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CLINICAL RESEARCH

Shoulder Arthroplasties have Fewer Complications than Hip or Knee Arthroplasties in US Veterans

Edward V. Fehringer MD, Ted R. Mikuls MD, MSPH, Kaleb D. Michaud PhD, William G. Henderson PhD, James R. O'Dell MD

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Abstract Total shoulder arthroplasties (TSA) are being performed more commonly for treatment of arthritis, although fewer than either hip (THA) or knee (TKA) arthroplasties. Total shoulder arthroplasty also provides general health improvements that are comparable to THA. One study suggests TSAs are associated with lower morbidity and mortality than THAs and TKAs. To confirm and extend that study, we therefore examined the association of patient characteristics (sociodemographics, comorbid illness, and other risk factors) with 30-day complications for patients undergoing TSAs, THAs, or TKAs. We used data from the Veterans Administration (VA) National Surgical Quality Improvement Program (NSQIP) for fiscal years 1999 to 2006. Sociodemographics, comorbidities, health behaviors, operative factors, and complications (mortality, return to the operating room, readmission within 14 days, cardiovascular events, and infections) were available for 10,407 THAs, 23,042 TKAs, and 793 TSAs. Sociodemographic features were comparable among groups. The mean operative time was greater for TSAs (3.0 hours) than for TKAs (2.2 hours) and THAs (2.4 hours). The 30-day mortality rates were 1.2%, 1.1%, and 0.4% for THAs, TKAs, and TSAs, respectively. The corresponding postoperative complication rates were 7.6%, 6.8%, and 2.8%. Adjusting for multiple risk factors, complications, readmissions, and postoperative stays were less for TSAs versus THAs and TKAs. In a VA population, TSAs required more operative time but resulted in shorter stays, fewer complications, and fewer readmissions than THAs and TKAs.
Level of Evidence: Level III, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
This work was performed at the Nebraska Arthritis Outcomes Research Center, Omaha, NE, USA.

E. V. Fehringer, T. R. Mikuls, K. D. Michaud, J. R. O'Dell
Nebraska Arthritis Outcomes Research Center (NAORC), Omaha, NE, USA

W. G. Henderson
University of Colorado Health Outcomes Program UCD, AMC, Denver, CO, USA

W. G. Henderson
Denver VA Medical Center, Denver, CO, USA

E. V. Fehringer (✉)
Department of Orthopaedic Surgery and Rehabilitation, University of Nebraska Medical Center, 981080 Nebraska Medical Center, Omaha, NE 68198-1080, USA
e-mail: evfehringer@unmc.edu

Introduction

A TSA improves shoulder-specific functional scores [4, 8, 15]. Boorman et al. [3] reported several general health measure improvements (SF-36) after TSA for glenohumeral osteoarthritis that were comparable to those after a THA and coronary artery bypass grafting. Accompanying favorable effects on patient outcome, the use of TSAs has increased [1]. Adams et al. [1] reported an age-adjusted increase in the use of TSA from 1.4 per 100,000 person-years (1976–1980) to 10.1 per 100,000 person-years (1996–2000) in Olmstead County, MN.

Farmer et al. [7] reported patients experienced less morbidity and mortality after TSAs than after THAs and TKAs. The Veterans Health Administration (VA) is the largest integrated health system in the United States and, as a result, is one of the largest providers of elective arthroplasties. Moreover, VA beneficiaries have a high prevalence of comorbid conditions, including diabetes, hypertension, and cardiovascular disease, rendering this population particularly vulnerable to postoperative complications.

We therefore sought to (1) define the health characteristics (sociodemographics, comorbid illnesses, and other risk factors) of US veterans undergoing TSAs, and (2) to define rates and determinants of 30-day mortality and postoperative complications (return to the operating room, readmission within 14 days, cardiovascular events, and infections) after TSAs referent to THAs and TKAs in this population.

