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Factors Affecting Outcome After Structural Failure of Repaired Rotator Cuff Tears

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Background: Failure of structural healing is not infrequent after rotator cuff repair and often is not associated with clinical outcome. The goals of this study are to describe outcomes in a cohort of patients with a failed rotator cuff repair and to evaluate factors associated with clinical outcome.

Methods: This was a retrospective study of all patients with failure of structural integrity after rotator cuff surgical repair. A threshold American Shoulder and Elbow Surgeons (ASES) score of 80 points was used to allocate patients into either the successful (≥80 points; Group 1) or unsuccessful (<80 points; Group 2) cohorts. Demographics, patient-centered instruments for shoulder function, radiographic parameters, and shoulder motion were compared between groups.

Results: On the basis of the postoperative ASES score, thirty-three patients (54.1%) were included in Group 1 and twenty-eight patients (45.9%) were included in Group 2. Fifteen patients (53.6%) in Group 2 reported a labor-intensive occupation compared with two patients (6.1%) in Group 1 ($p < 0.001$). Multiple regression analysis demonstrated that labor-intensive occupation (odds ratio [OR], 202.3; $p = 0.026$), preoperative Simple Shoulder Test (SST) score (OR, 0.50; $p = 0.028$), and preoperative external rotation (OR, 0.91; $p = 0.027$) were associated with inclusion in Group 2. Age and other demographic variables, including sex, dominant-sided surgery, and medical comorbidities, were similar for the groups.

Conclusions: Successful outcomes were achieved in 54% of patients with failed rotator cuff repair. Those who self-identified their occupation as being labor-intensive represented a special group of patients who are at high risk for a poor outcome after a failed rotator cuff repair.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

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Structural failure after rotator cuff repair is not consistently associated with the clinical outcome. Many studies have demonstrated successful outcomes in patients who have had structural failure after a rotator cuff repair[1-5]. Although the likelihood of tendon healing can often be predicted from demographic and tear-related variables[3,6-8], the patient's clinical result in the setting of structural failure cannot. This represents a knowledge gap in our understanding of the relationship among rotator cuff integrity, function, and pain in the postoperative shoulder.

Although some patients with failure of healing exhibit poor outcomes and require revision surgery[2,9-11], others report

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A commentary by Robert Tashjian, MD, is linked to the online version of this article at jbjs.org.

pain relief and a return of function despite a lack of healing[1,12-14]. The rate and cause of successful and unsuccessful outcomes with failed rotator cuff repair is unclear. Similarly, the specific demographic, radiographic, and/or physical examination variables that influence a patient's self-reported pain and function with an unhealed rotator cuff repair are not well established. This information is valuable in guiding physician and patient expectations both before and after rotator cuff surgery.

The purpose of this study was to describe the outcomes in a consecutive cohort of patients who failed to heal after rotator cuff repair and to identify factors associated with clinical outcome. To our knowledge, this study, utilizing a single-center database of rotator cuff repairs with standardized data acquisition methods, evaluated the largest number of patients with unhealed rotator cuffs after repair to date.

Materials and Methods

Study Sample

This retrospective study was approved by our institutional review board. Inclusion criteria for the study group were patients who (1) had preoperative imaging (magnetic resonance imaging [MRI] or ultrasound) documenting a full-thickness rotator cuff tear; (2) underwent arthroscopic repair of the rotator cuff tear; (3) had a postoperative ultrasound, regardless of the presence of symptoms, documenting failure of the repair at a minimum of twelve months after surgery; and (4) had a minimum of two years of clinical follow-up. All ultrasounds were performed by one of three musculoskeletal radiologists with more than ten years of experience in musculoskeletal ultrasonography[15,16]. A full-thickness rotator cuff tear was recorded when the rotator cuff could not be visualized, namely, because of complete avulsion and retraction under the acromion, when there was a focal defect in the rotator cuff, or when the torn cuff was retracted a variable degree from the greater tuberosity. A thinned rotator cuff or one with a subtle concave contour was considered to be intact in the absence of a focal defect[15]. Exclusion criteria included (1) patients with missing data, (2) repairs involving the subscapularis, (3) concomitant labral repair, and (4) partial-thickness tears.

