Preoperative Rotator Cuff Fatty Infiltration and Muscle Atrophy Do Not Negatively Influence Outcomes Following Anatomic Total Shoulder Arthroplasty

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INTRODUCTION:

Anatomic total shoulder arthroplasty (TSA) is an effective surgical option for the treatment of primary glenohumeral osteoarthritis with an intact rotator cuff (GHOA). While an intact rotator cuff is essential to the success of TSA, little is known about how preoperative rotator cuff muscle quality may impact clinical outcomes. In this study, we sought to determine the effects of rotator cuff fatty infiltration (FI) and muscle atrophy (MA) on clinical outcomes following TSA.

METHODS:

A retrospective review of a prospectively maintained, single-surgeon registry was used to identify patients undergoing TSA for GHOA between April 2015 and March 2020. Patients were included if they had preoperative magnetic resonance imaging (MRI) available, an intact rotator cuff, and complete preoperative and minimum 2-year postoperative patient-reported outcome measures (PROMs) and active range of motion (ROM) measurements. Preoperative MA and FI of the rotator cuff were assessed on MRI by measuring muscle cross-sectional area and using the Goutallier classification system, respectively. Pearson's correlation was used to determine any relationship between muscle atrophy and clinical outcomes. Univariate analysis was used to compare clinical outcomes of patients with moderate-to-severe FI to those with minimal-to-mild FI.

RESULTS:

There were 163 shoulders from 154 patients with a mean age of 62.5 (SD = 7.4) and a mean follow-up of 2.9 years (SD 1.2) that met inclusion criteria. Rotator cuff muscle area was not correlated with any preoperative or postoperative ROM or PROMs (P > 0.05). However, the ratio of infraspinatus and teres minor (posterior cuff) to subscapularis muscle area was minimally negatively correlated with change in Single Assessment Numerical Evaluation (r = -0.171, P = 0.029) and change in internal rotation (r = -0.207, P = 0.008), although the clinical relevance is unclear. No significant differences in preoperative ROM or PROMs were found between patients with minimal-to-mild and moderate-to-severe FI (P > 0.05).

DISCUSSION AND CONCLUSION:

Preoperative rotator cuff muscle volume and fatty infiltration do not impact clinical outcomes following TSA in patients with GHOA and intact rotator cuffs. TSA remains an excellent surgical treatment for individuals with GHOA and an intact rotator cuff, regardless of muscle atrophy or fatty infiltration.

Figure 1: Analysis of a sagittal magnetic resonance imaging (MRI) scan of a rotator cuff that exhibits partial fatty infiltration and muscular atrophy. The image selected for analysis was at the most lateral point where the scapular spine connects to the scapular body. Utilizing the OsiriX software, cross-sectional muscle areas were automatically computed by outlining the individual cuff muscles and subtracting fatty infiltration areas. The areas of the infraspinatus and teres minor muscles were combined for quantification.

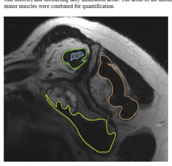

Table I: Whole Cohort Characteristics

Factor	
n	163
Age	62.5 ± 7.4
Sex	
Female	73 (44.8%)
Male	90 (55.2%)
Follow-up	2.9 ± 1.2
Comorbid Conditions	
Depression	51 (31.2%)
Diabetes	10 (6.1%)
Obesity	75 (46.0%)
Smoker	10 (6.1%)
Previous Surgery	50 (30.7%)
Walch Classification	
A1	85 (52.1%)
A2	4 (2.5%)
B1	11 (6.7%)
B2	45 (27.6%)
B3	11 (6.7%)
C	1 (0.6%)
D	6 (3.7%)
VAS Pain	
Preoperative	5.6 ± 2.3
Postoperative	0.9 ± 1.7
Change	-4.7 ± 2.6
SANE	
Preoperative	33.5 ± 20.1
Postoperative	87.3 ± 16.3
Change	53.8 ± 23.9
ASES	
Preoperative	39.5 ± 17.1
Postoperative	87.3 ± 15.7
Change	47.8 ± 20.2
Forward Elevation	
Preoperative	100 ± 23
Postoperative	147 ± 15
Change	47 ± 26
External Rotation	
Preoperative	29 ± 12
Postoperative	61 ± 18
Change	32 ± 19
Internal Rotation	
Preoperative	1.1 ± 1.5
Postoperative	4.4 ± 2.5
Change	3.2 ± 2.8