Materials and Methods

We retrospectively reviewed patients in the VA NSQIP database from 1999 through 2006. NSQIP is a validated prospective quality assurance and data collection program that includes comprehensive data [6, 12–14] from surgeries performed under either general or epidural anesthesia. The database includes data regarding preoperative risk variables, intraoperative variables, and postoperative variables, including International Classification of Diseases, 9th Revision (ICD-9) codes. Our study included surgical data from 104 collection sites from patients undergoing index total joint arthroplasty of the hip (n = 10,407), knee (23,042), or shoulder (n = 793) during the observation period. THAs, TKAs, and TSAs were defined using Current Procedural Terminology (CPT) codes of 27310, 27447, and 23472, respectively. Analyses were further limited to subjects with postoperative diagnoses of osteoarthritis (ICD-9 715) or rheumatoid arthritis (ICD-9 714). We excluded patients undergoing emergency surgery. NSQIP evaluates only major surgery. For many VA hospitals, that represents all of their major cases, and for a few of the higher-volume VA hospitals, it represents a systematic sample of all major cases. This protocol was approved by the Institutional Review Board and the Research & Development Committee at the Omaha VA Medical Center, in addition to the NSQIP Executive Committee.

As reported [6, 12–14], outcome information in the NSQIP database is abstracted by a study nurse using a standardized template 30 days after each surgery. Outcomes are collected using chart review and supplemented further through interviews with providers, reports from morbidity and mortality conferences, and through communications with the patient by letter and/or telephone. Postoperative mortality was defined as death from any cause within 30 days of surgery and verified using the VA Beneficiary Identification and Record Locator Subsystem (BIRLS), which is a reliable source of vital status in the VA [5]. Thirty-day outcomes examined included all-cause mortality, readmission within 14 days, return to the operating room after the initial surgery, any postoperative cardiovascular event, and any postoperative infection. We also examined the occurrence of any postoperative complication, a composite variable that included any of the major aforementioned events. Cardiovascular events were defined as the occurrence of any of the following: cardiac arrest, myocardial infarction, cerebrovascular event or stroke, deep venous thrombosis, or pulmonary embolism. Infectious complications included urinary tract infections, superficial and/or deep wound infections, pneumonia, and sepsis. In addition to these complications, we examined the duration of postoperative hospital stay as a continuous outcome variable.

In addition to the specific type of total joint arthroplasty and arthritis diagnosis (rheumatoid arthritis versus osteoarthritis), potential predictors of 30-day mortality and morbidity included preoperative and intraoperative factors. Preoperative factors examined included age, gender, race (white versus nonwhite), smoking status (current versus noncurrent), diabetes mellitus, alcohol use, chronic obstructive pulmonary disease, reported dyspnea, cerebrovascular disease (previous transient ischemic attack or cerebrovascular accident with or without deficit), chronic glucocorticoid use, American Society of Anesthesiologists (ASA) class (dichotomized as healthy/mild versus severe/very severe), dependent functional status, and inclusive fiscal period of procedure (categorized as 1999–2000, 2001–2002, 2003–2004, and 2005–2006). Additional preoperative risk factors examined included select laboratory abnormalities, including blood urea nitrogen greater than 40 mg/dL, creatinine greater than 1.2 mg/dL, hematocrit 38% or less, platelet count 150,000/μL or less, serum sodium 135 or less or greater than 145 mmol/L, or leukocyte count greater than 11,000/μL. Intraoperative factors examined included total operative time (hours) and anesthesia type (general anesthesia versus epidural/spinal only). We excluded potential predictor variables that were missing for more than 15% of patients (ie, do-not-resuscitate status, alkaline phosphatase, bilirubin, albumin, SGOT, prothrombin time, and partial thromboplastin time). In addition, we excluded possible preoperative predictor variables that were abnormal or prevalent in 0.9% or fewer patients (ie, weight loss, receipt of chemotherapy, or diagnosis of disseminated malignancy, impaired sensorium, central nervous system tumor, wound infection, or open wound).

