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Comorbidity effect on speed of recovery after arthroscopic rotator cuff repair

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Background: Comorbidities have been shown to affect rotator cuff healing and postoperative outcomes. The purpose of this study was to analyze the effect of comorbidities on speed of recovery (SOR) and overall outcomes after arthroscopic rotator cuff repair (RCR).
Methods: We identified 627 patients who underwent primary arthroscopic RCR from 2006 to 2015. Measured motion and patient-reported outcome measures for pain and function were analyzed for preoperative, 3-month, 6-month, and 1-year intervals. Subgroup analysis of overall outcome and plateau in maximum improvement was performed for diabetes, smoking, obesity, hypercholesterolemia, and age.
Results: Diabetic patients had worse pain (visual analog scale for pain) and functional outcome (American Shoulder and Elbow Surgeons function, Simple Shoulder Test, visual analog scale for function, and elevation) scores at 6 months and 1 year ($P < .05$), with an earlier plateau in recovery (6 months) for nearly all variables. Smoking had no impact on postoperative outcome scores; however, plateaus occurred earlier in smokers (6 months). Obese patients had worse American Shoulder and Elbow Surgeons function score and external rotation at 1 year ($P < .05$) with similar plateau points. No significant differences were observed in outcomes for patients with hypercholesterolemia; however, plateaus for Single Assessment Numeric Evaluation and motion occurred earlier (6 months). Outcome scores for patients older than 65 years were not significantly different from those for younger patients.
Conclusion: After arthroscopic RCR, SOR for pain outpaced that for function and motion. Diabetic patients had worse outcomes and earlier plateau points. Earlier plateaus were seen for smokers and for motion in patients with obesity or hypercholesterolemia. Obese patients showed lower functional scores and external rotation. Age did not significantly influence SOR.

Advancements in arthroscopic surgical techniques for rotator cuff repair (RCR) have led to decreased complication rates with equivalent functional outcomes compared with mini-open techniques, and biomechanical performance has been shown to be improved.[11] An abundance of evidence exists regarding 2-year outcomes after RCR, but little is known about what patients can expect during the recovery process. Our institution recently examined the speed of recovery (SOR) after arthroscopic RCR, and recovery of pain, function, and range of motion (ROM) was shown to plateau at 1 year.[17] This previous work focused on the overall SOR and examined the impact of tear size and retraction.

Various comorbidities have been shown to be associated with rotator cuff tear occurrence[1,4,14,24,25] and to affect rotator cuff tear size, degree of rotator cuff healing, and tear recurrence.[2,4-6,12,14,15,27] Rotator cuff healing has been associated with maximal postoperative restoration of motion and function in RCR patients,[16] and smaller tear size has been associated with a faster SOR.[17] The effect of comorbidities and body mass index (BMI) on SOR in RCR patients is largely unknown. It has previously been suggested that the number of comorbidities should not preclude a patient from undergoing RCR.[26] However, a better understanding of how comorbidities affect the SOR would be helpful in counseling patients about postoperative expectations. It may also prove useful in guiding a physician's

This study was granted an Institutional Review Board exemption determination (Protocol No. 2016-010-EX) before initiation of this research. This study was designed as a retrospective review and analysis of data collected from a Western Institutional Review Board (WIRB)–approved Levy Elbow and Shoulder Surgical Repository (WIRB Study No. 1138999, WIRB Protocol No. 20130731).

All work was performed at the Holy Cross Orthopedic Institute and Holy Cross Hospital.

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decision to operate on the basis of a patient's ability to cope with prolonged recovery periods that may be associated with certain comorbidities.

The purpose of this study was to analyze the effect of comorbidities including diabetes, smoking, obesity, hypercholesterolemia, and age on the SOR and overall outcomes after RCR. Given the volume of data required to analyze numerous comorbidities and patient-reported outcome measures (PROMs), it was thought necessary to perform a separate study focusing on comorbidities using the same cohort of patients previously examined.[17] This would allow a more concentrated analysis of the impact of comorbidities on both the SOR and overall outcomes. We hypothesized that the presence of any of the studied comorbidities will result in a slower SOR and worse overall outcomes.

Materials and methods

A retrospective analysis of data collected for patients undergoing primary arthroscopic RCR included in our institution's shoulder and elbow surgery registry between November 2006 and December 2015 was performed using the same cohort of patients previously described.[17] As part of the standard registry protocol, BMI and the presence of comorbidities are noted preoperatively, which was the focus of this study. PROMs and shoulder motion (forward elevation [FE] and external rotation [ER]) assessments by best-effort goniometer measurements are collected preoperatively and at 3 months, 6 months, and 1 year and subsequent annual intervals postoperatively. PROMs included in this study were visual analog scale (VAS) scores for pain and function, American Shoulder and Elbow Surgeons (ASES) function score, Simple Shoulder Test (SST) score, and Single Assessment Numeric Evaluation (SANE) score. Subgroup analysis was performed on the basis of the presence or absence of the following preoperative comorbidities: diabetes mellitus, smoking, obesity, hypercholesterolemia, and older age. Obesity was defined as having a BMI ≥30 kg/m^2. Patients were stratified into 2 age groups—older than 65 years and younger than 65 years.

