Outcome of Nonoperative Treatment of Symptomatic Rotator Cuff Tears Monitored by Magnetic Resonance Imaging

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Outcome of Nonoperative Treatment of Symptomatic Rotator Cuff Tears Monitored by Magnetic Resonance Imaging

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Background: Rotator cuff tears are very common, but little is known about the outcome of nonoperative treatment of symptomatic tears in terms of progression and the need for surgical intervention.

Methods: Fifty-nine shoulders in fifty-four patients (thirty-three women and a mean age of 58.8 years) with rotator cuff tears on initial magnetic resonance imaging who had been managed nonoperatively were studied retrospectively. All had magnetic resonance imaging scans acquired six months or more after the initial study. The progression of the rotator cuff tears was associated with age, anatomical and associated parameters, follow-up time, and structural and other magnetic resonance imaging findings.

Results: Baseline magnetic resonance imaging scans demonstrated thirty-three full-thickness tears, twenty-six partial-thickness tears, and four combined full-thickness and partial-thickness tears. Fifty-eight of the fifty-nine tears involved the supraspinatus tendon, and ten involved multiple tendons. Progression in tear size occurred more often among the patients who were followed more than eighteen months (thirteen [48%] of twenty-seven shoulders) compared with those who were followed for less than eighteen months (six [19%] of thirty-two shoulders). Five tears (one partial-thickness tear) decreased in size. More than half (52%; seventeen) of the thirty-three full-thickness tears increased in size compared with 8% (two) of the twenty-six partial-thickness tears (p = 0.0005). Only 17% (six) of the thirty-five tears in patients who were sixty years old or less deteriorated compared with 54% (thirteen) of the twenty-four tears in patients who were more than sixty years old (p = 0.007). No shoulder in a patient with a partial-thickness tear demonstrated supraspinatus atrophy, whereas 24% of those with a full-thickness tear demonstrated atrophy (p = 0.007). The proportion with an increase in tear size was significantly larger for shoulders with fatty infiltration than for those without it (p = 0.0089).

Conclusions: Factors that are associated with progression of a rotator cuff tear are an age of more than sixty years, a full-thickness tear, and fatty infiltration of the rotator cuff muscle(s). In the long-term follow-up of nonoperatively treated rotator cuff tears, magnetic resonance imaging can be used to monitor rotator cuff changes and guide patient management.

Level of Evidence: Prognostic Level IV. See Instructions to Authors for a complete description of levels of evidence.
found that 80% of them had enlarged or progressed to full-thickness tears, while 20% stayed the same size or disappeared. Weber' reviewed partial-thickness tears that had been debrided during a first arthroscopy and found no evidence of any healing at a second arthroscopy. Yamaguchi et al.9 examined asymptomatic full-thickness tears ultrasonographically over time: nine of the twenty-three patients remained asymptomatic although two of them demonstrated tear progression. Those authors concluded that there appears to be a risk for progression in tear size over an interval of five years.

The management of rotator cuff tears is a matter of controversy, especially for tears with limited symptoms. While surgery is certainly a recognized treatment option, not all rotator cuff tears actually warrant surgical management. The potential surgical risks, postoperative pain, and extensive rehabilitation must always be considered against the risks of expectant management, such as potential progression of tear size with advancement to an irreparable tear and development of rotator cuff arthropathy. Patients who improve clinically without surgical intervention and those for whom surgery is contraindicated or who are simply reluctant to undergo surgery may be followed clinically and monitored with imaging. The optimal frequency of clinical and imaging assessment, however, is unknown, and the factors predisposing to tear progression are not clear nor has the optimal timing of surgical intervention been established.

Magnetic resonance imaging is considered one of the most accurate tools for the detection of rotator cuff tears, with sensitivity and positive predictive values ranging from 97% to 100%, but with specificities ranging between 67% and 89% compared with findings at arthroscopy. Magnetic resonance imaging can also be used to assess the rotator cuff musculature for atrophy and fatty infiltration, both factors that indicate a poor prognosis for return of rotator cuff function. Magnetic resonance imaging has been our primary modality for imaging the rotator cuff since 1999, and it has been performed routinely on all patients with a suspected rotator cuff tear. Patients demonstrating clinical improvement after noninterventional management have undergone follow-up clinical examinations and repeat magnetic resonance imaging scans.

