Original Article

Female Sex and Higher Infraspinatus Fatty Infiltration Are Linked to Dissatisfaction at a Minimum Follow-Up of 4 Years after Arthroscopic Repair of Massive Rotator Cuff Tears

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Purpose: To evaluate patient satisfaction at a minimum of 4 years after arthroscopic rotator cuff repair (ARCR) of massive rotator cuff tears (MRCT), to identify preoperative and intraoperative characteristics associated with satisfaction, and to compare clinical outcomes between satisfied and dissatisfied patients. **Methods:** A retrospective review on prospectively collected data was conducted on ARCRs of MRCTs performed at 2 institutions between January 2015 and December 2018. Patients with a minimum 4-year follow-up, preoperative and postoperative data, and primary ARCR of MRCTs were included for analysis. Patient satisfaction was analyzed according to patient demographics, patient-reported outcome measures (American Shoulder and Elbow Surgeons score [ASES], visual analog scale [VAS] for pain, Veteran Rands 12-item health survey [VR-12], and Subjective Shoulder Value [SSV]), range of motion (forward flexion [FF], external rotation [ER], and internal rotation [IR]), tear characteristics (fatty infiltration, tendon involvement, and tear size), and clinical significant measures (minimal clinical important difference [MCID], substantial clinical benefit [SCB], and patient-acceptable symptomatic state [PASS]) for ASES and SSV. Rotator cuff healing was also assessed with ultrasound in 38 patients at final follow-up. **Results:** A total of 100 patients met the study's criteria. Overall, 89% of patients were satisfied with ARCR of a MRCT. Female sex ($P = .007$) and increased preoperative infraspinatus fatty infiltration ($P = .005$) were negatively associated with satisfaction. Those in the dissatisfied cohort had significantly lower postoperative ASES (80.7 vs 55.7; $P = .002$), VR-12 (49 vs 37.1; $P = .002$), and SSV scores (88.1 vs 56; $P = .003$), higher VAS pain (1.1 vs 4.1; $P = .002$) and lower postoperative range of motion in FF (147° vs 117°; $P = .04$), ER (46° vs 26°; $P = .003$), and IR (L2 vs L4; $P = .04$). Rotator cuff healing did not have an influence on patient satisfaction ($P = .306$). Satisfied patients were more likely to return to work than dissatisfied patients (97% vs 55%; $P < .001$). **Conclusions:** Nearly 90% of patients who undergo ARCR for MRCTs are satisfied at a minimum 4-year follow-up. Negative preoperative factors include female sex and increased preoperative infraspinatus fatty infiltration, but no association was observed with rotator cuff healing. Furthermore, dissatisfied patients were less likely to report a clinically important functional improvement. **Level of Evidence:** Level IV, prognostic case series.

Introduction

Massive rotator cuff tears (MRCT) can be difficult to manage. Retear rates are high, which may affect patient satisfaction.[1] Although one might expect repair integrity to influence patient experience, this has been inconsistently documented, as satisfaction can be achieved despite a negative or suboptimal physiological outcome.[2] This discrepancy is supported by Barnes et al., who retrospectively reviewed satisfaction and repair integrity in 150 patients undergoing either mini-open or arthroscopic rotator cuff repair (ARCR) and found no consistent relationship between the two.[3]

With the shift toward value-based care, there is growing interest in evaluating patient satisfaction after common procedures, such as ARCR.[4] It has been

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reported that female sex, younger age, and poor rotator cuff quality contribute to dissatisfaction after ARCR.[5,6] These studies, however, are single-center case series with limited follow-up and are not specific to ARCR of MRCTs.

The purposes of this study were 1) to evaluate patient satisfaction at a minimum of 4 years after arthroscopic repair (ARCR) of massive rotator cuff tears (MRCT), 2) to identify preoperative and intraoperative characteristics associated with satisfaction, and 3) to compare clinical outcomes between satisfied and dissatisfied patients. Our hypothesis was that satisfied patients would have less preoperative fatty infiltration and higher rates of postoperative rotator cuff healing.