Patient characteristics were summarized separately for each type of total joint arthroplasty examined. We compared categorical variables across procedures using the chi square test, whereas continuous variables were compared using one-way analysis of variance. To examine associations of TSA referent to other types of arthroplasties, patients undergoing THAs or TKAs were combined into one comparator group in all analyses of outcomes and complications. We used age- and gender-adjusted logistic regressions to examine the association of procedure type (shoulder versus hip/knee) and other possible predictors with dichotomous outcomes, whereas linear regression analyses were used to examine associations with the duration of postoperative length of stay. Factors with $p < 0.05$ in age- and gender-adjusted analyses subsequently were included in multivariable models with age, gender, and arthroplasty type (shoulder versus hip/knee) added to all models. All multivariable analyses accounted for clustering by hospital site [2]. We did not examine surgical volume because is not associated with outcomes after THA or TKA in NSQIP [10] and is not readily available in the data set. All analyses were conducted using SAS Version 9.1 (SAS Inc, Cary, NC) and STATA Version 10.0 (Statacorp, College Station, TX).

Results

Sociodemographic features were comparable among patients having THAs, TKAs, and TSAs. However, the mean operative time was greater ($p < 0.0001$) for TSAs (3.0 hours) than for TKAs (2.2 hours) and THAs (2.4 hours) (Table 1). Consistent with known VA demographics, patients undergoing arthroplasty were older (mean age, 64.9 years) and there was a predominance of males (95% or greater) across procedure types as would be expected. Those undergoing TKA were slightly older ($p < 0.0001$) and there were more Caucasians who underwent TSAs than THAs and TKAs ($p < 0.0001$). ASA Class II or less, consistent with a healthy or mild operative risk, was slightly more frequent for patients having THAs overall ($p = 0.001$) compared with patients having TKAs or TSAs. TSAs were performed much more commonly with the patient under general anesthesia (99.7%) compared with either THAs (81.2%) or TKAs (63.7%) ($p < 0.0001$). Compared with patients undergoing TKAs or TSAs, patients having THAs were more likely to be current smokers ($p < 0.0001$), use alcohol ($p < 0.0001$), and have a dependent functional status ($p < 0.0001$). Patients having TKAs were more likely than others to have diabetes ($p < 0.0001$) and report dyspnea ($p = 0.006$).

Thirty-day overall mortality rates were 1.2%, 1.1%, and 0.4% for patients having THAs, TKAs, and TSAs, respectively. The postoperative complication rates were 7.6%, 6.8%, and 2.8% for patients having THAs, TKAs, and TSAs, respectively (Table 2). Adjusting for age and gender, overall complications ($p < 0.0001$), return to the operating room ($p = 0.001$), hospital readmissions ($p = 0.02$), cardiovascular events ($p = 0.017$), and infection ($p < 0.0001$) were less frequent after TSA compared with THA and TKA combined. After adjusting for age and gender, patients undergoing TSAs had a mean (standard deviation) total postoperative hospital length of stay of 3.3 days (2.9), which was 4 to 5 days fewer than stays for patients having THAs (8.3 days [7.9]), or TKAs (7.6 days [6.8]) ($p < 0.0001$). There was no association of arthroplasty type with 30-day mortality risk. After adjusting for multiple confounders, patients undergoing TSAs were approximately 70% less likely than those undergoing THAs or TKAs to have any postoperative complication (odds ratio [OR], 0.31; 95% confidence interval [CI], 0.20–0.48) (Table 3). This was reflected in a lower risk of cardiac (OR, 0.23; 95% CI, 0.08–0.67) and infectious (OR, 0.28; 95% CI, 0.14–0.54) complications. Patients undergoing TSAs also were less likely to require a return to the operating room (OR, 0.24; 95% CI, 0.11–0.52) and had a substantially shorter postoperative hospital length of stay (5.2 days, $p < 0.0001$). Other determinants of increased postoperative complication risk included older age, longer operative time, higher ASA class, the use of general anesthesia, alcohol use, diabetes, chronic obstructive pulmonary disease, dependent functional status, dyspnea, a history of bleeding disorder, and select preoperative laboratory abnormalities (elevated creatinine, low hematocrit, and low platelet count) (data not shown).