Study Variables

Outcomes Instruments

Preoperative and postoperative patient-centered instruments for shoulder function included the American Shoulder and Elbow Surgeons (ASES) pain score[17], the total ASES score[17], and the Simple Shoulder Test (SST). The ASES score was used to dichotomize subjects into successful (Group 1) and unsuccessful (Group 2) outcomes groups. Previous studies have categorized ASES scores in the following manner: excellent (90 to 100 points), good (80 to 89 points), fair (70 to 79 points), and poor (<70 points)18,19. We utilized a threshold ASES score of 80 points to allocate patients into either the successful (≥80 points) or unsuccessful (<80 points) cohorts[18,19].

Demographics

Patient charts were reviewed to obtain demographic, physical examination, radiographic, and operative data. Demographic variables included age, sex, dominant side, occupation, Workers' Compensation claim, litigation claim, disability claim, comorbidities, smoking status, and a history of ipsilateral shoulder surgery. Occupations were classified as labor intensive or non-labor intensive on the basis of the patients' self-classifications. Medical comorbidities were compared by summation of total comorbidities in each group. The following comorbidities were considered: coronary artery disease or heart problems, hypertension, hypercholesterolemia, arthritis, depression or anxiety, colitis, diabetes, back pain or surgery, headaches or migraines, lung problems or asthma, thyroid problems, stomach problems, blood dyscrasias or clotting, seizures, fibromyalgia or chronic pain, connective tissue disorder, cancer, or hepatitis. Per preexisting protocol, this medical information was routinely documented on intake questionnaires.

Radiographic and Operative Variables

Preoperative tear size (width, length, and area) was determined from baseline MRI or ultrasound reports. Operative reports were reviewed for information regarding concomitant procedures performed (acromioplasty, biceps tenotomy, biceps tenodesis, and distal clavicular excision).

Physical Examination Parameters

All patients underwent a standardized preoperative and postoperative physical examination performed by a trained research nurse[10,20,21]. Active shoulder forward elevation and active external rotation with the arm at the side were consistently measured with a goniometer and were recorded.

Statistical Analysis

Demographic variables, shoulder function and pain scores, physical examination parameters, and radiographic variables for patients in Group 1 (successful) were compared with those in Group 2 (unsuccessful). Univariate analysis was performed and included paired t tests for continuous data and chi-square tests for categorical data. Logistic regression analysis was performed to identify factors associated with successful and unsuccessful outcome after structural failure of rotator cuff repair. A cutoff of $p < 0.1$ from the univariate analysis was used as a threshold to determine which factors to consider in the multivariate analysis. A separate multiple regression analysis was also performed using the ASES score as a continuous variable, rather than defining a so-called cutoff for successful and unsuccessful outcomes. Finally, two sensitivity analyses were performed by statistically analyzing data using an ASES score of ≥70 points and ≥90 points to define the successful outcome group. Statistical analysis was performed using Stata software (version 12; StataCorp, College Station, Texas). All results were considered significant at $p < 0.05$.

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Results

Total Cohort

To identify a cohort of patients with failure of structural healing after rotator cuff repair, we conducted a retrospective analysis of the cases of 212 patients with rotator cuff repairs. This database was partially created utilizing data from previous prospective studies performed at our institution[1,10,21,22] and partially created utilizing data from ongoing prospective studies. This database represented a heterogeneous population of rotator cuff tear sizes and repair constructs compiled for the purpose of identifying those who had failure of structural healing. Surgical procedures were performed by three fellowship-trained shoulder surgeons from May 1999 to January 2010. Seventy (33%) of 212 patients with a structural failure of rotator cuff repair confirmed by ultrasonography who met the inclusion criteria were included. Nine patients (six patients with missing data, two patients with subscapularis involvement, and one patient with a concomitant labral repair) were eliminated on the basis of exclusion criteria, leaving sixty-one patients for analysis. The mean age was 61.3 years (range, 47.8 to 82.2 years). There were thirty-three men and twenty-eight women. Thirty-five patients (57.4%) underwent surgery on the dominant side. Thirteen patients (21.3%) had prior ipsilateral shoulder surgery. Twelve patients had a prior rotator cuff repair, and two of these

