Rim-Rent Tear of the Rotator Cuff: A Common and Easily Overlooked Partial Tear

Emily N. Vinson[1]
Clyde A. Helms[1]
Laurence D. Higgins[2]

OBJECTIVE. The purpose of this study was to determine the incidence of rim-rent rotator cuff tears in a population of patients referred for shoulder MRI and to determine the sensitivity of MRI for the detection of these tears.

CONCLUSION. Rim-rent tears are a common type of partial-thickness rotator cuff tear, much more commonly present than has been previously reported. In particular, infraspinatus rim-rent tears are more common than previously believed. Rim-rent tears of the infraspinatus tendon and those involving the anterior-most fibers of the supraspinatus tendon are commonly overlooked on MRI, possibly because of failure to appreciate the high incidence of these types of tears and failure to inspect the anterior-most fibers of the rotator cuff.

The term "rim-rent" was first used by E. A. Codman [1] in 1934. He described four types of incomplete ruptures of the supraspinatus tendon, and one the four he described was a tear in which "a few of the lower fibers on the joint side, together with the synovial reflection, may be torn out…," and he termed these rotator cuff tears rim-rent tears [1]. To our knowledge, the only other mention of rim-rent tears in the literature was in a 1998 article by Tuite et al. [2] that reported 110 consecutive patients who had preoperative shoulder MRI examinations and either a partial-thickness or small full-thickness tear diagnosed at arthroscopy. Of these patients, nine had articular surface partial tears that were less than 2 cm in diameter and adjacent to the rotator cuff insertion into the greater tuberosity, which Tuite et al. called "rim-rent tears." Of the 110 patients with partial-thickness or small full-thickness cuff tears, only one patient's tear was isolated to the infraspinatus tendon. Although the article did not address whether this one tear was a rim-rent tear, we had previously believed that infraspinatus rim-rent tears were uncommon.

Through surgical follow-up, we recently discovered that we had overlooked several rim-rent tears on initial shoulder MRI interpretations. It seemed the location of the tears and the fact that many of the patients were positioned in marked internal rotation during the MRI examinations contributed to this. The purpose of this study was to determine the incidence of rim-rent tears in patients referred for shoulder MRI and to determine the sensitivity of MRI for the detection of these tears.

Materials and Methods

The study was performed after approval from our institutional review board. There were two parts to the study. The first part involved a cohort of patients with surgically proven rim-rent tears and an available preoperative shoulder MRI performed at our institution. This population was selected from a single orthopedic surgeon's database and consisted of 29 patients. There were 22 males and 7 females with a mean age of 41.6 years (age range, 17–77 years). The time interval between MRI and arthroscopy ranged from 7 to 179 days (mean, 51.9 days).

The preoperative MRI examinations were retrospectively reviewed by two musculoskeletal radiologists. We assessed our ability to see the rotator cuff tear on MRI, noted the location of the tear with regard to the anterior-to-posterior position in the rotator cuff, and subjectively assessed whether the patient was positioned in internal rotation during the MRI examination on the basis of the location of the bicipital groove on the axial images. The original MRI interpretation was reviewed to determine how often the correct diagnosis was made prospectively.

For the second part of the study, 225 consecutive shoulder MRI examinations performed at our institution between June 2002 and January 2005 were reviewed. Twenty-five examinations were excluded from the study: Three were excluded due to extensive artifact from postoperative changes, 10 were excluded because all of the images were not available

Keywords: rim-rent tear, rotator cuff tear, shoulder MRI

DOI:10.2214/AJR.07.2242

Received March 9, 2007; accepted after revision May 19, 2007.

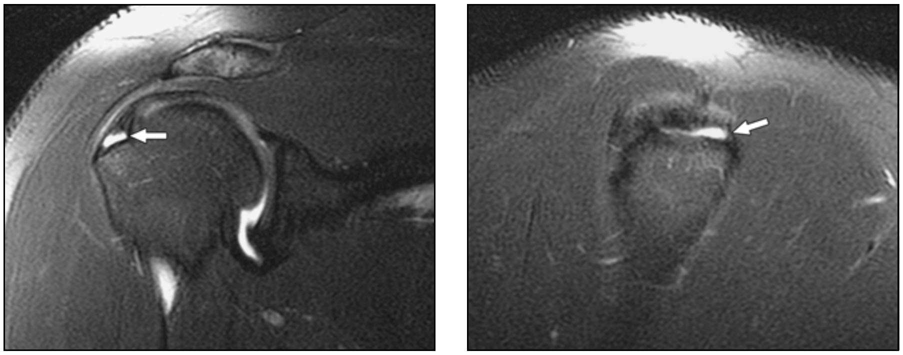
Presented at the 2006 annual meeting of the American Roentgen Ray Society, Vancouver, BC, Canada.

