CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 367, pp. 243–255

SECTION II
ORIGINAL ARTICLES

Repair of Full Thickness Rotator Cuff Tears

Gender, Age, and Other Factors Affecting Outcome

Anthony A. Romeo, MD; David W. Hang, MD*; Bernard R. Bach, Jr., MD*; and Susan Shott, PhD***

Seventy-two full thickness rotator cuff tears (72 patients) were treated with an open rotator cuff repair between 1986 and 1993. The average postoperative followup was 54 months (range, 24–102 months; standard deviation, 22 months). Fifty-three (74%) patients had no pain, 16 (22%) patients had slight pain without restriction of activities, and three (4%) patients had moderate pain with activity compromise. Women with an associated biceps tendon rupture tended to have worse results. Women had a negative, statistically significant relationship between age and shoulder scoring scales, but age at the time of surgery was not related to any outcome variables for men. A rotator cuff tear greater than or equal to 5 cm^2 as determined at the time of surgery was associated with a poorer outcome. The average University of California at Los Angeles score was 32 points (range, 7–35 points; standard deviation, 5 points). The average Constant-Murley score was 78 of 100 points (range, 12–95 points; standard deviation, 15 points). A yes response was given for an average of 10 of 12 questions on the Simple Shoulder Test (range, 0–12 questions; standard deviation, 3 questions). More than 4 years after open rotator cuff repair, patients had a 94% patient satisfaction rate with lasting relief of pain and improved function.

Rotator cuff tears usually affect individuals between 40 and 70 years of age. In cadaveric studies, more than ⅓ of the cadavers older than 60 years had significant rotator cuff disease, including full thickness rotator cuff tears.[23,31,39] The etiology of rotator cuff tears is multifactorial but often is related to two key factors: tensile strength of the rotator cuff tendon and the amount of force applied to the rotator cuff.[27,30,34,38,43] History of an acute traumatic event with an eccentric load to the rotator cuff is common in patients younger than 60 years of age with a full thickness rotator cuff tear. Less commonly, repetitive activities involving use

From the *Section of Sports Medicine, **Department of Neurosurgery, Rush Medical College, Rush-Presbyterian-St. Luke's Medical Center, Chicago, IL.

Reprint requests to Anthony A. Romeo, MD, Section of Sports Medicine, Rush-Presbyterian-St. Luke's Medical Center, 1725 West Harrison Street, Suite 1063, Chicago, IL 60612.

Received: November 4, 1997.

Revised: March 4, 1999.

Accepted: March 29, 1999.

of the rotator cuff may be associated with a full thickness rotator cuff tear in this population. As the senescent changes of the rotator cuff progress, less force is needed to precipitate failure of the rotator cuff tendon. Older patients may present with a gradual onset of shoulder pain, often affecting them at rest and disturbing their sleep, with clinical and radiographic evidence of a full thickness rotator cuff tear but without a clear history of antecedent trauma.

Most patients with rotator cuff disorders seek care for pain relief, especially when the pain affects their ability to sleep.[27,34,38] Nonoperative management is recommended for the initial treatment of rotator cuff disease, but acceptable results in patients with full thickness rotator cuff tears may be limited to sedentary patients who minimize the use of their affected shoulder. Full thickness rotator cuff tears will not heal in an anatomic position because of tendon retraction and other biologic factors, such as poor vascularity, interference from synovial fluid, and the lack of a confined space to control the microcellular environment needed for tissue healing.[4,43,47] Open surgical treatment of full thickness rotator cuff tears includes an acromioplasty and repair of the torn rotator cuff tendon to the humerus, preferably in its anatomic location.[5,8,10,18,22,38,41]

The purpose of this investigation was to evaluate the clinical results of open surgery to repair full thickness rotator cuff tears at an average of 54 months after surgery. Parameters such as pain relief, motion, strength, and patient satisfaction were analyzed. Preoperative and intraoperative factors were assessed for their potential impact on the final result. Shoulder evaluation tools, including the University of California at Los Angeles shoulder scale,[2] the Constant-Murley shoulder scale,[11] and the Simple Shoulder Test,[33] were used to study the relationship between specific outcome variables and the overall end result.

PATIENTS AND METHODS

A retrospective review and clinical examination were performed on a consecutive group of patients who had open rotator cuff surgery with more than 2 years' followup. All procedures were performed at the same institution by the same surgeon (BRB). Excluded from the analysis were patients who had an associated proximal humerus fracture, prior shoulder arthroplasty, rheumatoid arthritis, or failure of a prior cuff repair. Open rotator cuff surgery was performed on 109 patients between August 1986 and March 1993. Ninety-three patients (93 shoulders) met the inclusion criteria. Four patients were deceased, one patient was unable to return because of medical illness (cerebrovascular accident), and two patients did not return because of personal reasons. Three patients were identified and completed a questionnaire but did not return because of geographic constraints. Eleven patients could not be located. Seventy-two patients (72 shoulders) were evaluated independently by one examiner (DWH). Sixty-five patients were evaluated in the office, and seven were examined at their homes.

The study group included 44 men and 28 women whose mean age was 58 years (range, 24–87 years; standard deviation, 11 years). The right shoulder was involved in 56 patients and the left shoulder in 16 patients. The dominant arm was affected in 57 (79%) patients. Seven (10%) patients were involved with workers' compensation claims. The median interval from onset of symptoms to surgical treatment was 7 months (range, 1–241 months; standard deviation, 38 months). Preoperative confirmation of a full thickness rotator cuff tear was made by double contrast arthrography in 85% of the patients, with the remaining patients having a magnetic resonance scan or ultrasound showing a full thickness tear of the rotator cuff. The median postoperative followup was 55 months (range, 24–102 months; standard deviation, 22 months).

