Skeletal Radiol (1998) 27:237–243

ARTICLE

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Anterior versus posterior, and rim-rent rotator cuff tears: prevalence and MR sensitivity

Abstract *Purpose.* To determine the relative distribution of the locations of rotator cuff tears, and the sensitivity of anterior versus posterior tears on MR images.
Patients and methods. We identified 110 consecutive patients who had a shoulder MR and either a partial-thickness or a small full-thickness rotator cuff tear diagnosed at arthroscopy. From the arthroscopy videotapes, we classified the tears as centered in the anterior or posterior half of the cuff, and as either in the critical zone or adjacent to the bony insertion. The original MR interpretation was compared with the arthroscopic findings. MR sensitivity and patient age were compared between patients with tears in the anterior and posterior halves of the cuff. In addition, in patients with partial tears less than 2 cm in diameter, an age comparison between those with tears in the critical zone and those with articular surface tears adjacent to the bony insertion (rim-rent tear) was performed.
Results. The tear was centered in the anterior half of the rotator cuff in 79% of the patients younger than 36 years old, and in 89% of the patients 36 years old and over. The average age of the patients with tears in the anterior half (44 years) was not significantly different from the average age of those with posterior tears (40 years)(P=0.23). The sensitivity of MR for anterior tears was 0.69, and for posterior tears it was 0.56 (P=0.17). The average age of the 9 patients with rim-rent tears was 31 years, while that of the 28 patients with similarly-sized partial tears not involving the insertion was 40 years old (P=0.048). Five of the nine rim-rent tears (0.56) were interpreted correctly on the original MR report; two of the other tears were misinterpreted as intratendinous fluid but were diagnosable in retrospect.
Conclusion. Even in patients less than 36 years old, most partial and small full-thickness rotator cuff tears are centered in the anterior half of the supraspinatus. Although our figure for MR sensitivity for these tears is lower than in recent articles, we found no significant difference between the sensitivity of MR for diagnosing posterior tears versus tears in the anterior half of the supraspinatus tendon. Rim-rent tears can be mistaken for intratendinous signal, and should be carefully looked for in younger patients with shoulder pain.

Key words Shoulder, injuries · Shoulder, MR · Arthroscopy

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Introduction

Several articles have noted that most rotator cuff tears (RCTs) occur in the anterior half of the supraspinatus tendon about 1 cm from its insertion on the greater tuberosity, an area known as the anterior critical zone (Fig. 1) [1–3]. There has been no objective study, however, documenting the percentage of RCTs that are located in the anterior critical zone versus other regions of the rotator cuff.

While reviewing the operative reports of some RCTs that we had interpreted incorrectly on MR images, we noted that several tears were not located in the typical anterior critical zone. Various authors have reported RCTs occurring in less common locations. Codman described an articular surface partial tear adjacent to the insertion of the cuff onto the greater tuberosity, which he termed a "rim-rent" tear [4]. Another location for tears, especially in athletes who perform overhead activities, is the posterior supraspinatus near the junction with the infraspinatus [5, 6]. Finally, De Palma reported that 7% of the rotator cuff tears in his series were isolated to the infraspinatus portion of the cuff [2].

We were concerned that we may have been undercalling RCTs in these less typical locations. There were two purposes to our study. First, we wanted to determine the prevalence of RCTs centered other than in the anterior critical zone in patients who had been referred for shoulder MR imaging. Second, we wanted to determine if there was a difference in the sensitivity of our prospective MR interpretations for tears located in the anterior versus posterior portions of the rotator cuff.

Patients and methods

We reviewed the surgical reports in 304 consecutive patients who underwent MR imaging followed by shoulder arthroscopy between February 1991 and December 1996 at our institution. At arthroscopy, 114 patients had either a partial-thickness tear or a full-thickness tear less than 2 cm in maximum diameter, 50 patients had a full-thickness tear larger than 2 cm in diameter, and 140 patients did not have a tear of either the supraspinatus or infraspinatus tendon. We excluded the 50 patients with large full-thickness tears because determining the center of these tears can be difficult due to retraction and distortion of the cuff. Of the remaining 114 patients with RCTs, the arthroscopic videotapes were available for 110 patients who made up the study population.