TABLE I Comparison of Baseline Variables Between Groups

Variable	Total Cohort	Group 1 (Successful)	Group 2 (Unsuccessful)	P Value*
Age† *(yr)*	61.3 ± 8.4 (47.8.0-82.2)	62.2 ± 8.5 (49.0-78.9)	60.3 ± 8.3 (47.8-82.2)	0.380
M/F	33/28	20/13	13/15	0.190
Dominant-side surgery *(no. [%])*	35 (57.4)	19 (57.6)	16 (57.1)	0.330
Labor-intensive occupation *(no. [%])*	17 (27.9)	2 (6.1)	15 (53.6)	**<0.001**
Any claim *(no. [%])*	14‡ (23.0)	3‡ (9.1)	11 (39.2)	**0.005**
Workers' Compensation claim	6 (9.8)	2 (6.1)	4 (14.3)	0.280
Litigation claim	1 (1.6)	0	1 (3.6)	0.280
Disability claim	9 (14.8)	3 (9.1)	6 (21.4)	0.180
No. of comorbidities per patient§	2.1 ± 0.2	2.0 ± 0.3	2.2 ± 0.3	0.620
Smokers *(no. [%])*	9 (14.8)	5 (15.2)	4 (14.3)	0.700
Prior shoulder surgery *(no. [%])*	13 (21.3)	5 (15.2)	8 (28.6)	0.200
Prior rotator cuff repair *(no. [%])*	12 (19.7)	5 (15.2)	7 (25.0)	0.340
Follow-up§ *(mo)*	51.7 ± 5.2	54.2 ± 7.5	48.9 ± 7.3	0.620

*Boldface indicates significance. †The values are given as the mean and the standard deviation, with the range in parentheses. ‡Both Workers' Compensation patients also had a disability claim. §The values are given as the mean and the standard deviation.

patients had two prior rotator cuff repairs. Follow-up for the entire cohort was at a mean of 51.7 months (range, 24.1 to 135.2 months) (Table I).

In the overall cohort, the mean total ASES score improved from 42.4 to 72.7 ($p < 0.0001$) (Table II). The mean ASES pain score improved from 6.1 to 3.0 ($p < 0.0001$). Preoperatively, patients reported a mean of five "yes" responses on the SST compared with nine "yes" responses at the time of final follow-up ($p < 0.0001$). The mean preoperative active forward elevation improved from 115° to 147° ($p < 0.0001$); however, active external rotation was unchanged (53° preoperatively to 48° at the time of final follow-up; $p = 0.20$).

Stratified by Successful or Unsuccessful Outcome

On the basis of the postoperative total ASES score, thirty-three patients (54.1%) were included in Group 1 and twenty-eight patients (45.9%), in Group 2 (Table II). Fifteen patients (53.6%) in Group 2 reported a labor-intensive occupation compared with two patients (6.1%) in Group 1 ($p < 0.001$) (Table III). Eleven patients in Group 2 had a claim (Workers' Compensation, legal, or disability) compared with three patients in Group 1 ($p = 0.005$). Age and other demographic variables, including sex, dominant-sided surgery, medical comorbidities, smoking status, and previous surgery, were similar between groups. Both patients who had undergone two prior attempted rotator cuff repairs were in Group 2. Concomitant procedures in Groups 1 and 2 included acromioplasty (fifteen and eleven, respectively; $p = 0.627$), biceps tenotomy or tenodesis (eleven and twelve, respectively; $p = 0.444$), and distal clavicular excision (two and one, respectively; $p = 0.654$).

The mean preoperative total ASES score in Group 1 was significantly higher than that in Group 2 (48.0 versus 36.9; $p = 0.010$), and the SST score was significantly higher in Group 1 than in Group 2 (six versus three "yes" responses; $p = 0.004$) (Table II). The mean preoperative ASES pain scores were similar for Groups 1 and 2 (5.6 versus 6.5; $p = 0.14$). In addition to the postoperative total ASES score, the postoperative ASES pain scores were significantly lower and the SST scores were significantly higher in Group 1 than in Group 2 ($p < 0.001$). Seven (11.5%) of sixty-one patients, all from Group 2, had a decrease (mean, 6.6 points) in the total ASES score compared with preoperative values. The mean preoperative active forward elevation for Groups 1 and 2 (114° versus 116°; $p = 0.890$) was similar, but the mean postoperative active forward elevation (155° versus 136°) was significantly higher ($p = 0.008$) in Group 1 than in Group 2.

