An analysis of body weight changes after shoulder arthroplasty

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Background: To determine if there are postoperative weight changes for patients undergoing primary shoulder arthroplasty (SA). In addition, we aimed to determine if glycemic control (hemoglobin A1C levels) change postoperatively for patients undergoing SA.
Methods: All patients 18 years of age or older who had undergone primary SA over a 12-year period were analyzed. Patients were excluded if they did not have a preoperative body mass index or if they had less than 1-year follow-up. Baseline demographics were recorded for all patients and comparisons were made between the obese and nonobese groups. Clinically meaningful weight loss was defined as a ≥ 5% reduction in body weight postoperatively.
Results: A total of 469 patients met inclusion criteria. Of them, 65% of patients were obese, and the mean preoperative body mass index for all patients was 33. With a mean follow-up of 40 months, 70% of patients demonstrated clinically significant weight loss. Compared with patients without obesity, patients with obesity lost significantly more weight (10 vs. 6 kg) and demonstrated significantly greater postoperative body mass index reductions (4 vs. 2). Overall, 72% of patients with obesity demonstrated clinically meaningful postoperative weight loss of ≥5% body weight. Patients with obesity who lost weight also saw a decrease in their postoperative hemoglobin A1C: for every 10 pounds of weight loss, A1C decreased by 0.08 units.
Conclusions: In our series, 72% of patients with obesity undergoing primary SA achieved clinically meaningful weight loss, with a mean follow-up of more than 3 years. Patients who lose weight after SA additionally demonstrate improved glycemic control. Surgeons and patients should balance the association between postoperative weight loss after SA with the potential increased risks of operative complications, particularly for severely obese patients.

The prevalence of obesity has continued to increase, particularly in the United States.[21] While physical activity and exercise are indicated as part of comprehensive weight-loss strategies, patients with painful, arthritic shoulder conditions often report functional limitations and difficulty exercising. Patients with obesity may be at higher risk of complications when undergoing shoulder arthroplasty (SA).[20] However, regardless of body mass index (BMI), patients undergoing elective SA demonstrate improvements in both pain and function, which would allow for participation in exercise and weight-loss programs.[17]

Despite a number of investigations aiming to determine if patients lose weight after elective hip or knee arthroplasty, there have been conflicting results.[1,5,13,16,23] Recent systematic review have demonstrated insufficient evidence to determine if there are any clinically meaningful changes in body weight after lower-extremity arthroplasty.[10] There is a paucity of literature analyzing weight changes after SA, and it remains uncertain if patients with obesity undergoing primary, elective SA lose weight after surgery.

The purpose of this investigation was to determine if there were postoperative weight changes for patients undergoing primary SA. We hypothesized that patients with obesity undergoing primary total SA (TSA) or reverse TSA would demonstrate clinically significant weight loss at least a year after their procedure. In addition, we aimed to determine if glycemic control (hemoglobin A1C levels) change postoperatively for patients undergoing these SA procedures.

Materials and methods

Institutional review board approval was obtained for this retrospective investigation. By querying our institution's electronic medical record system, we identified all patients 18 years of age or older who had undergone primary TSA or reverse TSA between November 2006 and May 2019. In order for patients to be included, both of the following criteria had to be met:

1. Patients had a recorded height (inches) and weight (kg) within a 3-month period before undergoing their primary SA.
2. