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Predictors of pain and functional outcomes after operative treatment for rotator cuff tears

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Background: Optimal patient selection is key to success of operative treatment for cuff tears. We assessed predictors of pain and functional outcomes in a longitudinal cohort of patients undergoing operative treatment.
Methods: From March 2011 to January 2015, a cohort of patients with rotator cuff tears undergoing rotator cuff surgery was recruited. Patients completed a detailed health and demographic questionnaire, standardized shoulder questionnaires, including the Shoulder Pain and Disability Index (SPADI), and underwent a magnetic resonance imaging scan. Patients received follow-up questionnaires at 3, 6, 12, and 18 months. We assessed longitudinal predictors of SPADI using longitudinal mixed models. Interactions with follow-up duration after surgery were also assessed.
Results: In our analysis (n = 50), a lower Fear-Avoidance Beliefs Questionnaire physical activity score ($P = .001$) predicted a lower SPADI score (better shoulder pain and function). Those consuming alcohol 1 to 2 times per week or more had lower SPADI scores than those consuming alcohol 2 to 3 times per month or less ($P = .017$). Both of these variables had a significant interaction with duration of follow-up. Variables that were not significant predictors of SPADI included sociodemographic characteristics, magnetic resonance imaging characteristics, such as tear size and muscle quality, shoulder strength, and variations in surgical techniques/performance of adjuvant surgical procedures.
Conclusions: Those with higher fear avoidance behavior and alcohol use of 1 to 2 times per week had worse shoulder pain and function at 18 months of follow-up. These data can be used to select optimal candidates for operative treatment of rotator cuff tears and assist with patient education and expectations before treatment.
Level of evidence: Level II; Prospective Cohort Design; Treatment Study

Keywords: Rotator cuff; surgery; predictors; outcomes; SPADI; shoulder pain; cohort

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An estimated 272,148 rotator cuff repairs were performed on an ambulatory basis in the United States in 2006.[6,14] There has been an increase in surgery as the initial treatment for rotator cuff tears over time.[30] Optimal outcomes of operative treatment for rotator cuff tears are achieved by patient selection based on characteristics that predict better pain and functional outcomes after surgery. Few studies have analyzed a limited number of factors associated with better outcomes after operative treatment.[3,5,8,12,18,19,21-23,26-28] A comprehensive longitudinal analysis of possible predictors of better outcomes after operative treatment in a well-defined multicenter cohort is lacking according to our assessment.

We assessed predictors of better shoulder pain and function after surgery in a longitudinal multicenter cohort of patients with rotator cuff tears. This information can be used to guide clinicians and patients in identifying optimal candidates for surgical treatment of rotator cuff tears.

Materials and methods

Patient population

Between March 2011 and January 2015, the Rotator Cuff Outcomes Workgroup (ROW) cohort study recruited patients aged 45 years and older with symptomatic (for at least 4 weeks) rotator cuff tears undergoing operative treatment. Patients were recruited from sports/shoulder clinics in 3 academic settings and 1 community setting. Exclusion criteria were a current shoulder fracture, prior shoulder surgery on the index shoulder, and active cervical radiculopathy elicited as neck pain radiating to the shoulder/arm/hand. Patients provided informed consent. Although this analysis was performed in patients undergoing rotator cuff surgery, the entire ROW cohort recruited patients with and without tears and also those undergoing operative and nonoperative treatments.

Structured history questionnaire and outcome measures

A history questionnaire and outcome questionnaires were administered to each patient at each time point. The history questionnaire, which was abbreviated for follow-up, elicited comprehensive and structured information on patient demographics, comorbidities, symptoms, smoking and alcohol habits, and patient expectations from treatment. Performance of daily manual labor in the patient's current job or last job (if retired) was also asked.

The physical activity scale of the Fear-Avoidance and Beliefs Questionnaire (FABQ) was designed by Waddell et al[31] to assess fear-avoidance beliefs about physical activity in patients with low back pain. We modified the FABQ physical activity questions (4 items that contribute toward scoring) in this scale by using the term "shoulder" instead of "back." The scale has 24 possible points, with a higher score indicating worse fear-avoidance behavior with physical activity in relation to the shoulder.

Mental health was assessed using the Mental Health Inventory (MHI-5),[2] a component of the 36-Item Short Form Health Survey.[32] MHI-5 scores range from 0 to 100. A score of ≤68 on the MHI-5 is indicative of a probable mood disorder, including depression.[17,29]

Shoulder outcomes were assessed using the Shoulder Pain and Disability Index (SPADI),[24] a standardized 13-item questionnaire. SPADI has a pain scale (5 items) and a disability scale (8 items). SPADI scores range from 0 to 100, with lower scores reflecting better shoulder pain and function.

