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Comparison of outpatient vs. inpatient anatomic total shoulder arthroplasty: a propensity score–matched analysis of 20,035 procedures

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Background: As the proportion of anatomic total shoulder arthroplasty (aTSA) operations performed at outpatient surgical sites continues to increase, it is important to evaluate the clinical implications of this evolution in care.

Methods: Patients who underwent TSA for glenohumeral osteoarthritis from 2007 to 2019 were identified in the American College of Surgeons National Surgical Quality Improvement Program registry. Demographic data and 30-day outcomes were collected, and patients were separated into inpatient and outpatient (defined as same day discharge) groups. To control for confounding variables, a propensity score–matching algorithm was utilized. Outcomes included 30-day adverse events, readmission, and operative time.

Results: A total of 20,035 patients who underwent aTSA between 2007 and 2019 were identified: 18,707 inpatient aTSAs and 1328 outpatient aTSAs. On matching, there were no significant differences in patient characteristics between inpatient and outpatient cohorts. Patients who underwent outpatient aTSA were less likely to experience a serious adverse event when compared with their matched inpatient aTSA counterparts (outpatient: 1.1% vs. inpatient: 2.1%, $P = .03$). Outpatient aTSA was associated with similar rates of all specific individual complications and readmissions (1.5% vs. 1.9%, $P = .31$).

Conclusion: When compared with a propensity score–matched cohort of inpatient counterparts, the present study found outpatient aTSA was associated with significantly reduced severe adverse events and similar readmission rates. These findings support the growing use of outpatient aTSA in appropriately selected patients.

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The demand for anatomic total shoulder arthroplasty (aTSA) is steadily increasing, which has forced health care systems to place an emphasis on maximizing the quality of care delivered to patients

Mass General Brigham Institutional Review Board approved this study (Protocol #2021P001230).

Institution work was performed at the Sports Medicine, Department of Orthopedic Surgery, Massachusetts General Hospital, Mass General Brigham Integrated Health Care System, Boston, MA, USA.

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in a cost-effective manner.⁸ With a mean cost as high as \$50,000 per patient and estimated societal cost of up to \$1.8 billion annually, aTSA procedures are one of the most expensive orthopedic operations.^{16,29,37} To mitigate rising costs and exercise value-based health care, providers have recently shifted aTSA operations from the inpatient to outpatient setting in select patient populations.^{18,31} As the proportion of aTSA operations performed at outpatient surgical sites continues to increase,^{1,15} it is important to appraise the clinical implications of this evolution in care.

Several institutional studies comparing outpatient and inpatient aTSA procedures have reported similar complication and readmission rates between groups, supporting the notion that outpatient aTSA procedures can be safe and cost-saving in appropriately

selected patients.^{1,5,7,10,12,14,17,24,27,38} For example, in single-surgeon centers, Borakati et al¹⁰ and Brodin et al¹² found similar rates of total complications for inpatient and outpatient aTSA procedures. However, these studies may have been underpowered to detect a difference in outcomes and limited to specialized academic centers. Similarly, data on a national scale are largely limited to two small studies (100s of outpatient surgeries) with data through 2014, which also found outpatient aTSA to be safe in select patients.^{13,24} Although these studies have laid the foundation for such analyses, given the growing number of outpatient aTSAs, expanding criteria of patient selection, and increasing number of providers performing these procedures on an outpatient basis over the last several years, there is urgent need to assess whether outpatient aTSA is a viable option on a national scale in a sufficiently powered study.

Therefore, the purpose of this study was to use a large national sample to compare complication rates of patients undergoing aTSA in the outpatient vs. inpatient setting. We hypothesized that patients who underwent outpatient aTSA would experience similar rates of adverse events compared with propensity-matched inpatient counterparts. As a secondary analysis, we assessed patient factors associated with being selected to undergo outpatient (vs. inpatient) aTSA in current orthopedic practice.