[1]Department of Radiology, Duke University Medical Center, Box 3808, Durham, NC 27710. Address correspondence to E. N. Vinson (vinso003@mc.duke.edu).

[2]Department of Orthopedic Surgery, Brigham and Women's Hospital, Boston, MA 02115.

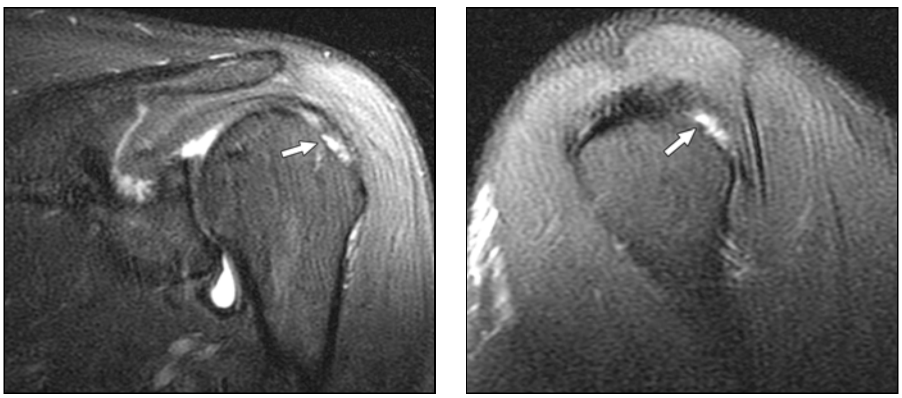
AJR 2007; 189:943–946

0361–803X/07/1894–943



A B

Fig. 1—25-year-old man with rim-rent tear of supraspinatus tendon.
A and **B,** Fat-suppressed fast spin-echo T2-weighted coronal oblique (TR/TE, 3,967/65) (**A**) and sagittal oblique (3,850/75) (**B**) MR arthrography images show rim-rent tear (*arrows*) at insertion of supraspinatus tendon onto greater tuberosity.



A B

Fig. 2—38-year-old man with rim-rent tear of infraspinatus tendon.
A and **B,** Fat-suppressed fast spin-echo T2-weighted coronal oblique (TR/TE, 4,000/65) (**A**) and sagittal oblique (3,000/74) (**B**) MR arthrography images show rim-rent tear (*arrows*) at insertion of infraspinatus tendon onto greater tuberosity. This tear was not seen prospectively but was diagnosed at time of surgery.

for review, nine were excluded because a nonstandard protocol was performed, two were excluded because extensive infection obscured visualization of the rotator cuff, and one was excluded because visualization of the rotator cuff was obscured due to extensive posttraumatic hematoma. The remaining 200 examinations composed the study population. There were 109 males and 91 females with a mean age of 46.7 years (age range, 15–85 years). The examinations were retrospectively reviewed by two musculoskeletal radiologists for the presence of rotator cuff tears, and the tears were classified as to location and as full or partial thickness. Of the partial-thickness tears, those of the rim-rent variety were noted. We assessed subjectively whether the patients were positioned in internal rotation during the examination. The original MRI interpretations and, when available, corresponding operative reports were reviewed.

All of the patients included in the study were scanned on a 1.5-T MRI scanner (Signa, GE Healthcare). In the cohort of 29 patients with surgically proven rim-rent tears, 27 had preoperative shoulder MR arthrograms and two had preoperative conventional shoulder MR examinations. In the cohort of 200 patients who underwent shoulder MRI at our institution, 86 had shoulder MR arthrograms and 114 had conventional shoulder MR examinations.