Strength testing

Trained research assistants performed strength testing using a handheld dynamometer in abduction, external rotation, and internal rotation. The affected and contralateral shoulders were both assessed, and a mean of 2 consecutive measurements that were at least 10 seconds apart was used in our analysis. Our detailed protocol for standardized strength testing has been previously described.[15,20] Strength testing using a dynamometer has good intrarater and interrater reliability.[11] We used a ratio of the affected shoulder vs. the contralateral shoulder strength in the analysis.

Surgical characteristics

A surgery report form was used to determine whether a biceps tenodesis or tenotomy was performed and the technique used when performing the rotator cuff repair. The technique was classified into single row, double row, and other (open repair or transosseous equivalent). The surgery report form was completed by the attending surgeon.

Diagnostic imaging

Shoulder magnetic resonance images (MRIs) were read in a blinded fashion by consensus by 2 shoulder experts (L.D.H. and N.B.J. or J.E.K. and N.B.J.). Our previous work has shown good inter-rater and intrarater reliability for these MRI readings compared with a reading by a musculoskeletal radiologist.[13] The κ values ranged from 0.75 to 0.90 for tear presence, tear size, and tear thickness.[13] MRI features were assessed, including tear thickness, tear size in longitudinal and transverse planes, fatty infiltration of the rotator cuff muscles, tendon retraction, and rotator cuff muscle atrophy. Criteria for each of these measurements follow standard nomenclature and have been previously described.[13]

Diagnosis of rotator cuff tear

Rotator cuff tears were diagnosed based on the clinical impression of a sports/shoulder fellowship-trained attending physician and evidence of structural deficit on MRI. Biceps tendon pathology was diagnosed based on the clinician's impression because imaging can be negative even if the patient has symptoms corresponding to biceps pathology or vice versa. An MRI was unavailable for 2 patients in the cohort.

Longitudinal follow-up

Patients were assessed at approximately 3, 6, 12, and 18 months after the baseline visit was completed. Patients were mailed follow-up questionnaires with a prestamped envelope. Patients received phone or email reminders if they did not return the questionnaires and, eventually, a call from the study principal investigator if questionnaires were still not returned. All 50 patients attended at least 1 follow-up

assessment from baseline. At 18 months, 35 patients were available for analysis.

Statistical analysis

Potential factors associated with treatment outcomes (SPADI) were assessed during 18 months of follow-up. Because variable effects can change over time, 27 variables and their interactions with time were assessed. An a priori sample size calculation was not performed for this analysis. Variables included in our analysis were categorized as demographics, patient symptoms, comorbidities, personal habits, shoulder strength, and patient expectations. For partial-thickness tears, size of tear was given a value of 0 for the analysis because there is no accepted standard method to calculate size in partial-thickness tears. Race and patient expectations after treatment could not be used in the analysis due to very few patients in one of the categories.

Prediction models were estimated using a linear mixed model incorporating an autoregressive(1) covariance structure. Our statistical model used all available follow-up time points (3, 6, 12, and 18 months) for a given patient. Resulting standard goodness-of-fit and residual analyses were unremarkable. The full model, including interactions regardless of statistical significance, was used to estimate least square mean differences between groups for significant variables for ease of clinical interpretation. Univariate *P* values are presented for each variable based on the global test for the variable and interactions with time. If desired, the 26 univariate models can be interpreted, adjusting for multiplicity, by the reader using the Bonferroni *P*-value adjustment (0.05/26 = 0.0019).

Results

There were 50 patients in the operative cohort who met the eligibility criteria for this analysis. Most patients undergoing surgery were male (62% [n = 31]; Table I). The mean age of patients having surgery was 59 (standard deviation, 9) years. Most patients were engaged in light or no manual labor for their current or last (in case of retirees or those not working) job (74% [n = 37]). An equal number of patients were never smokers or past/current smokers (n = 24 in each group). Biceps pathology was diagnosed in 30% (n = 15) of patients.

Most patients had a full-thickness tear (90% [n = 43]; Table II). The median longitudinal size of the tendon with the largest tear was 2 cm (25th percentile, 1 cm; 75th percentile, 6 cm), and median transverse size was 2 cm (25th percentile, 1 cm; 75th percentile, 3 cm). Grade 0 fatty infiltration was present in 48% of patients (n = 23).

