Clinical Outcomes of Anatomic and Reverse Total Shoulder Arthroplasty Considering Pre-Operative Fatty Infiltration of the Rotator Cuff

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INTRODUCTION: Anatomic and reverse total shoulder arthroplasty (aTSA and rTSA, respectively) have proven effective in the treatment of degenerative conditions of the glenohumeral joint. The goals of both aTSA and rTSA are to relieve pain and restore motion and stability to the joint while minimizing the potential for complications. The success of aTSA relies on function of the rotator cuff, as in natural anatomy, the rotator cuff is responsible for dynamic stability of the humeral head within the glenoid. Failure to restore natural biomechanics after aTSA may result in excessive translation of the humeral head, potentially leading to suboptimal mechanics and early implant failure via the rocking horse effect. Conversely, rTSA does not rely on a functioning rotator cuff, imparting joint stability via a fixed fulcrum on the glenoid while increasing the advantage of the deltoid for motion, but may have inferior clinical outcomes to aTSA from a functional standpoint. Although rotator cuff deficiency is generally associated with a tear in one or more of the tendons, the severity of the tear as it relates to the potential for repair is a consideration in clinical decision making between aTSA and rTSA. However, the presence of a rotator cuff tear may result in pathologic changes to the structure and integrity of the muscles in the form of fatty infiltration (FI) and atrophy, potentially compromising function even if the tendons are repaired. In this scenario, the optimal treatment choice remains unclear. Therefore, the objective of this study was to examine the relationship between pre-operative fatty infiltration of the rotator cuff muscles and clinical outcomes following aTSA and rTSA.

METHODS: Patients undergoing primary aTSA or rTSA with a diagnosis of osteoarthritis (OA) were identified retrospectively from a multi-center, IRB approved international database of a single, platform shoulder prosthesis (Equinoxe; Exactech Inc, Gainesville, FL). Patients with CT-based pre-operative assessment of rotator cuff FI according to the Goutallier classification and two-year minimum clinical follow-up were included. Patients with a diagnoses other than OA, revision procedures, and arthroplasty for fracture were excluded, along with patients with longest clinical follow-up less than two years and those without pre-operative assessment of FI. The cohort was stratified by implant type (aTSA vs rTSA) and presence of FI, where FI was defined as a Goutallier grade $\geq$1 in any of the rotator cuff muscles. Clinically, range of motion including active abduction, forward elevation, external rotation, and IR score and patient-reported outcome metrics (PROMs) including VAS pain, shoulder function, ASES, Constant, and the Shoulder Arthroplasty Smart Score (SAS) were evaluated pre-operatively and at defined post-operative intervals. Differences in pre-operative, latest post-operative, and improvement in ROM and PROMs between cohorts with and without fatty infiltration were assessed for aTSA and rTSA separately using Welch's t-test. Similarly, complication and revision rates were compared using Fisher's Exact test. Significance was set at $p < 0.05$.

RESULTS SECTION: A total of 769 patients were included in the study (286 aTSA; 483 rTSA). For the aTSA cohort, 67% (n=192) had no FI of the rotator cuff pre-operatively. The demographics for the aTSA cohorts without FI versus those with FI were: average age of 64.7 ± 7.2 vs 66.1 ± 8.4 years (p=0.177), 46.6% female vs 47.9% female (p=0.900), average BMI 29.2 ± 6.1 vs 31.8 ± 6.7 (p=0.002), and average longest follow-up of 45.6 ± 33.1 vs 78.7 ± 40.5 months (p<0.001). For the rTSA cohort, 38% (n=184) had no FI of the rotator cuff. The demographics for rTSA cohorts without FI versus those with FI were: average age of 71.7 ± 6.7 vs 71.8 ± 7.4 years (p=0.913), 54.9% female vs 58.2% female (p=0.508), average BMI 29.5 ± 5.7 vs 30.0 ± 6.0 (p=0.405), and average longest follow-up of 31.9 ± 10.7 vs 37.3 ± 20.2 months (p<0.001). Differences in pre-operative, post-operative, and improvement in ROM and PROMs between cohorts with and without FI are shown in Tables 1 and 2 for the aTSA and rTSA cohorts, respectively. Additionally, the complication and revision rates were significantly lower in the cohort of aTSA patients without FI versus those with FI [complication rates = 1.6% no FI vs 9.6% FI, p=0.003; revision rates = 1.0% no FI vs 8.5% FI, p=0.003]. Conversely, the complication and revision rates in the rTSA cohorts with and without FI were not significantly different [complication rates = 2.2% no FI vs 1.7% FI, p=0.737; revision rates = 1.1% no FI vs 1.0% FI, p=1.000].

DISCUSSION: This study examined the relationship between pre-operative FI of the rotator cuff and clinical outcomes, complication rates, and revision rates following aTSA and rTSA. For aTSA, the cohort without FI had significantly greater active forward elevation, active external rotation, shoulder function, ASES, Constant score, and SAS score post-operatively. However, differences in post-operative outcomes may have been a function of pre-operative differences, since there were no significant differences in pre-to-post-operative improvement between cohorts. The only significant difference in the rTSA cohorts with and without FI was in active abduction pre-operatively, where patients without FI had significantly less abduction. For complication and revision rates significant differences were found for aTSA cohorts with and without FI, where patients with FI had higher rates, but the same was not true for the rTSA cohorts. The main limitation of the study is the disparity in average follow-up times between cohorts with and without FI in both the aTSA and rTSA groups, which was particularly apparent in the aTSA group. While we found that complication and revision rates were significantly higher in the aTSA group with FI versus without, this finding may have been confounded by longer average clinical follow-up of the group with FI, allowing additional time for complications such as rotator cuff tears and glenoid loosening to develop. Future studies should seek to account for differences in follow-up duration specifically related to complication and revision rates to elucidate the potential effect of FI on implant longevity.