Discussion

Farmer et al. reported patients having TSAs had less morbidity and mortality than patients having THAs and TKAs performed in Maryland [7]. The VA is the largest integrated health system in the United States, is one of the largest providers of elective arthroplasties, and veterans are a population that has been underrepresented in arthritis research. VA beneficiaries also have a high prevalence of comorbid conditions [16] that increase perioperative risk [11]. With removal of major economic barriers to healthcare and equal healthcare access, veterans represent an ideal population for study of other factors affecting health outcomes. We therefore sought to (1) define the health characteristics of US veterans undergoing TSA, and (2) define rates and determinants of 30-day mortality and postoperative complications after TSA referent to TKA and THA.

This study has several potential limitations. First, long-term outcomes are not available for this population. With respect to patients potentially lost to followup within

Table 1. Sociodemographic features

Characteristic	Knee (N = 23,042)	Hip (N = 10,407)	Shoulder (N = 793)	p Value*
Sociodemographics				
Age (years)	65.3 (10.2)	64.1 (10.9)	64.4 (10.0)	< 0.0001
Male	95.4%	95.7%	95.6%	0.47
White	74.1%	72.0%	77.7%	< 0.0001
Operative factors				
Operating room time (hours)	2.2 (0.7)	2.4 (0.8)	3.0 (0.9)	< 0.0001
ASA Class II or less	36.6%	38.8%	38.0%	0.001
Fiscal year				
1999–2000	27.7%	26.1%	30.0%	0.003
2001–2002	25.8%	26.4%	26.0%	
2003–2004	21.9%	23.4%	20.4%	
2005–2006	24.6%	24.1%	23.6%	
Anesthesia type				
General	63.7%	81.2%	99.7%	< 0.0001
Spinal/epidural	35.9%	18.7%	0%	
Other	0.3%	0.2%	0.3%	
Comorbidity and health behaviors				
Current smoking	20.8%	27.0%	21.9%	< 0.0001
Alcohol use	6.5%	8.5%	6.5%	< 0.0001
Diabetes mellitus	18.8%	13.2%	16.7%	< 0.0001
Chronic obstructive pulmonary disease	9.3%	10.2%	9.3%	0.03
Rheumatoid arthritis	1.0%	0.7%	0.8%	0.09
Chronic glucocorticoid use	2.3%	2.4%	2.3%	0.84
History of CVA with deficit	2.1%	1.8%	1.8%	0.22
History of CVA without deficit	2.3%	2.3%	2.3%	0.99
History of TIA	2.4%	2.1%	2.0%	0.20
Dependent functional status	4.2%	7.1%	3.4%	< 0.0001
History of CHF	0.8%	0.8%	1.1%	0.53
Dyspnea	11.6%	10.4%	10.0%	0.006
Bleeding disorder	1.4%	1.3%	0.6%	0.21
Preoperative laboratory values				
Blood urea nitrogen greater than 40 mg/dL	0.9%	0.9%	1.1%	0.93
Creatinine greater than 1.2 mg/dL	32.5%	30.3%	28.3%	< 0.0001
Hematocrit 38% or less	14.1%	19.6%	15.1%	< 0.0001
Platelet count 150,000/μL or less	5.9%	5.2%	5.6%	0.05
Sodium 135 mmol/L or less	6.8%	7.9%	9.2%	< 0.0001
Sodium greater than 145 mmol/L	1.6%	1.5%	1.0%	0.38
Leukocyte count greater than 11,000/μL	3.8%	4.1%	5.3%	0.04

* p Values generated using chi square test for categorical variables and one-way analysis of variance for continuous variables; ASA = American Society of Anesthesiology; CVA = cerebrovascular accident; TIA = transient ischemic attack; CHF = congestive heart failure.

30 days, we do not have good information regarding morbidity outcomes. However, there should be virtually no patients lost to followup for mortality. Moreover, the focused term of this study is 30 days. Second, we used only the CPT code for TSA (23472), thus precluding conclusions relevant to shoulder hemiarthroplasty (23470), a frequently performed procedure for treatment of shoulder arthritis. However, our focus in this study was on replacements that resurfaced all joint surfaces to avoid this potentially confounding variable. Third, low risk of complications does not imply successful long-term patient-defined clinical outcomes [9]. Our goal was to evaluate 30-day results. Finally, surgeon case volume is unclear. It is possible some procedures were performed by lower-volume surgeons and staffs. This limitation exists with any large group with multiple surgeons.