On the follow-up ultrasound examination, there was no significant difference between the groups with regard to tear size (24 versus 28 mm wide [$p = 0.22$], 22 versus 26 mm long [$p = 0.15$], and 589.0 versus 805.1 mm^2 in area [$p = 0.12$]) or change in tear size (0 versus +3 mm in width [$p = 0.27$], 0 versus +1 mm in length [$p = 0.70$], and −52 versus +111 mm^2 in area [$p = 0.17$]) from preoperative values (Table IV). Three patients in Group 2 underwent repeat surgery (two revision rotator cuff repairs and one debridement and removal of a loose anchor), and no patient in Group 1 underwent revision surgery ($p = 0.24$). The three patients who underwent repeat surgery had preoperative ASES scores of 30.0, 61.7, and 24.7 points and postoperative ASES scores of 60.0, 61.7, and 66.7 points, respectively. Data are included for these patients in Group 2.

Regression Analyses

Logistic regression analyses were performed using variables that were significant, or trended toward significance ($p < 0.10$), on

TABLE II Comparison of Preoperative and Postoperative Functional Outcomes and Range of Motion Between Groups

Outcomes Variable*	Total Cohort†	Group 1† (Successful)	Range	Group 2† (Unsuccessful)	Range	P Value‡
ASES score *(points)*						
Preop.	42.4 ± 2.2	48.0 ± 3.0	23-65	36.9 ± 3.0	5-70	**0.010**
Postop.	72.7 ± 2.9	90.4 ± 1.1	80-100	51.9 ± 3.0	25-76.7	**<0.0001**
Change	+30.3 ± 3.0	+42.4 ± 15.7		+15.0 ± 20.2		**<0.0001**
ASES pain score *(points)*						
Preop.	6.1 ± 2.1	5.6 ± 1.7	3-8	6.5 ± 2.4	1-10	0.140
Postop.	3.0 ± 2.8	1.2 ± 1.0	0-4	5.0 ± 2.8	1-10	**<0.001**
Change	−3.1 ± 3.4	−4.4 ± 2.0		−1.5 ± 3.6		**<0.001**
SST *(no. of "yes" answers)*						
Preop.	5 ± 3	6 ± 3	0-11	3 ± 2	0-10	**0.004**
Postop.	9 ± 3	11 ± 1	7-12	6 ± 3	0-10	**<0.001**
Change	+4 ± 3	+5 ± 3		+3 ± 3		**0.004**
Active forward elevation *(deg)*						
Preop.	115 ± 47	114 ± 50	0-170	116 ± 44	30-160	0.890
Postop.	147 ± 28	155 ± 14	120-170	136 ± 36	45-175	**0.008**
Change	+32 ± 42	+41 ± 50		+20 ± 40		**0.040**
Active external rotation *(deg)*						
Preop.	53 ± 18	59 ± 15	50-80	48 ± 20	10-70	0.050
Postop.	48 ± 19	52 ± 19	35-80	44 ± 19	10-70	0.220
Change	−5 ± 14	−7 ± 12		−4 ± 11		0.410

*ASES = American Shoulder and Elbow Surgeons, and SST = Simple Shoulder Test. †The values are given as the mean and the standard deviation. ‡Boldface indicates significance.

univariate analysis and could be associated with outcome after failed structural healing of rotator cuff repair: labor-intensive occupation, claim (Workers' Compensation, legal, or disability), preoperative total ASES score, preoperative SST score, and preoperative active external rotation. All variables included in the model were assessed for collinearity and were transformed to a normal distribution as necessary. The only variables found to be significant were labor-intensive occupation (odds ratio [OR], 202.3; $p = 0.026$), preoperative SST value (OR, 0.50; $p = 0.028$), and preoperative active external rotation (OR, 0.91; $p = 0.027$). The Hosmer-Lemeshow goodness-of-fit test[23] ($p = 0.93$) indicated an acceptable model fit to the data, and the model satisfied the assumption of linearity between the covariates and the dependent variable. A post hoc power analysis demonstrated that this multiple regression analysis ($R^2 = 0.60$, alpha = 0.05) was adequately powered (power = 1.0)[24,25]. The total ASES score was also analyzed as a continuous variable. In this model, labor-intensive occupation ($p = 0.02$) and preoperative SST score ($p = 0.005$) were again associated with outcome.

