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Brief Communication

Gender and Total Joint Arthroplasty: Variable Outcomes by Procedure Type

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ABSTRACT

Background: Recent reports on the influence of gender on the outcomes of total joint arthroplasty were limited by either lack of longitudinal data or absent stratification by total hip arthroplasty (THA) or total knee arthroplasty (TKA). As a result, there remains a lack of clarity on this topic.
Methods: The American College of Surgeons National Surgical Quality Improvement Program was queried for all primary, elective THAs and TKAs performed between 2011 and 2017. Differences in demographics, comorbidity profiles, operative time, hospital length of stay (LOS), and 30-day outcomes were compared between male and female patients. Multivariate analyses were performed separately for THA and TKA.
Results: A total of 418,885 patients were analyzed; 59.1% were females. Compared with males, females were likely to be older, have a higher body mass index, identify as nonwhite, and require preoperative functional assistance ($P < .001$). Females had lower rates of diabetes, hypertension, anemia, and kidney disease but a higher rate of chronic steroid use ($P < .001$). They were also likely to have shorter operative times for both THA and TKA ($P < .001$). After controlling for the aforementioned differences, female gender was an independent risk factor for readmission, reoperation, and wound infection after THA ($P < .001$). In contrast, male sex was an independent risk factor for readmission, reoperation, and overall complications after TKA ($P < .001$). Regardless of the procedure, females were 64%–82% more likely to require an LOS >2 days than males.
Discussion: A variable effect of gender was observed on the post–total joint arthroplasty LOS and outcomes depending on the procedure type (THA or TKA). Differences attributed to gender should be accounted for in risk-stratification models. Future studies are also needed to elucidate the underlying causes of gender differences in joint arthroplasty.

Introduction

Total joint arthroplasty (TJA) is the gold standard treatment for symptomatic end-stage osteoarthritis (OA) [1]. Compared with males, females have a higher prevalence of OA, with a female-to-male ratio of 1.76. Despite this, previous reports have shown that females are 22% less likely to undergo TJA, a finding that has been attributed to fewer females broaching the topic of joint arthroplasty with their physicians [2]. As a result, females tend to present with more advanced OA and are more likely to require assistive devices than males [3-5].

When it comes to the influence of gender on the postoperative TJA outcomes, there remains a significant amount of variability depending on the research methodology, time interval, and assessed outcomes [4,6-8]. Recently, Basques et al published 2 reports [6,9] on gender differences in TJA outcomes using 2 separate national databases. Except for higher rates of urinary tract infection and blood transfusion among females, males were more likely to experience more serious adverse events. However, neither study was stratified by procedure type (total hip arthroplasty [THA] or

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total knee arthroplasty [TKA]). Other studies have identified gender differences in postoperative complications that were variable depending on the procedure type (THA or TKA) [7]. To date, there remains a lack of clarity on this topic.

As more females undergo TJA, there is a need for greater understanding of the effects of patient gender on TJA. The objective of this study was to present an updated and nationally representative analysis on the differences in demographics, comorbidity profiles, procedure utilization, operative time, hospital length of stay (LOS), and 30-day postoperative outcomes between males and females undergoing primary TJA.

Material and methods

This was a retrospective review of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), a national database capturing more than 600 hospitals. Institutional review board approval was not required to analyze this deidentified database. Elective primary THAs and TKAs performed between 2011 and 2017 were identified by Current Procedural Terminology codes 27447 and 27130, respectively. The elective nature of the procedures was verified against their respective International Classification of Diseases Ninth Revision and Tenth Revision diagnosis codes.