Within the study group of 110 patients, there were 56 patients with partial tears involving only the articular surface of the cuff, 16 with isolated bursal surface tears, and 14 with partial-thickness tears involving both surfaces. Twenty-four patients had a full-thickness RCT with a maximum diameter less than 2 cm. There were 79 men and 31 women. The average age was 44 years (range 17–76 years), with 82 patients above and 28 patients no older than 35 years old. Of the 140 patients without a RCT, there were 93 men and 47 women with an average age of 35 years (range 15–77 years).

All MR images were obtained with a 1.5-T imager (GE Medical Systems, Milwaukee, WI) with either an 18-cm single loop (GE Medical Systems, Milwaukee, WI) or a phased-array shoulder coil (Medical Advances, Milwaukee, WI). The MR sequences included (a) axial and (b) oblique coronal gradient-recalled echo [500/20 (TR/TE), 30° flip angle, four signals acquired], spin-echo (2000/20, 90, one signal acquired), or fast spin-echo with frequency-selective fat-suppression [2000–2200/88–90(eff), eight echo train, four signals acquired] images. We also obtained (c) oblique sagittal spin-echo (2000/20, 90) or fast spin-echo with frequency-selective fat-suppression [2000–2200/88–90(eff)] images. The section thickness was 3–4 mm, and the matrix was 256×192.

Thirty-two of the study patients, and 17 of the patients without a RCT, were scanned with our current protocol which includes fat-suppressed fast spin-echo images in all three planes and a 14-cm field of view. The tear location was anterior in 26 patients, and posterior in the other 6.

All the arthroscopies were performed by a single experienced orthopedic surgeon who knew the results of the MR examination. The glenohumeral joint arthroscopic technique included visualization of the articular surface from both an anterior portal through the rotator cuff interval, and a posterior portal through the "soft spot" near the superior aspect of the infraspinatus [7]. The bursal surface of the cuff was evaluated from a posterolateral portal in the subacromial/subdeltoid bursa while the humeral head was put through various degrees of rotation. The size of the RCT was graded using the Snyder classification by measuring the maximum diameter of the tear as compared with a 5-mm cannula [7].

The arthroscopic videotapes were reviewed together by a radiologist and an orthopedic surgery sports medicine fellow who knew the grade assigned to the cuff tear during the surgery. The tear location was mapped by consensus onto a rotator cuff diagram, with attention paid to whether the center of the tear was in the anterior or posterior half of the cuff and if the tear was adjacent to the bony insertion. For the articular surface, the cuff was divided in half by comparing the center of the tear with a line equidistant from the two arthroscopic portals. For the bursal surface, the dividing line was estimated after the cuff was viewed with the arm in maximum internal and external rotation.

The MR images had been interpreted prospectively by one of five experienced musculoskeletal radiologists. These MR reports were reviewed blind to the arthroscopic findings, and the interpretation of the cuff categorized as either torn or intact. An MR interpretation of cuff fraying was included in the intact category. The sensitivity and specificity of MR were determined by comparison with the arthroscopic results, and differences in sensitivity were compared using an unpaired *t*-test.

The age distribution of the patients with tears centered in the anterior half of the cuff was compared with those in the posterior half using the Mann-Whitney U test. A χ^2 test was used to compare tear location between patients above and below 35 years old. The age distribution of the patients with partial tears measuring less than 2 cm was also compared between those with articular surface partial tears adjacent to the insertion onto the greater tuberosity (rim-rent tear), and those with partial tears in the critical zone.

Results

The sensitivity of MR for interpreting the 110 partial-thickness and small full-thickness RCTs as torn was 0.67. Our MR specificity for interpreting the rotator cuff as intact in the 140 patients without a RCT was 0.77. Both of these improved slightly (0.72 and 0.82, respectively) in the subgroup of patients scanned with our current technique.