Materials and methods

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) registry was used to identify patients who underwent TSA from 2007 to 2019. The NSQIP registry is a nationally validated, outcome-based program and contains over 300 preoperative and perioperative variables from over 700 participating hospitals.^{30,32} Data are collected prospectively after the date of operation, and clinically trained reviewers assess information to ensure data accuracy. Consequently, it is considered one of the most accurate surgical outcome databases currently available.^{9,35}

Patients who underwent TSA were identified using the Current Procedural Terminology (CPT) code 23472. To ensure homogenous surgical indications between groups, only patients undergoing TSA for osteoarthritis (OA) of the glenohumeral joint were included in our analysis. Thus, patients with inflammatory arthropathies, rotator cuff arthropathies, osteonecrosis, and fractures were explicitly not included to ensure similar indications for surgery. Outpatient procedures were defined as procedures in which the patient was discharged on the same day as surgery.

The baseline demographics included the following: age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) status, race, functional status, diabetes mellitus, chronic obstructive pulmonary disease (COPD), congestive heart failure, hypertension treated with medication, disseminated cancer, steroid use for chronic conditions, current smoking status, and year of operation. Adapted from prior work,^{3,11,23,24,36} adverse events were classified as severe or minor. The severe adverse events included the following: death, reoperation, pulmonary complications (unplanned intubation or ventilator greater than 48 hours), pneumonia, cardiac complications (cardiac arrest or myocardial infarction), thromboembolic complications (deep vein thrombosis or pulmonary embolism), renal complications (progressive renal insufficiency or acute renal failure), wound complications (deep surgical site infection, periprosthetic joint infection, wound dehiscence), or sepsis. The minor complications included urinary tract infection and superficial surgical site infection. Operative time and readmission were also assessed.

Statistical analysis

Baseline patient factors were compared between groups with *t*-tests or chi-squared/Fisher's exact tests, as appropriate. To control for confounding variables, a propensity score–matching algorithm was utilized as has been well described.²³ Briefly, propensity scores were calculated and represent the conditional probability of undergoing outpatient vs. inpatient aTSA as a function of each patient's baseline factors similar to prior work.^{4,7,23,34} A 4:1 matching algorithm with exact matching for the year of operation was then used yielding 5288 inpatient and 1322 outpatient matched cases.²³ A total of 13 baseline demographics were balanced on matching: age, gender, BMI, ASA class, race, functional status, diabetes, steroid use, COPD, congestive heart failure, hypertension, disseminated cancer, and year of procedure. To statistically test for differences in categorical outcome measures between the matched groups, we performed univariate (ie, surgical setting) logistic regressions with robust standard errors clustering at the match level for each outcome. This is a generalization of the McNemar test to the 1:*k* setting where *k* > 1. Differences between continuous variables were assessed similarly with general linear regressions clustering at the match level, which is a generalization of the paired *t*-test. Conservative analyses using traditional (unpaired) *t*-tests and chi-squared/Fisher's exact tests are provided in the Appendix and did not change any conclusions.

For the second purpose of this study, we used multivariate logistic regression to determine factors associated with patients being selected to undergo outpatient aTSA across all 20,035 aTSA patients identified in this study. Statistics were performed in SAS v9.4 (SAS Institute, Cary, NC, USA), and significance was set to *P* < .05 for all analyses. This study was deemed exempt by our institutional review board.

Results

A total of 20,035 patients who underwent aTSA for glenohumeral OA between 2007 and 2019 were identified. There were 18,707 inpatient aTSAs and 1328 outpatient aTSAs. Notably, the 1328 outpatient aTSAs, 852 (64.2%) were performed in 2018 or 2019 (Fig. 1). Differences in patient characteristics were noted between inpatient and outpatient cohorts before matching; however, after matching, there were no significant differences (Table I).

Patients who underwent outpatient aTSA were significantly less likely to experience a serious adverse event than their matched inpatient aTSA counterparts (outpatient: 1.1% vs. inpatient: 2.1%, *P* = .03). Moreover, outpatient aTSA was associated with similar rates of all individual serious adverse events. In addition, outpatient aTSA procedures reported similar rates of readmission (1.5% vs. 1.9%, *P* = .31) with significantly lower operative times (105.3 ± 2.1 [95% confidence interval {CI}] minutes vs. 110.3 ± 1.2 minutes, *P* < .001) than inpatient procedures (Table II).