In the present study, we retrospectively investigated the outcome in terms of progression or regression of nonoperatively managed rotator cuff tears over a period of up to five years on the basis of longitudinal magnetic resonance imaging scans and correlated the outcome with patient age and anatomical and associated findings. Our purpose was to assess long-term structural outcomes of rotator cuff tears treated nonoperatively.

Materials and Methods

The investigational review board of our institution approved this study. Between 1999 and 2005, all patients with a documented rotator cuff tear initially received conservative treatment with physiotherapy, activity restriction, and selective cortisone injections. Surgery was recommended when no improvement was seen at the end of six months, and these patients were excluded from the study. Those who responded to the conservative protocol were followed clinically and with magnetic resonance imaging scans to determine the status of the rotator cuff. A comprehensive review of all consecutive magnetic resonance imaging scans detected eighty-three patients (108 shoulders) with rotator cuff tears who had undergone two or more scans. Forty-nine of the 108 shoulders with two or more magnetic resonance imaging scans were excluded; thirty of them had missing clinical documentation, eight had recurrent dislocations, five had previous surgery on the affected shoulder, three had a history of major joint trauma, and one each had osteonecrosis, bone malignancy, and inflammatory disease. The final cohort consisted of fifty-nine shoulders in fifty-four patients who had a follow-up period ranging from seven to fifty-eight months (mean, twenty months; median, eighteen months).

Magnetic Resonance Imaging Evaluation

For all patients, magnetic resonance imaging of the shoulder was performed at a single imaging center with use of a 1.5-T imaging unit (Sigma; GE Medical Systems, Milwaukee, Wisconsin) equipped with a dedicated shoulder coil, and a standardized imaging protocol was used. The patients were positioned supine with the humerus externally rotated and the arm positioned at the side of the body. Magnetic resonance imaging scans acquired for all patients included a fast-spin-echo intermediate-weighted axial sequence (repetition time of 3500 msec, echo time of 35 msec, echo train length of 8, 512 × 256 matrix, 14-cm field of view, 3.5-mm slice thickness, no interslice gap, and 2 NEX [number of excitations]), a fast-spin-echo coronal oblique intermediate-weighted sequence (repetition time of 2000 msec, echo time of 20 msec, echo train length of 4, 256 × 256 matrix, 14-cm field of view, 4-mm slice thickness, no interslice gap, and 2 NEX), and coronal oblique fast-spin-echo T2-weighted acquisitions with fat suppression (repetition time of 3500 msec, echo time of 85 msec, echo train length of 8, 256 × 192 matrix, 14-cm field of view, 4-mm slice thickness, no interslice gap, and 4 NEX).

The images were evaluated by experienced musculoskeletal radiologists (C.H. or L.W.) in a blinded fashion. The first and last magnetic resonance imaging scans of all patients were randomly assessed by the radiologists who were blinded to the order (i.e., whether it was the first or last scan of the patient) and to any other information. Each category (such as the size of the tear, tendons involved, and muscle atrophy) of each magnetic resonance imaging was scored separately, with no knowledge of the results of the other categories. The two radiologists subsequently established the magnetic resonance imaging diagnosis by consensus in interpreting the findings. All other magnetic resonance imaging scans of a given patient were examined when there was any change between the first and last scans in order to establish the timing of the changes.