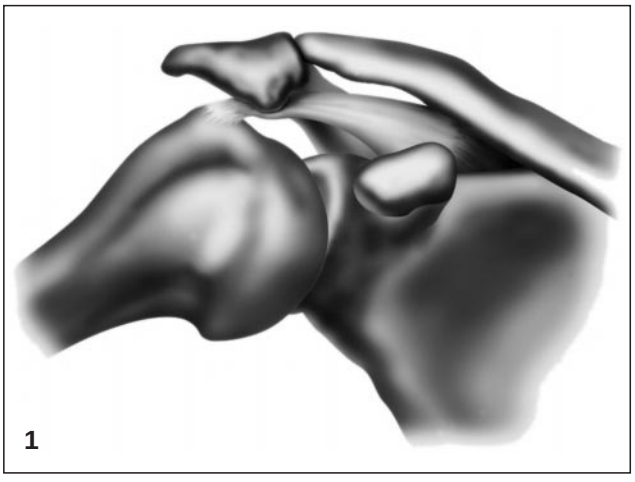
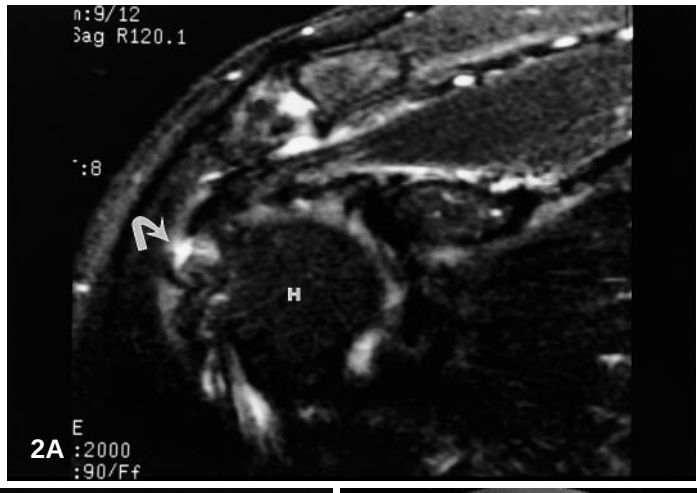
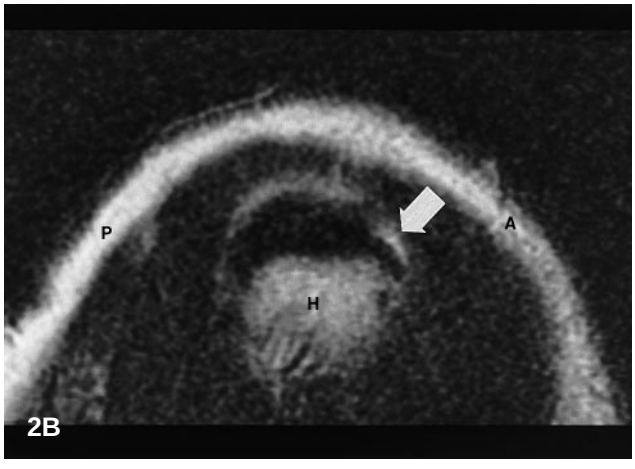


Fig. 1 Right shoulder with a hooked anterior acromion and the humerus in abduction and flexion. Note the contact between the acromion and the anterior critical zone of the supraspinatus tendon





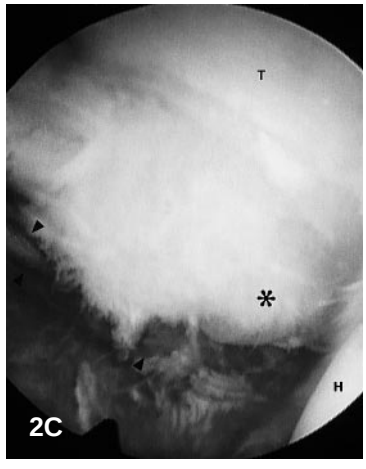
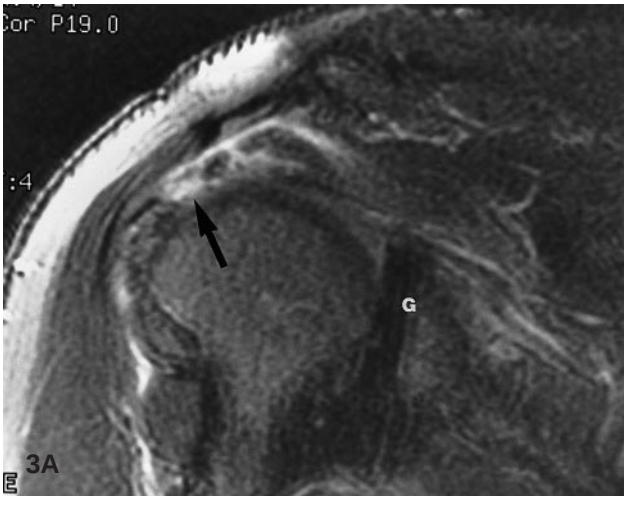


