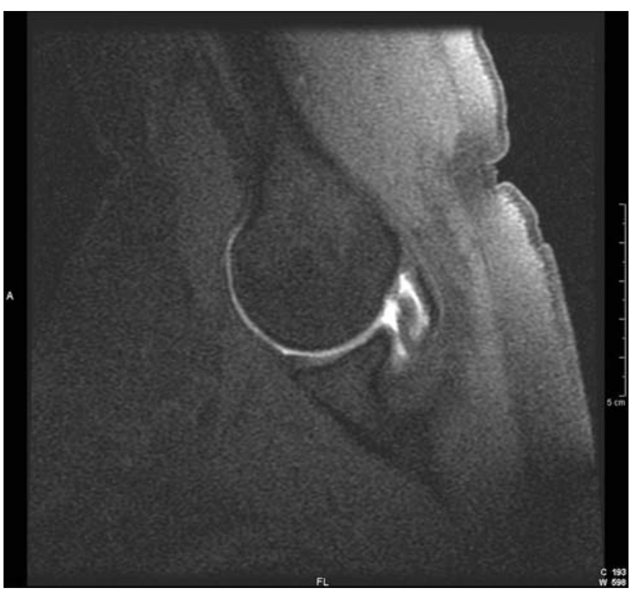

Fig. 4-C

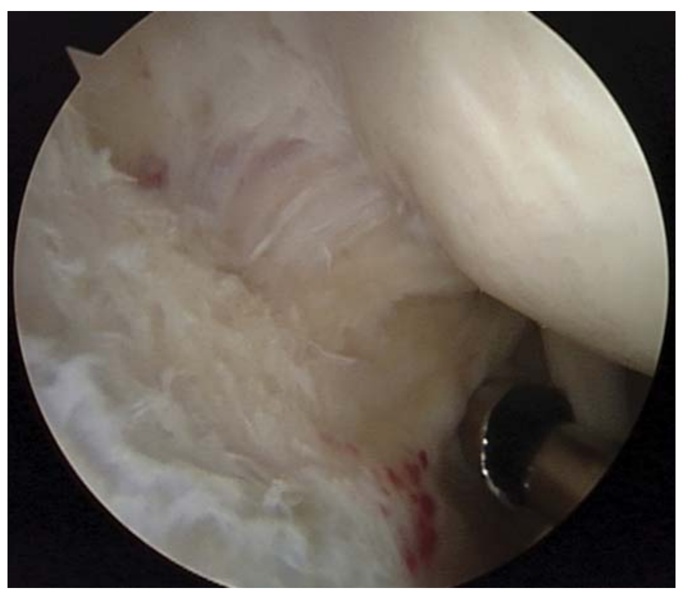

Fig. 4-D

Fig. 4-C Axial T2-weighted abduction and external rotation view showing the partial-thickness articular-sided tear of the supraspinatus tendon.
Fig. 4-D The partial-thickness tear of the supraspinatus tendon has been débrided with the full radius shaver, which is in the anterior superior portal in the rotator interval.