Procedure

The rotator cuff was exposed through an anterosuperior approach.[34,38] The coracoacromial ligament was released completely from the anterior acromion. A Neer acromioplasty[38] was performed in all cases, often with the modified technique described by Rockwood and Lyons.[44] A distal clavicle resection was performed through the same operative approach in 14 patients with symptomatic acromioclavicular joint arthropathy.[12,42,45] The decision for distal clavicle resection was based on the preoperative clinical examination. Rotator cuff tear size was classified using linear dimensions: less

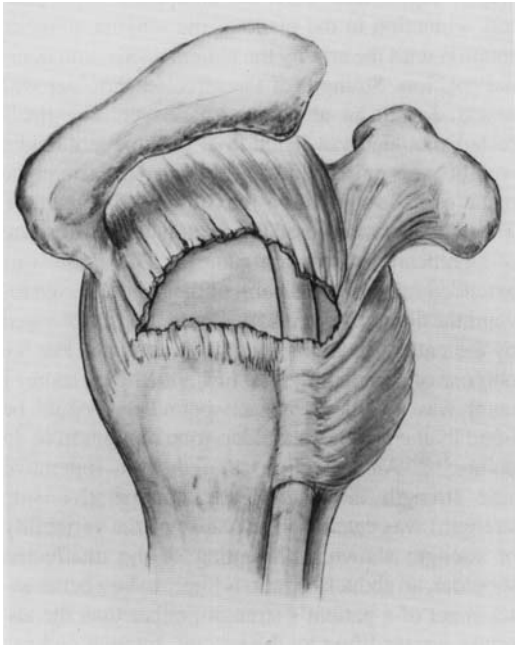

Fig 1. Full thickness rotator cuff tears most commonly occur at the supraspinatus tendon, adjacent to the long head of the biceps tendon.

than 1 cm^2, 1 to 3 cm^2, 3 to 5 cm^2, or greater than 5 cm^2. Twenty-one (29%) tears were larger than 5 cm^2, but all tears were repaired. A multiple suture technique was developed to distribute the tension of the repair over numerous size 0 nonabsorbable braided sutures and avoid multiple bone tunnels that potentially could weaken the greater tuberosity (Figs 1–3). After creating a shallow trough at the juxtaarticular surface of the humerus, sutures were placed approximately 3 mm apart in the edge of the torn rotator cuff tendon and grouped together. Three or four sets of sutures were passed through an osseous tunnel and individually tied. The deltoid was repaired to the acromion with nonabsorbable sutures placed through bone tunnels in the acromion. A standardized data form and the operative report were completed immediately after the surgical procedure.

The arm was immobilized with a sling for 51 patients. With tears larger than 5 cm^2 or tears with tension on the repair, an airplane splint was used (21 patients, 29%). Physical therapy was initiated on the first day after surgery. Exercises included pendulum motion of the shoulder, passive assist forward elevation, and passive external rotation in the supine position. Active elbow, wrist, and hand motion also was encouraged. Patients wearing an airplane splint were assisted with passive range of motion (ROM) above the level of the splint. Passive assist forward elevation in the supine position was continued for the first 3 weeks. An outpatient supervised physiotherapy program was initiated by 3 weeks after the surgery. Active ROM activities were allowed 4 weeks after the surgery, with strengthening exercises initiated 2 months after the surgery.

Questionnaire

All 72 patients completed an extensive questionnaire specifically designed for this investigation at an average of 54 months after their surgery (2-year

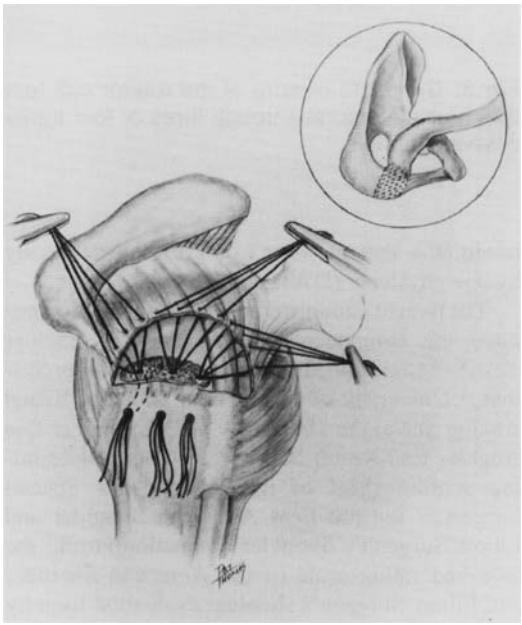

Fig 2. The surgical technique involves an anterosuperior approach, detachment of the anterior deltoid from the acromion, and an acromioplasty. After the acromioplasty and partial bursectomy, the rotator cuff tendon is exposed and mobilized. Multiple sutures are placed into the tear and grouped from three to five sutures. After a trough into the greater tuberosity region is created and transosseous towel clip holes are placed, sutures are passed as groups and individually tied.

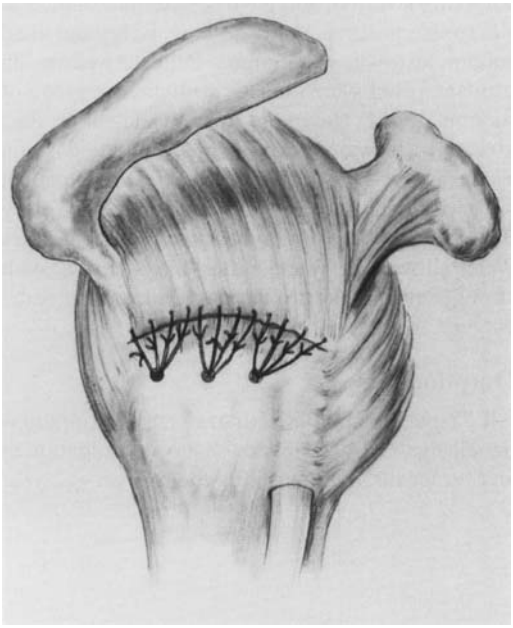

Fig 3. Complete closure of the rotator cuff tear with multiple sutures through three or four transosseous tunnels.

minimum). Patients were examined independently by one physician (DWH).