In unadjusted multiple comparisons among variables without a significant interaction with time, none of the structural, demographic, symptom, comorbidities, personal habits, shoulder strength, surgical technique, or patient expectation characteristics were significant predictors of the SPADI score during follow-up (Table III). When interactions were assessed, the FABQ physical activity score and alcohol use were significant predictors of SPADI scores with a differential effect over time. Alcohol use predicted the SPADI score: those consuming alcohol 1 to 2 times per week or more had lower SPADI scores (better shoulder pain and function) than those consuming alcohol 2 to 3 times per month or less. The effect size was greatest at 3 months of follow-up and then diminished during subsequent follow-up time points (Fig. 1). The FABQ physical activity score predicted SPADI such that those with higher FABQ physical activity scores (more fear avoidance behavior) had higher SPADI scores (worse shoulder pain and function). This difference was most pronounced at 3 months of follow-up (Fig. 2).

Discussion

We assessed predictors of better outcomes of operative treatment for rotator cuff tears. In a longitudinal analysis, the FABQ physical activity score and alcohol use were significant predictors of SPADI score and had an interaction with duration of follow-up. These variables showed a greater effect size during the initial duration of follow-up, and the magnitude of their estimates diminished during longer follow-up time points.

Operative treatment is routinely offered to patients with rotator cuff tears. Assessment of better prognostic indicators after operative treatment can help to optimize patient selection and educate patients on expectations of treatment outcomes. Thus, this information can be useful to patients and clinicians.

Castagna et al[4] studied 54 patients undergoing a transtendinous arthroscopic rotator cuff repair for partial-thickness tears. Although their study only assessed partial-thickness tears, less tendon retraction, younger age, and history of trauma were associated with better outcomes. Kamath et al[16] reported results of arthroscopic repair of high-grade partial-thickness rotator cuff tears. Their study was not specifically designed to assess prognostic factors associated with outcomes, but the authors found that the average age of patients with an intact repair at follow-up was significantly lower than those with a persistent defect. Nho et al[21] reported that shoulder strength predicted the American Shoulder and Elbow Surgeons score after rotator cuff repair. Gladstone et al[10] assessed 38 patients and reported that muscle atrophy and fatty infiltration were independent predictors of Constant and American Shoulder and Elbow Surgeons scores.

Our study found none of the structural characteristics of the rotator cuff, including fatty infiltration and muscle atrophy, were significant predictors of outcomes. There were, however, very few patients with grade 3 or 4 fatty infiltration in our study because surgery is usually not recommended for these patients. Longitudinal size of tear, although not statistically significant in our sample, was the closest measure to achieving significance and potentially could be significant in a larger sample of patients (*P* = .14). Prior studies have reported that a larger tear size is related to worse shoulder outcomes of pain and function.[22,25]

A higher number of comorbidities was not a significant predictor of rotator cuff surgery outcomes in our study. Tashjian

Table I Baseline characteristics of patients with rotator cuff tears having surgery: the Rotator Cuff Outcomes Workgroup cohort (n = 50)

Characteristics	Patients (n = 50)	
	Percent or median (lower-upper quartile)	No. or mean ± SD
Demographics		
Sex		
Female	38	19
Male	62	31
Age, yr	59 (52-65)	59 ± 9
Race/ethnicity		
Non-Hispanic white	92	46
Other	6	3
Missing	2	1
Highest level of education		
Less than college	32	16
College or above	64	32
Missing	4	2
Marital status		
Single/divorced/widowed	22	11
Married	78	39
Symptoms and shoulder strength		
Duration of symptoms, mo	6 (2-18)	23 ± 41
Daily shoulder use at work		
Heavy/moderate manual labor	24	12
Light/no manual labor	74	37
Missing	2	1
Dominant shoulder affected		
No	22	11
Yes	74	37
Missing	4	2
Tear as a result of trauma		
No	46	23
Yes	54	27
External rotation strength ratio[*,†]	0.5 (0.3-0.7)	0.5 ± 0.3
Isolated abduction strength ratio[*,†]	0.9 (0.8-1.0)	0.9 ± 0.2
Comorbidities and personal habits		
Comorbidities, No.		
≤1	58	29
>1	42	21
Smoking		
Never	48	24
Past/current	48	24
Missing	4	2
Alcohol use		
≤2-3 times/mo	36	18
≥1-2 times/week	60	30
Missing	4	2
FABQ score	19.0 (17.0-23.0)	19.0 ± 4.0
MHI-5	85.0 (76.0-90.0)	80.0 ± 17.0
Patient expectations after treatment		
A great improvement	94	47
Moderate/little/no improvement, or	6	3
Quality of my life will be worse		
Associated disorders		
Presence of biceps tendon pathology		
No	70	35
Yes	30	15

SD, standard deviation; *FABQ*, Fear Avoidance and Behavior Physical Activity Questionnaire; *MIH-5*, Mental Health Inventory 5.