A tear was defined as a discontinuity of tendon fibers with the gap filled with high T2 signal. A full-thickness tear was defined as a high T2 signal extending through the depth of the tendon, and a partial-thickness tear was defined as a high signal extending through the depth of the tendon.
T2 signal passing only partially through the tendon, from the bursal surface, from the articular surface, or in its mid-substance. The tears were measured in all three planes. The measurement was made by following the contour of the humeral head. In partial-thickness tears, the three orthogonal planes were measured. In full-thickness tears, the coronal and sagittal extents were measured. In tears involving the subscapularis and supraspinatus tendons, the measurement was made across the interval region. The acromial anterolateral undersurface was assessed on the sagittal sequences, and an acromial spur or enthesophyte was diagnosed if there was osseous overgrowth of ≥3 mm from the projected native acromial undersurface. Changes in the acromioclavicular joint were assessed according to the method of de Abreu et al. on a scale of 1 (mild), 2 (moderate), and 3 (severe) and with use of the following criteria. Grade-1 acromioclavicular joint osteoarthritis consisted of one or more of the following changes: joint space narrowing, irregularity of the joint margins, and the presence of high signal on T2-weighted images in the joint; Grade 2 consisted of Grade-1 changes as well as one or more of the following changes: the presence of subchondral cysts, bone sclerosis, small osteophytes (<2 mm), and soft-tissue formation (<2 mm) around the joint; and Grade 3 consisted of Grade-2 changes as well as one or more of the following changes: the presence of large osteophytes (>2 mm), soft-tissue proliferation (>2 mm), and a mass effect on the rotator cuff beneath the acromioclavicular joint.

The muscles of the rotator cuff were assessed for atrophy as described by Zanetti et al. The supraspinatus muscle belly was assessed in the sagittal plane medially, with a line (tangent) drawn through the superior borders of the scapular spine and the superior margin of the coracoid. The tangent sign was defined as positive (atrophy) when the supraspinatus muscle did not cross the tangent. Fatty infiltration was also graded on a scale from 0 to 4, as a modification of the classification of Goutallier et al. adapted to magnetic resonance imaging: grade 0 indicated no fatty deposits; grade 1, some fatty streaks; grade 2, more muscle than fat; grade 3, fat equal to muscle; and grade 4, more fat than muscle.

The magnetic resonance imaging scans of a patient were compared to determine whether the tear had been stable or had either increased or decreased in size. The extent of change was divided into five categories for full-thickness tears: (1) an increase of >5 mm, (2) an increase between 2 and 5 mm, (3) no change (increases of <2 mm to decreases of <2 mm), (4) a decrease between 2 and 5 mm, and (5) a decrease of >5 mm. Since small changes in tear size might be difficult to detect, only a change of >5 mm was classified as an increase or decrease for partial-thickness tears. The extent of change was compared between groups by age, length of follow-up (months), the involved tendon (supraspinatus, subscapularis, infraspinatus, or teres minor), the type of tear (partial-thickness tear compared with full-thickness tear, and bursal side compared with glenohumeral side), the existence of an acromial spur, acromioclavicular joint arthritis, and muscle atrophy or fatty infiltration.

Statistical Methods
Continuous variables were summarized by means or medians and their ranges. Categorical variables were summarized by percentages. The five size categories described above are used in the tables to present changes in tear size. For statistical comparisons between groups, a change in tear size was dichotomized as increased compared with unchanged or decreased. The Fisher exact test was used to make simple comparisons of percentages between groups formed on the basis of patient or shoulder characteristics. Confidence intervals for differences in percentages were calculated with use of the Newcombe method. The relationship between an increase in tear size and the elapsed time between a patient’s first and last magnetic resonance imaging scans was assessed with use of logistic regression, with elapsed time grouped into four a priori chosen categories, and treated as a continuous variable (with use of the logarithm of time to reduce the influence of outlying values). The level of significance was set at \( p < 0.05 \). All data analyses were done with use of R (version 2.7).

Source of Funding
There was no external funding source for this study.

Results
Fifty-nine shoulders in fifty-four patients (thirty-three women) with rotator cuff tears that had been documented on an initial magnetic resonance imaging scan and managed nonoperatively were studied. The mean age of the patients was 58.8 years (range, thirty-eight to eighty-four years). The mean follow-up period was twenty months (range, seven to fifty-eight months): sixteen shoulders (27%) had been followed for twelve months or less; sixteen (27%), for thirteen to eighteen months; twelve (20%), for nineteen to twenty-four months; and fifteen (25%), for twenty-five months or more. Each shoulder had a mean of 2.95 (range, two to six) magnetic resonance imaging scans, acquired at a mean interval of 10.1 months, for a total of 174 scans.

