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Clinical and Radiographic Outcomes of Failed Repairs of Large or Massive Rotator Cuff Tears

Minimum Ten-Year Follow-up

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Investigation performed at Washington University Orthopedics, Barnes-Jewish Hospital, St. Louis, and Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri

Introduction: Little information exists regarding the long-term outcome after structural failure of rotator cuff repair. We previously reported clinical improvement, despite a 94% rate of failure of healing, at two years of follow-up in a cohort of eighteen patients who had undergone arthroscopic repair of massive rotator cuff tears. The purpose of the present study was to evaluate the ten-year results for these patients with known structural failures of rotator cuff repairs.

Methods: Fifteen (83%) of eighteen patients were available for follow-up at ten years. Patients were evaluated with use of the American Shoulder and Elbow Surgeons (ASES) score, the Simple Shoulder Test (SST), a visual analog scale pain score, and the Constant score. Radiographs and sonograms were assessed.

Results: The average age was 74.6 years at the time of the latest follow-up. The average ASES score was 79.4 points (range, 50 to 95 points) and the average visual analog scale pain score was 2.2 points (range, 1 to 4 points); both scores were unchanged from those at two years. The average SST score was 9.2 points (range, 6 to 12 points), and the average age-adjusted Constant score was 73.2 points (range, 58.7 to 89.7 points). Of the patients with structurally failed repairs, all but one had radiographic signs of proximal humeral migration or cuff tear arthropathy: three had Hamada Grade-2 changes, five had Grade-3 changes, and three had Grade-4 changes (with two having Grade-4a changes and one having Grade-4b changes). Ultrasound confirmed the persistence of all tears that had been seen at two years.

Conclusions: Clinical improvements and pain relief after arthroscopic rotator cuff repair of large and massive tears are durable at the time of long-term (ten-year) follow-up, despite early structural failure of repair. Shoulders had a high rate of progression of radiographic signs associated with large rotator cuff tears. These results demonstrate that healing of large rotator cuff tears is not critical for long-term satisfactory clinical results in older patients.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Failure of healing following rotator cuff repair remains a substantial risk, especially in older individuals, yet little knowledge exists with regard to the long-term fate of these patients. We reported good initial outcomes after the arthroscopic repair of large and massive tears, despite a high rate of failure of healing. Several factors are associated with the failure of healing, such as age and tear size. However, healing is not always necessary for a successful outcome. As our population ages, it becomes increasingly important to identify not only factors that are associated with healing but also surgical and patient-related factors that are associated with durable pain relief and function postoperatively, especially in patients with structural failure.

Favorable short to intermediate-term clinical outcomes are often achieved after both open and arthroscopic repairs of massive rotator cuff tears, despite the failure of healing. Nevertheless, recent studies have shown that glenohumeral degenerative changes progress in many patients, regardless of

Disclosure: One or more of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of an aspect of this work. In addition, one or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete Disclosures of Potential Conflicts of Interest submitted by authors are always provided with the online version of the article.
the integrity of the repair. Furthermore, fatty degeneration of the rotator cuff muscles progresses in patients with failed repairs, and reversal of fatty atrophy does not occur in shoulders with intact repairs. Degenerative changes also have been reported to occur after nonoperative treatment of large and massive rotator cuff tears, despite satisfactory functional outcomes after four years of follow-up. The long-term impact of progressive osteoarthritic changes and increased fatty degeneration on the functional outcomes for patients with an unhealed cuff is unknown.

Our previous report included eighteen patients who underwent an arthroscopic single-row repair of a large or massive rotator cuff repair, seventeen of whom had ultrasound evidence of a persistent tear. The purpose of the present study was to evaluate the ten-year clinical and radiographic outcomes for this same cohort of patients with known structural failures.

Materials and Methods

After approval from the institutional review board, the original cohort of eighteen patients was contacted. Three patients were lost to follow-up. Therefore, fifteen (83%) of the original eighteen patients were included in the present study (see Appendix).