Sensitivity Analyses

Two separate sensitivity analyses were performed using an ASES score of ≥70 points and ≥90 points to define the successful outcome group. When a threshold ASES score of ≥70 points was used, labor-intensive occupation, any claim (Workers' Compensation, litigation, or disability), preoperative total ASES, preoperative SST, and preoperative active external rotation remained significantly different between Groups 1 and 2 on univariate analysis ($p < 0.05$). When a threshold ASES score of ≥90 points was used, labor-intensive occupation and preoperative SST score were the only demographic or radiographic factors found to be significantly different between Groups

TABLE III Description of Patient Self-Classified Labor-Intensive Occupations

Labor-Intensive Occupations	No. of Patients
Group 1 (successful)	
Mechanic	1
Construction	1
Group 2 (unsuccessful)	
Homemaker	3
Warehouse or stockroom worker	3
Construction	2
Welder	2
Truck driver	2
Machinist	1
Mechanic	1
Musician	1

TABLE IV Comparison of Radiographic Variables in Groups

Radiographic Variable	Total Cohort*	Group 1* (Successful)	Group 2* (Unsuccessful)	P Value
Tear width *(mm)*				
Preop.	25 ± 11	24 ± 12	25 ± 10	0.80
Postop.	26 ± 11	24 ± 10	28 ± 12	0.22
Change	+1 ± 9	0 ± 10	+3 ± 7	0.27
Tear length *(mm)*				
Preop.	23 ± 12	22 ± 13	25 ± 11	0.49
Postop.	24 ± 11	22 ± 11	26 ± 11	0.15
Change	+1 ± 11	0 ± 9	+1 ± 13	0.70
Tear area *(mm^2)*				
Preop.	667 ± 490	641 ± 508	694 ± 483	0.73
Postop.	686 ± 493	589 ± 418	805 ± 558	0.12
Change	+19 ± 61	−52 ± 103	+111 ± 116	0.17

*The values are given as the mean and the standard deviation.

1 and 2 on univariate analysis ($p < 0.05$). Regression analysis demonstrated that an unsuccessful outcome was again associated with labor-intensive occupation ($p = 0.026$), low preoperative SST score (0.028), and lower preoperative active external rotation ($p = 0.027$) when an ASES score of ≥70 points was used, and only the preoperative SST score ($p = 0.012$) was associated with an unsuccessful outcome when an ASES score of ≥90 points was used.

Discussion

Patient characteristics associated with successful and unsuccessful results after structural failure of rotator cuff repair have been poorly understood. The purpose of this study was to examine a cohort of patients with failure of healing after rotator cuff repair and to describe clinical outcomes and identify determinants of successful and unsuccessful outcomes. We demonstrated successful outcomes (as defined by an ASES score of >80 points) in 54% of patients with a failed rotator cuff repair and showed that those who self-identified their occupation as being labor intensive are at higher risk for a poorer outcome after a failed rotator cuff repair.

Galatz et al.[1] and Jost et al.[12] demonstrated that, despite structural failure of rotator cuff repair, there was marked clinical improvement in comparison with the preoperative state. Jost et al. evaluated twenty patients (mean age, fifty-nine years) with a failed rotator cuff repair at a mean follow-up of thirty-eight months and reported that the adjusted Constant-Murley score and subjective shoulder value averaged 83% and 75%, respectively, of the value for a normal shoulder[12]. We reported that 54% of patients with a failed rotator cuff repair still attained a successful clinical result, as defined by an ASES score of ≥80 points, and the overall cohort of failed repairs had a mean ASES score of 72.7 points. Of the 46% who achieved an unsuccessful result, we noted a mean 15.0-point improvement in the ASES score. This value should be considered within the context of a 12 to 17-point minimal clinically important difference for the ASES score[26]. Approximately 12% of patients with a failure of healing had a decrease in the ASES score. As age (sixty-three years or older)[21,27], large tear size, poor tissue quality, and other variables have been associated with poor healing rates[3,6-8], the risk of an unsuccessful outcome and the possibility for a functional outcome that was worse than baseline should be specifically discussed with patients with these characteristics.