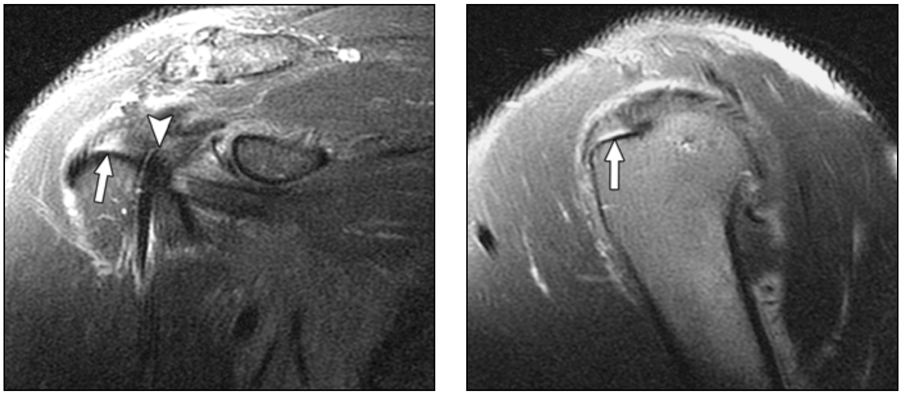
Our conventional shoulder MRI protocol consists of axial and oblique coronal fat-suppressed fast spin-echo T2-weighted images (TR/TE range, 4,000/65–75) and fat-suppressed fast spin-echo proton density images (TR range/TE range, 3,500–4,000/20–35), oblique sagittal T1-weighted images (500–620/14–15), and oblique sagittal fat-suppressed fast spin-echo T2-weighted images (4,000/65–75). The MR arthrogram images were obtained after the intraarticular instillation under fluoroscopic guidance via an anterior approach of 12 mL of dilute gadolinium (gadoteridol [Prohance, Bracco Diagnostics]) diluted 1:200 with normal saline). These patients were subsequently imaged using our shoulder MR arthrography protocol: axial, oblique coronal, and oblique sagittal fat-suppressed fast spin-echo T2-weighted images (3,000–4,000/65–75) and fat-suppressed T1-weighted images (500–650/14–15), and oblique sagittal T1-weighted images without fat suppression (500–617/14–15). The number of excitations was 2 for fast spin-echo sequences and 1 for T1-weighted sequences, and the echo-train length was 8 for all fast spin-echo sequences. A slice thickness of 4 mm with a 0.4-mm interslice gap was used with a field of view of 14 cm and matrix of 256 × 192 for all studies.

Full-thickness tears were diagnosed when there was discontinuity of the tendon with fluid signal intensity traversing the gap on the fast spin-echo T2-weighted images or dilute gadolinium traversing the gap on the postarthrography T1-weighted images. Partial-thickness tears were diagnosed when there was fluid signal intensity involving a portion of the tendon on the fast spin-echo T2-weighted images, without a visible gap. Rim-rent tears were defined as those partial-thickness tears occurring on the articular side of the rotator cuff at the tendon insertion on the greater tuberosity. Critical zone partial-thickness tears were defined as those partial-thickness tears occurring approximately 1–2 cm proximal to the cuff tendon insertion on the greater tuberosity.

Results

Of the 29 patients with surgically proven rim-rent tears, the tear was visible on MRI in retrospect in 28 cases (96.6%). In 17 (60.7%) of these 28 cases, the tear involved the anterior-most fibers of the supraspinatus tendon (Fig. 1), and the tear was prospectively diagnosed on the initial MRI interpretation in 12 (70.6%) of these cases. In nine (32.1%) of these 28 cases, the tear involved the infraspinatus tendon (Fig. 2), and the tear was prospectively diagnosed on the initial MRI interpretation in four (44.4%) of these cases. Overall, the presence of a rim-rent tear was prospectively diagnosed in 19 of the 29 (65.5%) surgically proven cases. Of the 10 cases in which the tear was missed prospectively, five tears involved the anterior-most fibers of the supraspinatus tendon and four tears involved the infraspinatus tendon; in one of the cases, the tear was not visible in retrospect. In 20 of the 29 cases, the patients were subjectively assessed to have been positioned in excessive internal rotation during imaging. Of the nine cases in which the tear was missed prospectively but visible in retrospect, seven were assessed to have been positioned in excessive internal rotation.