Methods

Study Design

A retrospective review was conducted of a prospective database to identify patients who underwent ARCR of a MRCT at two institutions between January 2015 and December 2018. This study's protocol was approved December 17, 2020, by the Salus Institutional Review Board (protocol #102). Inclusion criteria included a primary ARCR, intraoperative rotator cuff tear confirmation of a MRCT, defined as at least 5 cm in size,[7] or complete tear of 2 tendons,[8] and minimum 4-year follow-up. Exclusion criteria were a previous rotator cuff surgery and lack of baseline or postoperative functional outcome data. All patients had undergone surgery for rotator cuff tears identified clinically and/or via imaging for pain and/or weakness that was significantly interfering with their quality of life.

Surgical Technique

Surgeries were performed by two fellowship-trained shoulder surgeons (P.D., R.G.). All repairs were performed under general anesthesia and interscalene block, and the patient was placed in the lateral decubitus (P.J.D.) or beach chair (R.G.) position, per surgeon preference. The biceps tendon was either tenodesed or tenotomized at the surgeon's discretion. A limited acromioplasty with preservation of the coracoacromial ligament was routinely conducted. An anterior interval slide in continuity was routinely performed for mobilization. Posterior interval slides were added as needed (Table 2). If at least 75% coverage of the greater tuberosity was possible, a double-row repair was undertaken unless the construct was felt to be under too much tension, in which case, a single row or single row with rip-stop repair was performed instead. Partial repair was performed if tears were deemed irreparable. Complete repair was achieved in 92% and 100% of the satisfied and dissatisfied cohorts, respectively.

Postoperatively, patients were immobilized in a sling for 6 weeks. At 6 weeks, passive forward flexion and external rotation were allowed. Active range of motion and strengthening began 3 months after surgery. Unrestricted return to activities was deferred until 6 to 12 months postoperatively.

Study Variables

Patients were divided into two cohorts based on their reported satisfaction at the latest follow-up. Satisfaction was determined with a binary "yes/no'' question. Patients responded to the following question, "Are you satisfied with your shoulder?" [6]. Demographic factors included age, follow-up, gender, worker's compensation, and tobacco use. Active range of motion (ROM) and patient-reported outcomes (PROs) were documented at baseline and postoperatively. ROM was measured for forward flexion (FF), external rotation (ER), and internal rotation (IR) by the two treating surgeons (P.D., R.G.). Internal rotation was numerically scaled based on the nearest spinal level achieved with the thumb (T10 = 10, T12 = 12, L2 = 14, L4 = 16, S1 = 18, hip = 20). PROs included American Shoulder and Elbow Surgeons score (ASES), visual analog scale for pain (VAS), Veterans Rand 12-Item questionnaire (VR-12), and Subjective Shoulder Value (SSV). Clinically significant measures included minimal clinical important difference (MCID), substantial clinical benefit (SCB), and patient acceptable symptomatic state (PASS) for ASES and SSV.[9] Patients reaching or exceeding the values established by Cvetanovich et al. were recorded in both cohorts.

Preoperatively, fatty infiltration of the rotator cuff was assessed with magnetic resonance imaging (MRI) based on the Goutallier classification.[10] According to Gouttalier et al., grade 2 and above translated to irreversible muscle damage. Patients were, thus, divided into 2 groups based on fatty infiltration grade, with those with grade 0 and 1 in one group and grade 2 and above in another. Tendon tear pattern was classified on the basis of intraoperative appearance, according to the Collin classification, which provides patterns A to E.[11] This classification was modified to include pattern type F to describe a massive tear that consists of the entire subscapularis, supraspinatus, and infraspinatus tendons. Additionally, intraoperative tear size was measured in centimeters (cm) in the anteroposterior (AP) and mediolateral (ML) dimensions. Postoperative construct integrity was examined via ultrasound by each surgeon (P.J.D., R.G.) to determine healing per the Sugaya classification. Healing was further classified as complete (all tendons), partial (one or tendons), or nonhealing (no tendon healing).