Fig. 2A–C Small full-thickness rotator cuff tear of the anterior portion of the supraspinatus tendon in a 58-year-old man. **A** Oblique coronal fat-suppressed fast spin-echo T2-weighted [2000/90(eff)] and **B** oblique sagittal T2-weighted spin-echo (2000/90) MR images show that the tear (*arrows*) extends to the anterior edge of the tendon. **C** Arthroscopic photograph looking anteriorly shows the torn (*asterisk*) anterior portion of the supraspinatus tendon (*T*). Note the 5 mm cannula (*arrowheads*) entering the joint through the anterior interval. *A* Anterior, *P* posterior, *H* humeral head



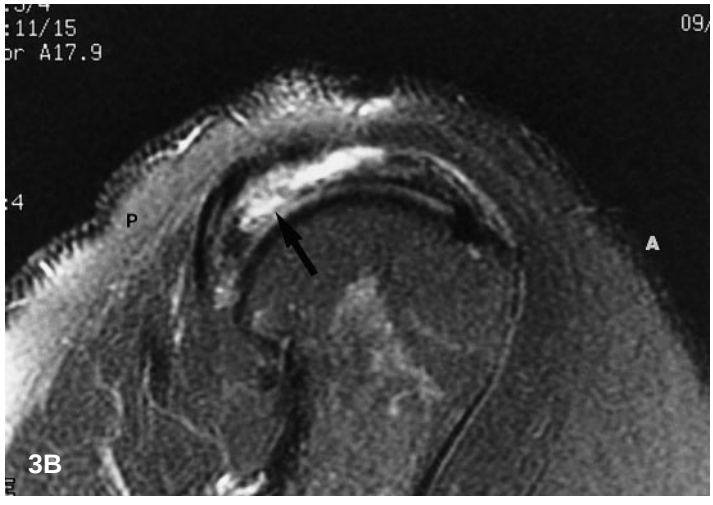
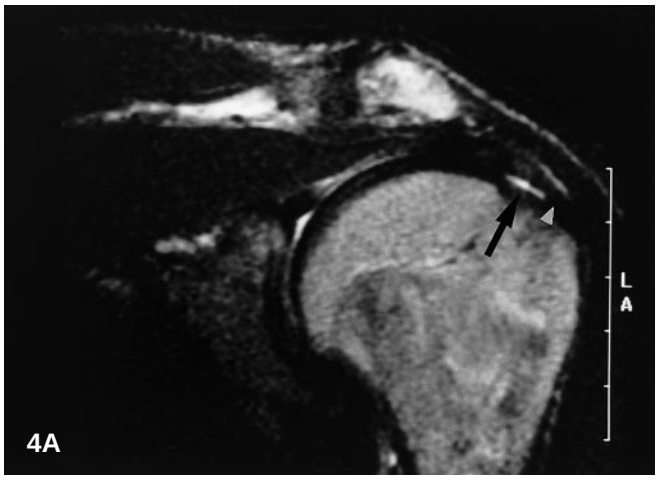
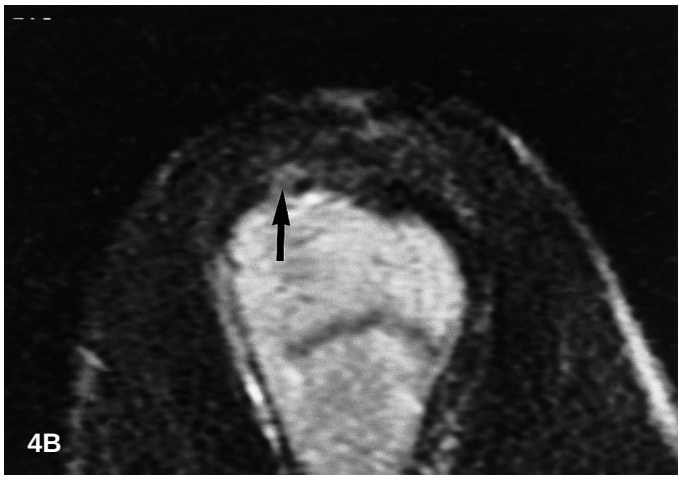
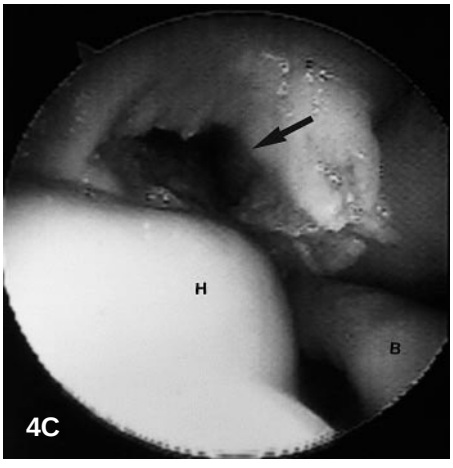