Of the cohort of 200 consecutive shoulder MRI examinations, a total of 117 tears were identified in retrospect in 101 of the examina-



A B

Fig. 3—56-year-old man with rim-rent tear of anterior fibers of supraspinatus tendon; patient positioned in internal rotation.
A and **B**, Fat-suppressed fast spin-echo T2-weighted coronal oblique (TR/TE, 4,000/67) (**A**) and sagittal oblique (4,000/67) (**B**) MR images show rim-rent tear at insertion of supraspinatus tendon onto greater tuberosity involving insertion of far anterior fibers of supraspinatus tendon (*arrows*) adjacent to biceps tendon (*arrowhead*, **A**). This tear was not diagnosed at time of initial MRI interpretation.

tions. Seventy (59.8%) of the tears were partial-thickness tears, and of these, 49 (70.0%) were of the rim-rent variety. The incidence of rim-rent tears in this population was 49 in 200, or 24.5%. Twenty-one of the 70 partial-thickness tears were not rim-rent tears: there were nine (12.9%) tears in the critical zone, 10 (14.3%) interstitial tears, and two (2.9%) bursal-sided tears. Of the 49 rim-rent tears, 24 (49.0%) involved the anterior-most fibers of the supraspinatus tendon, one of which extended to involve the infraspinatus tendon. Twenty-three (46.9%) involved the infraspinatus tendon alone. Two tears were isolated to the more-posterior aspect of the supraspinatus tendon. Of the 24 tears involving the anterior-most fibers of the supraspinatus tendon, 16 (66.7%) were prospectively diagnosed; of the eight cases not prospectively diagnosed, seven were imaged in excessive internal rotation (Fig. 3). Of the 24 rim-rent tears involving the infraspinatus tendon, nine (37.5%) were prospectively diagnosed. Of all 49 rim-rent tears, the correct diagnosis was made prospectively in 27 (55.1%) cases.

Of the cohort of 200 patients, 62 subsequently underwent shoulder surgery and had available operative reports. Fifty-two of these patients had rotator cuff tears diagnosed surgically, and 27 of these were full-thickness tears, of which 26 (96.3%) were diagnosed by MRI prospectively. Twenty-five of the tears were either partial-thickness tears or subscapularis tears, of which 15 (60.0%) were diagnosed by MRI prospectively. Of the 10 cases not diagnosed by MRI prospectively, one was interpreted as a full-thickness tear prospectively, and nine were not reported. Six of these nine were visible on MRI in retrospect, and all six of these were rim-rent tears. Of the 62 patients who underwent shoulder surgery after MRI, a total of 16 rim-rent tears were found. Of these, only seven (43.8%) were diagnosed prospectively by MRI. In all nine of the rim-rent tears not reported prospectively, the patients were imaged in internal rotation. Seven of these tears were visible in retrospect; four involved the anterior fibers of the supraspinatus tendon, and three involved the infraspinatus tendon.

Discussion

Partial-thickness tears of the rotator cuff are a significant and common cause of shoulder pain. However, both the cause and management of these lesions remain elusive and without consensus. Codman [1] believed that some combination of tendinitis and trauma occurring in a degenerated tendon led to incomplete ruptures of the supraspinatus tendon. Neer [3] emphasized the importance of impingement of the rotator cuff beneath the coracoacromial arch in the development of incomplete rotator cuff tears and espoused anterior acromioplasty, in addition to rotator cuff repair, to relieve the subacromial impingement in patients with complete and incomplete supraspinatus tears and in patients with irreparable tears. Chang et al. [4], using 3D shape analysis of the morphologic features of the acromial undersurface in a cohort of patients, concluded that osseous impingement by any portion of the acromion is not a primary cause of impingement syndrome or rotator cuff tears. Most now embrace a multifactorial pathogenesis of rotator cuff tears, with intrinsic degeneration, microtrauma, trauma, hypovascularity, and subacromial impingement all having a potential role [5, 6]. Although Codman believed that partial-thickness rotator cuff tears could heal spontaneously without surgery, this assumption has not been substantiated histologically, and many believe it to be the rare exception rather than the rule [5, 7].

It has long been thought that the majority of rotator cuff tears occur in the so-called critical zone—that portion of the tendon approximately 1 cm proximal to the cuff insertion onto the greater tuberosity—due to the relative hypovascularity of the tendon in that region [8, 9] (Fig. 4). However, feedback from our surgical colleagues contradicts this long-held belief. Their experience and the results derived in our study strongly suggest that rim-rent tears involving the insertional fibers of the rotator cuff are the most common type of partial-thickness rotator cuff tear. Since making this observation, we have also noted that many full-thickness rotator cuff tears appear on imaging as if they originated as rim-rent tears and progressed to involve the full thickness of the tendon (Fig. 5). The results of our study also suggest that bursal-sided partial-thickness tears are less common than previously believed, constituting only 2.9% of all partial-thickness tears in this series.

