



Early outcomes of shoulder arthroplasty according to sex

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Hypothesis: Among patients undergoing shoulder arthroplasty (SA), female patients would have worse outcomes than their male counterparts.

Methods: A multicenter prospective cohort of 2364 patients (1365 female and 999 male patients) treated with total SA or reverse total SA from 2007 to 2015 was retrospectively analyzed. Results were assessed using several validated outcome measures and range-of-motion testing. A multivariable analysis identified differences in preoperative values, postoperative values, and preoperative-to-postoperative improvements while adjusting for possible confounders.

Results: The mean follow-up period was 45.9 ± 23.7 months in female patients and 46.4 ± 23.6 months in male patients. Women underwent SA at a significantly older age (70.8 ± 8.4 years) than men (67.6 ± 8.8 years, $P < .01$) and began with lower preoperative outcome scores and range-of-motion measurements: American Shoulder and Elbow Surgeons score ($P < .01$), Constant score ($P < .01$), Simple Shoulder Test score ($P < .01$), active abduction ($P < .01$), forward flexion ($P < .01$), and external rotation ($P = .02$). Postoperatively, both groups showed significant improvement. When we evaluated overall improvement from preoperative values, female patients showed increased improvements in the American Shoulder and Elbow Surgeons score ($P = .04$) and Simple Shoulder Test score ($P < .01$), as well as active forward elevation ($P < .01$) and external rotation ($P = .02$). However, the difference in improvements did not reach the minimal clinically important difference. Women had a higher incidence of component loosening ($P = .03$) and periprosthetic fractures due to falls ($P = .01$), whereas men showed a higher incidence of periprosthetic joint infections ($P < .01$).

Conclusion: This study found that female patients undergo SA at an older age and begin with worse shoulder range of motion and outcome scores than male patients. Although women experienced a greater improvement postoperatively in outcome scores and range of motion, this improvement did not reach the minimal clinically important difference. These findings suggest that male and female patients can expect similar improvements in function after undergoing SA; however, the incidence of complications may vary depending on sex.

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Total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RTSA) are increasingly used for the treatment of shoulder arthritis and/or rotator cuff deficiency. As the incidence of patients with glenohumeral arthritis continues to increase and these procedures are performed more commonly across the United

States, interest in the outcomes of patients undergoing the procedures becomes increasingly relevant.^{1,3,7,12,14,17,19,24,25} Previous studies have identified outcome disparities based on sex in patients undergoing total hip and knee arthroplasty.^{6,11,23,26} These sex-based differences in patient characteristics have the potential to translate to patients undergoing TSA or RTSA.

Among patients undergoing shoulder arthroplasty (SA), the literature has suggested that female sex is associated with greater risks of perioperative complications.^{4,13,17,27} Studies have also shown that female patients maintain lower functional demands postoperatively than male patients.⁹ These studies have suggested

Institutional review board approval was obtained before the study was begun (Western Institutional Review Board).

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that a difference in expectations may contribute to differences in functional outcomes.

Although previous studies have found differences based on sex preoperatively and immediately postoperatively in patients undergoing SA,^{3,4,8,9,13} there are limited data on sex-based outcomes after SA with at least 2 years of follow-up.⁹ The purpose of this study was to assess the early sex-based outcomes of patients undergoing SA at short-term follow-up. Our hypothesis was that similarly to previous studies, our study would show that female patients have worse postoperative improvement than their male counterparts.

Materials and methods

Informed consent was obtained from all patients involved in the study, and each patient had the opportunity to opt out of the study at all time points. We performed a retrospective review of multicenter, prospectively collected data from all patients undergoing primary TSA or RTSA by 16 different surgeons. All surgeons used the same implant—the Equinnox Primary Shoulder System (Exactech, Gainesville, FL, USA)—and the same surgical technique.² The inclusion criteria included patients undergoing primary TSA or RTSA with a minimum of 2 years of follow-up and recorded preoperative and postoperative functional scores.