The study analyzed all variables captured by the ACS-NSQIP database including the demographics, comorbidities, perioperative data, LOS, and 30-day postoperative outcomes. Demographic variables comprised age, gender, body mass index (BMI), tobacco smoking status, race/ethnicity, functional status before surgery, preoperative living environment, and the American Society of Anesthesiologists physical classification. Comorbidities consisted of diabetes, hypertension, chronic obstructive pulmonary disease, chronic heart failure, anemia metastatic cancer, bleeding disorders, dyspnea, ascites, chronic kidney disease, and a history of chronic steroids use. Perioperative data included surgical indication, laterality, and procedure length. Thirty-day postoperative outcomes consisted of readmission, reoperation, complications, and mortality. Complications were divided into medical and surgical categories. Medical complications were sepsis, cardiac arrest, myocardial infarction (MI), stroke, acute renal insufficiency, pneumonia, and urinary tract infection. Surgical complications were wound infections, reintubation, ventilator use greater than 48 hours, pulmonary embolism, and deep vein thrombosis.

Table 1
Baseline characteristics of the study cohort.

Variable	Female	Male	*P*–value
N = 418,885	247,561	171,324	–
Demographic characteristics			
Age (years)	66.7 ± 10.2	65.2 ± 10.4	**<.0001**
Body mass index (kg/m^2)	32.2 ± 7.3	31.7 ± 6.0	**<.0001**
Current smoker	22,580 (9.1%)	19,532 (11.4%)	**<.0001**
Chronic steroid use	10,057 (4.1%)	4853 (2.8%)	**<.0001**
ASA classification	2.4 ± 0.6	2.5 ± 0.6	**<.0001**
Race			
White	179,285 (82.7%)*	127,460 (85.6%)*	**<.0001**
Non-Hispanic black	20,117 (9.3%)*	10,952 (7.4%)*	
Hispanic	10,325 (4.8%)*	6548 (4.4%)*	
Asian	5170 (2.4%)*	2538 (1.7%)*	
Other minority race	1793 (0.8%)*	1468 (1.0%)*	
Functional status			**<.0001**
Independent	242,510 (98.5%)	168,637 (98.9%)	
Partially or completely dependent	3793 (1.5%)	1820 (1.1%)	
Preoperative living environment			**<.0001**
Admitted directly from home	246,572 (99.7%)	170,778 (99.8%)	
Admitted from a facility	784 (0.3%)	379 (0.2%)	
Comorbidity characteristics			
Diabetes	36,276 (14.7%)	29,466 (17.2%)	**<.0001**
Hypertension	151,014 (61.0%)	107,435 (62.7%)	**<.0001**
Chronic obstructive pulmonary disease	9149 (3.7%)	6059 (3.5%)	**.007**
Chronic heart failure	569 (0.2%)	557 (0.3%)	**<.0001**
Anemia	28,584 (12.1%)	45,015 (27.5%)	**<.0001**
Metastatic cancer	294 (0.1%)	227 (0.1%)	.215
Bleeding disorder	4083 (1.7%)	4742 (2.8%)	**<.0001**
Dyspnea	14,691 (5.9%)	7749 (4.5%)	**<.0001**
Ascites	33 (0.0%)	36 (0.0%)	.057
Chronic kidney disease	3825 (1.6%)	6830 (4.3%)	**<.0001**
Perioperative characteristics			
Procedure type			
Total hip arthroplasty (THA)	85,179 (34.4%)	70,712 (41.3%)	**<.0001**
Total knee arthroplasty (TKA)	162,382 (65.6%)	100,612 (58.7%)	
Diagnosis			**<.0001**
Primary osteoarthritis	80,861 (94.9%)*	65,621 (92.8%)*	
Inflammatory arthritis	418 (0.5%)*	145 (0.2%)*	
Posttraumatic arthritis	366 (0.4%)*	542 (0.8%)*	
Childhood dysplasia (THA only)	628 (0.7%)*	287 (0.4%)*	
Osteonecrosis (THA only)	2906 (3.4%)*	4117 (5.8%)*	
Bilateral procedure	4523 (1.8%)	3656 (2.1%)	**<.0001**
Procedure length (minutes) > 100	71,084 (28.7%)	61,041 (35.6%)	**<.0001**

ASA, American Society of Anesthesiologists physical classification system.
Values are presented as the mean and standard deviation (continuous variables) or as the frequency and percentage (nominal variables). *P*–values indicate significant overall differences between patient groups and are determined using a chi-squared test (nominal variables) or Welch's *t*-test (continuous variables).
An asterisk indicates attribution of the overall significance to the respective variable category, as determined using adjusted residuals.
Bold indicates statistical significance.