Secondary analysis exploring factors associated with selection of surgical setting found operative year (odds ratio [OR] 1.40 per year, 95% CI 1.36–1.45; *p* < 0.001) to be significantly associated with increased odds of undergoing outpatient aTSA surgery. Conversely, the following demographics were significantly associated with reduced odds of undergoing outpatient aTSA surgery: increasing age (OR 0.98 per additional year, 95% CI 0.97–0.98; *P* < .001), female sex (OR 0.75, 95% CI 0.66–0.84; *P* < .001), ASA class 4+ vs. 1 (OR 0.34, 95% CI 0.18–0.63; *P* = .002), ASA class 3 vs. 1 (OR 0.59, 95% CI 0.42–0.84; *P* = .003), higher BMI (OR 0.97 per additional kg/m², 95% CI 0.96–0.98; *P* < .001), dependent functional status (OR 0.34, 95% CI 0.14–0.83; *P* = .018), steroid use for chronic conditions (OR 0.63, 95% CI 0.44–0.90; *P* = .01), currently smoking (OR 0.67, 95% 0.53–0.83;

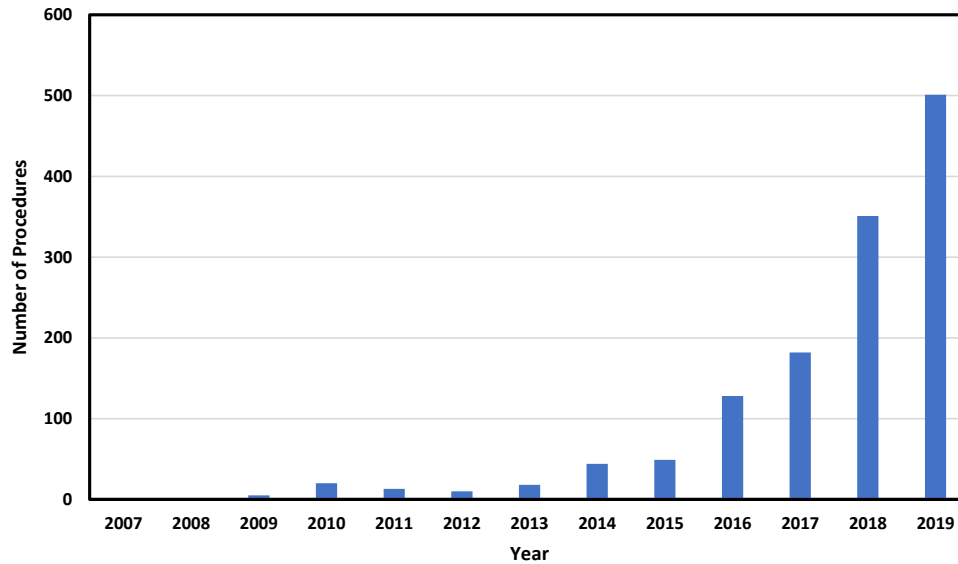


Figure 1 Annual volume of outpatient anatomic total shoulder arthroplasties performed in the NSQIP registry. NSQIP, National Surgical Quality Improvement Program.

Table I Patient characteristics by inpatient status compared with outpatient status.