Surgical Procedure/Rehabilitation

Details on the surgical procedure and rehabilitation were previously reported. The repairs were performed from 1997 to 2000. Only patients with rotator cuff tears involving two or more tendons were included. The average age at the time of the index procedure was sixty-one years (range, fifty to eighty-seven years). A biceps tenotomy was performed in three patients. A coracocromial ligament release and conservative subacromial decompression was performed in fifteen patients. The rotator cuff repair was performed with use of a single-row construct with 5-mm bioabsorbable corkscrew anchors (Arthrex, Naples, Florida). Two to five anchors were used, depending on tear size and configuration. The arm was immobilized in a sling.

The rehabilitation protocol began on the first postoperative day with passive shoulder range-of-motion exercises, including passive forward flexion, external rotation, pendulum, and pulley exercises, as was the authors’ preferred approach at the time of the index procedure. Active-assisted motion was initiated at six weeks. A return to recreational activity with heavy demands on the shoulder or to manual labor was delayed for six months.

Clinical Evaluation

Subjects were evaluated by an independent examiner at a minimum of ten years (average, 10.6 years) after the time of the index procedure. All patients completed a comprehensive shoulder questionnaire that included questions allowing for the calculation of the American Shoulder and Elbow Surgeons (ASES) score and the Simple Shoulder Test (SST) score. Physical examination and strength parameters were obtained to calculate the Constant score. Each subject provided information on current pain, satisfaction, functional abilities, employment, and sporting activity. Pain was recorded on a visual analog scale (VAS) from 0 to 10.

Physical examination was performed in a standardized fashion. Physical examination measurements were performed with use of a goniometer by an independent orthopaedic surgeon or a research assistant trained in the physical examination of the shoulder. Measured shoulder motions included scapular plane abduction and with the arm at the side, and internal rotation behind the back. The strength of shoulder elevation was measured with a dynamometer (Isobex, Bern, Switzerland) in 90° of scapular plane abduction and with the arm at the side in neutral rotation. Strength testing was repeated three times, and an average value was calculated. The Constant score was converted to the age-adjusted normative value as expressed by Katolik et al.

Radiographic Evaluation

Anteroposterior, true anteroposterior, scapular Y, and axillary view radiographs were made in a standardized fashion. Two orthopaedic surgeons (L.M.G. and E.S.P.) independently reviewed the radiographs to assess the presence and degree of rotator cuff arthropathy according to the grading system of Hamada et al. Discrepancies were discussed to reach a consensus in terms of the grade.

Ultronography

Shoulder ultrasonography was performed and interpreted in real time with use of an Elegra and Antares scanner (Siemens Medical Solutions, Mountain View, California) and a variable high-frequency linear array transducer (7.5 to 10 MHz) by one of two radiologists with extensive experience in musculoskeletal ultrasonography. The maximum anteroposterior dimension of a tear was measured on a transverse view (i.e., perpendicular to the long axis of the rotator cuff) and was designated as the width of the tear. The maximum degree of retraction was measured on a longitudinal view (i.e., parallel to the long axis of the rotator cuff). Ultrasound accuracy has been validated at our institution for the evaluation of cuff tear size both preoperatively and postoperatively.

In order to assess fatty degeneration, the echogenicity and architecture of each muscle were examined with use of a 3-point scale, modified from the technique previously described by Strobel et al. The echogenicity of the muscles was determined in comparison with the echogenicity of the overlying trapezius or deltoid. The architecture was determined on the basis of the visibility of the intramuscular tendons and the normal muscle pennate pattern. Tear size progression was defined as a change of >5 mm in the width or length of the tear compared with the tear size at two years.

Statistical Evaluation

Calculations were performed with use of Excel 2007 (Microsoft, Redmond, Washington). The Student t test was used to evaluate for differences between values at different time points.

Source of Funding

A grant from the Mallinckrodt Institute of Radiology supported the imaging studies.

Results

Fifteen of the original eighteen patients were available for follow-up, including five women and ten men. The average age was 74.6 years (range, sixty-three to ninety years) at the time of the most recent follow-up. Two patients underwent subsequent surgical procedures. The first patient underwent revision arthroscopic rotator cuff repair after a traumatic episode 112 months after the index procedure. This patient was evaluated eleven months after the subsequent revision and had a retear of the revision repair. He was included in this cohort of long-term follow-up patients with known structural failure of a rotator cuff repair. The second patient had development of advanced rotator cuff arthropathy and underwent hemiarthroplasty with pectoralis major tendon transfer four years postoperatively and was not included in the present study. A third patient had an intact repair at both the two-year and ten-year follow-up time points and was not included in the present study. A fourth patient agreed only to a telephone interview but would not return for clinical or radiographic evaluation. A fifth patient refused range-of-motion and strength testing secondary to hand and forearm comorbidities but had radiographic and ultrasound evaluations. Therefore, follow-up was completed for thirteen patients who had not undergone arthroplasty and had a known structural rotator cuff repair failure,
eleven patients with complete follow-up, and two patients with partial clinical follow-up.