Patients were selected to undergo surgery based on the surgeon's discretion, and the indications for surgery were recorded in an encrypted database. Postoperative complications—which consisted of loosening, dislocation, infection, neuropathy, pulmonary embolism, stroke, and periprosthetic fracture—were also recorded. Unrelenting or continued pain in the shoulder postoperatively was not considered a complication within the context of this study (Table I). On follow-up, 2 standardized questionnaires were used for evaluation of clinical outcomes. The first was a modified visual analog scale for pain, which also asked a series of questions regarding patients' level of shoulder function. The second was a physician-reported form that recorded range of motion, strength, current physical therapy, pain medication requirements, and complications. Range of motion, including active abduction, forward flexion, and external rotation, was measured using a goniometer both preoperatively and postoperatively to quantify function.

Outcomes were also assessed preoperatively and postoperatively using several validated outcome scores including the American Shoulder and Elbow Surgeons (ASES) score, Simple Shoulder Test (SST) score, and Constant score. Patient scores were assessed at the last preoperative visit before surgery and at the most recent clinic follow-up date. The minimal clinically important

difference in outcome scores was defined according to previous literature as follows^{21,22}: ASES score, 21 points; SST score, 2.4 points; and Constant score, 8 points. Postoperative physical therapy regimens were not standardized across the different study sites.

All continuous data are described using means and standard deviations, whereas categorical data are described as counts. Comparison of the 2 groups defined by sex was performed using Student *t* tests. A paired *t* test was used initially to compare preoperative values, postoperative values, and preoperative-to-postoperative improvements in outcome scores and range of motion. Next, a multivariable linear regression analysis was performed to adjust *P* values for differences in outcomes while controlling for covariates including type of surgery, age, body mass index, history of surgery, and preoperative diagnosis. Results for preoperative values, postoperative values, and preoperative-to-postoperative improvements are displayed in this article according to adjusted *P* values for multivariable covariates. Complications between the 2 groups were compared using the χ^2 test.

Results

A total of 2364 patients were included in the study, comprising 1365 female patients and 999 male patients with mean follow-up periods of 45.9 ± 23.7 months and 46.4 ± 23.6 months, respectively. Preoperative diagnoses included osteoarthritis (1702), osteonecrosis (59), rotator cuff tear (512), rotator cuff arthropathy (548), rheumatoid arthritis (73), ankylosing spondylitis (4), post-traumatic arthritis (48), fracture (5), infection (2), and other (374). Female patients were found to undergo SA, on average, at an older age (71.2 ± 8.5 years vs. 67.4 ± 8.9 years, $P < .01$) than male patients. Demographic data are listed in Table II.

When performing a multivariable linear regression, which adjusted our results for possible confounders (type of surgery [TSA vs. RTSA], age, body mass index, history of surgery, and preoperative diagnosis), we found the following results: No significant difference was observed when comparing RTSA vs. TSA, and this was not found to be a confounder. Preoperative clinical outcome scores were worse in female patients than male patients in terms of the ASES score (33.0 ± 14.9 points vs. 40.0 ± 15.9 points, $P < .01$), Constant score (33.1 ± 12.9 points vs. 39.5 ± 14.1 points, $P < .01$), and SST score (3.0 ± 2.5 points vs. 4.6 ± 3.0 points, $P < .01$) (Table III). In addition, female patients had decreased range of motion compared with male patients in terms of active abduction ($P < .01$), forward flexion ($P < .01$), and external rotation ($P = .02$) (Table IV).

Postoperatively, female and male patients showed significant improvements in all validated outcome measures. Women continued to show lower ASES, SST, and Constant scores, as well as

Table I
Postoperative complications by sex and type of arthroplasty

	Sex			Arthroplasty		
	Female patients	Male patients	<i>P</i> value	TSA	RTSA	<i>P</i> value
Complications (excluding periprosthetic fractures and acromial or scapular stress fractures)						
Glenoid or humeral loosening	28	9	.03*	28	9	<.01*
Instability	10	10	.48	7	13	.24
Infection	3	12	<.01*	7	8	.91
Neuropathy	2	3	.42	4	1	.15
Pulmonary embolism	0	1	.39	0	1	.61
Stroke	0	1	.39	0	1	.61
Myocardial infarction	1	0	.75	0	1	.61
Total	44	36	.61	46	34	.09
Periprosthetic fractures and acromial or scapular stress fractures	26	7	.01*	3	30	<.01*

TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty.