* Number for missing external rotation strength ratio = 4; isolated abduction strength ratio = 7.

† Strength ratio is measured as affected shoulder vs. unaffected shoulder.

Table II Magnetic resonance imaging and surgical characteristics of rotator cuff tear in patients having surgery: the Rotator Cuff Outcomes Workgroup cohort

Rotator cuff tear characteristics	Patients (n = 50)	
	Percent or median (lower-upper quartile)	No. or mean ± SD
MRI characteristics*		
Longitudinal size of tear, † cm	2 (1-6)	4 ± 3
Transverse size of tear,† cm	2 (1-3)	2 ± 2
Cross-sectional area of tear,† cm^2	3 (2-21)	14 ± 19
Thickness of tear‡		
Partial-thickness	10	5
Full-thickness	90	43
Fatty infiltration§		
Grade 0	48	23
Grade ≥1	40	19
Missing	12	6
Muscle atrophy§		
None/mild	62	30
Moderate/severe	25	12
Missing	12	6
Number of tendons torn		
0 or 1	60	29
2 or 3	40	19
Tendon retraction		
Stage I or not applicable‖	60	29
Stage II or more	40	19
Surgical characteristics		
Biceps tenodesis/tenotomy		
Yes	60	30
No	36	18
Missing	4	2
Type of repair		
Single row	58	29
Double row	24	12
Other	12	6
Missing	6	3

SD, standard deviation; *MRI*, magnetic resonance imaging.

* MRI was not available for review for 2 patients, so total number for MRI variables in the table is 48.

† Tear size determined by sum of supraspinatus and infraspinatus tear size in longitudinal or transverse planes for full-thickness tears only; number for missing: transverse size = 5; longitudinal size = 4; cross-sectional area = 5.

‡ If any of the tendons had a full-thickness tear, the tear was classified as full-thickness.

§ Grading reported for muscle most severely affected.

‖ Since tear was partial-thickness.

Table III Predictors of Shoulder Pain and Disability Index score at 18 months in patients with rotator cuff tears having surgery

Variable*	*P* value	
	Variable	Interaction of variable with duration of follow-up†
Demographics		
Highest level of education	.79	.38
Marital status	.22	.92
Sex	.40	.99
Age	.76	.70
Symptoms and shoulder strength		
Duration of symptoms	.62	.74
Daily shoulder use at work	.12	.69
Tear as a result of trauma	.74	.34
Dominant shoulder affected	.91	.09
External rotation strength ratio	.27	.46
Isolated abduction strength ratio	.17	.43
Comorbidities and personal habits		
Alcohol use	–	*.02*
FABQ physical activity	–	*.001*
Number of comorbidities	.98	.54
Smoking	.73	.70
MIH-5	.11	.28
Associated disorders		
Presence of biceps tendon pathology	.49	.60
Rotator cuff tear characteristics		
Longitudinal size of tear	.14	.67
Transverse size of tear	.30	.20
Cross-sectional area of tear	.16	.42
Number of torn tendons	.68	.14
Fatty infiltration	.18	.25
Tendon retraction	.38	.92
Muscle atrophy	.48	.64
Surgical characteristics		
Biceps tenodesis/tenotomy	.78	.32
Type of repair	.91	.74

FABQ, Fear Avoidance and Behavior Questionnaire; *MIH-5*, Mental Health Inventory.

* Variables significant at $P < .05$ are reported in *italics*.

† If interaction is significant, the *P* value for variable is not reported.

et al[28] reported in 151 patients that those with a greater number of comorbidities had worse general health status after a rotator cuff repair but also had a greater improvement in overall shoulder pain, function, and quality of life scores.

Differences in surgical techniques, such as single-row repair vs. double-row repair vs. transosseous/open repair and whether a biceps tenodesis or tenotomy was performed, were not significant predictors of surgical outcomes in our study. Whether differences in surgical techniques or adjuvant procedures with rotator cuff surgery affect treatment outcomes is debated in the literature. A review from the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine concluded that double-row repair has not been proven to be more effective than single-row in full-thickness tears.[1] Prior literature has also found no significant difference in outcomes in patients who underwent a rotator cuff repair with a tenotomy/tenodesis vs. without tenotomy/tenodesis.[7,9]

Our analysis showed alcohol use and psychosocial factors, such as fear-avoidance behavior, were significant predictors