Table 2. Postoperative complications and hospital stay

Postoperative event/complication	Knee (N = 23,042)	Hip (10,407)	Shoulder (N = 793)	p Value*
Any complication	6.8%	7.6%	2.8%	< 0.0001
Hospital readmission within 14 days	4.0%	3.5%	5.6%	0.015
Return to operating room	2.6%	3.8%	0.8%	0.001
Duration postoperative stay (days)	7.6 (6.8)	8.3 (7.9)	3.3 (2.9)	< 0.0001
Death	0.7%	0.4%	0.4%	0.54
Cardiovascular event, any	2.2%	1.8%	6 (0.8%)	0.017
Cardiac arrest	0.4%	0.3%	0 (0%)	
Myocardial infarction	0.4%	0.3%	2 (0.3%)	
Cerebrovascular event	0.1%	0.2%	3 (0.4%)	
Deep venous thrombosis	1.0%	0.8%	2 (0.3%)	
Pulmonary embolism	0.5%	0.3%	1 (0.1%)	
Infection, any	932 (4.0%)	4.4%	1.0%	< 0.0001
Urinary tract infection	364 (1.6%)	2.0%	0.1%	
Superficial wound infection	282 (1.2%)	0.8%	0%	
Deep wound infection	136 (0.6%)	0.6%	0%	
Pneumonia	176 (0.8%)	1.0%	0.8%	
Sepsis	60 (0.3%)	0.4%	0.1%	

*p Values generated using chi square test for categorical variables and one-way analysis of variance for continuous variables; all p values adjusted for age and gender and reflect comparison of shoulder arthroplasty versus hip/knee arthroplasty combined.

Table 3. Multivariable associations for complications and healthcare use

Variable	Odds ratio (95% CI)
30-day complications	
Any	0.31 (0.20–0.48)
Cardiac	0.23 (0.08–0.67)
Infection	0.28 (0.14–0.54)
Death within 30 days	0.55 (0.13–2.27)
Healthcare use	
Hospital readmission	0.92 (0.48–1.80)
Return to operating room	0.24 (0.11–0.52)
Postoperative length of stay, beta coefficient (p value)	−5.2 (p < 0.001)

Our findings corroborate and extend the results reported by Farmer et al. [7], suggesting a TSA is associated with less morbidity and mortality than THA and TKA. In their study of the Maryland Health Services Cost Review Commission discharge database, they identified 994 shoulder arthroplasties, 15,414 hip arthroplasties, and 34,471 knee arthroplasties performed for osteoarthritis from 1994 to 2001. Similar to our findings, Farmer et al. [7] observed relatively low in-hospital mortality across procedures but found complication rates ranging from 8% for TSA to 16% after THA. They also observed lower complication rates, shorter length of hospital stay, and fewer healthcare costs associated with TSA referent to THA and TKA. However, their study did not account for several other potentially important preoperative and perioperative risk factors (eg, functional status, ASA class, anesthesia type, and preoperative laboratory abnormalities), suggesting these results could be impacted by unmeasured confounding variables. Moreover, we also provide estimates for the frequency of several specific types of complications, including cardiovascular and infectious complications and specific events in these categories (eg, myocardial infarction, sepsis). Covariates assessed in the study by Farmer et al. were limited to sociodemographic factors, insurance status, and a comorbidity index [7]. The breadth of risk factor data available in NSQIP has allowed us to extend these findings, showing the lower complication rates and shorter lengths of postoperative hospital stay associated with TSA are independent of several other important operative risk factors. Thus, our findings confirm and expand on those of Farmer et al. but in a VA population that to date has not been studied in this fashion.

In a US VA population for fiscal years 1999-2006, TSAs required more operative time but resulted in less 30-day complications than THAs and TKAs when performed in VA hospitals in the United States.

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