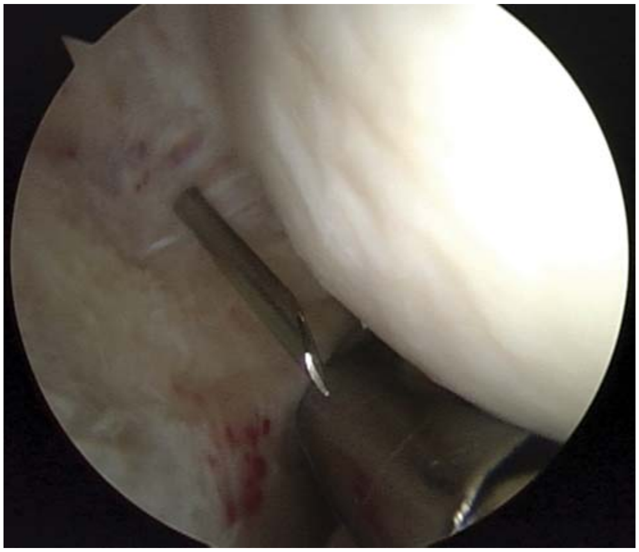

Fig. 4-E

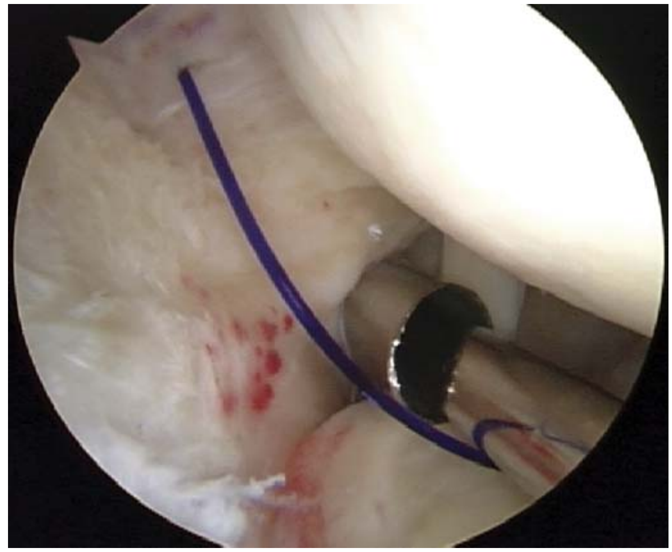

Fig. 4-F

Fig. 4-E A spinal needle is inserted percutaneously through the partial tear so that a marker suture (PDS; polydioxanone) can be placed. **Fig. 4-F** The marker suture is placed, and the spinal needle removed. This allows easy identification of the bursal side of the tear when entering the subacromial space.

Case 2. A forty-five-year-old man reported a six-month history of pain in the right shoulder following a fall on the shoulder while wrestling. He stated that he had landed directly on the shoulder. Since the injury, he had persistent night pain and had been unable to go back to wrestling or to participate in any other extracurricular or sporting activities. On physical examination, he had full range of motion of the shoulder with pain, especially with forward elevation, and impingement-like signs. He had full motor strength with rotator cuff testing and had no evidence of instability. Initial radiographs had normal findings, and a cortisone injection was given in the subacromial space. He received physical therapy for six weeks, but the pain returned after four weeks. A magnetic resonance imaging scan showed supraspinatus tendinosis (Fig. 4-A). The patient received a second subacromial injection, which helped to relieve the symptoms for another six weeks during which time he attempted to go back to sporting activities, but the pain returned. A magnetic resonance arthrogram was then done, and it showed a partial-thickness undersurface tear of the supraspinatus tendon (Figs. 4-B and 4-C). At the time of surgery, one year after the original injury, he was found to have a large partial-thickness tear of the supraspinatus tendon (Figs. 4-D, 4-E, and 4-F).

Discussion

Magnetic resonance imaging of the shoulder has been described as an accurate diagnostic tool to assess the rotator cuff[13,14]. Although a useful and established technique for detecting full-thickness tears, magnetic resonance imaging has been found to be less reliable in detecting partial-thickness tears. With use of a T1-weighted image, a diagnosis of a partial-thickness tear is suggested by an increased signal in the rotator cuff without evidence of tendon discontinuity (Fig. 5). An additional increase in signal changes on a T2-weighted image of a focal defect that is intratendinous or limited to the bursal or articular surface increases the sensitivity of detecting partial tears[15]. Wnorowski et al. found that routine magnetic resonance imaging had a sensitivity of only 20% for detecting partial-thickness tears[12]. Traughber and Goodwin[9], in a study of twenty-eight patients evaluated with magnetic resonance imaging and arthroscopy, found that magnetic resonance imaging was 100% sensitive and specific for the diag-

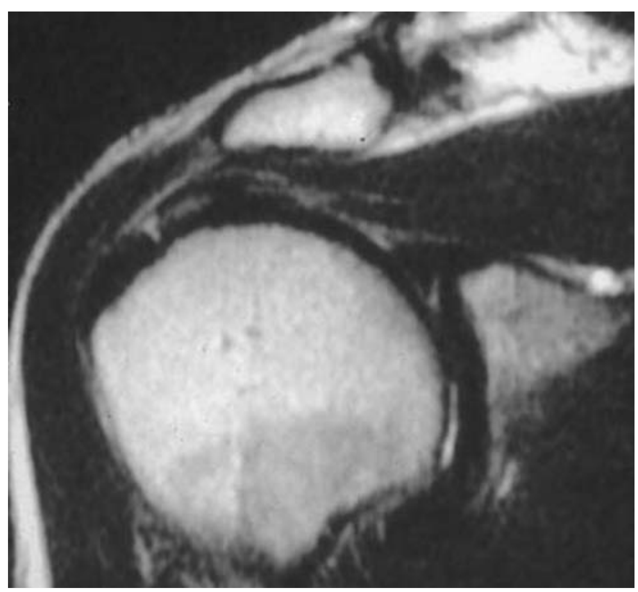

Fig. 5

Coronal oblique T1-weighted magnetic resonance image of a partial-thickness bursal-sided supraspinatus tendon tear. Note the signal changes within the supraspinatus tendon near its insertion.

nosis of five full-thickness tears, but it provided an accurate diagnosis in only five of nine partial-thickness tears.