The primary study outcomes were differences in the baseline characteristics, perioperative variables, LOS, complications, and 30-day postdischarge outcomes. Patients were divided by their reported gender (male or female) and further by their procedure type (THA or TKA). Values were presented as the mean and standard deviation for continuous variables or the frequency and percentage for binary variables. Pearson's chi-squared tests were performed to examine categorical variables and a Welch's t-test for continuous variables. Multivariable logistic regressions were used to analyze the impact of gender on various outcome measures, resulting in odds ratios for each group. Significance was defined as a P value < .05 before any Bonferroni adjustments for multiple comparisons. Data were analyzed using Stata, version 16.0 (Stata Statistical Software: Release 16; StataCorp LLC, College Station, TX).

Results

A total of 418,885 patients were included in the analysis. There were 247,561 (59.1%) females and 171,324 (40.9%) males. Of the total patients, 262,994 (62.8%) patients underwent TKA, of which 162,383 (61.7%) were females and 100,612 (38.3%) were males; 155,891 (37.2%) patients underwent THA. of which 85,179 (54.6%) were females and 70,712 (45.4%) were males. The baseline characteristics were similar for THA and TKA. In general, females were likely to be older than males by an average of 1.5 years ($P < .001$), have a slightly higher BMI (32.2 vs 31.7, $P < .001$), identify as nonwhite (17.3% vs 14.4%, $P < .001$), and be either partially or completely dependent for activities of daily living (1.5% vs 1.1%, $P < .001$). Females had higher prevalence of chronic obstructive pulmonary disease (3.7% vs 3.5%, $P = .007$), dyspnea (5.9% vs 4.5% $P < .0001$), and chronic steroid use (4.1% vs 2.8%, $P < .001$) but lower prevalence of tobacco smoking (9.1% vs 11.4%, $P < .001$), diabetes (14.7% vs 17.2%, $P < .001$), hypertension (61.0% vs 62.7%, $P < .001$), chronic heart failure (0.2% vs 0.3%, $P < .001$), anemia (12.1% vs 27.5%, $P < .001$), bleeding disorders (1.7% vs 2.8%, $P < .001$), and chronic kidney disease (1.6% vs 4.3%, $P < .001$).

A higher proportion of females had a diagnosis of primary OA than males (94.9% vs 92.8%, $P < .001$). Females were less likely to have undergone a bilateral procedure (1.8% vs 2.1%, $P < .001$) and had shorter operative times, with only 28.7% of procedures lasting longer than 100 minutes compared with 35.6% for males ($P < .001$). Table 1 summarizes the baseline and perioperative characteristics of the study cohort.

After controlling for all aforementioned differences between males and females, multivariate logistic regression modeling showed variable results for outcomes between males and females when analyzed by the procedure type (TKA or THA). For TKA, females had lower rates of readmission (odds ratio [OR]: 0.83, 95% confidence interval [CI]: 0.79-0.88, $P < .001$), reoperation (OR: 0.77, 95% CI: 0.71-0.84, $P < .001$), any complication (OR: 0.89, 95% CI: 0.84-0.95, $P < .001$), deep vein thromboses (OR: 0.89, 95% CI: 0.80-0.98, $P = .017$), and sepsis (OR: 0.69, 95% CI: 0.58-0.83, $P < .0001$) than males.

For THA, females had increased rates of developing 30-day adverse events (OR: 1.08, 95% CI: 1.02-1.14, $P < .001$). These included readmission (OR: 1.13, 95% CI: 1.06-1.21, $P < .001$), reoperation (OR: 1.18, 95% CI: 1.08-1.28, $P < .001$), and wound infection (OR: 1.15, 95% CI: 1.00-1.35, $P = .045$).