The patient administered questionnaire incorporated the components of the Simple Shoulder Test,[33,36] Constant-Murley Shoulder Function System,[11] University of Connecticut Shoulder Visual Analog Scale, the University of California at Los Angeles End-Result Score,[2,14,15] the shoulder rating scoring sheet of the Hospital for Special Surgery,[20] the pre-1994 American Shoulder and Elbow Surgeon's Shoulder Evaluation Form,[3] the modified rating scale of the American Shoulder and Elbow Surgeon's shoulder evaluation form by Gartsman,[19] the Neer rating scale,[38,39] the rating scale of Hawkins et al,[26] and the shoulder evaluation scale of Rowe et al.[48] Approximately 30 minutes were needed to complete the questionnaire.

Clinical Evaluation

The clinical examination focused on ROM and strength measurements. Passive and active ROM measurements were determined with a goniometer with the patients in the supine and standing positions. The measurements were performed in a consistent sequential manner and included forward flexion, abduction in the plane of the scapula, external rotation with the arm by the patient's side, and internal rotation. Strength of the affected shoulder was assessed with an abduction maneuver. The unaffected shoulder was tested first. Each patient held a weight in his or her hand and abducted the arm in the plane of the scapula to a maximum 90° abduction. The examiner monitored the motion for the presence of significant substitution patterns. The elbow was extended fully with the palm of the hand directed toward the floor. The weight was increased as tolerated by the patient to a maximum of 25 pounds. For the purpose of completing the Constant-Murley score, 1 point was awarded for each pound that could be lifted by the affected shoulder, for a maximum of 25 points.[11,20] An abduction strength ratio (operative side strength divided by the nonoperative side strength) was calculated. Because of the variability of strength shown with testing of the unaffected shoulder, an abduction ratio is likely to be a better assessment of a patient's strength, rather than the absolute weight lifted by the patient. Internal and external rotation strength were assessed with the elbow at the patient's side. The rotation strength was graded by the ability of the patient to move the arm against resistance provided by the examiner according to the British Medical Research Commission guidelines.[49]

Statistical Analysis

Data were collected and managed using Microsoft Excel software (version 4.0; Microsoft, Redmond, WA) on a personal computer. Statistical analysis was performed using SPSS for Windows statistical software (version 7.5, SPSS, Inc, Chicago, IL). Most variables, including the results of the shoulder scoring scales, had distributions that were not normal. Thus, nonparametric methods were used to analyze the data. Spearman correlation coefficients and scatterplots were obtained to investigate the association between variables that were at least ordinal. To compare groups with respect to variables that were at least ordinal, the Mann-Whitney test was used. The chi squared test of association was done to compare groups with respect to nominal variables. Logistic regression was used to determine whether any variables could predict patient satisfaction (satisfactory result versus unsatisfactory result). A 0.05 significance level was used for all statistical tests.

The results of the University of California at Los Angeles scoring scale and the Simple Shoulder

Test questionnaire were converted to a percentage scale for comparison with results of the Constant-Murley system, which originally was constructed on a 100-point scale. Conversion of the Simple Shoulder Test to a percentage scale has not been reported previously, but the composition of the patient based, subjective, Simple Shoulder Test has similarities to the University of California at Los Angeles and Constant-Murley scales, which incorporate significant objective, examiner based data into their calculations.

The evaluation of shoulder motion focused on the examiner measured maximal active forward elevation. Analysis of shoulder strength was defined by the abduction strength ratio between the operative and nonoperative shoulders. Patient satisfaction was based on the rating system proposed by Neer et al, which includes four categories: excellent, satisfactory, unsatisfactory, limited goals.[39,40] For this study, patient responses were separated into two categories (satisfactory and unsatisfactory) without consideration of a limited goals category. If a patient qualified for a limited goals classification, the result was rated as unsatisfactory. A satisfactory result was achieved if patients were satisfied with the result of their surgery, had no pain or minimal pain, good use of arm for activities of daily living, less than 20° loss of forward elevation when compared with the opposite shoulder, and 75% of normal strength, defined as an abduction strength ratio greater than or equal to 0.75.

RESULTS

The mean age of the study group was 58 years at the time of surgery and 62 years at the time of followup. Although the average time from the onset of symptoms that led to surgical treatment was 22 months, the median duration was 7 months. Sixteen (22%) rotator cuff repairs were performed within 3 months of the onset of symptoms.

Men and women were analyzed separately for statistically significant Spearman correlations between the shoulder scores (Simple Shoulder Test, Constant-Murley scale, University of California at Los Angeles scale), the abduction ratio, and the following variables: age at surgery, time from injury to surgery, number of subacromial injections, and tear size. Neither men nor women had any statistically significant correlations between the outcome variables and the number of subacromial

TABLE 1. Spearman Correlations for Shoulder Assessment Tools and Abduction Ratio

Variable	Spearman Correlation (p value)			
	Simple Shoulder Test	*Constant-Murley*	*UCLA*	*Abduction Ratio*
All patients				
Age at surgery	NS	−0.29 (0.013)	NS	NS
Time from injury to surgery	NS	NS	NS	NS
Number of subacromial injections	NS	NS	NS	NS
Tear (1–4 cm^2)	−0.35 (0.003)	−0.35 (0.003)	NS	−0.34 (0.004)
Women				
Age at surgery	−0.38 (0.048)	−0.54 (0.003)	NS	NS
Time from injury to surgery	NS	NS	NS	NS
Number of subacromial injections	NS	NS	NS	NS
Tear (1–4 cm^2)	NS	NS	NS	NS
Men				
Age at surgery	NS	NS	NS	NS
Time from injury to surgery	NS	NS	NS	NS
Number of subacromial injections	NS	NS	NS	NS
Tear (1–4 cm^2)	−0.42 (0.005)	−0.49 (0.001)	NS	−0.33 (0.027)