A preoperative labor-intensive occupation was associated with an unsuccessful outcome after structural failure of rotator cuff repair. In their analysis of patients with structural failure of rotator cuff repair, Jost et al. reported that eight of the nineteen patients were classified as having a strenuous job[12]. Although fifteen patients returned to their original occupation, two patients who had been performing manual work changed to a less strenuous job, and two patients began receiving a disability pension[12]. Anderson et al. reported that the presence of a defect after rotator cuff repair did not appear to affect patient-reported function and return to preinjury activity, but failed repairs did result in significantly less strength[2]. Similarly, Thomazeau et al. correlated structural failure of rotator cuff repair with decreased shoulder flexion strength compared with intact repairs[8]. Strength was not a variable that was investigated in our study and may be related to unsuccessful outcomes in laborers. To our knowledge, the present study is the first to describe an association between labor-intensive occupation and outcome after structural failure of rotator cuff repair. Although other studies have not specifically evaluated predictors of outcomes in unhealed patients, Tashjian et al. reported better outcomes after rotator cuff repair in those who returned to work and those without a disability claim[28]. While a Workers' Compensation, legal, or disability claim was associated with an unsuccessful outcome on univariate analysis, this finding was not confirmed on multiple regression analysis. Henn et al. reported

better outcomes in patients with higher preoperative expectations[29]. In a separate study, Henn et al. also noted that patients with Workers' Compensation claims reported worse outcomes, even after controlling for confounding factors[30]. These studies did not include an assessment of healing at the time of follow-up, and the influence of rotator cuff healing on these variables is unclear. Patients with labor-intensive occupations should be counseled regarding a higher risk of a poor outcome following surgery, especially when biologic or tear-related risk factors that place them at higher risk for failure of healing are identified.

Although preoperative ASES and SST scores were significantly lower for patients who experienced an unsuccessful outcome, the preoperative pain score was not significantly different. It was likely that variables other than pain accounted for this lower self-perceived function at baseline. In contrast, patients with an unsuccessful outcome had higher pain scores postoperatively. Although the cause for greater pain is likely multifactorial and is ill defined, we suspected that occupation, activity level, and tear-related factors may account for higher pain scores in certain patients who exhibit structural failure after rotator cuff repair. In their evaluation of patients with failed structural integrity after rotator cuff repair, Jost et al. correlated the size of the postoperative tear, the stage of postoperative fatty muscle degeneration of the infraspinatus and subscapularis, the postoperative acromiohumeral distance, and the degree of postoperative glenohumeral osteoarthritis ($p < 0.05$) with poor outcome[12]. We did not evaluate postoperative fatty degeneration, acromiohumeral distance, or degree of postoperative glenohumeral osteoarthritis, and found similar tear sizes preoperatively and postoperatively.

The present study has a number of weaknesses. Patients were evaluated preoperatively with either ultrasound or MRI. Subsequently, all patients underwent postoperative ultrasound evaluation of the rotator cuff, and so changes in tear size may be influenced by any variability in these imaging modalities. Additionally, tear size was not documented intraoperatively to confirm MRI or ultrasound reports. Nevertheless, ultrasonography and MRI have been shown to have comparable accuracy for identifying and measuring the size of full-thickness and partial-thickness rotator cuff tears[31]. This was a retrospective review of prospectively collected data from heterogeneous groups of rotator cuff repair patients, and therefore several important variables, including duration of symptoms, preoperative patient expectations, return to work, fatty degeneration, tear location, strength, and rehabilitation protocol, could not be assessed. The use of the ASES score to determine successful and unsuccessful outcomes is prone to weaknesses inherent to the outcomes instrument. It is possible that patients who were placed in the unsuccessful group on the basis of the ASES score were actually satisfied with their functional outcome despite a low score. In order to address this weakness, we also showed similarly poor scores for ASES pain and SST in patients in the unsuccessful group; however, the lack of a true satisfaction score is a weakness that bears mention. Finally, although supported in the literature, the definition of a successful outcome by an ASES score of ≥80 points is somewhat arbitrary. In order to address this, we considered the ASES score as a continuous variable and also performed sensitivity analyses with an unsuccessful outcome defined as an ASES score of ≥70 and ≥90 points, respectively.