Regardless of the procedure (THA or TKA), females had lower rates of MI, acute kidney injury, and mortality but higher rates of LOS >2 days for TKA. Table 2 summarizes the differences in the LOS and 30-day outcomes between males and females.

Discussion

In this study, we sought to compare the differences in the demographics, comorbidity profiles, operative time, hospital LOS, and 30-day outcomes between male and female patients undergoing primary TJA. Compared with males, females were likely to be older, have a higher BMI, identify as nonwhite, and require preoperative functional assistance. Females also had lower rates of diabetes, hypertension, anemia, and kidney disease. Surgically, females had higher rates of primary OA as the indication for TJA and were less

Table 2
Results of multivariate analyses for 30-day postsurgical outcomes between males and females.

Variable	Adjusted outcomes for TKA			Adjusted outcomes for THA		
	Odds ratio (male = 1.0)	95% CI	*P*-value	Odds ratio (male = 1.0)	95% CI	*P*–value
Inpatient stay (>2 days)	1.67	1.64-1.71	**<.0001**	1.82	1.78-1.87	**<.0001**
Any postsurgical event	0.87	0.83-0.90	**<.0001**	1.08	1.02-1.14	**.008**
Mortality	0.84	0.65-1.08	.171	0.70	0.51-0.98	**.035**
Readmission	0.83	0.79-0.88	**<.0001**	1.13	1.06-1.21	**<.0001**
Reoperation	0.77	0.71-0.84	**<.0001**	1.18	1.08-1.28	**<.0001**
Any complication	0.89	0.84-0.95	**<.0001**	0.99	0.92-1.07	.849
Any surgical complication	0.95	0.89-1.02	.169	1.05	0.95-1.16	.326
Wound infection	0.99	0.87-1.12	.839	1.15	1.00-1.31	**.045**
Reintubation	0.99	0.80-1.25	.916	0.92	0.68-1.24	.584
Ventilator >48 hours	0.89	0.63-1.27	.531	1.00	0.61-1.64	.993
Pulmonary embolism	1.04	0.91-1.18	.578	1.08	0.85-1.38	.525
Deep vein thrombosis	0.89	0.80-0.98	**.017**	0.90	0.74-1.09	.268
Any medical complication	0.78	0.71-0.85	**<.0001**	0.92	0.81-1.04	.171
Sepsis or septic shock	0.69	0.58-0.83	**<.0001**	0.87	0.71-1.08	.218
Cardiac arrest	0.86	0.63-1.18	.354	0.89	0.56-1.40	.613
Myocardial infarction	0.66	0.54-0.81	**<.0001**	0.64	0.49-0.83	**.001**
Stroke	0.96	0.70-1.32	.808	1.28	0.86-1.91	.221
Acute renal insufficiency	0.58	0.45-0.76	**<.0001**	0.57	0.39-0.83	**.004**
Pneumonia	0.91	0.78-1.07	.252	1.21	0.98-1.50	.078
Urinary tract infection	0.96	0.70-1.32	.808	1.28	0.86-1.91	.221

Values of postsurgical events are presented as the frequency and percentage. *P* values for rates of postsurgical adverse events are determined from a chi-squared test. Odds ratios indicate the relative risk of each postsurgical event in female relative to male patients (reference = 1.0). Unadjusted odds ratios are determined from a univariate logistic regression. Adjusted odds ratios are determined from a multivariable logistic regression that accounts for patient factors demonstrating significant differences between subgroups in Table 1.
For all analyses, significant values in bold and defined as $P < .05$.

likely to undergo bilateral surgery in addition to having shorter operative times. After controlling for all preoperative and perioperative differences, female gender was an independent risk factor for readmission, reoperation, and wound infection after THA ($P < .001$). In contrast, male sex was an independent risk factor for readmission, reoperation, and overall complications after TKA ($P < .001$). Regardless of the procedure, females were 64%–82% more likely to require LOS >2 days than males.