NS = nonsignificant correlation; UCLA = University of California at Los Angeles.

injections or the time from injury to surgery. For men, none of the correlations between age and the outcome variables were statistically significant, although women had negative, statistically significant correlations between age and the Simple Shoulder Test ($p = 0.048$) and Constant-Murley ($p = 0.003$) scores (Table 1). Women had no statistically significant correlations between the outcome variables and tear size, although men had negative statistically significant correlations between tear size and the Simple Shoulder Test ($p = 0.005$), the Constant-Murley ($p = 0.001$) scores, and the abduction ratio ($p = 0.027$) (Table 1).

Women with a biceps tendon rupture tended to have lower Simple Shoulder Test results ($p = 0.0044$), Constant-Murley scores ($p = 0.035$), and University of California at Los Angeles scores ($p = 0.0058$) than did women without a biceps tendon rupture (Table 2). Only one of the four women with a biceps tendon rupture had a satisfactory result, compared with 75% of the 24 women without a biceps tendon rupture. The presence of a biceps tendon rupture in men did not have a statistically significant affect on the final result.

No differences were found between patients having the dominant side injured versus those having the nondominant side, between patients with distal clavicle resection and patients without distal clavicle resection, or between patients receiving workers compensation and those not receiving workers compensation. However, only seven (10%) patients had workers' compensation claims at the time of surgery. Women tended to have lower Constant-Murley scores than did men (74.9 ± 16.2 versus 80.4 ± 13.5, $p = 0.0073$), but there were no other statistically significant differences between women and men with respect to the other scores or the percentage with satisfactory results. Patients with a tear greater than 5 cm^2 tended to have lower Simple Shoulder Test results ($p = 0.001$), Constant-Murley scores ($p = 0.0027$), and University of California at Los Angeles scores ($p = 0.0050$) than did patients with smaller tears (Table 2). Fifty-seven percent of the 21 patients with a tear greater than 5 cm^2 had a satisfactory result, compared with 84% of the 51 patients with a smaller tear ($p = 0.014$).

Pain

A pain visual analog scale showed that at the time of followup, 59 (82%) patients rated their pain as less than or equal to 2 on a scale of 10, with 10 being the worst pain possible and 0 representing the absence of pain (Fig 4). Pain relief was stratified into the following categories: complete resolution, slight pain

TABLE 2. Comparison of Groups With Respect to Shoulder Assessment Tools and Abduction Ratio*

Variable	Simple Shoulder Test**	Constant-Murley	UCLA**	Abduction Ratio
Women				
Biceps tendon rupture	41.7 ± 34.7	58.0 ± 30.9	65.7 ± 31.6	0.67 ± 0.18
No biceps tendon rupture	89.2 ± 18.5	77.7 ± 11.1	94.6 ± 7.6	0.90 ± 0.21
All patients				
Massive tear	71.4 ± 31.1	68.9 ± 21.6	81.5 ± 23.2	0.77 ± 0.24
Nonmassive tear	93.1 ± 13.2	82.1 ± 8.4	95.2 ± 6.9	0.93 ± 0.15
Traumatic etiology	—	—	—	0.86 ± 0.19
Nontraumatic etiology	—	—	—	0.95 ± 0.19

UCLA = University of California at Los Angeles.

Values are mean ± standard deviation.

* All differences between groups with means and standard deviations shown are statistically significant.

** Converted to percentage (100 point) scale.

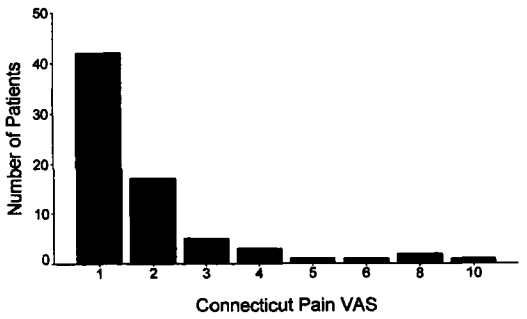

Fig 4. Distribution of responses to the visual analog scale from the Connecticut Shoulder Scale.

without restriction of activities, and moderate pain with activity compromise. Fifty-four (74%) patients had no pain, 16 (22%) had slight pain without restriction of activities, and three (4%) had moderate pain with activity compromise. In addition, the Simple Shoulder Test asks the patient two specific questions regarding pain: (1) Is your shoulder comfortable with your arm at rest by your side?, and (2) Does your shoulder allow you to sleep comfortably? Ninety-seven percent of the patients responded yes to the first question, and 88% of patients responded yes to the second question.

Motion

The average active forward flexion was 165° (range, 15°–180°; standard deviation, 33°; median, 180°). Sixty-three of 72 (88%) patients could actively forward elevate the arm to 160° or greater. The average active external rotation was 63° (range, 15°–100°; standard deviation, 19°; median, 60°). The average active internal rotation allowed patients to reach up behind them to the level of the T12 vertebrae (range, level of trochanter to T7; standard deviation, two vertebral levels). Subjectively, 90% of patients stated they could place their hand behind their head with the elbow straight out to the side, 93% stated they could reach the small of their back to tuck in their shirt, and 89% stated they could wash the back of their opposite shoulder with the affected extremity.

Strength

The patient's ability to abduct weight with their shoulder was used as the primary outcome measurement for strength. To account for the tremendous variability of normal abduction strength in this patient population, an abduction strength ratio was calculated from the measured abduction strength of the affected shoulder and contralateral shoulder. On average, the abduction strength ratio for the affected shoulder was 0.88 (88%) of the strength of the contralateral shoulder (range, 0.13–1.25; standard deviation, 0.19). Subjectively, only 68% of the patients stated they could lift 8 pounds to the level of their shoulder without bending their elbow, but 85% thought they could carry 20 pounds at their side with the affected extremity.