Demographics	Unmatched cohort		P value	Matched cohort		P value
	Inpatient N = 18,707	Outpatient N = 1328		Inpatient N = 5288	Outpatient N = 1322	
Age (years)			<.001			.40
<50	2.5%	5.2%		4.4%	5.1%	
50-74	67.8%	72.3%		74.2%	72.3%	
75-84	25.9%	20.6%		19.3%	20.7%	
85+	3.8%	2.0%		2.2%	2.0%	
Gender			<.001			.83
Female	53.6%	42.9%		42.6%	43.0%	
Male	46.4%	57.1%		57.4%	57.0%	
BMI			<.001			.81
Underweight (<18.5 kg/m ²)	0.5%	0.4%		0.6%	0.4%	
Normal (18.6 to 24.9 kg/m ²)	14.6%	18.1%		17.3%	18.1%	
Overweight (25 to 29.9 kg/m ²)	31.9%	36.1%		37.0%	36.2%	
Mildly obese (30 to 34.9 kg/m ²)	27.0%	27.4%		26.7%	27.5%	
Morbidly obese (≥35 kg/m ²)	25.9%	18.0%		18.4%	17.9%	
ASA			<.001			.75
1	1.7%	3.6%		3.2%	3.6%	
2	44.1%	55.3%		55.7%	55.2%	
3	51.8%	40.2%		40.1%	40.2%	
4+	2.5%	0.9%		1.0%	0.9%	
Race			.71			.94
White	85.0%	84.2%		84.5%	84.3%	
Black	4.3%	4.5%		4.3%	4.5%	
Other	10.7%	11.3%		11.1%	11.2%	
Dependent functional status	1.8%	0.4%	<.001	0.4%	0.4%	.78
Diabetes mellitus			<.001			.96
None	83.4%	87.9%		88.0%	87.8%	
Noninsulin dependent	12.1%	9.3%		9.3%	9.3%	
Insulin dependent	4.4%	2.9%		2.7%	2.9%	
Steroid use for chronic condition	4.3%	3.2%	.001	2.7%	2.5%	.70
Current smoker	9.4%	7.8%	.05	8.0%	7.6%	.68
History of severe COPD	6.1%	3.2%	<.001	3.3%	3.2%	.89
Congestive heart failure	0.5%	0.1%	.03	0.1%	0.1%	1.00
Hypertension requiring medication	67.2%	56.6%	<.001	57.4%	56.5%	.58
Disseminated cancer	0.1%	0.0%	.40	0.1%	0.0%	1.00

ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease. The values are given as the percentage of patients.

$P < .001$), history of severe COPD (OR 0.71, 95% CI 0.51-0.98; $P = .04$), and hypertension requiring medication (OR 0.86, 95% CI 0.76-0.97; $P = .02$). Notably, race was not significantly associated with surgical setting (black vs. white, $P = .25$; other vs. white, $P = .44$) (Table III).

Discussion

The present study utilizes matched cohorts to compare adverse events and readmission between patients who underwent

Table II
Association between surgical setting and outcomes for patients undergoing aTSA in matched group analysis.

Outcomes	Surgical setting		P value
	Inpatient N = 5288	Outpatient N = 1322	
Any serious adverse event	2.1%	1.1%	.03
Death	0.1%	0.1%	.71
Reoperation	1.1%	0.6%	.14
Deep wound infection	0.2%	0.1%	.48*
Unplanned intubation or ventilation >48 hours	0.2%	0.0%	.37
Pneumonia	0.3%	0.2%	.40
Cardiac arrest or myocardial infarction	0.2%	0.2%	.89
Progressive renal insufficiency or acute renal failure	0.1%	0.1%	.80
Deep vein thrombosis or pulmonary embolism	0.4%	0.2%	.32
Septic shock	0.1%	0.0%	.59*
Any minor complication	0.7%	0.6%	.82
Superficial surgical site infection	0.2%	0.2%	.77
Urinary tract infection	0.5%	0.5%	.93
Readmission	1.9%	1.5%	.31
Operative time (minutes) [mean ± 95% CI]	110.3 ± 1.2	105.3 ± 2.1	<.001

aTSA, anatomic total shoulder arthroplasty; CI, confidence interval.

All values are given as a percentage of patients, with the exception of operative time, which is reported as mean ± 95% confidence interval.

*Fisher's P value as clustered logistic regression incomputable for the event rate of 0.

Table III
Multivariate logistic regression analysis identifying independent risk factors for outpatient aTSA procedure.