Newer techniques have been developed to increase the sensitivity of detecting partial-thickness rotator cuff tears. Fat-suppression techniques accentuate fluid signal contrast on T2-weighted images and have been suggested as a means of increasing the detection of partial-thickness tears (Fig. 6). Clinical results with use of this technique have varied. Quinn et al. found a sensitivity of 82% and a specificity of 99% in eleven arthroscopically proven partial-thickness tears with use of fat-suppression techniques[16]. Reinus et al., however, found that the sensitivity increased from only 15% with conventional magnetic resonance imaging to 35% with this technique[17].

Rotator cuff tendinitis is often difficult to distinguish from a partial-thickness tear. Fat-suppression techniques are not always helpful in distinguishing between the two. Tendinitis may be diagnosed when there is an increased signal on T1-weighted images but a decreased signal on T2-weighted images (Fig. 7). However, many cases of tendinitis may actually be partial-thickness rotator cuff tears[18].

The study by Karzel and Snyder was one of the first to describe the technique of magnetic resonance arthrography to detect partial-thickness rotator cuff tears and other shoulder abnormalities[19]. They found magnetic resonance arthrography to be superior to T2-weighted standard imaging in depicting substantial partial-thickness tears involving the articular side of the rotator cuff. However, Hodler et al. found that, although intra-articular injection of gadolinium improved sensitivity, five of thirteen tears found at the time of arthroscopy were missed by a magnetic resonance arthrogram[10]. It should be noted that this study was performed in 1992, and the imaging techniques have improved since then.

Lee and Lee examined magnetic resonance arthrograms in a retrospective study of sixteen patients who underwent shoulder arthroscopy[20]. Standard magnetic resonance arthrogram oblique coronal images detected only five partial tears. Use of the abduction and external rotation view increased the accuracy to 100% for the detection of partial-thickness articular-sided tears.

For the last two years, we have been using intra-articular gadolinium to improve the sensitivity of detecting partial-thickness rotator cuff tears and labral abnormalities in our patients. Originally, we used this technique only when we suspected labral abnormalities (SLAP [superior labral anterior posterior] or Bankart lesions). However, we expanded the indications when we began to discover the number of partial-thickness rotator cuff tears that were being diagnosed at the same time. Prior to this, we had noticed a high rate of false-negative results on routine magnetic resonance imaging in diagnosing partial-thickness articular-sided cuff tears. We believed that a technique that would enable us to diagnose partial-thickness rotator cuff tears earlier would help in the nonoperative and operative management of our patients.

Although the use of intra-articular gadolinium increases the cost of the procedure, we have found it to be useful in improving the detection of partial-thickness rotator cuff tears (Fig. 8). We routinely use the abduction and external rotation view, which helps to further increase the sensitivity of the test. However, it should be noted that the abduction and external rotation view is not mandatory or necessary. We have found that most partial-thickness tears can be diagnosed with use of the sagittal and oblique coronal images.

The treatment and classification of these partial-thickness rotator cuff tears remain controversial. As we know from the work of Sher et al., not all partial-thickness rotator cuff tears are

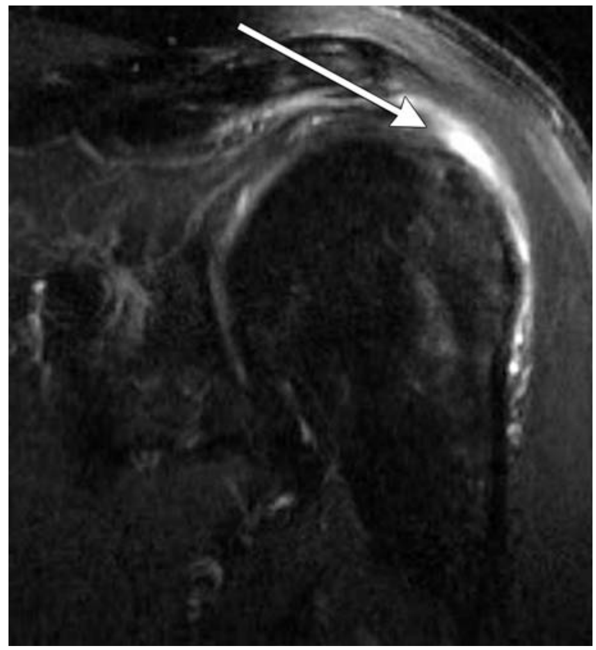

Fig. 6
Use of a fat-suppression technique accentuates fluid signal changes showing a tear (arrow).