All patients undergoing an arthroscopic primary repair of a full-thickness rotator cuff tear were included. Patients undergoing a partial or revision RCR were excluded. For each outcome variable, only those patients with minimum 6-month follow-up data were included in the analysis. Missing data were replaced using specific time point group means.

The senior author (J.C.L.) performed all operations arthroscopically in a beach chair position using the surgical technique previously described.[17] Postoperatively, all patients were maintained in a shoulder immobilizer for 6 weeks, with rehabilitation protocols determined on the basis of the tear size and not the presence of comorbidities. Patients with small tears were started in a physical therapist–directed protocol that allowed early active assisted and passive motion. Patients with larger tears were placed in a self-directed home program for the first 3 months that called for pendulum exercises only for the first 6 weeks followed by active assisted stretching exercises for the subsequent 6 weeks. No strengthening exercises were prescribed for the first 3 months for all patients.

Plateau in maximal improvement

Using methodology previously described,[19] the plateau in maximal improvement was defined as the follow-up point at which no subsequent statistically significant improvement was observed compared with the immediately preceding follow-up interval. Using the VAS function column in Table I as an example, diabetic patients improved their mean scores from 4.2 preoperatively to 6.4 at 3 months, 7.1 at 6 months, and 7.3 at 1 year postoperatively. However, the improvement from 6 months to 1 year was not

Table I
Comparison of outcomes at various time points in recovery and the speed of recovery and plateau in maximal improvement for each outcome in patients with or without diabetes

	Diabetes		ASES function	SST	SANE	VAS function	VAS pain	FE	ER
Outcomes	Preoperative	Nondiabetic	23.1	5.1	46	4.6	5.5	133.4	49.6
		Diabetic	19.4	3.9	43.1	4.2	6	118	44.2
		P value	***.036****	***.026****	.45	.201	.163	***.005****	***.025****
	3 months	Nondiabetic	30.1	7.2	67.5	6.7	2.5	137.5	43.7
		Diabetic	27.4	6.2	64.9	6.4	3.4	135.2	42.5
		P value	.05	***.045****	.502	.3	***.028****	.579	.599
	6 months	Nondiabetic	38.2	9.3	78.9	7.8	1.9	151.8	49.9
		Diabetic	35.4	8.1	71.9	7.1	2.9	144.5	50.3
		P value	***.037****	***.01****	.58	***.032****	***.008****	***.03****	.852
	1 year	Nondiabetic	41.7	10.1	83	8.5	1.5	157.2	52.1
		Diabetic	39.3	8	73.1	7.3	2.6	142.4	45.5
		P value	***.015****	***.022****	.106	***.038****	***.017****	***.003****	.157
Speed of recovery	No diabetes	3 months	38%	42%	58%	54%	75%	17%	†
		6 months	81%	84%	89%	82%	90%	77%	12%
		1 year	100%	100%	100%	100%	100%	100%	100%
	Diabetes	3 months	40%	55%	73%	71%	76%	65%	†
		6 months	80%	100%	96%	94%	91%	100%	100%
		1 year	100%	98%	100%	100%	100%	92%	21%
Plateau		6 months		Diabetes	Diabetes	Diabetes	Diabetes	Diabetes	Diabetes
		1 year	Diabetes and no diabetes	No diabetes	No diabetes	No diabetes	No diabetes	No diabetes	No diabetes

ASES, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *FE*, forward elevation; *ER*, external rotation.

* Significant difference.

† ER decreased compared with preoperative value and thus is excluded.

statistically significant. Therefore, the plateau in maximal improvement was determined to occur at 6 months postoperatively (Table I).

Speed of recovery

SOR was defined as the percentage of the total improvement attained at each follow-up interval for each outcome measure.[19] This was calculated by the following formula:

$$\frac{\left[\begin{array}{c}(\text{Mean score at postoperative interval})\\ -(\text{Mean preoperative score})\end{array}\right]\times 100\%}{\left[\begin{array}{c}(\text{Maximum mean score achieved})\\ -(\text{Mean preoperative score})\end{array}\right]}$$

Again using the VAS function column in Table I as an example, SOR at 3 months postoperatively was calculated as the following (Table I):

$$\frac{[(6.4)-(4.2)]\times 100\%}{[(7.3)-(4.2)]} = 71\%$$

Statistical analysis

Independent samples *t*-test, paired samples *t*-tests, and repeated-measures ANOVAs were used where appropriate. Statistical analyses were conducted using SPSS version 22 (IBM Corp., Armonk, NY, USA). Significance was set at $P < .05$.