Risk factor	Odds ratio*	P value
Age	0.98 (0.97 to 0.98)	<.001
Sex (female vs. male)	0.75 (0.66 to 0.84)	<.001
ASA class		
Class 2 vs. 1	0.76 (0.55 to 1.06)	.11
Class 3 vs. 1	0.59 (0.42 to 0.84)	.003
Class 4+ vs. 1	0.34 (0.18 to 0.68)	.002
Race		
Black vs. white	1.18 (0.89 to 1.56)	.25
Other vs. white	0.93 (0.78 to 1.12)	.44
BMI	0.97 (0.96 to 0.98)	<.001
Functional status—dependent	0.34 (0.14 to 0.83)	.02
Diabetes mellitus		
Insulin dependent vs. none	0.88 (0.63 to 1.24)	.48
Noninsulin dependent vs. none	0.92 (0.76 to 1.13)	.44
Steroid use for chronic condition	0.63 (0.44 to 0.90)	.01
Current smoker	0.67 (0.53 to 0.83)	<.001
History of severe COPD	0.71 (0.51 to 0.98)	.04
Congestive heart failure	0.25 (0.03 to 1.78)	.16
Hypertension requiring medication	0.86 (0.76 to 0.97)	.02
Year of operation	1.40 (1.36 to 1.45)	<.001

aTSA, anatomic total shoulder arthroplasty; ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

*The values are given as the odds ratio (95% confidence interval).

inpatient or outpatient aTSA for glenohumeral OA. By using propensity matching and a large national database, we found that outpatient aTSA procedures were associated with a lower rate of total serious adverse events. Moreover, outpatient aTSA patients had similar rates of minor complications, 30-day readmissions, and all individual complications. As a secondary analysis, we explored factors that were associated with patients receiving care in an outpatient setting and found several comorbidities to be significantly associated with decreased odds of undergoing outpatient aTSA. To our knowledge, this is the first study to utilize contemporary national data to compare morbidity, mortality, and patient selection criteria for inpatient and outpatient aTSA procedures.

With the increasing volume of outpatient aTSAs, containing costs without sacrificing the quality of care is of utmost importance for health care providers. In a database study measuring cost of inpatient vs. outpatient TSA from 2010 to 2015, Gregory et al¹⁸

found mean total inpatient TSA costs to be \$76,109 compared with \$22,907 for analogous outpatient procedures. Moreover, even when adjusting for inpatient-specific charges, the inpatient TSA cohort still proved to be more costly (\$32,330 vs. \$22,907). In an attempt to evaluate future cost-savings of outpatient aTSA, Steinhilber et al³¹ created a model and found reductions in cost to be as high as \$15,507 per case, \$349 million per year, and an estimated \$5.4 billion over the next ten years. In tandem with the results of the present study, providers should be encouraged that outpatient aTSA can be safely utilized in a growing body of patients to exercise value-based health care.

Our hypothesis that the rates of adverse events would be similar when propensity score matching for baseline differences and comorbidities was disproven. Although the rarity of individual complications limited the ability to detect significant differences for these outcomes, the additive effect of slightly lower rates across all individual complications yielded a significantly lower rate in our composite primary outcome of severe adverse events in the outpatient cohort. Our findings are consistent with several other studies supporting the safety of outpatient aTSA. In a systematic review and meta-analysis of outcomes of inpatient and outpatient aTSA, Ahmed et al¹ found no significant differences across all complications between groups, which remained consistent when analyzing database^{6,7,13,22,24,28} and nondatabase^{12,17,27} studies as part of a subgroup analysis. Although these studies were unable to find a significant difference across all complications, the present study detected a significantly lower rate of severe adverse events in the outpatient cohort. The contrasting results are likely due to the sample size of the present study, as it boasts one of the largest samples of outpatient aTSA procedures with updated data through 2019. This is a trend seen in the orthopedic literature, as database studies investigating complications in other joints with updated data have also found a significant lower rate of complications for patients undergoing outpatient procedures than for their matched inpatient counterparts.^{23,25,26} In addition to growing sample sizes, this phenomenon could also be related to learning effects, as surgeons and institutions continue to gain experience and optimize both their patient selection and postoperative protocols. Furthermore, a possible contributing factor could be the decreased exposure time to nosocomial bacteria in the outpatient setting. Relatedly, the current results are extremely encouraging given that outpatient aTSA appears to continue to be safe despite the growing

expansion of patient inclusion criteria and number of providers performing these procedures in recent years. For instance, there were more patients in the NSQIP database who underwent outpatient aTSA in 2018–2019 (852, 64.4%) than the previous eleven years (470, 35.6%) combined.