Failure of healing and a recurrent tear are recognized outcomes of rotator cuff repair. Since patients at risk for tear failure can often be identified preoperatively by several demographic and tear-specific characteristics, it is important to provide these patients with realistic expectations regarding outcomes after failure of repair. In this study, we demonstrated successful outcomes in 54% of patients with failed rotator cuff repair, which is substantially lower than those seen with healed rotator cuff repairs[2,9-11,21]. Additionally, those who self-identified their occupation as being labor intensive are at risk for a poorer outcome after a failed rotator cuff repair. Further prospective study is necessary to comprehensively identify patient and tear-specific factors that correlate with outcome after rotator cuff repair. ■

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References

1. Galatz LM, Ball CM, Teefey SA, Middleton WD, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Joint Surg Am. 2004 Feb;86(2):219-24.

2. Anderson K, Boothby M, Aschenbrener D, van Holsbeeck M. Outcome and structural integrity after arthroscopic rotator cuff repair using 2 rows of fixation: minimum 2-year follow-up. Am J Sports Med. 2006 Dec;34(12):1899-905. Epub 2006 Jul 26.

3. Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, Krishnan SG. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg Am. 2005 Jun;87(6):1229-40.

4. Cole BJ, McCarty LP 3rd, Kang RW, Alford W, Lewis PB, Hayden JK. Arthroscopic rotator cuff repair: prospective functional outcome and repair integrity at minimum 2-year follow-up. J Shoulder Elbow Surg. 2007 Sep-Oct;16(5):579-85. Epub 2007 Jul 12.

5. Lafosse L, Brozska R, Toussaint B, Gobezie R. The outcome and structural integrity of arthroscopic rotator cuff repair with use of the double-row suture anchor technique. J Bone Joint Surg Am. 2007 Jul;89(7):1533-41.

6. Gazielly DF, Gleyze P, Montagnon C. Functional and anatomical results after rotator cuff repair. Clin Orthop Relat Res. 1994 Jul;(30456):43-53.

7. Harryman DT 2nd, Mack LA, Wang KY, Jackins SE, Richardson ML, Matsen FA 3rd. Repairs of the rotator cuff. Correlation of functional results with integrity of the cuff. J Bone Joint Surg Am. 1991 Aug;73(7):982-9.

8. Thomazeau H, Boukobza E, Morcet N, Chaperon J, Langlais F. Prediction of rotator cuff repair results by magnetic resonance imaging. Clin Orthop Relat Res. 1997 Nov;(344):275-83.

9. McCarron JA, Derwin KA, Bey MJ, Polster JM, Schils JP, Ricchetti ET, Iannotti JP. Failure with continuity in rotator cuff repair ''healing.'' Am J Sports Med. 2013 Jan;41(1):134-41.

10. Keener JD, Wei AS, Kim HM, Paxton ES, Teefey SA, Galatz LM, Yamaguchi K. Revision arthroscopic rotator cuff repair: repair integrity and clinical outcome. J Bone Joint Surg Am. 2010 Mar;92(3):590-8.

11. Lapner PL, Sabri E, Rakhra K, McRae S, Leiter J, Bell K, Macdonald P. A multicenter randomized controlled trial comparing single-row with double-row fixation in arthroscopic rotator cuff repair. J Bone Joint Surg Am. 2012 Jul 18;94(14):1249-57.

12. Jost B, Pfirrmann CW, Gerber C. Clinical outcome after structural failure of rotator cuff repairs. J Bone Joint Surg Am. 2000 Mar;82(3):304-14.

13. Kim KC, Shin HD, Lee WY. Repair integrity and functional outcomes after arthroscopic suture-bridge rotator cuff repair. J Bone Joint Surg Am. 2012 Apr 18;94(8):e48.

14. Oh JH, Kim SH, Ji HM, Jo KH, Bin SW, Gong HS. Prognostic factors affecting anatomic outcome of rotator cuff repair and correlation with functional outcome. Arthroscopy. 2009 Jan;25(1):30-9. Epub 2008 Oct 10.