Follow-up Time
Among the sixteen shoulders in patients with twelve months of follow-up or less, the tear size increased in two, with an increase of >5 mm in one partial-thickness tear. In the sixteen shoulders in patients who had a follow-up of thirteen to eighteen months, four (all full-thickness) tears increased in size, with an increase of >5 mm in two. In the twelve shoulders followed for nineteen to twenty-four months, the tear size increased in seven, with changes of >5 mm in three full-thickness tears and one partial-thickness tear. In the fifteen shoulders followed for twenty-five to sixty months, the tear size increased in six, with changes of >5 mm in three full-thickness tears. In summary, progression in tear size occurred more often among the patients who were followed more than eighteen months (thirteen [48%] of twenty-seven shoulders) than among those followed less than eighteen months (six [19%] of thirty-two shoulders). Using logistic regression analysis, there was a significant increasing linear trend over the
four follow-up groups ($p = 0.036$). In a model with the logarithm of follow-up time as a continuous variable, the odds ratio for an increase in tear size was 2.1 (95% confidence interval, 1.01 to 4.8) with a doubling of the follow-up time.

For the full-thickness tears, five of the fifteen tears with up to eighteen months of follow-up increased in size, whereas twelve of the eighteen tears with between nineteen and sixty months of follow-up increased in size. A total of five rotator cuff tears (8%) decreased in size (with a decrease of >5 mm in two, one of which was a partial-thickness tear), thirty-five (59%) remained the same size, and the remaining nineteen (32%) became larger (an increase of >5 mm in ten, two of which were partial-thickness tears) (Table I). More than half (52%; seventeen) of the thirty-three full-thickness tears increased in size compared with 8% (two) of the twenty-six partial-thickness tears ($p = 0.0005$).

**Patient Age**
We divided the patients into two age groups (after examining the distribution of ages): sixty years or less (thirty-one patients; thirty-five shoulders) and more than sixty years (twenty-three patients; twenty-four shoulders). We found more shoulders with increases in tear size in the older group (thirteen shoulders in twelve patients; 54%) than in the younger group (six shoulders in six patients; 17%). This difference was significant (95% confidence interval for difference, 10% to 64%; $p = 0.007$).

<table>
<thead>
<tr>
<th>TABLE I Changes in Full and Partial-Thickness Tears During Follow-up*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of &gt;5 mm</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Full-thickness tear (n = 33)</td>
</tr>
<tr>
<td>Partial-thickness tear† (n = 26)</td>
</tr>
</tbody>
</table>

*The values are given as the number of shoulders, with the percentage in parentheses. †Of the thirty patients with a partial-thickness tear, four had combined full-thickness and partial-thickness tears, leaving twenty-six with a partial-thickness tear only.

In the partial-thickness group, only one shoulder (in a patient who was less than sixty years old) had a reduction in tear size and two shoulders (one from each group) had an increase (Table II).

**Tear Type**
Initially, thirty (51%) of the fifty-nine shoulders were diagnosed as having a partial-thickness tear of the rotator cuff; eighteen (31%) had an articular-side tear, eleven (19%) had a bursal-side tear, and one shoulder was diagnosed with a combined articular and bursal partial-thickness tear of the cuff (Table III). The sizes of the tears (width $\times$ retraction $\times$ depth) ranged between 2 $\times$ 3 $\times$ mm and 18 $\times$ 18 $\times$ mm for the articular-side tears and between 4 $\times$ 2 $\times$ mm and 15 $\times$ 8 $\times$ mm for the bursal-side tears. Twenty-six (87%) of these tears remained stable during follow-up.

Thirty-three shoulders (56%) had a full-thickness tear of the rotator cuff (an additional partial tear was diagnosed in four of them: three on the articular side and one on the bursal side). The size of the full-thickness tears ranged from 6 $\times$ 6 mm to 75 $\times$ 60 mm. Only twelve (36%) of the full-thickness tears had not undergone any change with time: seventeen increased in size and four decreased in size (Table I).

**Type of Tendon**
Forty-nine shoulders (83%) had one torn tendon (forty-eight tears were in the supraspinatus and one was in the infraspi-
natus), eight (14%) had two torn tendons (the supraspinatus and infraspinatus or the supraspinatus and subscapularis), and two (3%) had three torn tendons (supraspinatus, infraspinatus, and subscapularis). All partial-thickness tears involved the supraspinatus tendon. Two of these tears involved the infraspinatus tendon as well.