Our study also found similar rates of readmission and decreased operative time, despite propensity score matching for various baseline demographics and comorbidities. The reduced operative time may be related to the ability of these procedures to be performed in hospital outpatient departments or surgery centers, which may have greater efficiency than large inpatient surgery departments.^{2,19,21} As decreasing operative time contributes to reducing societal costs,^{20,33} this is another point in favor of value-based health care among patients undergoing outpatient aTSAs.

For surgeons looking to compare their selection criteria for outpatient aTSA with the selection criteria that are being used nationally, we conducted a secondary analysis to evaluate patient factors that were associated with outpatient aTSA and found several factors that were associated with decreased odds of patients undergoing aTSA as an outpatient. Specifically, increasing age, female sex, and higher BMI, as well as other comorbidities, were associated with undergoing inpatient aTSA. In particular, smokers and patients with COPD, hypertension, chronic steroid use, and dependent functional status are strongly favored to undergo inpatient rather than outpatient aTSA. Consistent with this, ASA class 1 patients are the most strongly favored to undergo outpatient aTSA, whereas ASA class 3 and class 4 patients are strongly favored not to undergo inpatient aTSA. We find that aTSA is currently being used in at least some patients with ASA class 2. In addition, increasing year was associated with an increased likelihood of undergoing outpatient aTSA, again reflecting the growing relative use of outpatient vs. inpatient aTSA.

Although this study is the first to provide contemporary data from a national sample and provides among the largest samples of outpatient aTSAs to date, it is not without limitations. First, consistent with standard practice, patients undergoing aTSA were identified by patients receiving CPT 23472 for glenohumeral OA.^{7,13,24} Although it would be less common for a reverse TSA to be performed for this indication in the absence of rotator cuff pathology and reverse TSA indications were specifically ignored (ie, rotator cuff arthropathy, inflammatory arthropathy, etc.), it is theoretically possible that some patients in this cohort could have undergone reverse TSA, as aTSA and reverse TSA currently have the same CPT code. Second, although the NSQIP database is an excellent source to evaluate complications through the first 30 postoperative days given its large sample size and high-quality data extraction by trained reviewers directly from the medical record (as opposed to International Classification of Diseases codes like in most large databases), there are inherent limitations to any large database study. For example, definitions and procedural coding evolve over time; however, we mitigated this limitation by exact matching for the year of procedure. In addition, large databases limit resolution of specific features such as specific radiographic findings and OA severity. Next, although we can confidently hypothesize that the outpatient aTSA cohort was associated with lower costs based on results of previous studies,^{1,18} NSQIP cannot directly evaluate the exact cost of each procedure as an outcome measure. Finally, because of the exceedingly low number of patients in the outpatient TSA cohort who were readmitted ($n = 19$), we were underpowered to determine factors associated with readmission for outpatient aTSA patients. As the volume of outpatient aTSA procedures continues to increase, future studies should evaluate patterns of readmission for these patients.

Conclusion

With the increasing popularity of outpatient TSA, it is imperative to evaluate the safety of moving these procedures to the outpatient setting. When compared with a propensity score–matched cohort of inpatient counterparts, the present study found outpatient aTSA to be associated with significantly reduced overall rates of severe adverse events and similar 30-day readmissions. Furthermore, we identify factors currently being used by providers nationally in selecting patients for outpatient aTSA. Although providers should still ultimately be guided by patient comorbidities when determining the optimal operative setting, the present study supports the safety of outpatient TSA in appropriately selected patients.

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Supplementary data

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