When groups were compared with respect to the abduction ratio, no statistically significant differences were found between women and men, between patients having the dominant side injured and patients having the nondominant side injured, between patients with distal clavicle resection and patients without distal clavicle resection, or between patients receiving workers compensation and those not receiving workers compensation. Patients with a tear greater than 5 cm^2 tended to have lower abduction ratios ($p = 0.0028$) than did patients with smaller tears (Table 2). There was no difference between men with an associated biceps tendon rupture and men without a biceps tendon rupture with respect to the abduction ratio. However, women with a biceps tendon rupture tended to have lower abduction ratios ($p = 0.029$) than did women without a biceps tendon rupture (Table 2).

Scoring Scales

All 72 patients completed the questionnaire. Components of nine various shoulder evaluation systems were included in the questionnaire. However, some systems query the patient regarding sports participation and use their responses for the determination of the result. Many patients in this study group did not participate in sports and thus could not be

evaluated using the shoulder rating scoring sheet of the Hospital for Special Surgery, the pre-1994 American Shoulder and Elbow Surgeon's Shoulder Evaluation Form, the modified rating scale of the American Shoulder and Elbow Surgeon's shoulder evaluation form by Gartsman, or the shoulder evaluation scale of Rowe et al.[48] However, in the subgroup (46 patients) that participated in various sports, a mean score of 94 points (maximum, 100 points) was seen using the Hospital for Special Surgery shoulder scale and the scoring scale of Rowe et al.[48]

The subjective components of the University of California at Los Angeles shoulder scale, the Constant-Murley shoulder scale, and the Simple Shoulder Test could be answered effectively by all patients. The objective parameters were determined by the examiner at the time of followup. The average University of California at Los Angeles score was 32 points of a maximum of 35 points (range, 7–35 points; standard deviation, 5 points). The average raw Constant-Murley score was 78 points of a maximum of 100 points (range, 12–95 points; standard deviation, 15 points). An average of 10 of 12 questions on the Simple Shoulder Test were answered with yes (range, 0–12 questions; standard deviation, 3 questions).

Patient Satisfaction

Patient satisfaction was assessed using a modified Neer satisfaction rating. Fifty-five of 72 (76%) patients had satisfactory results: satisfaction with the result of their surgery, no pain or minimal pain, good use of arm for activities of daily living, less than a 20° loss of forward elevation when compared with their opposite shoulder, and 75% of the abduction strength of their opposite shoulder. Patient satisfaction also was evaluated using the University of California at Los Angeles shoulder rating scale. When the patients were asked whether they were satisfied with their surgery and were better as a result of their surgery, 68 of 72 (94%) answered positively.

Analysis of Unsatisfied Patients and Complications

There were no statistically significant differences between patients with a satisfactory result and patients with an unsatisfactory result with respect to the number of subacromial injections or the time from injury to surgery. Only five patients had surgery within 6 weeks of the injury. For men, there was no difference between patients with a satisfactory result and patients with an unsatisfactory result with respect to age at the time of surgery. However, women with a satisfactory result tended to be younger than were women with an unsatisfactory result (58 $\pm$ 8 years versus 67 $\pm$ 9 years; $p = 0.015$). When backward elimination stepwise logistic regression was done to determine whether any preoperative variables could be used to predict whether the result would be satisfactory, two variables were statistically significant in the final equation: an indicator variable representing whether the tear was greater than 5 cm^2 ($p = 0.0088$) and a cross-product term representing the interactive effect of age and gender ($p = 0.034$) (age was related negatively to the chance of a satisfactory outcome for women but not for men). Although the equation was able to correctly identify 96% of the patients with a satisfactory result, it correctly identified only 24% of the patients with an unsatisfactory result.

When backward elimination logistic regression was done with only female patients, better prediction was obtained. The final equation had only one variable: age at surgery ($p = 0.0086$). Women who were 66 years of age or older were predicted to have an unsatisfactory result, although women who were younger than 66 years of age were predicted to have a satisfactory result. Using the age of 66 years at the time of surgery, 79% of women with a satisfactory result (specificity) and 67% of women with an unsatisfactory result (sensitivity) could be identified correctly. Eighty-three percent of women who were predicted to have a satisfactory result had a satisfactory result (negative predictive value), and 60% of women who were predicted

to have an unsatisfactory result actually had an unsatisfactory result (positive predictive value).

Six (8%) patients had complications, and five of these patients were part of the unsatisfactory group. A 46-year-old man had a recurrent rotator cuff tear develop, but he had minimal pain, good motion, and an abduction strength ratio of 0.8, was personally satisfied with the result, and thus was considered to have a satisfactory result. He did not desire revision surgery to repair his rotator cuff. A recurrent rotator cuff tear developed in three additional patients. These patients improved after their surgery and all were pain free at 1 year, but before their followup examination at an average of 59 months after their surgery, evidence of a recurrent rotator cuff tear had developed. All three patients did not desire additional surgery. One patient had brief postoperative paresthesias in an ulnar nerve distribution, which resolved without sequelae. One patient required reoperation for removal of nonabsorbable sutures that were painful to palpation. After suture removal, the result was considered satisfactory. There was no evidence of infection, deltoid detachment, or cardiopulmonary complication.