Results

There were 627 patients who met inclusion criteria; 382 (60.9%) were male and 245 (39.1%) were female, and the average age was 62.1 years (range, 29-87 years). Preoperatively, 74 patients were noted to have diabetes (11.8%), 49 patients were smokers (7.8%), 200 patients had a BMI ≥30 (31.9%), and 132 patients had hypercholesterolemia (21.1%).

Diabetes

Preoperative ASES function score, SST score, and ROM were significantly lower for diabetics. At 3 months, SST and VAS pain scores were worse in diabetic patients. These patients had worse pain (VAS pain score), functional outcome scores (ASES function, SST, VAS function), and FE at 6 months and 1 year compared with nondiabetics ($P < .05$). In patients with diabetes, plateau in maximal recovery occurred at 6 months for all variables except ASES function (plateau at 1 year). Nondiabetic patients plateaued at 1 year for all variables. SOR for pain was faster than recovery for function or ROM in diabetic and nondiabetic patients, with approximately 75% of ultimate improvement in pain being observed at 3 months. Diabetic patients demonstrated rapid improvements in FE at 3 months, achieving 65% improvement (Table I; Fig. 1).

Smoking

There were no significant differences between smokers and nonsmokers for all variables at all time points with the exception of greater preoperative VAS function ($P = .048$) in nonsmokers. Plateaus occurred at 6 months for all variables in smokers. Nonsmokers plateaued at 1 year for all variables with the exception of ER, which occurred at 6 months. SOR for pain was faster than recovery for function or ROM in smokers and nonsmokers, with 73%-83% of ultimate improvement in pain being observed at 3 months (Table II; Fig. 2).

Table II
Comparison of outcomes at various time points in recovery and the speed of recovery and plateau in maximal improvement for each outcome in smokers and nonsmokers

	Smoking		ASES function	SST	SANE	VAS function	VAS pain	FE	ER
Outcomes	Preoperative	No smoking	22.7	5	46.2	4.7	5.5	131.9	49.2
		Smoking	22	4.1	37.7	3.8	6.3	125	44.9
		P value	.766	.217	.095	***.048****	.093	.338	.175
	3 months	No smoking	29.7	7.1	67.2	6.7	2.6	197.4	43.9
		Smoking	31.2	6.7	67.2	6.8	2.5	135.1	39.9
		P value	.377	.446	.986	.644	.884	.72	.179
	6 months	No smoking	37.8	9.1	77.8	7.7	2	151.5	49.9
		Smoking	39	8.9	82.4	7.8	2.1	142.8	50.4
		P value	.511	.626	.067	.559	.815	.161	.862
	1 year	No smoking	41.6	10.1	82	8.5	1.5	156.9	51.9
		Smoking	39.6	9.4	85.2	7.9	1.7	148	47.8
		P value	.114	.257	.51	.127	.668	.161	.175
Speed of recovery	No smoking	3 months	37%	41%	59%	53%	73%	22%	†
		6 months	80%	80%	88%	79%	88%	78%	26%
		1 year	100%	100%	100%	100%	100%	100%	100%
	Smoking	3 months	52%	49%	62%	73%	83%	44%	†
		6 months	97%	91%	94%	98%	91%	77%	100%
		1 year	100%	100%	100%	100%	100%	100%	53%
Plateau		6 months	Smoking	Smoking	Smoking	Smoking	Smoking	Smoking	Smoking and no smoking
		1 year	No smoking	No smoking	No smoking	No smoking	No smoking	No smoking	

ASES, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *FE*, forward elevation; *ER*, external rotation.
* Significant difference.
† ER decreased compared with preoperative value and thus is excluded.