MRI has proven to be reliable in the diagnosis of full-thickness rotator cuff tears, with sensitivities reported as high as 100% [10]. Reported sensitivities for the detection of partial-thickness rotator cuff tears with MRI have been more variable, ranging from 35% to 92% [10–13]. During our routine quality assurance conferences, it was noted that we had missed several partial-thickness and full-thickness rotator cuff tears localized to the anterior-most fi-

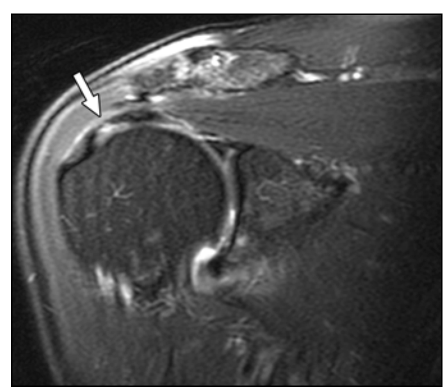


Fig. 4—58-year-old woman with critical zone partial-thickness tear. Coronal oblique fat-suppressed fast spin-echo T2-weighted (TR/TE, 4,000/67) MR image shows partial-thickness, articular-sided tear of supraspinatus tendon 1–2 cm proximal to its insertion, in so-called critical zone (*arrow*).

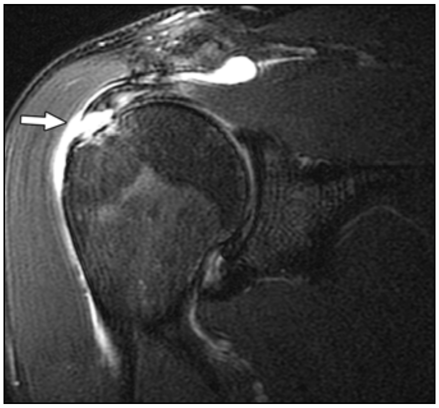


Fig. 5—46-year-old man with full-thickness rotator cuff tear. Coronal oblique fat-suppressed fast spin-echo T2-weighted (TR/TE, 4,000/66) MR arthrography image shows full-thickness tear of rotator cuff from insertion on greater tuberosity (*arrow*).

bers of the supraspinatus tendon, sometimes referred to as the leading edge of the rotator cuff.

We noted that many of these tears were of the rim-rent variety and that the tears were difficult to visualize in many instances because the patients were positioned in marked internal rotation during imaging. This internal rotation made the anterior cuff difficult to visualize on MRI, particularly on the sagittal oblique images. We learned to routinely inspect the anterior-most fibers of the cuff on the coronal oblique images by finding the image with the long head of the biceps tendon passing over the humeral head and inspecting the cuff from that point posteriorly (Fig. 6). Through experience, we have also learned that partial-thickness tears in general—and rim-rent tears in particular—are not rare in the infraspinatus tendon, and we carefully inspect the infraspinatus insertion on both the coronal oblique and sagittal oblique images for this type of tear.

Limitations of this study include the fact that this was a retrospective, nonblinded study. Also, although the cohort of 29 patients was chosen because they had surgically proven rim-rent tears, no surgical data were available for the majority of the cohort of 200 patients. However, the sensitivity of MRI for the prospective detection of rim-rent tears was similar across the cohorts of patients studied. In the cohort of 29 surgically proven rim-rent tears, 19 (65.5%) were diagnosed correctly by MRI prospectively. In the cohort of 200 consecutive shoulder MRI examinations, there were 49 rim-rent tears, 27 (55.1%) of which were diagnosed correctly by MRI prospectively. Within that group, there were 16 patients who underwent shoulder surgery and were diagnosed with rim-rent tears, of which seven (43.8%) were diagnosed prospectively. This low sensitivity for rim-rent tears may be rectified by learning to inspect the leading edge of the supraspinatus, just lateral to the bicipital groove on the oblique coronal images, and to look closely at the infraspinatus insertion because tears were initially overlooked in both of these locations.