15. Prickett WD, Teefey SA, Galatz LM, Calfee RP, Middleton WD, Yamaguchi K. Accuracy of ultrasound imaging of the rotator cuff in shoulders that are painful postoperatively. J Bone Joint Surg Am. 2003 Jun;85(6):1084-9.

16. Teefey SA, Hasan SA, Middleton WD, Patel M, Wright RW, Yamaguchi K. Ultrasonography of the rotator cuff. A comparison of ultrasonographic and arthroscopic findings in one hundred consecutive cases. J Bone Joint Surg Am. 2000 Apr;82(4):498-504.

17. Richards RR, An KN, Bigliani LU, Friedman RJ, Gartsman GM, Gristina AG, Iannotti JP, Mow VC, Sidles JA, Zuckerman JD. A standardized method for the assessment of shoulder function. J Shoulder Elbow Surg. 1994 Nov;3(6):347-52.

18. Duralde XA, McClelland WB Jr. The clinical results of arthroscopic transtendinous repair of grade III partial articular-sided supraspinatus tendon tears. Arthroscopy. 2012 Feb;28(2):160-8.

19. Park JY, Chung KT, Yoo MJ. A serial comparison of arthroscopic repairs for partial- and full-thickness rotator cuff tears. Arthroscopy. 2004 Sep;20(7):705-11.

20. Kamath G, Galatz LM, Keener JD, Teefey S, Middleton W, Yamaguchi K. Tendon integrity and functional outcome after arthroscopic repair of high-grade partial-thickness supraspinatus tears. J Bone Joint Surg Am. 2009 May;91(5):1055-62.

21. Tashjian RZ, Hollins AM, Kim HM, Teefey SA, Middleton WD, Steger-May K, Galatz LM, Yamaguchi K. Factors affecting healing rates after arthroscopic double-row rotator cuff repair. Am J Sports Med. 2010 Dec;38(12):2435-42. Epub 2010 Oct 28.

22. Paxton ES, Teefey SA, Dahiya N, Keener JD, Yamaguchi K, Galatz LM. Clinical and radiographic outcomes of failed repairs of large or massive rotator cuff tears: minimum ten-year follow-up. J Bone Joint Surg Am. 2013 Apr 3;95(7):627-32.

23. Hosmer DW, Lemeshow S, editors. Applied logistic regression. New York: John Wiley and Sons; 2000.

24. Soper DS. Post-hoc statistical power calculator for multiple regression [software]. 2013. http://www.danielsoper.com/statcalc. Accessed 2013 Sep 27.

25. Cohen J. Statistical power analysis for the behavioral sciences. New Jersey: Lawrence Erlbaum Associates, Inc.; 1988.

26. Tashjian RZ, Deloach J, Green A, Porucznik CA, Powell AP. Minimal clinically important differences in ASES and simple shoulder test scores after nonoperative treatment of rotator cuff disease. J Bone Joint Surg Am. 2010 Feb;92(2):296-303.

27. Nho SJ, Adler RS, Tomlinson DP, Allen AA, Cordasco FA, Warren RF, Altchek DW, MacGillivray JD. Arthroscopic rotator cuff repair: prospective evaluation with sequential ultrasonography. Am J Sports Med. 2009 Oct;37(10):1938-45.

28. Tashjian RZ, Bradley MP, Tocci S, Rey J, Henn RF, Green A. Factors influencing patient satisfaction after rotator cuff repair. J Shoulder Elbow Surg. 2007 Nov-Dec;16(6):752-8. Epub 2007 Oct 26.

29. Henn RF 3rd, Kang L, Tashjian RZ, Green A. Patients' preoperative expectations predict the outcome of rotator cuff repair. J Bone Joint Surg Am. 2007 Sep;89(9):1913-9.

30. Henn RF 3rd, Kang L, Tashjian RZ, Green A. Patients with Workers' Compensation claims have worse outcomes after rotator cuff repair. J Bone Joint Surg Am. 2008 Oct;90(10):2105-13.

31. Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. J Bone Joint Surg Am. 2004 Apr;86(4):708-16.