DISCUSSION

The most common indication for surgery of the shoulder is rotator cuff disease, encompassing pathologic conditions from subacromial impingement to full thickness rotator cuff tears. Patients primarily desire pain relief, with a secondary goal of improved function.[7,15,22,29,41] Nonoperative treatment of full thickness rotator cuff tears often results in continued pain and dysfunction of the shoulder and should be limited to sedentary patients who infrequently use their upper extremity or patients with medical comorbidities that prohibit the risks of anesthesia.[7,29] Full thickness rotator cuff tears can be treated effectively with an open acromioplasty and direct repair of the rotator cuff tendon to bone.[4,8,15,22,24,26,28,34,38,53] This investigation provides an indepth analysis of the results of open rotator cuff repairs at an average of 54 months after the surgery, including subjective and objective factors that may affect the final result.

Surgical intervention within 6 weeks of the onset of symptoms from a full thickness rotator cuff tear has been associated with better postoperative results, including improvements in strength.[4] Other investigations failed to show any difference in results based on the relationship of surgical repair to the onset of symptoms.[5,8,28,26] The mean duration of symptoms before surgery in the current study was 7 months, with 16 patients having surgery within 3 months. With current methods of health care delivery, it is more likely that patients with shoulder pain and weakness will receive nonoperative treatment for at least 3 months before an orthopaedic evaluation.[50] Fortunately, the time from the onset of symptoms to the surgical procedure did not significantly affect the outcome as an independent variable. However, rotator cuff tendon mobilization and repair of the tendon with minimal tension at the repair site are facilitated with earlier intervention.

The mean age of the patient at the time of surgery was 58 years, which is similar to patients reported in other studies.[22,24–26,38] Age greater than or equal to 65 years has been associated with poorer results without analysis of the effect of gender.[25] In the current study, increased chronologic age for men did not appear to be an independent negative prognostic factor, although it is likely that attritional changes of the rotator cuff that occur with age predispose the rotator cuff to more extensive damage.[24,38] Advancing age is a negative prognostic factor for women. Female patients older than 66 years of age had lower scores on the shoulder scales and an increased rate of unsatisfactory results. These findings suggest some aspect of the open rotator cuff surgery is tolerated less well by female patients or that the unaffected structures, such as the deltoid and remaining rotator cuff, cannot compensate easily for persistent deficiencies related to the repaired cuff.

Several investigators have shown that the size of the rotator cuff tear at the time of surgery affects the result of surgical repair.[4,8,10,18,28,38] In the current investigation, male and female patients with a tear greater than 5 cm^2 generally had inferior results, but this was statistically significant only for men. Fifty-three percent of the patients with a tear greater than 5 cm^2 had an unsatisfactory result.

The postoperative results of women with a biceps tendon rupture were inferior to those of women with an intact biceps tendon, as shown by lower Simple Shoulder Test scores, University of California at Los Angeles scores, Constant-Murley scores, and a decreased abduction ratio. Of the four women with a rotator cuff and biceps tendon rupture, only one woman had a satisfactory result. The combination of a female patient older than 66 years of age with pain related to a rotator cuff and biceps tendon rupture is not rare. In this subset of patients, nonoperative management should be the primary focus of treatment because it appears the results of an open rotator cuff repair are unpredictable.

Pain was relieved completely in 74% of the patients, with an additional 22% of patients stating they had slight pain without restriction of activities. Pain relief in 96% of the study group compared favorably with the pain relief achieved by patients reported in other studies.[1,5,8,10,13,15,18,22,24–26,38,53] When patients were asked questions regarding the characteristics of their pain, 97% stated their shoulder was comfortable with their arm by their side, whereas 86% stated their shoulder allowed them to sleep comfortably. Based on this investigation and earlier studies, open acromioplasty and rotator cuff repair is effective at alleviating pain in most patients.

Patients regain active motion after rotator cuff surgery, with 88% of patients having active forward elevation equal or greater than 160°. The average active internal rotation was restricted slightly to reaching behind the back to the T12 vertebral level. Despite releasing adhesions and the glenohumeral capsule, as indicated for mobilization of the rotator cuff tendon, some restriction with internal rotation was common. Loss of internal rotation is a sign of posterior shoulder tightness, which is a common feature of rotator cuff disorders, most likely because of contracture of the glenohumeral capsule.[35] Perilabral release of the glenohumeral capsule from the undersurface of the affected rotator cuff tendon may assist in decreasing the limits of internal rotation. Functionally, most patients could reach behind their head, reach to the small of their back, and reach across to their opposite shoulder. The results of this investigation compare favorably with results described in previous reports.[1,5,6,8,10,18,22,26,37,38,53]

Improvement in strength after repairs of full thickness rotator cuff is common, but return to strength equal to the opposite shoulder is less common.[1,21,22,32,51] Postoperative isokinetic shoulder strength may be increased dramatically from the time of surgery to 1 year after surgery.[32] A recent study showed mean peak torque of abduction at 90% of the opposite shoulder in a group of 42 patients evaluated 12 months after repair of their torn rotator cuff.[46] This correlated well with previous reports showing postoperative strength of 80% of the opposite shoulder when testing abduction at 1 year of followup.[51] In addition, abduction strength of 86% of the opposite shoulder has been shown as long as 66 months after surgery, suggesting lasting results.[21] In the current study, abduction was tested using hand held weights lifted in the plane of the scapula. This technique may be less precise than isokinetic machine testing, but the motion of abduction without the constraint of maintaining the fixed axis of the machine represents a functional, inexpensive, and practical test of strength. The average abduction strength ratio was 0.88, or 88% of the unaffected shoulder abduction strength. Rotator cuff tears greater than or equal to 5 cm^2 and proximal biceps tendon rupture adversely affected the abduction strength.