* Statistically significant.

Table II
Patient demographic data

	Male patients	Female patients	P value
No. of subjects	999	1365	
TSA	542	594	
RTSA	457	771	
Average age, yr	70.8 ± 8.4	67.6 ± 8.8	<.01*
Average BMI, kg/m ²	29.3 ± 5.5	29.0 ± 6.5	.19
Average follow-up, mo	46.4 ± 23.6	45.9 ± 23.7	.69
Previous surgery, %	22.8	20.3	.14
Preoperative diagnosis, %			
Osteoarthritis	75.6	69.4	<.01*
Osteonecrosis	1.9	2.9	.11
Rotator cuff tear	20.1	22.8	.12
Rotator cuff arthropathy	19.4	25.9	<.01*
Post-traumatic arthritis	1.7	2.3	.33
Fracture	0.1	0.3	.40
Infection	0.2	0.0	.18
Rheumatoid arthritis	1.6	4.2	<.01*
Ankylosing spondylitis	0.3	0.1	.32
Other	15.2	16.3	.49

TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty; BMI, body mass index.

Data are presented as mean ± standard deviation unless otherwise indicated.

* Statistically significant.

decreased active abduction ($P < .01$). When differences in preoperative-to-postoperative improvements were compared between sexes, female patients showed increased improvements in the ASES score ($P = .04$) and SST score ($P < .01$), as well as active forward elevation ($P < .01$) and external rotation ($P = .02$). Although women experienced a significantly greater improvement in select outcome scores and range-of-motion measures, these values did not reach the minimal clinically important difference for each score (Table V). Patient satisfaction also did not differ between the 2 groups, with 90% of each group reporting to be better (269 of 1365 female patients and 187 of 999 male patients) or much better (991 of 1365 female patients and 742 of 999 male patients) after surgery.

There were 44 postoperative complications in the female cohort (3.2%) and 36 in the male cohort (3.6%, $P = .61$). Women showed a higher incidence of implant loosening ($P = .03$), whereas men showed a higher incidence of periprosthetic infection ($P < .01$). Periprosthetic fractures and stress fractures were considered separately. Female patients were more likely to fall and sustain stress fractures or periprosthetic fractures than their male counterparts ($P = .01$). The overall complication rates were not different when surgery types were compared. However, patients undergoing

TSA were more likely to have glenoid or humeral loosening ($P < .01$), and patients undergoing RTSA were more likely to have periprosthetic or stress fractures ($P < .01$). Postoperative complications are listed in Table I.

Discussion

The incidence of SA is projected to increase by 333% to 755% by the year 2030.^{10,16,28} As the incidence of the procedure continues to rise, it is important to determine how sex affects postoperative outcomes. Our study found that women undergo SA at a significantly older age and tend to have lower functional scores preoperatively and postoperatively. Although female patients experienced greater absolute improvements in outcome scores from the preoperative to postoperative state, these differences did not reach the minimal clinically important difference. These findings suggest that female and male patients can expect similar improvements in function after SA; however, complication rates after the procedure may differ based on sex.

Multiple studies have evaluated predictive factors of outcomes in patients undergoing joint arthroplasty.^{5–7,11,15,18} Fehring et al⁵ evaluated 102 patients undergoing TSA with a minimum follow-up period of 30 months. They found that preoperative function predicted postoperative function in patients undergoing TSA. Stutz et al¹⁹ reported on outcomes of reverse shoulder arthroplasty in a subgroup of 41 patients with morbid obesity with a minimum 2-year follow-up. Their study concluded that female patients have decreased ASES scores, SST scores, abduction, and internal rotation after surgery. In accordance with the previous studies, our study found that female patients undergoing SA begin and end with lower outcome scores and range of motion than male patients. However, in contrast to the literature, we found that female patients have greater absolute improvements from preoperatively to postoperatively in select outcome scores and range-of-motion measures when the sexes are compared. These results were significant when accounting for possible covariates in our cohort, including differences in surgical procedure. However, these differences do not reach the minimal clinically important difference and, as such, are likely not noticeable by patients. The difference in our study may be explained by our larger subset of patients and longer clinical follow-up, which add to the power of the study. Our study also evaluated improvement from the preoperative state, which negates the fact that female patients start with worse scores.