None of the tears that involved more than one tendon became smaller with time. Two isolated supraspinatus tendon tears progressed to involve the infraspinatus tendon as well. Six of the two-tendon tears remained the same, while two others (both full-thickness tears) became larger, with one increasing by >5 mm. Among the two three-tendon tears, one remained stable and the other increased by 2 to 5 mm.

**Acromioclavicular Joint Arthritis**

The magnetic resonance imaging scan initially demonstrated moderate-to-severe acromioclavicular joint arthritis in thirty-three shoulders (56%). During follow-up, fourteen (42%) of them demonstrated an increase in tear size and sixteen underwent no change. The remaining three showed a decrease of 2 to 5 mm. In the twenty-six shoulders with acromioclavicular joint arthritis classified as none to mild, twelve showed no change in tear size and seven tears (27%) increased in size. Five had a decrease of 2 to 5 mm, and two had a decrease of >5 mm. With the numbers studied, this difference in the percentage of tears increasing in size was not significant (95% confidence interval, −9% to 37%; p = 0.28).

**TABLE III Changes in Partial-Thickness Tears During Follow-up**

<table>
<thead>
<tr>
<th>Decrease of &gt;5 mm</th>
<th>No Change</th>
<th>Increase of &gt;5 mm</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articular side</td>
<td>2</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Bursal side</td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Articular and bursal sides</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

*The values are given as the number of shoulders.

**Acromial Spur**

When all tears were examined, the presence of an acromial spur seemed to have little effect on tear progression. An acromial spur was found in forty-six shoulders (78%). Of those, twenty-six shoulders (57%) did not undergo any change in tear size over time and seventeen (37%) became larger. Among the thirteen shoulders with no acromial spur, two tears increased in size. With the numbers studied, no significant difference was detected between the groups with and without acromial spurs with regard to tear progression (95% confidence interval for difference, −7.4% to 50.5%; p = 0.26); however, the frequency of the presence of a spur differed between the partial-thickness tear and full-thickness tear groups. Most (twenty-nine; 88%) of the thirty-three full-thickness tears had an acromial spur, while only seventeen (65%) of the twenty-six partial-thickness tears had one (95% confidence interval for difference, 0% to 43%; p = 0.058).

**Supraspinatus Atrophy**

Only eight shoulders (14%) had supraspinatus atrophy. Five of them had tear progression of ≥2 mm over time. Among the fifty-one shoulders with no atrophy, sixteen (31%) had tear progression of at least 2 mm. None of the rotator cuff tears in shoulders with supraspinatus atrophy decreased in size. With the numbers studied, a comparison of the proportion of shoulders with tear progression with and without supraspinatus atrophy revealed no significant difference (difference, 31%; 95% confidence interval, −4% to 57%; p = 0.119). Eight (24%) of the thirty-three full-thickness tears demonstrated supraspinatus atrophy compared with none of the partial-thickness tears (difference, 24%; 95% confidence interval, 7% to 41%; p = 0.007).

**Fatty Infiltration of the Rotator Cuff Musculature**

The increase in tear size was more common for shoulders with fatty infiltration than for those without (Table IV). Eight shoulders (14%), one of which had a partial-thickness tear, showed fatty infiltration of the rotator cuff musculature on the initial magnetic resonance imaging scan. The grade of fatty infiltration worsened in four of them. Another six shoulders (one with a partial-thickness tear) developed fatty infiltration over time in a previously normal muscle, yielding a total of ten

**TABLE IV Muscle Fatty Infiltration in Association with Tear Progression**

<table>
<thead>
<tr>
<th>Fatty Degeneration</th>
<th>Measurably Increased†</th>
<th>No Change in Size‡</th>
<th>Measurably Decreased§</th>
<th>Total No. of Shoulders</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>10 (22)</td>
<td>30 (67)</td>
<td>5 (11)</td>
<td>45 (76)</td>
</tr>
<tr>
<td>Developed or advanced</td>
<td>7 (70)</td>
<td>3 (30)</td>
<td>0 (0)</td>
<td>10 (17)</td>
</tr>
<tr>
<td>Present but not greater than baseline</td>
<td>2 (50)</td>
<td>2 (50)</td>
<td>0 (0)</td>
<td>4 (7)</td>
</tr>
</tbody>
</table>