Statistical Analysis

Two-sample *t*-tests were used to compare continuous variables (PROs and ROM). Categorical variables displayed as proportions were compared with Chi-squared

Table 1. Baseline Characteristics of MRCT Patients: Satisfied Versus Dissatisfied

Patient Demographics	Satisfied ($n = 89$)		Dissatisfied ($n = 11$)		P
Age					
years (mean, SD)	62	8.7	63	9.6	.646
Follow-up					
months (mean, SD)	64	8.9	62	9.4	.462
Gender					
male (n, %)	61	69%	3	27%	**.007**
Worker's Compensation					
yes (n, %)	10	11%	1	9%	.830
Smoker					
yes (n, %)	7	8%	1	9%	.896

MRCTs, massive rotator cuff tears. Bolded value indicates significant difference.

tests. These variables include demographic characteristics, cuff integrity, surgery-related factors, concomitant procedures, need for revision, and clinically significant measures. Data analysis was performed on the basis of patient availability for each variable, regardless of whether the total number of patients was reached. P values under .05 were considered statistically significant. Multivariate logistic regression analysis was conducted to determine factors affecting satisfaction by inputting significant variables derived from univariate analysis using the stepwise forward method. All analyses were performed with R (version 4.2.1) and RStudio (version 2022.07.1) software. A power analysis was performed for satisfaction rate, based on a binary

Table 2. Tendon Integrity and Surgery-Related Factors of MRCT Patients: Satisfied Versus Dissatisfied

	Satisfied ($n = 89$)		Dissatisfied ($n = 11$)		
	n	%	n	%	P
Fatty Infiltration (Goutallier grade)					
	grade ≥ 2 (n)	%	grade ≥ 2 (n)	%	
Supraspinatus atrophy	22	55%	5	71%	.417
Infraspinatus atrophy	20	51%	7	100%	**.016**
Subscapularis atrophy	10	32%	4	67%	.112
Tear Characteristics					
Tear size					
Medial-Lateral					
≤ 3 cm	29	50%	5	46%	.956
3-5 cm	20	35%	4	36%	
≥ 5 cm	9	16%	2	18%	
Anterior-Posterior					
≤ 3 cm	20	34%	6	55%	.418
3-5 cm	21	36%	3	27%	
≥ 5 cm	18	31%	2	18%	
Tendons Involved					
Type A	7	10%	1	9%	.263
Type B	7	10%	0	0%	
Type C	21	29%	2	18%	
Type D	21	29%	2	18%	
Type F	17	23%	6	54%	
Repair Technique					
Posterior Slide	4	5%	1	9%	.509
Fixation Construct					
Single Row	24	41%	5	46%	.201
Double Row	25	42%	2	18%	
Rip Stop	10	17%	4	36%	
Repair					
Complete repair	82	92%	11	100%	.335
Concomitant Procedures					
Distal clavicle excision	3	3%	0	0%	.536
Biceps tenodesis	67	75%	8	73%	.854
Biceps tenotomy	1	1%	0	0%	.724
Others	20	23%	0	0%	.079

MRCTs, massive rotator cuff tears.

Table 3. Baseline PROs and ROM of MRCT Patients: Satisfied Versus Dissatisfied

	Satisfied ($n = 89$)		Dissatisfied ($n = 11$)		
	Mean	Std. Dev.	Mean	Std. Dev.	*P*
Patient Reported Outcomes					
VAS Pain	5.1	2.2	5.6	2.3	.535
ASES	40.8	20.7	32.6	20.1	.250
VR-12	37.0	8.9	38.3	12.9	.771
SSV	37.3	22.1	33.2	26.7	.651
Range of Motion					
Active FF, °	127	40	116	46	.477
Active ER at Side, °	49	20	35	21	**.050**
Active IR (spinal level)	16	3	17	2	.242

ASES, American Shoulder and Elbow Surgeons; ER, external rotation; FF, forward flexion; IR, internal rotation; MRCT, massive rotator cuff tear; PROs, patient reported outcomes; ROM, range of motion; SSV, Subjective Shoulder Value; VAS, visual analog scale; VR-12, Veterans RAND 12. Bolded value indicates significant difference.

question, resulting in a minimum sample size of 73 patients.