Fig. 3A, B Small full-thickness tear involving the infraspinatus and posterior supraspinatus portions of the rotator cuff in a 50-year-old woman, interpreted correctly on the MR images. **A** Oblique coronal and **B** oblique sagittal fat-suppressed fast spin-echo T2-weighted [2200/88(eff)] MR images show the tear (*arrows*). The increased signal in the subcutaneous fat superolaterally is due to poor placement of the surface coil and nonuniform fat suppression. A Anterior, *P* posterior, *G* posterior glenoid







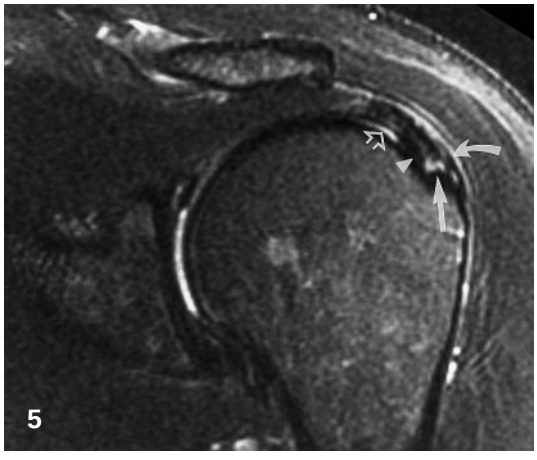


Fig. 4A–C Rim-rent articular surface partial-thickness rotator cuff tear in a 32-year-old man. **A** Oblique coronal and **B** oblique sagittal spin-echo T2-weighted (2000/90) MR images show high-signal fluid (*arrow*) in the tear near the greater tuberosity, with disruption of the articular surface fibers adjacent to the insertion. Note that the bursal portion of the rotator cuff is intact to its attachment (*arrowhead*). This was correctly interpreted prospectively as an articular surface partial tear. **C** Arthroscopic photograph looking anterolaterally demonstrates the ″rim-rent″ tear (*arrow*). *H* Humeral head, *B* long head of biceps tendon

Fig. 5 Normal rotator cuff at arthroscopy in a 31-year-old man. Oblique coronal fat-suppressed fast spin-echo T2-weighed [2000, 90(eff)] image shows joint fluid (*open arrow*) and intrasubstance high signal (*straight arrow*), but intact articular (*arrowhead*) and bursal (*curved arrow*) surfaces of the rotator cuff

Table 1 Anterior versus posterior location of rotator cuff tears[a]

	Anterior	Posterior	Total
MR sensitivity	0.69	0.56	0.67
Average age (years)	44	40	44
Location by age[b]			
<35 years	22 (79)	6 (21)	28 (100)
>35 years	72 (88)	10 (12)	82 (100)
Total	94 (85)	16 (15)	110 (100)
Total tears by type			
Articular partial	60 (86)	10 (14)	70 (100)
Bursal partial	26 (87)	4 (13)	30 (100)
Small full-thickness	20 (83)	4 (17)	24 (100)

[a] Supraspinatus and infraspinatus tendon only, dividing line approximately mid-supraspinatus tendon; no difference statistically significant