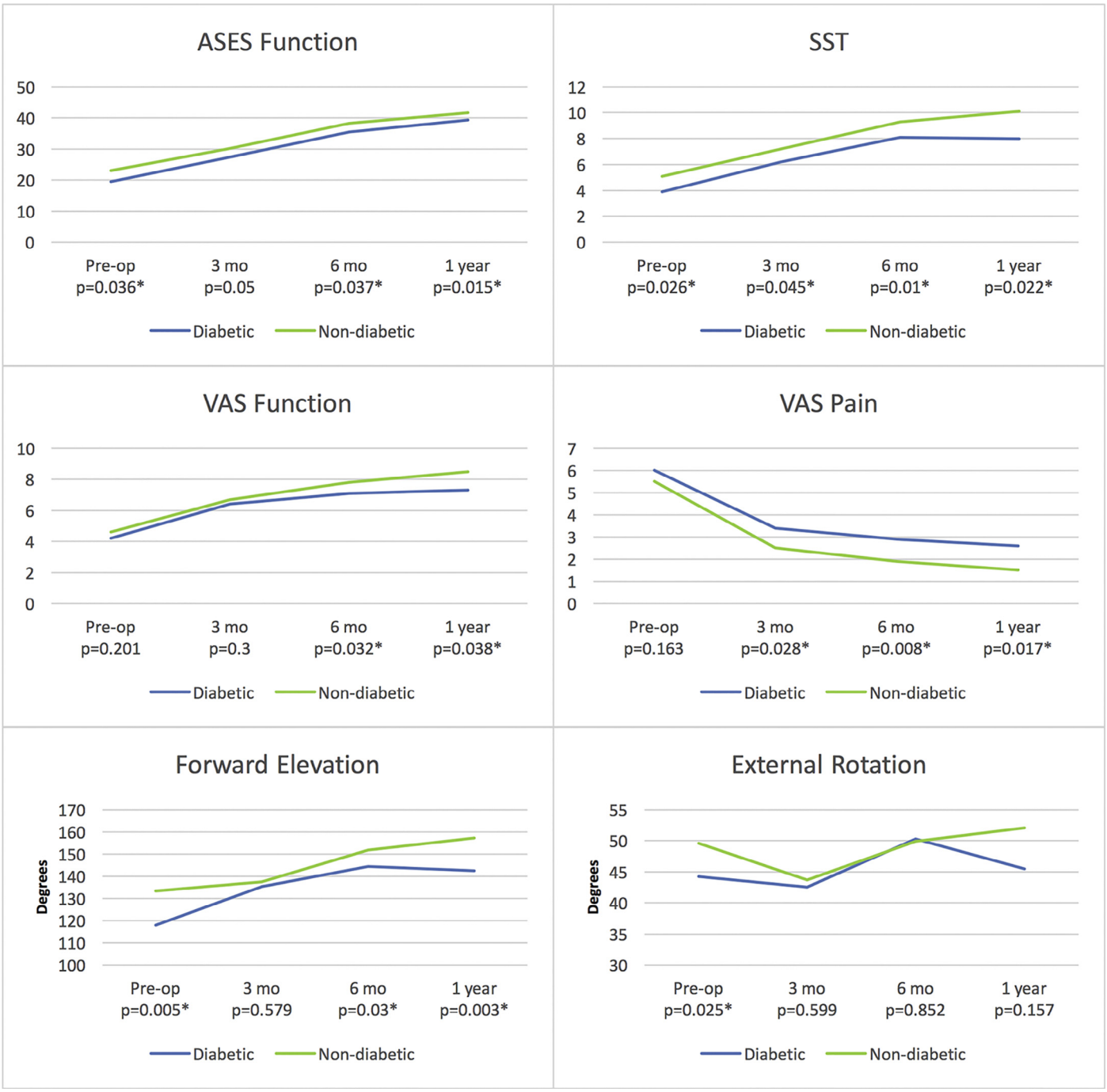

Figure 1 Graphical depiction of mean outcomes during recovery after rotator cuff repair for patients with and without diabetes. Outcomes shown include those with at least 1 statistically significant difference during recovery due to comorbidity status. *ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *VAS*, visual analog scale. *Significant difference.

Obesity

Obese patients had worse SST scores, VAS scores for pain, and ER preoperatively ($P < .05$) and had worse ASES function scores and ER at 1-year follow-up ($P < .05$) compared with nonobese patients. Outcomes at 3-month and 6-month follow-up were not significantly different between obese and nonobese patients with the exception of SST score at 3 months ($P = .003$) and VAS score for pain and abduction at 6 months ($P < .05$), which were worse in obese patients. Plateaus for all variables in both groups occurred at 1 year except for SANE in nonobese patients (plateau at 6 months) and ER in obese patients (plateau at 6 months). SOR for pain was faster than recovery for function or ROM in obese and nonobese patients, with 73%-77% of ultimate improvement in pain being observed at 3 months (Table III; Fig. 3).

Hypercholesterolemia

There were no significant differences between patients with and patients without hypercholesterolemia for all variables at all time points with the exception of FE at 1 year postoperatively, which was greater in patients without hypercholesterolemia ($P = .034$). Plateau

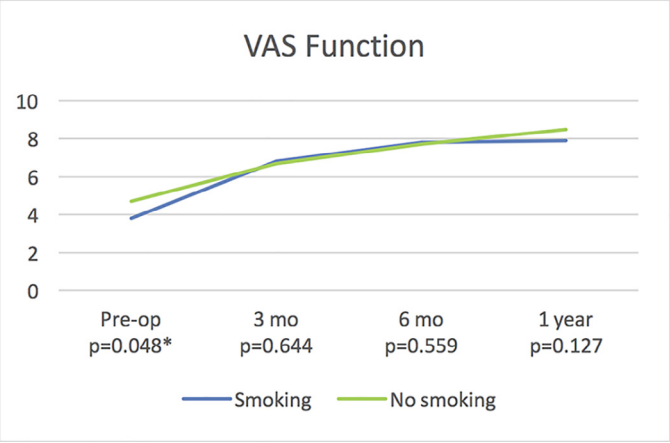

Figure 2 Graphical depiction of mean outcomes during recovery after rotator cuff repair for smokers and nonsmokers. Outcomes shown include those with at least 1 statistically significant difference during recovery due to comorbidity status. *VAS*, visual analog scale. *Significant difference.

occurred at 6 months for SANE and ROM in patients with hypercholesterolemia. All other plateaus for patients with and without hypercholesterolemia occurred at 1 year. SOR for pain was faster than recovery for function or ROM in both groups, with 70%-75% of ultimate improvement in pain being observed 3 months (Table IV; Fig. 4).

