Association of Patient and Surgical Characteristics with Patient Reported Outcomes at 1-year Following Primary Anatomic Total Shoulder Arthroplasty

Vahid Entezari, Sambit Sahoo, Jason Ho, Bong-Jae Jun, Yuxuan Jin, Peter Bert Imrey, Kathleen Derwin, Joseph P Iannotti, Eric Thomas Ricchetti

INTRODUCTION:
Clinical outcome of anatomic total shoulder arthroplasty (aTSA) is influenced by a wide range of pre- and intraoperative factors that are not well understood, in part due to lack of large prospective cohort studies suitable for multivariable analysis. This study investigated associations of baseline patient, disease-specific, and surgical factors with one-year postoperative PENN Shoulder Score (1-yr PSS) in patients undergoing primary aTSA. We hypothesized that worse baseline mental health status (VR-12 MCS) and PSS, female sex, prior ipsilateral shoulder surgery, opioid use, and worse anatomic reconstruction of the humeral head would be associated with lower 1-yr PSS.
METHODS:
Patients undergoing primary anatomic TSA for glenohumeral osteoarthritis with intact rotator cuff at our institution from February 2015 to August 2021 with complete baseline PSS were included. We excluded patients with glenoid bone grafting (n=7), Walch classification of C or D (n=13) or intraoperative complications (n=4). Multivariable identity-link beta regression modeling and Akaike's Information Criterion (AIC) change statistics were used to examine the unique associations with and relative importances of the hypothesized factors in accounting for variation in 1-yr PSS, adjusted for each other and 15 additional prospectively identified factors (**Figure 1**) possibly predicting 1-yr PSS. Missing predictor and outcome data were multiply imputed (m=50). Surgeries were classified into seven categories based on glenoid component shape (standard, augmented), fixation (onlay, inlay), material (all-poly, metal-backed, hybrid), and subscapularis takedown/repair (tenotomy, peel, lesser tuberosity osteotomy (LTO)). Results are shown as estimated changes of means between predictor categories or lower to upper predictor quartiles.
RESULTS:
797 eligible primary TSAs had complete baseline PSS though 118 (15%) were missing 1-yr PSS data that was multiply imputed. Patients were of median age 65 (quartiles, 59-71) years, 62% male, 7% current smokers, 51% had used opioids ≤3 months of surgery, 20% had a chronic pain diagnosis, and 13% had prior ipsilateral shoulder surgery. Most patients had standard, all-poly, on-lay glenoids with LTO (51%); augmented, all-poly, on-lay glenoids with LTO (17%); or standard, all-poly inlay glenoids with tenotomy (11%). Median baseline VR-12 MCS was 53 (43-60). PSS improved significantly from baseline (34 (25-46)) to 1-yr (92 (83-97)). In multivariable modeling (**Table 1**), among patient characteristics, younger age, lower baseline VR-12 MCS and lower baseline PSS were significantly associated with lower 1-yr total PSS, and self-identified race (neither White nor Black) nearly so. 8.6 points lower baseline VR-12 MCS and 15.0 points lower baseline PSS were each associated with 1 point lower 1-yr PSS (p=0.001 and 0.02, respectively). Unexpectedly, patient sex and preoperative opioid use were not significantly associated with 1-yr PSS. Among disease/surgical factors, history of prior ipsilateral shoulder surgery and less anatomic reconstruction of the humeral head (larger humeral head size difference ratio and larger prosthetic head center deviation) were associated with lower 1-yr PSS. A 2.3 mm deviation of the center of the prosthetic humeral head from the anatomic head and a 9% increase in the size ratio of the prosthetic to native humeral head were associated with a 1-point drops in 1-yr PSS (p=0.04 and 0.052, respectively) (**Table 1**). Walch classification and surgical group were not significantly associated with 1-yr PSS. Top model predictors by the AIC criterion were prior ipsilateral surgery, baseline VR-12 MCS, race, age, baseline PSS and humeral head anatomic reconstruction (**Figure 1**).
DISCUSSION AND CONCLUSION:
A history of prior ipsilateral surgery, lower mental health status, neither Black nor White self-reported race, younger age and lower baseline PSS were associated with lower 1-yr PSS in patients undergoing primary aTSA. Parameters of anatomic humeral head reconstruction, including native to prosthetic humeral head size ratio and prosthetic humeral head center deviation statistically predicted 1-yr PSS, while variations in glenoid component design and subscapularis repair did not. Patient, disease-specific, and surgical factors can be used to predict postoperative outcomes following primary aTSA for improved preoperative patient counseling regarding expected outcomes following these procedures. However, future studies are needed to determine if these factors are confirmed in other cohorts to be associated with lower 1-yr PSS and also predict lower outcomes in the longer-term.