$x \pm s$ denotes mean and standard deviation; n (%) denotes count and frequency; VAS Pain - Visual Analog Scale for Pain; SANE - Single Assessment Numerical Evaluation; ASES - American Shoulder and Elbow Surgeons Score

Table II: Descriptive measurements of fatty infiltration and muscle atrophy for each rotator cuff muscle

Muscle	Fatty Infiltration[Φ] n (%)					Cross-sectional Muscle Area[φ] mean ± standard deviation
	0	1	2	3	4	
Supraspinatus	5 (3.0%)	40 (24.5%)	89 (54.6%)	23 (14.1%)	5 (3.0%)	5.1 ± 1.6
Infraspinatus	3 (1.8%)	42 (25.7%)	110 (67.4%)	7 (4.3%)	1 (0.6%)	12.0 ± 4.3[†]
Teres minor	51 (31.3%)	67 (41.1%)	40 (24.5%)	2 (1.2%)	3 (1.8%)	
Subscapularis	76 (46.6%)	48 (29.4%)	33 (20.2%)	6 (3.7%)	0	13.9 ± 5.5

[φ]Cross-sectional measurement of muscle area; [†]Cross-sectional measurement of the combined infraspinatus and teres minor muscles; [Φ]denotes grading according to Goutallier classification system

Table III: Influence of rotator cuff fatty infiltration on clinical outcomes

Outcome	Combined rotator cuff fatty infiltration ≥ 8[Φ]		P-Value	Adjusted P-Value[‡]
	Yes n = 21	No n = 142		
ASES score				
Preoperative	39.9 ± 16.4	39.4 ± 17.5	0.873	0.873
Postoperative	90.1 ± 14.5	86.4 ± 16.1	0.190	0.518
Change	50.2 ± 19.6	47.1 ± 21.0	0.398	0.597
SANE score				
Preoperative	31.0 ± 19.9	34.3 ± 20.2	0.381	0.597
Postoperative	89.8 ± 12.6	86.5 ± 17.3	0.203	0.518
Change	58.8 ± 22.2	52.2 ± 24.3	0.124	0.518
VAS pain				
Preoperative	5.4 ± 2.2	5.7 ± 2.4	0.550	0.750
Postoperative	0.4 ± 1.2	1.0 ± 1.8	**0.013***	0.188
Change	-5.0 ± 2.3	-4.6 ± 2.7	0.383	0.597
Forward Elevation (degrees)				
Preoperative	101.7 ± 27.2	100.0 ± 22.1	0.727	0.873
Postoperative	149.7 ± 12.6	146.6 ± 16.1	0.207	0.518
Change	48.1 ± 26.8	46.6 ± 25.9	0.765	0.873
External Rotation (degrees)				
Preoperative	31.4 ± 15.1	28.6 ± 10.4	0.276	0.592
Postoperative	64.1 ± 17.4	59.8 ± 15.6	0.175	0.518
Change	32.6 ± 17.6	32.0 ± 19.0	0.850	0.873
	Combined IS + TM ≥ 4[Φ]			
	Yes n = 38	No n = 125		
ASES score				
Preoperative	39.9 ± 16.4	39.3 ± 17.5	0.846	0.974
Postoperative	89.4 ± 14.1	86.6 ± 16.2	0.319	0.954
Change	49.4 ± 17.8	47.3 ± 21.5	0.543	0.974
SANE score				
Preoperative	27.8 ± 19.5	35.3 ± 20.1	**0.045***	0.319
Postoperative	89.6 ± 17.0	86.6 ± 16.1	0.330	0.954
Change	61.8 ± 26.7	51.3 ± 22.6	**0.032***	0.319
VAS pain				
Preoperative	5.7 ± 2.1	5.6 ± 2.4	0.895	0.974
Postoperative	0.5 ± 1.2	1.0 ± 1.8	0.053	0.319
Change	-5.2 ± 2.2	-4.6 ± 2.7	0.202	0.909
External Rotation (degrees)				
Preoperative	29.3 ± 12.8	29.2 ± 11.3	0.951	0.974
Postoperative	61.6 ± 14.5	60.5 ± 16.6	0.705	0.974
Change	32.2 ± 19.7	32.1 ± 18.4	0.974	0.974
	Subscapularis grade ≥ 2[Φ]			
	Yes n = 39	No n = 124		
ASES score				
Preoperative	37.2 ± 16.3	40.2 ± 17.5	0.319	> 0.999
Postoperative	87.8 ± 16.1	87.1 ± 15.7	0.811	> 0.999
Change	50.6 ± 21.5	46.9 ± 20.5	0.338	> 0.999
Internal Rotation				
Preoperative	1.1 ± 1.7	1.1 ± 1.4	0.961	> 0.999
Postoperative	4.4 ± 2.7	4.3 ± 2.4	0.897	> 0.999
Change	3.3 ± 2.9	3.2 ± 2.7	0.927	> 0.999
	Supraspinatus grade ≥ 2[Φ]			
	Yes n = 118	No n = 45		
ASES score				
Preoperative	39.6 ± 16.6	39.1 ± 18.9	0.865	0.924
Postoperative	87.4 ± 16.2	87.0 ± 14.8	0.869	0.924
Change	47.8 ± 20.8	47.9 ± 20.7	0.977	0.977
Forward Elevation (degrees)				
Preoperative	101.2 ± 24.4	98.1 ± 20.2	0.412	0.924
Postoperative	147.5 ± 13.5	146.9 ± 19.7	0.859	0.924
Change	46.2 ± 25.7	48.8 ± 27.3	0.592	0.924