*The values are given as the number of shoulders, with the percentage in parentheses. †An increase of ≥2 mm for full-thickness tears and ≥5 mm for partial-thickness tears. ‡A decrease of <2 mm to an increase of <2 mm for full-thickness tears and a decrease of <5 mm to an increase of <5 mm for partial-thickness tears. §A decrease of ≥2 mm for full-thickness tears and ≥5 mm for partial-thickness tears.
shoulders (17%) that either developed or underwent an increase in fatty infiltration of the rotator cuff. Of the ten shoulders, seven (one with a partial-thickness tear) also showed an increase in tear size. By comparison, twelve (24%) of the forty-nine with no fatty infiltration or no new fatty infiltration had an increase in tear size (95% confidence interval for difference, 12% to 67%; p = 0.0089).

One shoulder with progressing fatty infiltration had three involved tendons, and three shoulders had two involved tendons (the supraspinatus and infraspinatus were involved in two shoulders, one of which had a partial-thickness tear, and the supraspinatus and subscapularis were involved in the third shoulder).

Fatty infiltration was present in two (8%) of the twenty-six shoulders in the partial-thickness tear group. It was also present in eight (24%) of the thirty-three shoulders in the full-thickness tear group. With the numbers studied, no significant difference was identified between the two groups (95% confidence interval for difference, −3% to 34%; p = 0.161).

Discussion

Despite the high prevalence of both symptomatic and asymptomatic rotator cuff tears in the general population, the outcome of nonoperative treatment of symptomatic rotator cuff tears remains unclear. Previous cadaver studies have demonstrated a wide spectrum of pathologic changes to the rotator cuff, which were seen with increasing frequency in older individuals, reaching a prevalence of as high as 80% in individuals who were eighty years of age or older. Beyond these anatomical studies, there is very little epidemiologic information on this often debilitating condition. In an attempt to shed some light on the subject and evaluate the factors affecting the natural history of rotator cuff tears, Yamaguchi et al. investigated the demographic and morphologic characteristics of both symptomatic and asymptomatic rotator cuff tears. From a large group of 376 patients, increasing age was correlated to the onset of partial and full-thickness tears, and the development of symptoms was affected by the size of the tear. In another study by Yamaguchi et al. that evaluated the natural history of asymptomatic full-thickness tears, nine of twenty-three patients had substantial tear progression (>5 mm), and no patient had a tear that became smaller. Two of the nine patients who had remained asymptomatic went on to have tear progression compared with seven of fourteen in a newly symptomatic group.

Little is known about the outcome of nonoperative treatment of partial-thickness tears as well. In a series of thirty-five en bloc histological sections from surgical specimens of partial-thickness tears, Fukuda and Hamada observed no evidence of active repair in any portion examined. Rather, there were many instances of impending full-thickness tears on histological sections, which showed only narrow tissue connections. Yamanaka and Matsumoto undertook a two-year arthrographic follow-up study of forty joint-side partial-thickness tears, which had not been treated surgically. They found that 20% of the tears had decreased in size or disappeared, but 80% had become larger or progressed to full-thickness tears. In two other studies, arthroscopic follow-up after débridement of joint-side partial-thickness tears demonstrated no evidence of healing at the time of the second arthroscopy.

With the increasing availability and clinical use of magnetic resonance imaging, fatty infiltration of rotator cuff muscles has become an important prognostic indicator for repair. Grade-4 fatty changes are associated with inferior results after repair, and fatty infiltration is also known to progress with age in unrepaired rotator cuffs. On the other hand, the current common practice is not to operate on asymptomatic tears. This can leave the physician with a clinical paradox. Many patients with full-thickness tears may remain asymptomatic, while fatty infiltration might progress. By the time symptoms have become bad enough to justify surgery, the rotator cuff tissue may not be amenable to repair. By investigating the outcome, as documented on magnetic resonance imaging, of nonoperatively treated rotator cuff tears, we hoped to provide guidelines for the management of asymptomatic tears that had been successfully treated nonoperatively.