Age

There were no significant differences between patients older than 65 years and patients younger than 65 years for all variables at all time points. Plateau occurred at 1 year for all variables in both age groups with the exception of ER. In patients younger than 65 years, no true plateau was observed for ER as there was no significant improvement after surgery ($P = .091$). In patients older than 65 years, plateau in ER occurred at 1 year although significant improvement was seen only from 6 months to 1 year postoperatively ($P = .026$; Table V).

Discussion

Comorbidities of patients continue to be important risk factors for the development of various medical problems as well as predictors for recovery. As it pertains to rotator cuff disease, the literature suggests that several comorbidities are associated with the development of rotator cuff tears[1,4,14,24,25]; thus, a significant percentage of patients with tears requiring RCR present with these comorbidities. It is therefore important to determine the impact of these comorbidities on patients' recovery. This study illustrated the impacts of diabetes, smoking, obesity, age, and hypercholesterolemia on overall outcome and the SOR after RCR. Diabetes was found to have the greatest influence on SOR, with lower outcomes peaking at earlier time points.

Diabetic patients were found to have inferior outcomes for ROM and PROMs, with earlier plateau points in recovery. Previous studies have shown worse postoperative outcomes in diabetic patients after RCR.[7,10,12] The results of this study further support the impact of diabetes as plateaus in maximal improvement were found to occur earlier at these inferior outcome points. Diabetics reached plateaus in maximum improvement at 6 months, whereas those without diabetes continued to improve up to 1 year. The inferior outcomes and earlier plateau in recovery observed in diabetic patients may be linked to impaired cuff healing. Diabetes has been

Table III
Comparison of outcomes at various time points in recovery and the speed of recovery and plateau in maximal improvement for each outcome in obese and nonobese patients

	BMI		ASES function	SST	SANE	VAS function	VAS pain	FE	ER
Outcomes	Preoperative	Nonobese	22.9	5.3	46.8	4.6	5.4	132.3	50.7
		Obese	22	4.1	43	4.5	6.1	129.2	44.6
		P value	.448	***.002****	.175	.728	***.004****	.434	***.001****
	3 months	Nonobese	30.2	7.4	68.1	6.7	2.5	136.5	44.2
		Obese	28.7	6.4	65.1	6.6	2.8	139	42.2
		P value	.231	***.003****	.22	.531	.266	.401	.245
	6 months	Nonobese	38.4	9.2	79.1	7.8	1.8	151.6	51
		Obese	36.7	8.9	75.7	7.5	2.3	149.2	47.8
		P value	.096	.293	.104	.236	***.034****	.325	.051
	1 year	Nonobese	41.9	10.2	81.2	8.4	1.4	156.3	53.1
		Obese	39.4	9.7	85	8.4	1.8	155.3	48.3
		P value	***.028****	.254	.151	.734	.231	.711	***.032****
Speed of recovery	BMI <30	3 months	38%	43%	62%	55%	73%	18%	†
		6 months	82%	80%	94%	84%	90%	80%	12%
		1 year	100%	100%	100%	100%	100%	100%	100%
	BMI 30+	3 months	39%	41%	53%	54%	77%	38%	†
		6 months	84%	86%	78%	77%	88%	77%	86%
		1 year	100%	100%	100%	100%	100%	100%	100%
Plateau		6 months			Nonobese				Obese
		1 year	Obese and nonobese	Obese and nonobese	Obese	Obese and nonobese	Obese and nonobese	Obese and nonobese	Nonobese

BMI, body mass index; *ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *FE*, forward elevation; *ER*, external rotation.
* Significant difference.
† ER decreased compared with preoperative value and thus is excluded.