**Clinical Outcomes**
At ten years of follow-up, ASES, SST, and VAS pain scores were available for fourteen patients. Only outcome scores for patients with structural failure of rotator cuff repair are reported in Table I. The average ASES score was 79.4 points (range, 50 to 95 points), the average SST score was 9.2 points (range, 6 to 12 points), and the average VAS pain score was 2.2 points (range, 1 to 4 points). At two years postoperatively, the average ASES score had been 79.9 points (range, 35 to 100 points) and the average VAS pain score had been 2.3 points (range, 0 to 7 points). The ten-year ASES and VAS scores were not significantly different from two-year follow-up values (p > 0.05). The SST was not measured in our previous study.

The Constant score was calculated for eleven patients. The average Constant score was 65.3 points (range, 54.0 to 82.6 points); the average age-adjusted Constant score was 73.2 points (range, 58.7 to 89.7 points). The Constant score was not utilized in the original study.

**Range of Motion and Strength**
Forward flexion averaged 143.6° (range, 120° to 176°). External rotation strength in this study ranged from 18.6 to 129.4 Nm for men and from <10 to 46.2 Nm for women. External rotation averaged 46.3° (range, 5° to 75°). The average external rotation strength was 6.0 kg (range, 1.9 to 13.1 kg) (58.8 Nm [range, 18.6 to 128.5 Nm]), and the average abduction strength was 2.7 kg (range, <1 to 7.1 kg) (26.5 Nm [range, <9.8 to 69.6 Nm]). The average external rotation strength was 69.5 Nm for the male patients and 30.7 Nm for the three female patients. The average abduction strength was 36.3 Nm for male patients and <10 Nm for female patients. The normal average external rotation strength for males with an age of sixty years or more ranges from 92.2 to 100.0 Nm, depending on age and hand dominance, whereas the normal average for women ranges from 49.0 to 61.0 Nm.

**Radiographic Results**
Radiographs were available for twelve of the thirteen patients. One patient was unwilling to travel for radiographic analysis. Eleven patients had radiographic evidence of proximal migration of the humeral head with or without arthritic changes of the glenohumeral joint. One patient had Hamada Grade-1 changes, three patients had Grade-2 changes (acromiohumeral

**TABLE I Outcome Scores and Range of Motion**

<table>
<thead>
<tr>
<th></th>
<th>Preop.</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 10</th>
</tr>
</thead>
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<tr>
<td>SST score† (points)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>9.2</td>
</tr>
<tr>
<td>VAS pain score (points)</td>
<td>5.2</td>
<td>1.3</td>
<td>2.3</td>
<td>2.2</td>
</tr>
<tr>
<td>ASES score (points)</td>
<td>48.3</td>
<td>84.6</td>
<td>79.9</td>
<td>79.4</td>
</tr>
<tr>
<td>Constant score† (points)</td>
<td>Raw</td>
<td>NA</td>
<td>NA</td>
<td>65.3</td>
</tr>
<tr>
<td></td>
<td>Age-adjusted</td>
<td>NA</td>
<td>NA</td>
<td>73.2</td>
</tr>
<tr>
<td>Forward flexion (deg)</td>
<td>92</td>
<td>152</td>
<td>142</td>
<td>143.6</td>
</tr>
<tr>
<td>External rotation (deg)</td>
<td>44</td>
<td>NA†</td>
<td>53</td>
<td>46.3</td>
</tr>
</tbody>
</table>

*NA = not available. †SST and Constant scores were not measured previously. ‡External rotation strength for the one-year time point was not available.