As reported by Yamaguchi et al., patients who have nonoperative treatment of rotator cuff tears should be monitored for tear size progression over time. They recommend repeating ultrasonography six months from the initial assessment and on a yearly basis if that imaging study does not show tear size progression. In our study of nonoperatively treated rotator cuff tears, we found that, while up to eighteen months of follow-up could demonstrate progression of the tears in 12% to 25% of the shoulders on magnetic resonance imaging, longer follow-up increased this rate to 40% to 60%. Our findings show that the probability of an increase in tear size had a significant increasing linear trend with groups followed over time (p = 0.036), with an odds ratio of 2.1 (95% confidence interval, 1.01 to 4.8) for an increase in tear size occurring with a doubling of the follow-up time. These percentages are similar to those of Yamaguchi et al. who reported a 40% progression rate with 5.5 years of follow-up. However, they studied only full-thickness tears and used ultrasound imaging. Our study included partial-thickness tears as well, and one partial-thickness tear in each group (those followed for up to eighteen months and those followed for nineteen to sixty months) increased in size. In the shoulders with a full-thickness tear, five of fifteen tears with eighteen months of follow-up increased in size, while twelve of eighteen tears with nineteen to sixty months of follow-up increased in size. From these results, one may conclude that most of the changes occurring (usually enlargement) in the full-thickness tear group may have occurred after the first eighteen months of follow-up. Since our number of tear size changes in the partial-thickness tear group is small, no conclusion can be drawn.

Yamaguchi et al. did not find a decrease in tear size with time. In contrast, five (9%) of our patients demonstrated a
decrease in tear size on magnetic resonance imaging. Notably, four of them had full-thickness tears. Yamanaka and Matsumoto reported that a decrease in tear size was usually seen in partial-thickness tears. Fukuda described synovial proliferation that may mask small rotator cuff defects at the time of surgery. Jost et al. followed patients with a failed rotator cuff repair, and eight of twenty tears could no longer be identified on a repeat magnetic resonance imaging scan. The rotator cuff was in continuity without any detectable full-thickness structural defect, and the bridging tissue had a signal intensity ranging from that of scar tissue to that of normal tendon tissue. We are aware that our observation of a rotator cuff tear decreasing in size is in contrast to most previous reports in the literature. Fukuda stated that these tears do not heal. Various studies have supported that statement, and it is commonly accepted that rotator cuff lesions not only fail to heal spontaneously but also have a strong tendency to progress. These earlier studies have not, however, involved sequential examinations of the tears. Although a comparison of all of the available sources of information is not ideal because of the use of different materials and methods, we contend that, on the basis of our data and those of several other reports, a decrease in the size of a rotator cuff tear may occur with time as detected by different imaging methods (i.e., magnetic resonance imaging and arthrography). The quality of the tissue forming in the tear site (synovial proliferation and scar tissue) either in full-thickness tears or in partial-thickness tears has yet to be determined.

Our findings showed a significant (p = 0.007) and direct association between tear deterioration and increasing patient age. Fewer than 20% of the tears in patients who were sixty years of age or younger had an increase in tear size, whereas most of the older patients showed an increase in tear size. This finding may be explained by the presence of poor quality tendon tissue among older patients.

Overall, nineteen (32%) of the fifty-nine rotator cuff tears in our study deteriorated, while thirty-five (59%) stayed the same over time. The picture changed, however, when full-thickness tears were compared with partial-thickness tears. Full-thickness tears were less likely to remain stable or decrease in size. Indeed, 52% increased in size and were substantially less stable than partial-thickness tears. The progression of full-thickness tears in our study was similar to that in the study by Yamaguchi et al.; however, the progression of partial-thickness tears in our study was different from that in the study by Yamanaka and Matsumoto. The rate of progression for articular-sided tears was 80% in their study compared with 17% (five) of thirty shoulders with a partial-thickness tear and four of eighteen shoulders with an articular-sided tear in our study. This difference may be explained by the use of different diagnostic techniques (arthrography compared with magnetic resonance imaging).