In addition to differences in outcomes, evidence suggests that female patients are less willing to undergo joint replacement and

Table III
Outcome scores preoperatively and postoperatively

	Preoperative			Multivariate adjusted P value	Postoperative		
	Male patients	Female patients			Male patients	Female patients	Multivariate adjusted P value
ASES score, points							
Total	40.0 ± 15.9	33.0 ± 14.9	<.01*	84.8 ± 19.3	80.4 ± 20.7	<.01*	
TSA	39.5 ± 16.5	33.3 ± 15.5		85.3 ± 19.5	81.4 ± 21.4		
RTSA	40.4 ± 15.2	32.7 ± 14.5		84.2 ± 18.9	79.7 ± 20.1		
Constant score, points							
Total	39.5 ± 14.1	33.1 ± 12.9	<.01*	72.7 ± 14.8	66.9 ± 14.7	<.01*	
TSA	41.1 ± 14.3	34.9 ± 12.6		73.1 ± 15.8	68.2 ± 14.8		
RTSA	38.0 ± 13.7	31.9 ± 12.9		72.3 ± 13.7	66.0 ± 14.6		
SST score, points							
Total	4.6 ± 3.0	3.0 ± 2.5	<.01*	10.6 ± 2.4	9.7 ± 2.8	<.01*	
TSA	4.8 ± 3.1	3.3 ± 2.6		10.8 ± 2.3	10.0 ± 2.7		
RTSA	4.4 ± 2.9	2.8 ± 2.3		10.4 ± 2.5	9.4 ± 2.9		

ASES, American Shoulder and Elbow Surgeons; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty; SST, Simple Shoulder Test.

* Statistically significant.

Table IV
Range-of-motion measurements

	Preoperative			Postoperative		
	Male patients	Female patients	Multivariate adjusted P value	Male patients	Female patients	Multivariate adjusted P value
Active abduction, °						
Total	82.3 ± 32.6	72.7 ± 31.9	<.01*	123.9 ± 31.9	117.2 ± 32.5	<.01*
TSA	86.6 ± 29.2	80.2 ± 28.5		127.3 ± 33.5	122.9 ± 34.3	
RTSA	77.4 ± 35.5	67.3 ± 33.0		120.0 ± 29.5	113.1 ± 30.5	
Forward flexion, °						
Total	95.7 ± 33.9	88.1 ± 36.7	<.01*	142.3 ± 28.0	138.9 ± 31.0	.19
TSA	100.1 ± 30.0	95.0 ± 32.4		145.0 ± 29.6	141.5 ± 33.2	
RTSA	91.0 ± 37.3	83.1 ± 38.8		139.4 ± 25.9	137.1 ± 29.1	
External rotation, °						
Total	19.1 ± 20.6	17.2 ± 21.1	.02*	43.3 ± 20.6	41.8 ± 20.6	.88
TSA	19.0 ± 18.5	19.0 ± 20.3		49.6 ± 20.3	51.3 ± 19.6	
RTSA	19.2 ± 22.8	15.8 ± 21.6		36.3 ± 18.6	34.8 ± 18.3	

TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty.

* Statistically significant.

expect lower-demand activities of daily living with aging. Jawa et al⁹ surveyed 63 patients undergoing TSA and found that men most often desired to return to athletic activity or sports and women aspired to return to their daily routines and chores. Hawker et al⁶ performed a questionnaire study of 48,218 patients to identify the willingness of patients with hip and knee pain to undergo arthroplasty. With a 72% overall response rate, they found that women were statistically less likely to be willing to undergo arthroplasty than men. In addition, preoperative expectations have been shown to be linked to a patient's postoperative outcomes. A study by Styron et al²⁰ demonstrated that the better the outlook a patient has on his or her future shoulder function, the better the patient will perform functionally after surgery. Our study did not evaluate willingness to undergo surgery or expectations; however,

we also found that women underwent SA at an older age than men. These findings may suggest that female patients have lower expectations for shoulder function as they age and are willing to delay surgery until function is more severely compromised. However, it is difficult to determine the actual causes of these differences as they are ultimately multifactorial in nature.