Figs. 1-A and 1-B A sixty-six-year-old man who had a Constant score of 89.7, forward flexion to 150°, and a VAS pain score of 1. Fig. 1-A Anteroposterior radiograph of the shoulder, showing Hamada Grade-4b changes. Fig. 1-B Coronal ultrasound image, with the greater tuberosity on the left and the retracted tear margin on the right, showing a persistent massive rotator cuff tear. Cursors mark the extent of the tear for the purposes of measurement.
interval, <5 mm), five patients had Grade-3 changes (acetabularization), and three patients had Grade-4 changes (Figs. 1-A and 1-B) (including two with Grade-4a changes [glenohumeral arthritis with an acromiohumeral interval of <7 mm] and one with Grade-4b changes [glenohumeral arthritis with acetabularization]). The patient who had repeat rotator cuff repair had Hamada Grade-2 changes. Comparison of Hamada grades and other outcome measures is shown in Table II.

**Ultrasound**

Twelve patients, including the patient who had undergone revision surgery and the patient with a healed rotator cuff at two years, underwent ultrasound evaluation. Ultrasound confirmed a cuff tear in all eleven patients who had a tear at two years (Figs. 2-A and 2-B). Two patients had progression in the size of the tear, four had no change in the size of the tear, one patient had a massive tear that could not be measured accurately, and four patients had a decrease in the size of the tear. Measurements could not be accurately obtained at two years of follow-up for another patient because of the size of the tear, so no comparison in tear size could be determined at the time of the ten-year follow-up. The patient with an intact cuff at two years had an intact cuff at ten years and was excluded from the outcomes analysis. The patient who had undergone revision surgery eleven months before the latest follow-up had a

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**TABLE II Radiographic and Clinical Outcomes**

<table>
<thead>
<tr>
<th>Hamada Grade</th>
<th>No. of Patients</th>
<th>ASES Score* (points)</th>
<th>SST Score* (points)</th>
<th>VAS Score* (points)</th>
<th>Age-Adjusted Constant Score* (points)</th>
<th>External Rotation Strength* (kg)</th>
<th>Abduction Strength* (kg)</th>
<th>Forward Flexion Range of Motion* (deg)</th>
<th>Supraspinatus Atrophy* (fatty degeneration grade)</th>
<th>Infraspinatus Atrophy* (fatty degeneration grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>86.7</td>
<td>8</td>
<td>2</td>
<td>83</td>
<td>4.8</td>
<td>3.2</td>
<td>155</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>61.1</td>
<td>8.3</td>
<td>2.3</td>
<td>67.1</td>
<td>8.6</td>
<td>2.8</td>
<td>146.7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>83.0</td>
<td>8.8</td>
<td>2.2</td>
<td>71.52</td>
<td>4.48</td>
<td>1.54</td>
<td>136.8</td>
<td>1.6</td>
<td>0.8</td>
</tr>
<tr>
<td>4a</td>
<td>2</td>
<td>78.3</td>
<td>7.5</td>
<td>3</td>
<td>73.7</td>
<td>1.9</td>
<td>3.1</td>
<td>150</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4b</td>
<td>1</td>
<td>95.0</td>
<td>12</td>
<td>1</td>
<td>89.7</td>
<td>11.1</td>
<td>7.1</td>
<td>150</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

*The values are given as the average.

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**Figs. 2-A and 2-B** A seventy-nine-year-old man who had a Constant score of 83.0, forward flexion to 155°, and a VAS pain score of 2. **Fig. 2-A** Anteroposterior radiograph of the shoulder showing Hamada Grade-1 changes. **Fig. 2-B** Sagittal ultrasound image showing a persistent massive rotator cuff tear, with cursors marking the anterior and posterior extent of the tear.
Discussion

Healing of the rotator cuff is not critical for a successful long-term outcome after a rotator cuff repair in older patients, even with progressive degenerative radiographic changes. In the present study, early clinical improvement and pain relief after arthroscopic repair of massive rotator cuff tears persisted at the time of long-term follow-up of at least ten years, despite early structural failure of the repair. In the current series, patients had a high rate of progression of early degenerative joint changes and no patient had healing of the tear, yet only two patients underwent subsequent surgical procedures. To our knowledge, this is the first study to demonstrate the minimum ten-year results following failed arthroscopic repairs of rotator cuff tears.