Figure 1. Relative importance of patient, disease-specific, and surgical factors on 1-yr total PSS based on increase in AIC.

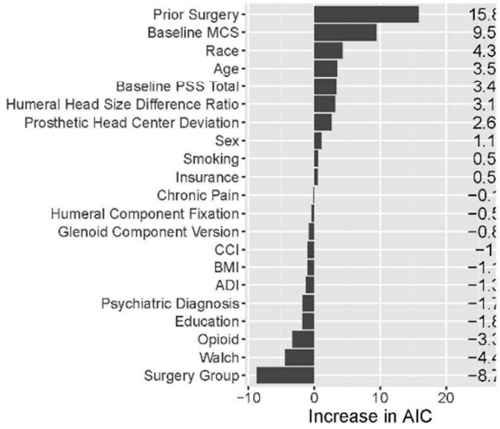

Table 1. Estimated differences (95% confidence intervals) in means of 1-yr PSS associated with patient demographic and surgical characteristics. † Statistically significant.

Variable	Level	Estimated Difference	p-value
Patient characteristics			
Age	**11.5 yr increase**	**1.6 (0.1, 3.0)**	**0.032†**
Sex (vs. Male)	Female	1.4 (-0.3, 3.1)	0.10
Body Mass Index (BMI)	7.7kg/m^2 increase	-0.4 (-1.23, 0.5)	0.37
Charlson Comorbidity Index (CCI)	1 unit increase	-0.2 (-0.76, 0.3)	0.40
Education	4y increase	-0.1 (-1.1, 0.9)	0.82
Area Deprivation Index (ADI)	39 unit increase	0.5 (-0.8, 1.7)	0.48
Race (vs. White)	Black	2.6 (-4.1, 9.3)	0.053
	Other	**-4.9 (-9.1, -0.8)**	
Smoking status (vs. Never)	Quit	-1.1 (-2.5, 0.3)	0.12
	Current	-2.5 (-6.2, 1.3)	0.2
Preoperative opioid use (vs. None in 12 mo)	Yes, but not within 3mo	-0.2 (-1.4, 0.9)	0.56
	Yes, within 3mo	0.4 (-1.0, 1.8)	
Chronic pain (vs. No)	Yes	-1.2 (-3.2, 0.8)	0.23
Psychiatric diagnosis (vs. No)	Yes	-0.3 (-1.9, 1.4)	0.77
Insurance status (vs. Private)	Medicare	-0.4 (-2.2, 1.4)	0.23
	Medicaid	-4.4 (-9.3, 0.6)	
Baseline VR12-MCS	**17.2 point increase**	**2.0 (0.8, 3.2)**	**0.001†**
Baseline PSS-total	**21 point increase**	**1.4 (0.2, 2.6)**	**0.02†**
Disease/ surgical characteristics			
Prior Ipsilateral surgery (vs. No)	**Yes**	**-6.4 (-9.9, -2.9)**	**<0.001†**
Surgery Group (vs Standard-Onlay-All Poly-LTO)	Augmented-Onlay-All Poly-LTO	-0.9 (-3.0, 1.2)	
	Standard-Inlay-All Poly-Tenotomy	-0.8 (-3.3, 1.8)	
	Standard-Onlay-All Poly-Tenotomy	-2.2 (-6.4, 1.9)	
	Standard-Onlay-Hybrid-Tenotomy	-2.0 (-6.0, 1.8)	0.76
	Standard-Onlay-Metal-backed-Tenotomy	1.5 (-4.4, 7.3)	
	Standard-Onlay-Hybrid-Direct Takedown	1.5 (-3.4, 6.3)	
	Standard-Onlay-All Poly-Direct Takedown	-0.3 (-5.3, 4.8)	
Humeral Component Fixation (vs. Uncemented)	Cemented	-3.1 (-8.4, 2.2)	0.25
Walch (vs. A1)	A2	1.2 (-1.1, 3.4)	
	B1	1.6 (-0.9, 4.2)	
	B2	1.4 (-0.5, 3.2)	0.57
	B3	1.4 (-1.7, 4.5)	
Glenoid Component Version	7.4° increase	-0.4 (-1.4, 0.5)	0.40
Prosthetic Head Center Deviation	**2.1 mm increase**	**-0.9 (-1.8, 0.0)**	**0.052**
Humeral Head Size Difference Ratio	**0.1 increase**	**-1.1 (-2.1, -0.1)**	**0.04†**