Our findings appear to be variably consistent with those of previous studies. Basques et al [6] retrospectively reviewed 173,700 patients who underwent primary TJA between 2005 and 2014 using the ACS-NSQIP database. The authors found that males had increased risk of 30-day wound infections, readmissions, reoperations, and mortality. In another study by the same group using the Nationwide Inpatient Sample from 2002 to 2011, Robinson et al [7] showed that male gender was associated with increased risks of infection, MI, acute kidney injury, pneumonia, sepsis, wound dehiscence, and mortality. Only the rates of urinary tract infection (UTI) and blood transfusion were higher among females. The findings of these 2 studies are inconsistent with our analysis. This mainly stems from the fact that Basques et al did not perform separate analyses for THA and TKA. Given that the number of TKAs in the studies by Basques et al was nearly twofold that of THAs, grouping both procedures will result in findings that are skewed by the much larger subgroup of TKAs. This further results in important differences being missed. As demonstrated in our study, although differences do exist between males and females undergoing TJA, the differences vary based on whether a TKA or THA is performed.

Although our findings largely diverge from those of Basques et al [6], they converge on the higher LOS among females undergoing TJA. This was a consistent finding in our study for both THA and TKA. Our findings are also consistent with that of Robinson et al [7]. Using the ACS-NSQIP database between 2012 and 2014, the authors found a similar differential effect of gender by the procedure type. Female gender was protective for certain adverse events including sepsis, MI, reintubation, UTI, blood transfusion, and nonhome discharge. However, a few of those associations could not be established in our study. While both studies were based on the ACS-NSQIP database, our study had a large patient sample and therefore was more powered to detect differences in outcomes. In addition, unlike Robinson et al, we accounted for perioperative differences (not just demographics and comorbidities) in the multivariate models. Finally, as our study covered more recent years, it is not surprising that we did not observe higher rates of UTI as most arthroplasty surgeons have abandoned the practice of indwelling urinary catheters leading to lower rates of catheter-associated UTIs.

The reasons for the variable outcomes based on gender are unclear and not possible to discern from our study. Previous studies have shown that females are at a higher risk for certain complications such as blood transfusions, instability, and periprosthetic fracture after THA. These complications are not captured in the ACS-NSQIP database but could potentially explain the higher rates of readmissions and reoperations after THA. For example, Slover et al [10] retrospectively reviewed 320,746 TJAs using a statewide database and showed that females had a 75% higher risk of requiring blood transfusion than males. With regard to instability, in retrospective review of 6623 primary THAs performed at a single institution, Berry et al [11] found that females had a twofold higher risk of dislocation. In another retrospective review of 1598 primary THAs, Gromov et al [12] demonstrated that females had nearly twofold increased risk for experiencing periprosthetic fractures regardless of the time point postoperatively. As for higher rates of wound infections, this could be explained by higher TJA utilization and BMI among females as observed in our study.

The major limitations of this study are those inherent to a retrospective review of a large database. First, the collected patient characteristics are not all comprehensive. For example, the ACS-NSQIP does not contain information on the socioeconomic status and mental health. Therefore, it is possible that additional differences exist, which could have potentially impacted the observed outcomes. Second, the reasons for reoperations and readmissions are not provided by the ACS-NSQIP. This information would be very helpful to better understand the scope of the problem and mitigate it. Third, our findings are limited to the immediate postoperative period. Further research is needed to examine whether the procedure-specific gender differences persist with longer follow-up.

Conclusions

In conclusion, a variable effect of gender was observed on the post-TJA LOS and outcomes depending on the procedure type (THA or TKA). At least in the immediate postoperative period, female gender was an independent risk factor for readmission, reoperation, and wound infection after THA. In contrast, male sex was an independent risk factor for readmission, reoperation, and overall complications after TKA. Differences attributed to gender should be accounted for in risk-stratification models. Future studies are also needed to elucidate the underlying causes of gender differences in joint arthroplasty.

Conflict of interest

The authors declare there are no conflicts of interest.

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