SIGNIFICANCE: The decision to perform aTSA or rTSA in the setting of rotator cuff deficiency as defined by fatty infiltration of the muscles remains challenging. This study found similar improvements in ROM and PROMs in cohorts of aTSA and rTSA patients with and without fatty infiltration, but that post-operative complications were significantly higher in a cohort of aTSA patients with fatty infiltration versus without, whereas the same was not true for rTSA.

Table 1. Comparison of Clinical Outcomes between Primary aTSA Patients with and without rotator cuff fatty infiltration.

Timepoint	Cohort	ASES	Constant	SAS	VAS Pain	Global Shoulder Function	Active Abduction	Active Forward Elevation	Active External Rotation	IR Score
Pre-op	No FI	39.4 ± 16.3	44.5 ± 15.2	52 ± 12.4	6.2 ± 2.2	4.7 ± 2	100.8 ± 37.7	113.1 ± 35.5	29.2 ± 20.6	3.4 ± 1.7
	FI	36.8 ± 16	36.3 ± 12.8	46.1 ± 11.4	6.3 ± 2.3	4.4 ± 2	89 ± 32.2	96.1 ± 30	21.8 ± 19.2	3.0 ± 1.7
	p-value	0.246	**<.001**	**<.001**	0.716	0.426	**0.009**	**<.001**	**0.004**	**0.043**
Post-op	No FI	85.6 ± 17.8	69.5 ± 15.2	81.2 ± 11.7	1.3 ± 2	8.6 ± 1.7	135.1 ± 33.1	150.9 ± 30.1	54 ± 18.4	5.1 ± 1.2
	FI	75.2 ± 25.2	62.4 ± 18.6	73.7 ± 17	2.2 ± 2.7	7.9 ± 2.4	126.8 ± 36.3	136.6 ± 29.9	48.6 ± 18.4	4.7 ± 1.7
	p-value	**<.001**	**0.016**	**0.002**	**0.002**	**0.008**	0.101	**0.001**	**0.038**	0.099
Improvement	No FI	45.7 ± 21.3	26.4 ± 17.6	28.9 ± 15.4	4.9 ± 2.8	4.0 ± 2.4	36.6 ± 40.6	39.2 ± 43.1	24.9 ± 21.5	1.7 ± 1.7
	FI	40.9 ± 22.9	27.0 ± 17.9	29.7 ± 15.1	4.3 ± 2.8	3.7 ± 2.7	39.6 ± 37	42.5 ± 31.8	26.5 ± 19.7	1.7 ± 2
	p-value	0.125	0.862	0.768	0.117	0.536	0.599	0.513	0.606	0.899

Table 2. Comparison of Clinical Outcomes between Primary rTSA Patients with and without rotator cuff fatty infiltration.

Timepoint	Cohort	ASES	Constant	SAS	VAS Pain	Global Shoulder Function	Active Abduction	Active Forward Elevation	Active External Rotation	IR Score
Pre-op	No FI	38.7 ± 17.8	37.1 ± 14.8	46.9 ± 11.9	6.0 ± 2.5	4.2 ± 2.0	76.2 ± 30.0	94.4 ± 30.9	22.7 ± 19.5	2.7 ± 1.6
	FI	39.0 ± 15.4	38.1 ± 13	47.3 ± 11.6	5.9 ± 2.3	4.1 ± 2.0	84.3 ± 36.7	96.5 ± 35.1	20.1 ± 20.4	3.0 ± 1.7
	p-value	0.883	0.553	0.748	0.970	0.741	**0.010**	0.493	0.176	0.070
Post-op	No FI	87.2 ± 15.8	70.6 ± 16	78.3 ± 12.7	0.9 ± 1.9	8.6 ± 1.8	129.1 ± 29.3	147.6 ± 26.8	45.7 ± 18.3	4.2 ± 1.7
	FI	85.5 ± 18	70.2 ± 14.1	77.8 ± 10.9	1.1 ± 2.0	8.6 ± 1.9	133.9 ± 29.0	147.3 ± 23.5	42.7 ± 16.7	4.3 ± 1.6
	p-value	0.307	0.815	0.709	0.443	0.860	0.096	0.895	0.086	0.535
Improvement	No FI	47.7 ± 21.0	34.8 ± 15.7	31.1 ± 13.4	5.0 ± 2.9	4.4 ± 2.4	53.2 ± 32.1	53.1 ± 31.6	22.8 ± 20.7	1.4 ± 1.8
	FI	46.6 ± 20.8	31.4 ± 16.6	30.5 ± 13.8	4.9 ± 2.7	4.5 ± 2.6	50.5 ± 37.7	50.8 ± 32.9	23 ± 21.4	1.2 ± 1.9
	p-value	0.572	0.117	0.692	0.768	0.713	0.431	0.477	0.919	0.175