In the present study, the outcome scores that demonstrated improvement at the time of the two-year follow-up were essentially unchanged at ten years. These results were unchanged in spite of radiographic progression of arthropathy in the majority of patients. Muscle degeneration was not measured in the initial study, so fatty changes in the rotator cuff muscles from previous time points are unknown. At the time of the most recent follow-up, eight patients had severe fatty atrophy of the supraspinatus, the infraspinatus, or both. Not surprisingly, these findings show that an unhealed repair is not protective against further degeneration of the muscles.

There is a paucity of literature on the long-term outcomes for shoulders with structurally failed rotator cuff repairs. Our results after an arthroscopic repair are consistent with existing studies in terms of successful pain relief, restoration of function, and overall satisfaction. Zingg et al. reported on a series of twenty patients with known structural failure after an open rotator cuff repair at an average of 3.2 years, and Jost et al. performed a further evaluation after 7.6 years. There was no decrease in Constant score, strength, pain, or range of shoulder motion over the course of time. There was no increase in glenohumeral arthritis on radiographs according to the grading system of Samilson and Prieto, but there was a significant decrease in acromiohumeral distance. The Samilson and Prieto classification system only measures degenerative changes associated with glenohumeral joint osteoarthritis and, according to this system, if there is no joint space degeneration, then there is no arthropathy.

Dodson et al. evaluated fifteen of eighteen patients who had known failures of arthroscopic and mini-open rotator cuff repairs at 7.9 years postoperatively. That study revealed persistent benefits in terms of shoulder motion and clinical outcome, with an average VAS pain score of 0, an average ASES score of 95, and an average SST score of 11 at the time of the latest follow-up. However, there was no radiographic measure of cuff tear arthropathy or evaluation of fatty atrophy.

Zumstein et al. reported clinical and structural results at a mean of 9.9 years after open repair of massive rotator cuff tears. At the time of the latest follow-up, 57% of the patients had a retear but had no decline in the initial improvement in strength and Constant scores that had been seen at 3.1 years after the repair. The average age-adjusted Constant score was 77 for patients with a retear. The study also demonstrated radiographic progression of degenerative changes at the time of the latest follow-up, with greater progression of fatty atrophy in patients who had a retear as compared with those who had healing.

The durability of postoperative improvements over long-term follow-up has been reported in the absence of radiographic imaging studies. Galatz et al. found continued benefit of open rotator cuff repair from two to ten years of follow-up, with an increase in the number of patients with satisfactory results over this time course. Eight of the eleven patients with large tears had a good or excellent outcome.

In the present study, ultrasound evaluation showed no change in tear size or tear size progression in six patients and an apparent decrease in tear size in four. Accurate measurement of massive tears is challenging because of the difficulty of identifying tendon ends, which are often retracted beneath the acromion. Marked bursal thickening can obscure the visualization of retracted tendons. An apparent reduction in size may represent imaging artifact rather than actual reduction in tear size.

This study had limitations. It was a retrospective review of a small series of patients with no control group. In addition, certain variables, including the Constant score, the SST, and fatty atrophy of the rotator cuff musculature, were not evaluated preoperatively. The number of patients was too small to correlate outcomes with any associated comorbidities. The cohort of patients was older (average age, 63.9 years at the time of the initial surgical procedure) and the long-term outcome of structural failure may be dramatically different in younger individuals with failed healing.

In summary, although repair of a large or massive rotator cuff tear has a known higher likelihood to fail, the improved function and pain relief after attempted repair of a large or massive tear may still persist over the long term. The improvements in clinical outcome, pain relief, and range of motion experienced two years after an arthroscopic repair of large or massive rotator cuff tears appear to last over at least ten years, in spite of radiographic signs of rotator cuff arthropathy and ultrasound evidence of fatty atrophy of the rotator cuff musculature. As good long-term outcomes were achieved in older individuals, it remains to be seen whether similar results can be obtained in younger patients. Further investigation regarding the effect of age on the ability to tolerate or benefit from a structurally failed rotator cuff repair is needed to answer this question. In this cohort of older patients, healing was not critical for a successful outcome after rotator cuff repair.
Appendix
A table showing demographic details is available with the online version of this article as a data supplement at jbjs.org.

References