[b] Number of patients (percentage); 14 patients had both articular and bursal partial tears

Ninety-four (85%) of the 110 patients with a rotator cuff tear had their tear centered in the anterior half of the cuff (Table 1). This percentage was consistent for both sides of the rotator cuff, with 80 of the 94 (85%) full-thickness and partial-thickness tears that involved the articular surface, and 46 of the 54 (85%) tears involving the bursal surface, located anteriorly. None of the 38 patients with full- or partial-thickness tears involving both sides of the rotator cuff had their tear on the two sides centered in opposite halves of the cuff. Twenty-eight of the 94 (30%) full-thickness and articular surface partial tears involved the anterior edge of the supraspinatus tendon (Fig. 2). One full-thickness tear was isolated to the infraspinatus.

The RCT was centered anteriorly in 88% of the patients older than 35 years old, and in 79% of the patients less than or equal to 35 years old (P=0.23). The average age of the patients with tears centered in the anterior half (44 years, range 17–76 years) was not significantly different from that of those with posterior tears (40 years, range 19–61 years) (P=0.23) (Fig. 3). The sensitivity of MR for anterior tears was 0.69, and for posterior tears it was 0.56 (P=0.17), with a slight improvement in both (0.73 and 0.66, respectively) for the patients scanned with our current technique.

There were 9 patients with articular surface partial tears that were less than 2 cm in diameter and adjacent to the insertion into the greater tuberosity (rim-rent tear) (Fig. 4). Seven patients were less than 35 years old. The remainder of the tears in our series were centered approximately 1–1.5 cm from the insertion, and these included 28 additional patients with partial-thickness tears less than 2 cm in diameter. The average age of the 9 patients with rim-rent tears was 31 years (standard deviation 11.9 years), and for the other 28 patients it was 40 years (standard deviation 11.6 years). This difference was statistically significant with P=0.048. Five of the nine rim-rent tears (0.56) were correctly diagnosed on the original MR interpretation.

Discussion

The most commonly cited reason for why RCTs typically occur in the anterior critical zone of the supraspinatus tendon, especially in older patients, is outlet impingement. In outlet impingement, the space beneath the coracoacromial arch is narrowed by a downward curving anterior acromion, inferiorly directed acromioclavicular joint osteophytes, or a thickened coracoacromial ligament, leading to wear on the rotator cuff during arm flexion, abduction, and external rotation. Supportive evidence for this mechanism includes the high association between cuff tears and both a hooked anterior acromion and inferiorly directed acromioclavicular joint osteophytes [8, 9]. In addition, patients with rotator cuff tears often have signs of mechanical erosion on the undersurface of the coracoacromial arch [10]. The outlet impingement theory states that tears should occur at the usual site of contact between the cuff and coracoacromial arch during flexion and abduction of the arm, which is the anterolateral portion of the supraspinatus tendon. Similar to Neer's estimate [11], we found that 88% of tears in patients over 35 years old were in the anterior half of the cuff, predominantly 0.5–1.5 cm from the bony insertion.

Although tears in the typical anterior portion of the cuff have been described in younger patients, several authors have stressed the high prevalence of posterior cuff tears in young people with overuse, asymmetric strengthening of the rotator cuff muscles, or secondary impingement from instability [5, 6, 12]. Our study shows that tears are still more common in the anterior than the posterior half of the cuff in patients less than 36 years old, the age that has been cited as separating outlet from non-outlet causes of cuff tears [13].

Despite our radiologists knowing that most RCTs in older people occur in the anterior critical zone, we could not document a significant difference in our prospective MR sensitivity for tears in the anterior versus posterior half of the cuff. Although there was a slightly lower sensitivity for tears in the posterior cuff, our data suggest that RCTs in the two halves of the cuff are demonstrated fairly comparably using typical MR imaging techniques, and that radiologists do inspect the entire cuff for tears when interpreting MR images. A possible cause of our slightly lower sensitivity for posterior tears may be because some of these patients had small partial tears near the supraspinatus/infraspinatus junction. These tears, which usually occur in athletes performing overhead activities, have been shown to be difficult to see on conventional MR images, although they are easier to identify by MR arthrography [14]. Tears in the posterior half of the cuff have also been reported to be more common in individuals with paraplegia [15].