Results

Preoperative Factors

One hundred patients met the study's criteria and, thus, were included in the analysis (Table 1). Overall, 89% of patients were satisfied at final follow-up of mean of 64 months postoperation. Females were less likely to be satisfied with the procedure ($P = .007$). Otherwise, there were no differences in satisfaction based on demographics. These variables included preoperative MRI and postoperative ultrasound in both cohorts. There were 49 patients who had preoperative MRIs, with 42 belonging to the satisfaction group and 7 to the dissatisfaction group. At the latest follow-up, 38 patients returned for ultrasound with 32 and 6 being satisfied and dissatisfied patients, respectively.

Compared to the satisfied group, dissatisfied patients demonstrated significantly lower preoperative ER (35° vs 49°; $P = .049$) and a higher grade (at least grade 2) of IS fatty infiltration (100% vs 51%; $P = .016$) (Tables 2 and 3). Intraoperatively, tear size and tear pattern were comparable between groups. Concomitant procedures were statistically similar between groups ($P > .05$).

Preoperative ER and sex were included in the multivariate analysis (Table 4). A 1-degree increase in ER at baseline correlated with a 3% increase in likelihood of achieving satisfaction ($P = .07$). Furthermore, sex significantly correlated with satisfaction. Males are 4.8× more likely to be satisfied than females after ARCR for MRCT ($P = .03$).

Table 4. Multivariate Analysis of Factors Associated with Patient Satisfaction

	Coefficient Estimate	*P* Value	OR (95% CI)
Active ER at side, °	0.029	.0721	1.029 (0.997-1.062)
Sex (male)	1.567	**.0322**	4.793 (1.142-20.121)

ER, external rotation; OR, odds ratio. Bolded value indicates significant difference.

Postoperative Factors

Satisfied patients achieved higher postoperative values in PROs, including VAS, ASES, VR-12, and SSV ($P < .05$) (Table 5). Likewise, postoperative values in ROM were significantly higher in the satisfied group (FF 147° vs 117°; ER 46° vs 26°; IR 14 vs 16; $P < .05$).

There was no association between tendon healing and satisfaction. Complete healing was higher in the dissatisfied group (5 of 6, or 83%), compared to the satisfied group (16 of 32, or 50%), but this difference did not reach statistical significance ($P = .306$) (Table 6). A significantly higher proportion of satisfied patients were able to return to work compared to dissatisfied patients (97% vs 55%; $P < .001$).

One complication was observed. In the dissatisfied group, one patient had an anchor pullout in the early postoperative protocol and was revised to reverse shoulder arthroplasty (RSA) 2 months postoperatively. In addition, two dissatisfied patients underwent revision to RSA for persistent pain and limited function 18 months postoperatively. In the satisfied group, one patient underwent RSA prior to final follow-up for progression of glenohumeral arthritis, and another required open reduction and internal fixation for an unrelated proximal humerus fracture.

Clinically Significant Measures

A significantly higher proportion of satisfied patients achieved SCB and PASS for ASES compared to the dissatisfied cohort (SCB 84% vs 45%; $P < .01$; PASS 65% vs 18%; $P < .01$) (Table 7). Although the percentage of satisfied patients reaching MCID for ASES was higher, this did not reach significance (MCID 89% vs 73%; $P = .14$). For SSV, all measures were significantly different between cohorts ($P < .01$). A higher proportion of satisfied patients reached these thresholds for MCID (96% vs 64%), SSV (88% vs 45%), and PASS (80% vs 18%).