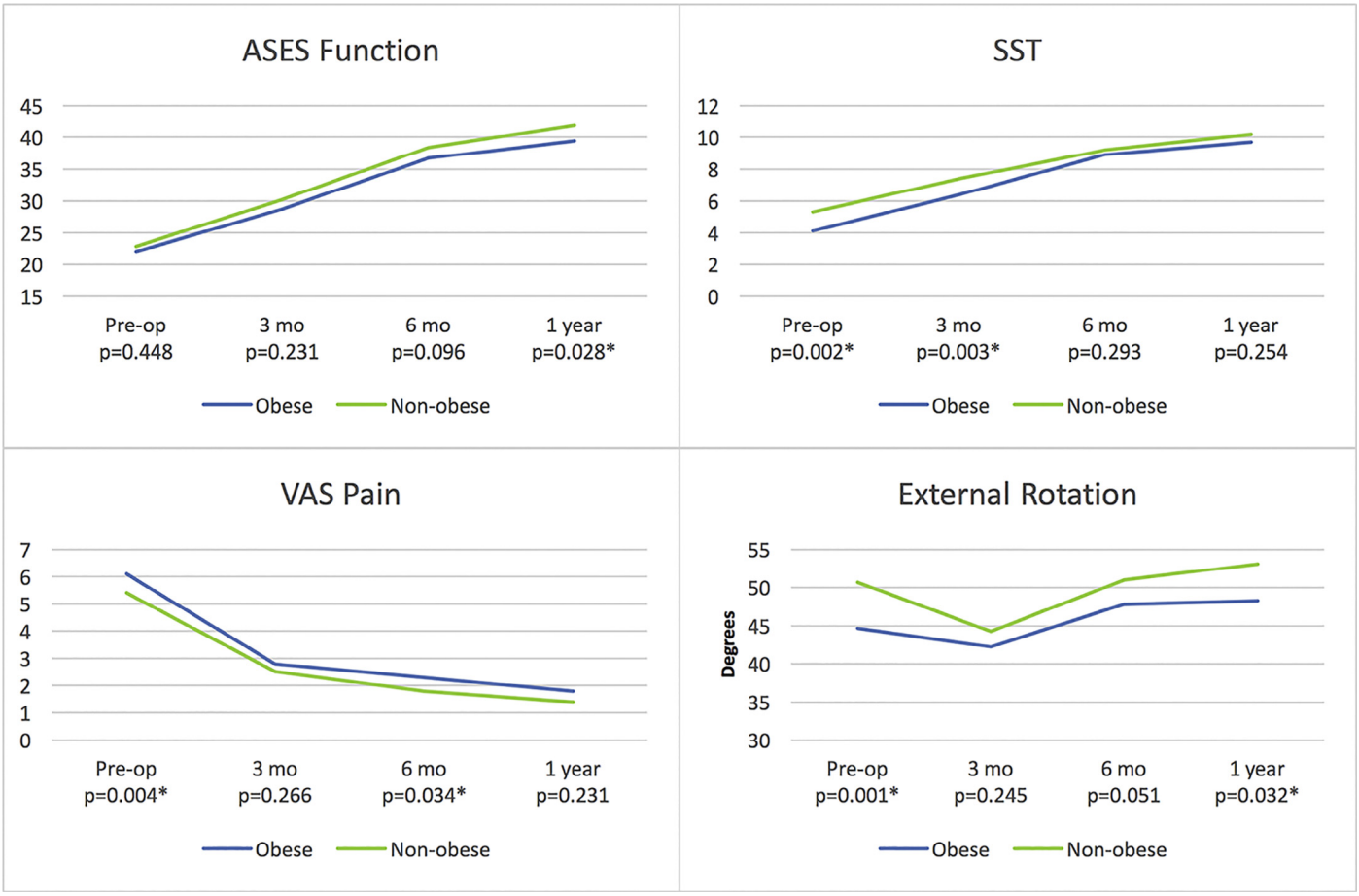

Figure 3 Graphical depiction of mean outcomes during recovery after rotator cuff repair for obese and nonobese patients. Outcomes shown include those with at least 1 statistically significant difference during recovery due to comorbidity status. *ASES*, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *VAS*, visual analog scale. *Significant difference.

shown to have an impact on tendon-bone healing after RCRs in both animal studies[3] and clinical follow-up studies.[7,9,21]

This study showed no differences between smokers and nonsmokers for all postoperative outcomes. Histologic studies have shown increased degenerative changes and apoptotic cells in smokers[20] as well as lower cellular proliferation and type I collagen expression in rats exposed to nicotine.[13] Yet there appears to be controversy in the current literature about outcomes in smokers after RCR. A systematic review by Bishop et al suggested that smoking is correlated with lower shoulder rating scores.[4] In contrast, another systematic review by Lambers Heerspink et al advocated that there is not enough evidence to support smoking's having an effect on outcomes.[18] Despite the controversy, this study does support an earlier plateau in recovery for smokers (6 months). Nonsmokers can expect continued improvement up to 1 year postoperatively.

There were no significant differences in final postoperative outcomes in our study between obese and nonobese patients except for final ASES function score and ER, which were worse in obese patients. The decreased ASES scores relative to nonobese patients are consistent with a retrospective review by Warrender et al, which found that obesity is associated with lower total ASES scores after RCR.[28] Similar to that for nonobese patients, plateau in maximal recovery for obese patients in this study occurred at 1 year for most variables. However, ER plateaued at 6 months.