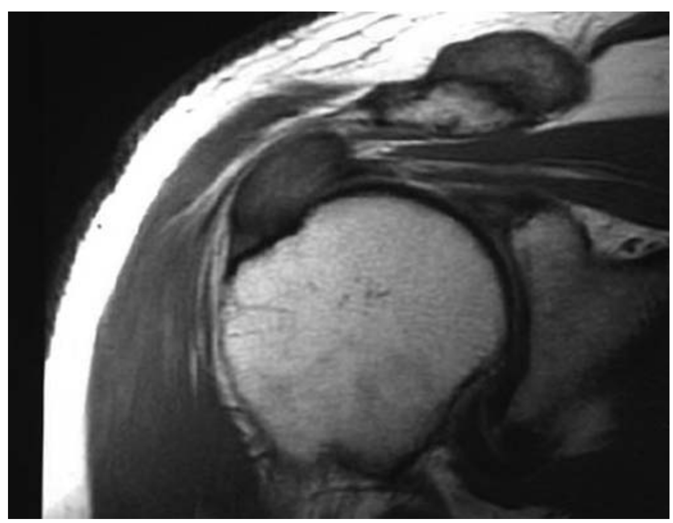

Fig. 7
Coronal oblique T1-weighted magnetic resonance image showing signal changes within the supraspinatus tendon characteristic of rotator cuff tendinitis.

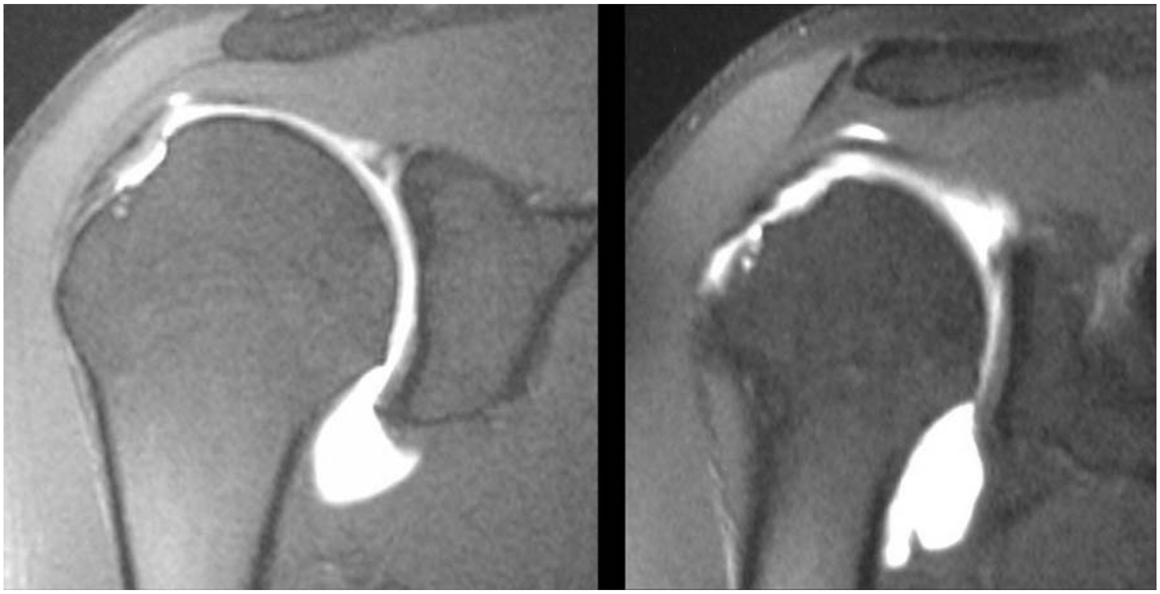

Fig. 8

Coronal oblique T1-weighted magnetic resonance images with gadolinium, showing a partial-thickness undersurface tear involving the supraspinatus tendon.

symptomatic[21]. In a magnetic resonance imaging study of ninety-six asymptomatic individuals, nineteen were found to have partial-thickness tears. Such tears may be asymptomatic and must be evaluated on a case-by-case basis to determine whether the tear is truly causing symptoms. The symptoms of partial-thickness rotator cuff tears are nonspecific and may overlap with those of rotator cuff tendinitis and small full-thickness rotator cuff tears[18]. Nonoperative treatment of the symptomatic shoulder with a partial-thickness tear should be directed toward any underlying primary pathological condition, such as instability, which can produce a tear. When this fails, arthroscopic surgical intervention can be considered; however, the surgical treatment of partial-thickness rotator cuff tears is also controversial. A lack of uniformity in describing rotator cuff tears and the failure to establish an accepted classification system has made it difficult to compare study results. Surgical treatment options include tear débridement, acromioplasty with tear débridement, or rotator cuff repair in addition to acromioplasty. Surgery may be performed as an open, arthroscopically assisted, or entirely arthroscopic procedure[22].

In summary, it appears that magnetic resonance arthrography can improve the differentiation of rotator cuff degeneration from partial or complete rotator cuff tears. This is primarily because of the ability of the contrast medium to enter into mechanical defect(s) in the rotator cuff[19]. In this study, we found a rate of false-negative results of only 9% and a sensitivity of 91%, making the test very reliable. We do not use the technique routinely, but we do use it when the diagnosis is unclear and a possible partial-thickness rotator cuff tear is suspected. ■

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