Three shoulder evaluation tools were used to assess the results. The University of California at Los Angeles scoring scale initially

was described for use in the evaluation of shoulder arthroplasty,[2] but it has been used frequently in the evaluation of surgery for rotator cuff disorders.[9,14,15,17] The Constant-Murley rating system[11] is used extensively on an international basis. Measurement of abduction strength for the purpose of the Constant-Murley scale is troublesome. A point is awarded for each pound that is abducted by the patient. Minimal guidelines are provided regarding patient position, hand or elbow position, and the duration of the lift. A maximum of 25 points can be awarded for a lift of 25 pounds. The maximum lift by any participant in the current study was 22 pounds, which was achieved by a well conditioned man using his nonoperative shoulder. Comparing abduction strength to that of the nonaffected shoulder and establishing a ratio appears to be a more effective assessment method than an isolated single maximum lift.

The Simple Shoulder Test[33] is a compilation of 12 easily understood questions, designed in a binomial format with only two possible responses: yes or no. The questionnaire was not intended for use as a scoring system, but the parameters examined on the questionnaire (pain, motion, strength, and function) are similar to those used in other scoring systems. Thus, the results were evaluated based on the percentage of questions that were answered yes.

The results of the University of California at Los Angeles score and the Simple Shoulder Test score were similar, although the Constant-Murley scoring scale showed lower scores. This was particularly evident with female patients because of the contribution of strength to the overall score. The descriptive results using the University of California at Los Angeles and Simple Shoulder Test scales are similar to results described in previous reports[1,5,8,10,15,18,22,24–26,28,38,53] and qualitatively better than the Constant-Murley scores.

Because of the differences between the scoring scales, the descriptive results of an investigation may be biased based on the shoulder scoring scale used for evaluation of the results. One system is not obviously better than another, with each system having unique characteristics that may be important for improved comprehension of the treatment of rotator cuff disease.

Patient satisfaction was high. The results of this investigation were similar to results from previous studies with followup greater than 2 years.[1,8,15] Based on responses from the University of California at Los Angeles scoring scale, 94% of patients were satisfied and thought they were better because of the surgery. This patient based methodology for assessing patient values is typical of many outcome assessment tools.[16,36,52]

Open repair of a torn rotator cuff and acromioplasty effectively improves comfort, active motion, and strength in most patients. The timing of surgery after a rotator cuff repair did not affect the result of surgical management. Female patients 66 years of age and older are more likely to have an unsatisfactory result. In addition, an associated biceps tear in female patients is a poor prognostic factor.

Overall, better results were seen in patients with tears less than 5 cm^2 and in patients with an intact proximal biceps tendon. Scores from different shoulder evaluation systems have similarities, but they may introduce the potential for a biased description of the result, depending on the system selected. At an average of 54 months after open rotator cuff repair and acromioplasty, 94% of patients were satisfied and stated they were better because of the surgery to repair their torn rotator cuff.

References

1. Adamson GJ, Tibone JE: Ten-year assessment of primary rotator cuff repairs. J Shoulder Elbow Surg 2:57–63, 1993.
2. Amstutz HC, Sew Hoy AL, Clarke IC: UCLA anatomic total shoulder arthroplasty. Clin Orthop 155:7–24, 1981.
3. Barrett WP, Franklin JL, Jackins SE, et al: Total shoulder arthroplasty. J Bone Joint Surg 69A: 865–872, 1987.
4. Bassett RW, Cofield RH: Acute tears of the rotator cuff: The timing of surgical repair. Clin Orthop 175:18–24, 1983.
5. Bigliani LU, Kimmel J, McCann P: Repair of rotator cuff tears in tennis players. Am J Sports Med 20: 112–117, 1992.
6. Blevins FT, Warren RF, Cavo C, et al: Arthroscopic