This study showed no difference in final postoperative outcomes between patients with and patients without hypercholesterolemia. There appears to be little knowledge as to how hypercholesterolemia affects postoperative outcomes after RCR. However, a prospective rat study by Beason et al determined that high cholesterol concentration is associated with decreased normalized stiffness of the rotator cuff and potentially impaired healing,[2] which has been linked to worse outcomes after RCR.[16]

The age of the patient did not have a significant effect on SOR or final postoperative outcomes as similar results were observed for patients regardless of the age group. Boileau et al determined that patients older than 65 years had significantly lower rates of cuff healing compared with younger patients.[5] Similarly, a multivariate regression analysis by Tashjian et al found that age was independently associated with lower odds of cuff healing, although healing was not significantly associated with improved motion.[27] This study did not evaluate for postoperative cuff healing; however, the results suggest that irrespective of rotator cuff healing, the SOR is not different between the 2 age groups. Furthermore, age did not influence the overall 1-year clinical outcome at the plateau point in recovery. This is in agreement with Pauly et al, who showed no difference in clinical outcomes between patients aged 65 years and older and younger patients.[23]

Regardless of comorbidity status, all outcomes improved postoperatively, with pain improvements outpacing functional improvements. The SOR for pain was 70%-75% at 3 months regardless of comorbidity. Functional outcomes and motion seemed to be more variable and more commonly influenced by comorbidity. Many of these functional differences in the SOR relate to the severity of the preoperative baseline. For example, patients with diabetes had

Table IV
Comparison of outcomes at various time points in recovery and the speed of recovery and plateau in maximal improvement for each outcome in patients with or without hypercholesterolemia

Cholesterol			ASES function	SST	SANE	VAS function	VAS pain	FE	ER
Outcomes	Preoperative	No hypercholesterolemia	23.1	5	45.4	4.6	5.6	131.4	48.8
		Hypercholesterolemia	21.1	4.7	46.5	4.7	5.6	131.6	49
		P value	.143	.417	.722	.643	.846	.965	.941
	3 months	No hypercholesterolemia	29.7	7.1	66.8	6.9	2.6	136.9	43.5
		Hypercholesterolemia	30.4	7.1	68.8	6.7	2.5	138.6	44.1
		P value	.53	.972	.406	.904	.58	.618	.759
	6 months	No hypercholesterolemia	37.7	9.2	78.4	7.8	2	151.4	50.1
		Hypercholesterolemia	38.6	8.9	77.1	7.5	1.8	148.9	49.5
		P value	.381	.517	.585	.303	.363	.352	.735
	1 year	No hypercholesterolemia	41.3	10.2	83.1	8.4	1.6	157.2	52.1
		Hypercholesterolemia	42	9.7	79.5	8.4	1.2	142.4	49.8
		P value	.352	.238	.24	.792	.147	***.034****	.269
Speed of recovery	No hypercholesterolemia	3 months	36%	40%	57%	61%	75%	21%	†
		6 months	80%	81%	88%	84%	90%	75%	39%
		1 year	100%	100%	100%	100%	100%	100%	100%
	Hypercholesterolemia	3 months	44%	48%	68%	54%	70%	40%	†
		6 months	84%	84%	93%	76%	86%	98%	63%
		1 year	100%	100%	100%	100%	100%	100%	100%
Plateau		6 months			Hypercholes-terolemia			Hypercholes-terolemia	Hypercholes-terolemia
		1 year	Hypercholes-terolemia and no hypercholes-terolemia	Hypercholes-terolemia and no hypercholes-terolemia	No hypercholes-terolemia	Hypercholes-terolemia and no hypercholes-terolemia	Hypercholes-terolemia and no hypercholes-terolemia	No hypercholes-terolemia	No hypercholes-terolemia

ASES, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *FE*, forward elevation; *ER*, external rotation.

* Significant difference.

† ER decreased compared to preoperative value and thus is excluded.

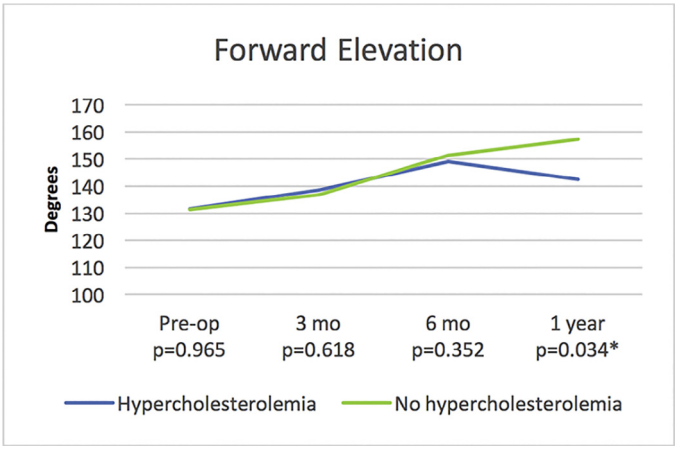

Figure 4 Graphical depiction of mean outcomes during recovery after rotator cuff repair for patients with and without hypercholesterolemia. Outcomes shown include those with at least 1 statistically significant difference during recovery due to comorbidity status. *Significant difference.

significantly worse FE (average, 118°; $P = .005$). At 3 months, 65% of the ultimate improvement in FE had been observed, with a plateau in improvement seen at 6 months.