Interestingly, the only tendon that demonstrated a decrease in tear size was the supraspinatus and that occurred when it was the only tendon involved. All five tears in our study that decreased in size involved the supraspinatus, although most of (thirty-three) of the isolated supraspinatus tears in our study did not deteriorate. According to Jost et al., seven of the eight tendons in their series that healed spontaneously after a failed repair were isolated supraspinatus tears. It can be argued that isolated supraspinatus tears may experience less severe degeneration over time.

A significant difference was found between the partial-thickness tears, none of which demonstrated supraspinatus atrophy, and the full-thickness tears, 24% of which demonstrated this atrophy (p = 0.007).

The prevalence of muscle fatty infiltration in our study was 24% (fourteen shoulders), with eight shoulders demonstrating the process of infiltration on the initial magnetic resonance imaging and an additional six that had infiltration develop over time in previously normal muscle. Examinations of the correlation between developed or advanced fatty infiltration of the muscle and tear progression demonstrated an increase in tear size in seven of the ten such shoulders compared with twelve (24%) of forty-nine shoulders without new appearance or advancement of muscle fatty infiltration (p = 0.0089). Four of those tears involved more than one tendon. Of all the shoulders with a partial-thickness tear, only two had fatty infiltration. Six of nine tears with fatty infiltration of the muscle that increased in size progressed by ≥5 mm. We do not know which factor contributes more than others to the deterioration, and we know of no relevant data in the literature. As for the prevalence of muscle fatty infiltration in patients with rotator cuff retears, Jost et al. reported that 55% had stage-3 or 4 fatty infiltration of the supraspinatus and infraspinatus muscles at the time of the final follow-up (7.6 years). Mellado et al. found a prevalence ranging from 39.2% to 53.5% depending on the muscle involved. These figures are higher than ours, but they may be attributed to the longer follow-up period in those studies, the high percentage of partial-thickness tears in our study, and the fact that their patients had reached the point when surgical intervention was necessary, which might be indicative of the severity of the process. Another study, by Zingg et al., aimed to determine the clinical and structural mid-term outcomes in a series of nonoperatively managed massive rotator cuff tears. Similar to those in our study, massive tears had a tendency to progress and have increased fatty infiltration.

There are some limitations to our study. Our patient dropout rate (twenty-nine of eighty-three patients) may have compromised our analysis. Either those patients did not respond to the conservative protocol and sought treatment elsewhere, or they improved clinically and did not return for follow-up. Our study, however, focused on magnetic resonance imaging follow-up and not on the clinical aspects of rotator cuff tears. We do not use steroid injections in the presence of a rotator cuff tear, but some of the study patients began treatment elsewhere, and we know of at least two who had injections previously. There are marked variations in follow-up periods and timing of the magnetic resonance imaging studies because of the retrospective nature of our study. We looked at many relationships between the characteristics of the injured
shoulders, and this should be borne in mind when interpreting individual positive findings. Conversely, with a sample of this size, a negative finding (i.e., with no association) may not convincingly rule out the possibility that there is an important association. To give the reader a sense of what true differences in percentages are consistent with our observed data, we presented confidence intervals for most of our findings as has been recommended recently. Although magnetic resonance imaging is considered one of the most accurate tools for the detection of a rotator cuff tear, its accuracy in measuring tears of <1 cm in size (partial-thickness or full-thickness) remains in dispute. Teefey et al. found that only 63% to 80% of tear measurements were accurate to within 5 mm of the measurements recorded at arthroscopy. The ability of magnetic resonance imaging in distinguishing between tendon healing or other tissue formation is not clear, and we cannot come to any conclusions about tissue quality. Finally, some of our results (such as fatty infiltration) are based on small numbers of shoulders, and no firm conclusions can be drawn from them.

In conclusion, we set out to find answers to the dilemma of optimum management of asymptomatic rotator cuff tears documented on magnetic resonance imaging. It can be concluded that multitendon (more than one), full-thickness tears in the older age groups progress over time, and fatty infiltration appears to be a significant determinant of tear reparable.

### References