[Φ] denotes classification according to Goutallier; * denotes statistical significance with alpha-risk at 0.05; [‡] adjusted P-Values were calculated using the False Discovery Rate correction method; $x \pm s$ denotes mean and standard deviation

IS - infraspinatus; TM - teres minor; VAS Pain - Visual Analog Scale for Pain; SANE - Single Assessment Numerical Evaluation; ASES - American Shoulder and Elbow Surgeons Score

Table IV: Influence of rotator cuff muscle volume on clinical outcomes

Outcome	Supraspinatus muscle volume, Pearson Correlation	P-Value
ASES score		
Preoperative	0.054	0.493
Postoperative	-0.122	0.121
Change	-0.138	0.080
SANE score		
Preoperative	-0.074	0.349
Postoperative	-0.121	0.124
Change	-0.020	0.796
VAS pain		
Preoperative	-0.047	0.553
Postoperative	0.149	0.057
Change	0.138	0.078
Forward Elevation (degrees)		
Preoperative	0.019	0.809
Postoperative	0.052	0.506
Change	0.014	0.860
	IS + TM muscle volume, Pearson Correlation	
ASES score		
Preoperative	-0.012	0.883
Postoperative	-0.110	0.163
Change	-0.074	0.349
SANE score		
Preoperative	0.041	0.604
Postoperative	-0.108	0.169
Change	-0.108	0.169
VAS pain		
Preoperative	-0.021	0.786
Postoperative	0.055	0.489
Change	0.054	0.490
External Rotation (degrees)		
Preoperative	0.095	0.228
Postoperative	-0.121	0.123
Change	-0.141	0.073
	Subscapularis muscle volume, Pearson Correlation	
ASES score		
Preoperative	0.040	0.609
Postoperative	-0.118	0.135
Change	-0.123	0.118
SANE score		
Preoperative	-0.041	0.602
Postoperative	-0.099	0.209
Change	-0.033	0.677
VAS pain		
Preoperative	-0.003	0.972
Postoperative	0.138	0.080
Change	0.092	0.244
Internal Rotation		
Preoperative	-0.030	0.701
Postoperative	-0.146	0.064
Change	-0.114	0.147
	Ratio of posterior cuff to subscapularis muscle volume, Pearson Correlation	
ASES score		
Preoperative	-0.070	0.376
Postoperative	-0.122	0.121
Change	-0.035	0.660
SANE score		
Preoperative	0.127	0.106
Postoperative	-0.094	0.234
Change	**-0.171**	**0.029***
VAS pain		
Preoperative	-0.006	0.941
Postoperative	0.090	0.253
Change	0.064	0.420
Forward Elevation (degrees)		
Preoperative	-0.038	0.632
Postoperative	-0.051	0.518
Change	0.004	0.963
External Rotation (degrees)		
Preoperative	0.110	0.163
Postoperative	-0.055	0.484
Change	-0.129	0.102
Internal Rotation		
Preoperative	0.152	0.052
Postoperative	-0.139	0.077
Change	**-0.207**	**0.008***

* Denotes statistical significance with alpha-risk at 0.05; IS - Infraspinatus; TM - Teres Minor; Posterior Cuff - Combination of IS and TM; VAS Pain - Visual Analog Score for Pain; SANE - Single Assessment Numerical Evaluation; ASES - American Shoulder and Elbow Surgeons Score