There are several limitations in this study. Comorbidities were not evaluated for degree of management. Comorbidities such as diabetes may be more influential if they are poorly controlled. The impact of effectively treating each comorbidity may have influenced outcomes and the SOR. In addition, there is inherent selection bias in this retrospective analysis of patients surgically operated on as patients with comorbidities may be more commonly treated with nonoperative treatment on the basis of the surgeon's judgment or the patient's preference. Furthermore, all RCRs were performed under the experience of a single surgeon. Patients in this study were not routinely assessed with postoperative imaging for the presence of cuff degeneration or retear. The presence of these factors could have contributed to differences in outcomes, plateaus, or SOR between groups, as some studies have associated certain comorbidities with poor cuff healing and increased risk of degeneration or retear.[4,8,9,22] The impact of tear size on the SOR was not specifically analyzed in this study, as this was performed previously. Tear size does have an impact on SOR after RCR[17] and could exist as a confounding variable as the presence of several comorbidities has been associated with increased tear size.[4,6,14,15] However, this does not detract from the knowledge that comorbidities are associated with SOR and outcomes, as this understanding will likely help guide physicians' decision-making and patients' expectations. A significant strength of this study is its large cohort of patients. It also included large numbers of data points at each time interval during recovery, whereas a majority of previous studies primarily looked at data >2 years after surgery.

Conclusion

Diabetes most dramatically affected the SOR, with earlier plateaus in recovery and worse overall outcomes. Smokers plateaued at 6 months, whereas nonsmokers continued to improve up to 1 year postoperatively. Obese patients showed lower overall functional scores and ER postoperatively compared with nonobese patients. Hypercholesterolemia did not have a significant effect on overall outcomes. ROM measurements in obese patients and those with hypercholesterolemia plateaued early. Older age did not have an impact on SOR or overall outcomes. SOR for pain was 70%-83%

Table V
Comparison of outcomes at various time points in recovery and the speed of recovery and plateau in maximal improvement for elderly patients (aged 65 years and older) and younger patients

	Age (y)		ASES function	SST	SANE	VAS function	VAS pain	FE	ER
Outcomes	Preoperative	Age < 65	22.7	5.0	45.6	4.6	5.6	132.5	49.1
		Age ≥ 65	22.5	4.9	45.6	4.6	5.5	130	48.5
		P value	.801	.634	.993	.799	.643	.439	.645
	3 months	Age < 65	29.4	7.1	66.8	6.6	2.6	136.8	43.5
		Age ≥ 65	30.4	7.2	67.8	6.7	2.6	138	43.4
		P value	.273	.682	.565	.473	.746	.616	.956
	6 months	Age < 65	37.9	9.3	78.3	7.7	2	152.5	50.5
		Age ≥ 65	37.9	8.9	77.7	7.8	1.9	148.7	49.3
		P value	.983	.128	.725	.476	.574	.070	.334
	1 year	Age < 65	41.6	10.1	81.3	8.3	1.6	155.9	51.9
		Age ≥ 65	41.3	10.0	81.6	8.4	1.5	154.2	51.2
		P value	.652	.349	.860	.732	.252	.204	.445
Speed of recovery	Age < 65	3 months	35%	41%	59%	54%	75%	18%	*
		6 months	80%	84%	92%	84%	90%	85%	50%
		1 year	100%	100%	100%	100%	100%	100%	100%
	Age ≥ 65	3 months	42%	65%	62%	55%	73%	33%	*
		6 months	82%	78%	89%	84%	90%	77%	30%
		1 year	100%	100%	100%	100%	100%	100%	100%
Plateau		6 months							Age < 65†
		1 year	Age < 65 and age ≥ 65	Age < 65 and age ≥ 65	Age < 65 and age ≥ 65	Age < 65 and age ≥ 65	Age < 65 and age ≥ 65	Age < 65 and age ≥ 65	Age ≥ 65‡

ASES, American Shoulder and Elbow Surgeons; *SST*, Simple Shoulder Test; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *FE*, forward elevation; *ER*, external rotation.

* ER decreased compared with preoperative value and thus is excluded.

† No true plateau as there was no significant improvement from preoperative value.

‡ Only significant improvement is from 6 months to 1 year.

and outpaced that for function and ROM, regardless of comorbidity status.

Disclaimer

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