assisted rotator cuff repair: Results using a mini-open deltoid splitting approach. Arthroscopy 12:50–59, 1996.
7. Bokor DJ, Hawkins RJ, Huckell GH, Angelo RL, Schickendantz MS: Results of nonoperative management of full-thickness tears of the rotator cuff. Clin Orthop 294:103–110, 1993.
8. Borkerheim J, Paavolainen P, Ahovuo J, et al: Surgical repair of the rotator cuff and surrounding tissues: Factors influencing the results. Clin Orthop 236:145–148, 1988.
9. Burns TP, Turba JE: Arthroscopic treatment of shoulder impingement in athletes. Am J Sports Med 20:13–16, 1992.
10. Cofield RH, Hoffmeyer P, Lanzer WH: Surgical repair of chronic rotator cuff tears. Orthop Trans 14: 251–252, 1990.
11. Constant CR, Murley AHG: A clinical method of functional assessment of the shoulder. Clin Orthop 214:160–164, 1987.
12. Cook FF, Tibone JE: The Mumford procedure in athletes: An objective analysis of function. Am J Sports Med 16:97–100, 1988.
13. Debeyre J, Patte D, Elmelik E: Repair of ruptures of the rotator cuff of the shoulder. With a note on advancement of the supraspinatus muscle. J Bone Joint Surg 47B:36–42, 1965.
14. Ellman H: Arthroscopic subacromial decompression. Arthroscopy 3:173–181, 1987.
15. Ellman H, Hanker G, Bayer M: Repair of the rotator cuff: End-result study of factors influencing reconstruction. J Bone Joint Surg 68A:1136–1144, 1986.
16. Ellwood PM: Shattuck Lecture—Outcomes management. A technology of patient experience. N Engl J Med 318:1549–1556, 1988.
17. Esch JC: Arthroscopic subacromial decompression. Orthop Rev 18:733–742, 1989.
18. Essman JA, Bell RH, Askew M: Full-thickness rotator-cuff tear: An analysis of results. Clin Orthop 265:170–177, 1991.
19. Gartsman GM: Arthroscopic acromioplasty for lesions of the rotator cuff. J Bone Joint Surg 72A:169–180, 1990.
20. Gerber C: Integrated Scoring Systems for the Functional Assessment of the Shoulder. In Matsen FA (ed). The Shoulder: A Balance of Mobility and Stability. Rosemont, IL, American Academy of Orthopaedic Surgeons 545–559, 1992.
21. Gore DR, Murray MP, Sepic SB, et al: Shoulder-muscle strength and range of motion following surgical repair of full-thickness rotator-cuff tears. J Bone Joint Surg 68A:266–272, 1986.
22. Grana WA, Teague B, King M, et al: An analysis of rotator cuff repair. Am J Sports Med 22:585–588, 1994.
23. Grant JCB, Smith CG: Aging incidence of rupture of the supraspinatus tendon. Anat Rec 100:666–669, 1948.
24. Harryman D, Mack L, Wang K, et al: Repairs of the rotator cuff. J Bone Joint Surg 73A:982–989, 1991.
25. Hattrup SJ: Rotator cuff repair: Relevance of patient age. J Shoulder Elbow Surg 4:95–100, 1995.
26. Hawkins R, Misamore G, Hobeika P: Surgery for full-thickness rotator-cuff tears. J Bone Joint Surg 67A:1349–1355, 1985.
27. Iannotti JP: Rotator Cuff Disorders: Evaluation and Treatment. Am Acad Orthop Surg Monograph Series. Rosemont, IL, American Academy of Orthopaedic Surgeons 1–4, 1991.
28. Iannotti JP: Full-thickness rotator cuff tears: Factors affecting surgical outcome. J Am Acad Orthop Surg 2:87–95, 1994.
29. Itoi E, Tabata S: Conservative treatment of rotator cuff tears. Clin Orthop 275:165–173, 1992.
30. Kannus P, Jozsa L: Histopathological changes preceding spontaneous rupture of a tendon. J Bone Joint Surg 73A:1507–1525, 1991.
31. Keyes EL: Observations on rupture of the supraspinatus tendon. Based upon a study of seventy-three cadavers. Ann Surg 97:849–856, 1933.
32. Kirschenbaum D, Coyle MP, Leddy JP, et al: Shoulder strength with rotator cuff tears: Pre- and postoperative analysis. Clin Orthop 288:174–178, 1993.
33. Lippitt SB, Harryman DT, Matsen FA: A Practical Tool for Evaluating Function: The Simple Shoulder Test. In Matsen III FA, Fu FH, Hawkins RJ (eds). The Shoulder: A Balance of Mobility and Stability. Rosemont, IL, American Academy of Orthopaedic Surgeons 501–518, 1993.
34. Matsen FA, Arntz C: Rotator Cuff Tendon Failure. In Rockwood CA, Matsen III FA (eds). The Shoulder. Philadelphia, WB Saunders Co 647–677, 1985.
35. Matsen FA, Lippitt SB, Sidles JA, Harryman II DT: Strength. In Matsen III FA, Lippitt SB, Sidles JA, Harryman II DT (eds). Practical Evaluation and Management of the Shoulder. Philadelphia, WB Saunders Co 111–150, 1994.
36. Matsen FA, Ziegler DW, DeBartolo SE: Patient self-assessment of health status and function in glenohumeral degenerative joint disease. J Shoulder Elbow Surg 4:345–351, 1995.
37. Montgomery TJ, Yerger B, Savoie FH: Management of rotator cuff tears: A comparison of arthroscopic debridement and surgical repair. J Shoulder Elbow Surg 3:70–78, 1994.
38. Neer CS: Anterior acromioplasty for the chronic impingement syndrome in the shoulders: A preliminary report. J Bone Joint Surg 54A:41–50, 1972.
39. Neer CS: Impingement lesions. Clin Orthop 173: 70–77, 1983.
40. Neer CS, Craig E, Fukuda G: Cuff tear arthropathy. J Bone Joint Surg 65A:1232–1244, 1983.
41. Norwood LA, Barrack R, Jacobson KE: Clinical presentation of complete tears of the rotator cuff. J Bone Joint Surg 71A:499–505, 1989.
42. Novak PJ, Bach BR, Romeo AA, et al: Surgical resection of the distal clavicle. J Shoulder Elbow Surg 4:35–40, 1995.
43. Rathburn J, Macnab I: The microvascular pattern of the rotator cuff. J Bone Joint Surg 52B:540–553, 1970.
44. Rockwood CA, Lyons FR: Shoulder impingement syndrome: Diagnosis, radiographic evaluation and treatment with a modified Neer acromioplasty. J Bone Joint Surg 75A:409–424, 1993.
45. Rockwood CA, Young DC: Disorders of the

Acromioclavicular Joint. In Rockwood CA, Matsen III FA (eds). The Shoulder. Philadelphia, WB Saunders 413–476, 1990.
46. Rokito AS, Zuckerman JD, Gallagher MA, et al: Strength after surgical repair of the rotator cuff. J Shoulder Elbow Surg 5:12–17, 1996.
47. Rothman RH, Parke WW: The vascular anatomy of the rotator cuff. Clin Orthop 41:176–186, 1965.
48. Rowe C, Patel D, Southmayd W: The Bankart procedure. A long-term end-result study. J Bone Joint Surg 60A:1–16, 1978.
49. Sapega AA: Current concepts review. Muscle performance evaluation in orthopaedic practice. J Bone Joint Surg 72A:1562–1574, 1990.
50. Savoie III FH, Field LD, Jenkins RN: Costs analysis of successful rotator cuff repair surgery: An outcome study. Comparison of gatekeeper system in surgical patients. Arthroscopy 11:672–676, 1995.
51. Walker SW, Couch WH, Boester GA, et al: Isokinetic strength of the shoulder after repair of a torn rotator cuff. J Bone Joint Surg 69A:1041–1044, 1987.
52. Ware J, Sherbourne C: The MOS 36-item short-form health survey (SF-36) 1. Conceptual framework and item selection. Med Care 30:473–481, 1992.
53. Wolfgang GL: Surgical repair of tears of the rotator cuff of the shoulder: Factors influencing the result. J Bone Joint Surg 56A:14–26, 1974.