In conclusion, rim-rent tears are a common type of rotator cuff tear, occurring in 24.5% of 200 consecutive shoulder MRI examinations in this series and accounting for 70% of all partial-thickness rotator cuff tears. Critical zone and bursal-sided partial-thickness tears were much less common, accounting for 12.9% and 2.9% of partial-thickness tears, respectively. Contrary to previous beliefs, the infraspinatus is a relatively common location of rim-rent tears, with almost half of all rim-rent tears involving the infraspinatus tendon in this series. Rim-rent tears, especially infraspinatus rim-rent tears, are often overlooked on MRI, possibly in part because we did not previously recognize this to be a common type of tear. We believe that excessive internal rotation and a failure to inspect the anterior-most fibers of the rotator cuff contributed to prospectively missing many supraspinatus rim-rent tears because they commonly involve the far anterior fibers of the rotator cuff. We also believe that, rather than healing, many rim-rent tears will progress to full-thickness tears if not diagnosed and treated appropriately. Being more aware of these tears and more comfortable looking for them on the far anterior coronal oblique images and on the sagittal oblique images should improve our sensitivity in detecting these common tears on MRI.

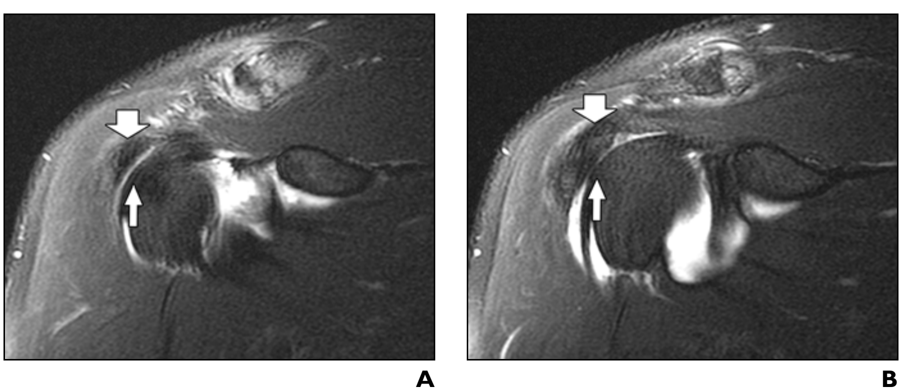


Fig. 6—36-year-old man with normal supraspinatus anterior fibers.
A and **B,** Consecutive far anterior coronal oblique fat-suppressed fast spin-echo T2-weighted (TR/TE, 4,000/67) MR arthrography images show normal appearance of anterior fibers of rotator cuff insertion (*thick arrows*) adjacent to long head of biceps tendon (*thin arrows*).

References

1. Codman EA. *The shoulder*. Boston, MA: Thomas Todd, 1934:123–177
2. Tuite MJ, Turnbull JR, Orwin JF. Anterior versus posterior, and rim-rent rotator cuff tears: prevalence and MR sensitivity. *Skeletal Radiol* 1998; 27:237–243
3. Neer CS 2nd. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J Bone Joint Surg (Am)* 1972; 54:41–50
4. Chang EY, Moses DA, Babb JS, Schweitzer ME. Shoulder impingement: objective 3D shape analysis of acromial morphologic features. *Radiology* 2006; 239:497–505
5. Fukuda H. Partial-thickness rotator cuff tears: a modern view on Codman's classic. *J Shoulder Elbow Surg* 2000; 9:163–168
6. Ko J-Y, Huang CC, Chen W-J, Chen C-E, Chen S-H, Wang C-J. Pathogenesis of partial tear of the rotator cuff: a clinical and pathologic study. *J Shoulder Elbow Surg* 2006; 15:271–278
7. Fukuda H. The management of partial-thickness tears of the rotator cuff. *J Bone Joint Surg (Br)* 2003; 85:3–11
8. Neviaser RJ, Neviaser TJ. Observations on impingement. *Clin Orthop Rel Res* 1990; 254:60–63
9. Bergman AG. Rotator cuff impingement. *Magn Reson Imaging Clin N Am* 1997; 5:705–719
10. Singson RD, Hoang T, Dan S, Friedman M. MR evaluation of rotator cuff pathology using T2-weighted fast spin-echo technique with and without fat suppression. *AJR* 1996; 166:1061–1065
11. Balich SM, Sheley RC, Brown TR, Sauser DD, Quinn SF. MR imaging of the rotator cuff tendon: interobserver agreement and analysis of interpretive errors. *Radiology* 1997; 204:191–194
12. Magee T, Williams D. 3.0-T MRI of the supraspinatus tendon. *AJR* 2006; 187:881–886
13. Rafii M, Firooznia H, Sherman O, et al. Rotator cuff lesions: signal patterns at MR imaging. *Radiology* 1990; 177:817–823