Various studies have suggested that female sex is a risk factor for complications postoperatively.^{4,8,13,17,18,27} Menendez et al¹³ and Dunn et al⁴ used large, national databases to perform retrospective analyses of patients undergoing TSA. Both studies showed that women are at an increased risk of extended hospital stays, and they postulated that longer hospital stays may be associated with a greater risk of complications and higher likelihood of a less-than-desirable outcome.^{4,13} Matsen et al¹² analyzed 17,311 patients from the New York Statewide Planning and Research database and found female sex to be associated with a longer length of hospital stay after SA. Our study did not find any differences in length of stay or overall complications. However, female patients were more likely to experience implant loosening, whereas male patients were more likely to experience periprosthetic infection. These results suggest differences in specific complications between sexes. It is possible that owing to a higher bacterial load around the shoulder region in male patients, men are at increased risk of infection compared with women. Female patients were more likely to have complications related to falls including stress fractures or periprosthetic fractures. Women may benefit from increased fall-prevention methods postoperatively.

Limitations

This study has several potential limitations, which are due to the multicenter design and retrospective nature. The multicenter retrospective design introduces the possibility of operator bias, patient selection bias, and performance bias based on non-standardized rehabilitation protocols. This could not be controlled for given the retrospective nature of the study. However, all surgeons performed RTSA based on the implant surgical technique without major variations. Only 1 arthroplasty system was used for all patients in this study; thus, these results may not be transferable to other patient populations in which other implant systems are used. In a large database, failure of consistent and standardized coding can lead to biases in reported results. However, our study was well coordinated, and each facility was briefed in detail on coding specifics of the database. Our results are limited by the patient follow-up and do not account for implant failure at

Table V
Preoperative-to-postoperative improvements

Variable	Male patients	Female patients	Multivariate adjusted P value
ASES score, points			
Total	45.3 ± 22.1	47.9 ± 22.7	<.01*
TSA	47.2 ± 22.2	49.1 ± 23.7	
RTSA	43.3 ± 21.8	47.1 ± 22.0	
Constant score, points			
Total	33.5 ± 16.7	34.0 ± 16.1	.60
TSA	33.6 ± 16.4	33.5 ± 16.2	
RTSA	33.4 ± 16.9	34.2 ± 16.1	
SST score, points			
Total	6.0 ± 3.3	6.8 ± 3.2	<.01*
TSA	6.1 ± 3.3	6.9 ± 3.2	
RTSA	5.9 ± 3.4	6.7 ± 3.3	
Active abduction, °			
Total	40.5 ± 40.5	44.8 ± 39.0	.06
TSA	39.9 ± 40.5	43.4 ± 40.4	
RTSA	41.1 ± 40.7	45.7 ± 38.0	
Forward flexion, °			
Total	45.8 ± 40.0	51.7 ± 41.1	<.01*
TSA	44.7 ± 38.3	47.8 ± 38.5	
RTSA	46.9 ± 41.8	54.4 ± 42.6	
External rotation, °			
Total	23.9 ± 24.5	24.8 ± 24.0	.02*
TSA	31.1 ± 21.1	33.5 ± 22.2	
RTSA	16.3 ± 25.4	18.9 ± 23.3	

ASES, American Shoulder and Elbow Surgeons; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty; SST, Simple Shoulder Test.

The coefficients describe the change experienced by female patients compared with male patients.

* Statistically significant.

long-term follow-up. The strengths of our study include the large number of patients and minimum 2-year follow-up.

Conclusion

This study found that female patients undergo SA at an older age than male patients and begin with worse shoulder range of motion and outcome scores. Although women experienced a greater improvement postoperatively in outcome scores and range of motion, this improvement did not reach the minimal clinically important difference. These findings suggest that male and female patients can expect similar improvements in function after undergoing SA.

Disclaimer

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