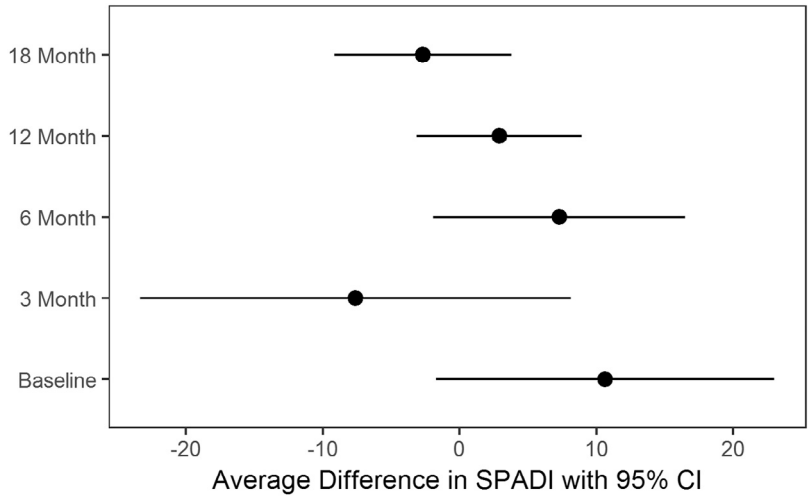

Figure 1 Estimated differences with 95% confidence intervals (*CI*) in Shoulder Pain and Disability Index (*SPADI*) scores for patients with alcohol consumption of 2 to 3 times per month or less vs. those with 1 to 2 times per week or more. Note: Estimated differences at each of the time points are presented given the significant interaction of alcohol use with time.

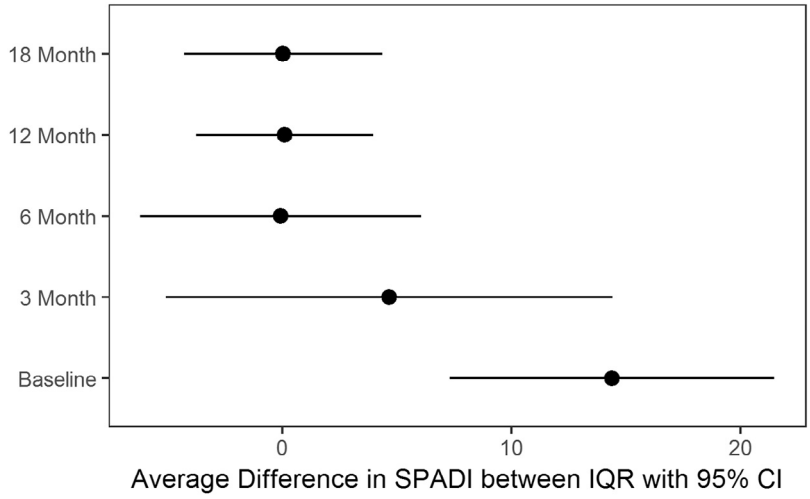

Figure 2 Estimated differences with 95% confidence intervals (*CI*) in the Shoulder Pain and Disability Index (*SPADI*) for Fear-Avoidance Beliefs Questionnaire physical activity score. Note: Estimated differences for the interquartile range (*IQR*), 75th percentile (23 points) vs. 25th percentile (17 points) at each of the time points are presented given the significant interaction of Fear-Avoidance Beliefs Questionnaire physical activity with time.

of surgical outcomes. Patients who had a greater fear of physical activity causing increased shoulder pain had worse shoulder pain and functional outcomes after surgery. Most of the effect was seen in the immediate postoperative period at 3 months of follow-up in our analysis.

There is increasing literature on the role of psychosocial factors in treatment outcomes of musculoskeletal disorders. Woollard et al[33] assessed factors associated with shoulder disability in 46 patients undergoing surgery for rotator cuff pathology at 6 months of follow-up. Patients underwent a subacromial decompression or subacromial decompression with a rotator cuff repair. Surgery on the dominant arm and FABQ score were associated with treatment outcomes in the Woollard et al[33] study. Explaining the association of greater alcohol use with treatment outcomes in our study is difficult; however, greater alcohol use could possibly be a proxy for another variable that was not captured or controlled for in our data and univariate analysis.

Limitations of our study include a relatively small sample size and unavailability of complete data at all of the outcome time points. However, this is one of the few studies to longitudinally assess prognostic factors in patients undergoing operative treatment with a comprehensive set of potential predictor variables.

Conclusions

Longitudinal predictors of better pain and functional outcomes at 18 months of follow-up after operative treatment for rotator cuff tears included alcohol use of 1-2 times per week and a lower fear-avoidance behavior. The greatest effect of these variables was seen in the immediate 3 months of follow-up after surgery. These data can be used to select optimal candidates for operative treatment of rotator cuff tears and assist with patient education and expectations before treatment.

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