We had only one patient (1%) in our study with an isolated infraspinatus tendon tear. Although small posterior supraspinatus tears and, more commonly, massive full-thickness cuff tears often extend posteriorly to involve the infraspinatus, there are few reports of tears involving only the infraspinatus tendon. DePalma did report an isolated infraspinatus tendon tear among the 13 cadavers (7%) in his study but, as in our series, other authors have not confirmed a frequency this high [2]. Because the infraspinatus tendon inserts along the posterior greater tuberosity, these tears can be difficult to see on oblique coronal MR images. Small infraspinatus tendon tears have been shown to be better visualized on MR arthrography with the arm in abduction and external rotation [14].

Codman was the first to describe the rim-rent tear, an articular surface partial tear adjacent to the insertion of the cuff into the greater tuberosity [4]. Although less common than in the critical zone, the rotator cuff is vulnerable to tearing in this region because the collagen fibers make an abrupt 90° turn as they approach the greater tuberosity [1]. Rim-rent tears appear on MR images as a thin linear area of high signal adjacent to the horizontal superior portion of the greater tuberosity, interrupting the normal attachment of the articular surface cuff fibers. MR images of a partial-thickness tear that appears to be a rim-rent tear have been published [16], but ours is the first detailed description that we are aware of in the radiology literature. These tears are important because they can be confused with intrasubstance high signal that does not communicate with the surface of the cuff, an MR finding common

in older patients (Fig. 5). Interruption of the articular surface cuff fibers by the high signal could be seen in retrospect in two of the four rim-rent tears that were missed on the prospective MR interpretation.

Our study also objectively confirms Rockwood and Matsen's assertion that rim-rent tears tend to occur in younger patients [1], as the average age of patients with these tears was statistically significantly younger than that of patients with similarly sized partial tears located more medially in the critical zone. Rim-rent tears should be looked for carefully on MR images in young adults referred for shoulder pain, especially when there is high signal that appears to be within the substance of the supraspinatus tendon at the insertion.

There is some controversy about the treatment of partial-thickness and small full-thickness rotator cuff tears. Although some surgeons will operate only on full-thickness tears, other surgeons will perform arthroscopic debridement of partial tears [7]. Burkhart's data suggest that laterally located rim-rent tears, even though they do not alter the mechanics of the supraspinatus tendon, may have an unstable edge which can cause pain such that these patients may benefit from debridement [17]. Burkhart has also shown that large full-thickness tears in the critical zone that disrupt the cablelike transverse thickening of the rotator cuff usually require surgical repair [17]. For partial-thickness or small full-thickness RCTs identified on MR images at our institution, our shoulder surgeon will perform arthroscopic debridement if the patient's pain does not improve with 2–3 months of physical therapy.

There are several weaknesses in this study. Our sensitivity for partial-thickness and small full-thickness RCTs is lower than in some recent articles, although it improved in the patients scanned with our current technique. Several recent articles have reported sensitivity values for partial RCTs similar to ours, and have noted that some of these tears can be difficult to diagnose even with fat-suppressed T2-weighted images [18, 19]. We might have been able to report higher accuracies with a retrospective blinded review, but one of our purposes was to determine whether there had been a difference in our prospective MR sensitivity for anterior versus posterior cuff tears. An additional limitation was that not all the MR reports specified the location of the tear, so we cannot confirm that all of the tears identified on the MR images correlated with the location seen at arthroscopy. Finally, there was a selection bias as all the patients had an MR at our institution and underwent surgery. Although patients who go to arthroscopy tend to have more severe disease than those treated conservatively, we felt that it was important to include only patients with surgically proven and sized tears.

In summary, we have found that even in patients less than 36 years old, a majority (79%) of RCTs are located in the anterior half of the rotator cuff. Although our MR sensitivity is lower than in recent articles, we found that the sensitivity of MR for cuff tears in the infraspinatus and posterior supraspinatus tendons is almost as high as for anterior tears. Although most rotator cuff tears occur in older individuals, rim-rent tears comprise 25% of the tears found in patients less than 36 years old and therefore should be carefully looked for in younger patients who undergo MR imaging for shoulder pain.

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