Table 5. Outcomes at a Minimum of 4 Years Postoperatively: Satisfied Versus Dissatisfied Patients after ARCR of MRCTs

	≥ 4-Year Outcomes					Change From Baseline				
	Satisfied ($n = 89$)		Dissatisfied ($n = 11$)			Satisfied ($n = 89$)		Dissatisfied ($n = 11$)		
Patient-reported outcomes	Mean	Std. Dev.	Mean	Std. Dev.	*P*	Mean	Std. Dev.	Mean	Std. Dev.	*P*
VAS pain	1.1	2.1	4.1	2.5	**.002**	-4.0	2.4	-1.6	3.0	**.034**
ASES	80.7	26.9	55.7	20.2	**.002**	39.3	29.5	23.8	23.6	.081
VR-12	49.0	12.3	37.1	9.1	**.002**	11.5	12.6	-1.2	12.8	**.013**
SSV	88.1	15.6	56.0	27.4	**.003**	50.2	24.7	27.4	40.1	.109
Range of motion										
Active FF (°)	147	21	117	41	**.040**	22	45	1	60	.280
Active ER at side (°)	46	19	25	18	**.003**	−1	23	−9	25	.328
Active IR (spinal level)	14	4	16	3	**.040**	−2	4	−1	2	.253
Return to work										
yes (*n*, %)	86	96.6%	6	54.5%	**.000**					

ARCR, arthroscopic rotator cuff repair; ASES, American Shoulder and Elbow Surgeons; ER, external rotation; FF, forward flexion; IR, internal rotation; MRCT, massive rotator cuff tear; SSV, Subjective Shoulder Value; VAS, visual analog scale; VR-12, Veterans RAND 12. Bolded values indicate significant difference.

Discussion

The primary finding of this study was that ARCR of MRCT led to a satisfaction rate of 89% at a minimum 4 years of follow-up. Negative preoperative factors include female sex, limited preoperative ER, and increased IS fatty infiltration. Postoperatively, satisfied patients had higher ROM and PROs, despite identifying complete healing in only half of the cases. Moreover, the revision rate to RSA was low, but more commonly seen with dissatisfied patients. These findings may have implications for patient counseling and the overall management of MRCTs.

Patient satisfaction appears to be overall high following rotator cuff repair of a MRCT.[2,3,6,12,13] Razmjou et al. reported on 145 patients 2 years following ARCR for all tear sizes and noted that 83% of MRCTs were very or somewhat satisfied.[13] Similarly, Rousseau et al. reported an 88% satisfaction rate, which included very satisfied and satisfied patients, in a study of 50 ARCR of MRCTs retrospectively reviewed at midterm follow-up.[12] However, they did not stratify on the basis of tear size. In this study, analysis was limited to MRCTs and observed a satisfaction rate of 89%. This corroborates with the previous studies in demonstrating the generally high rate of patient satisfaction with ARCR of MRCTs. The large cohort size also provided the opportunity to evaluate factors associated with satisfaction.

According to the present study, females and patients with preoperative limited ER or increased infraspinatus fatty infiltration preoperatively were most likely to be dissatisfied. Although the link to patient sex has been described,[14,15] other reports have not reported differences based on sex.[13,16] In this analysis, males were nearly 5 times more likely to be satisfied postoperatively. Kim et al. and Tashijan et al. associated young age with lower rates of satisfaction.[6,17] Older age has been linked to poor tissue quality, worse functional outcomes, and multiple tendon involvement, but not with satisfaction.[5,15,18] Conversely, younger patients have higher preoperative expectations with postoperative functional outcomes.[19] Interestingly, the present study suggested a link between higher preoperative ER and satisfaction. Although the multivariate *P* value was not significant ($P = .07$), each 1-degree increase of ER translated to a 3% increase in likelihood of reaching satisfaction. This is consistent with the study by Manaka et al., who reported that preoperative stiffness, defined as <120° total (internal plus external rotation at 90° of abduction), negatively influenced functional recovery time,[20] which is contrary to the findings by Fermont et al.[21] While in this study univariate analysis of infraspinatus fatty infiltration was directly linked to lower satisfaction, tendon involvement was not impactful. Multiple studies have reported that fatty infiltration leads to lower postoperative PROs.[2,22,23] Shin et al. reported that patients with grade 3 or higher IS fatty infiltration had lower KSS outcomes scores.[22] Similarly, Shon et al. reported that dissatisfied patients had higher teres minor fatty infiltration preoperatively in a cohort of 31 patients treated with arthroscopic partial repair for large to massive cuff tears.[24] This high grade of fatty infiltration has been implicated in limited functional improvement postoperatively.

With regard to function, the best results following ARCR of MRCTs are achieved with complete repairs.[25] Satisfaction is often linked to the degree of functional

Table 6. Rate of Tendon Healing

Tendon Healing	Satisfied ($n = 32$)	Dissatisfied ($n = 6$)	*P*
Nonhealing	3 (9%)	0 (0%)	.306
Partial healing	13 (41%)	1 (17%)	
Complete healing	16 (50%)	5 (83%)	

$n = 39$.

Table 7. MCID, SCB, and PASS for ARCR of MRCT: Satisfied Versus Dissatisfied

		Satisfied ($n = 89$)		Dissatisfied ($n = 11$)		P
ASES						
	MCID	79	89%	8	73%	.14
	SCB	75	84%	5	45%	<.01
	PASS	58	65%	2	18%	<.01
SSV						
	MCID	85	96%	7	64%	<.01
	SCB	78	88%	5	45%	<.01
	PASS	71	80%	2	18%	<.01

ARCR, arthroscopic rotator cuff repair; ASES, American Shoulder and Elbow Surgeons; MCID, minimal clinical important difference; MRCT, massive rotator cuff tear; PASS, patient acceptable symptomatic state; SCB, substantial clinical benefit; SSV, Subjective Shoulder Value.

improvement patients are able to attain.[6,13] Significantly higher PROs and ROM in satisfied patients were observed postoperatively in this study. Similarly, Razmjou and Holtby, and O'Holleran et al. reported lower ASES scores and higher VAS pain scores postoperatively in dissatisfied patients at 2-year follow-up.[13,26]

Similar to other reports, we found no relationship between patient outcomes and tendon healing. Generally, infiltration is directly linked to tendon healing.[1,2,27] This is particularly important to consider in the setting of MRCT, where nonhealing rates are high, and functional outcomes are reportedly lower than other tear sizes.[1,12,23] Healing, nonetheless, has not been implicated with satisfaction in MRCTs, which concurs with our study findings.[2,28] Rousseau et al. reported a satisfaction rate of 88% and an intact RCR identified via ultrasound in 56% of cases at a mean follow-up of 38.6 months after ARCR of large and MRCT.[12] Patients with retears experienced significant improvement in Constant score compared to their preoperative status. Their findings correlated with Jost et al., who reported that failure of healing following open repair of MRCTs did not preclude improvement in pain and function.[29]

Limitations

This study is not without limitations. One is the use of a binary satisfaction question, which could lead to unbalanced cohorts. A small number of patients in one cohort may predispose to type I or II statistical errors. Furthermore, the retrospective nature of this study is a limitation. Given that these are the outcomes of two large-volume shoulder surgeons, the results could vary if the same procedure is performed by less experienced surgeons. Also, many patients did not return for ultrasound, which may influence postoperative healing analysis. Other variables, such as education level or psychosocial parameters, proven in other studies to influence patient expectations, and, therefore, satisfaction, could have also been integrated at the study's inception.[2,30]

Conclusion

Nearly 90% of patients who undergo an ARCR for a MRCT are satisfied at a minimum 4-year follow-up. Negative preoperative factors include female sex and increased preoperative infraspinatus fatty infiltration, but no association was observed with rotator cuff healing. Furthermore, dissatisfied patients were less likely to report a clinically important functional improvement.

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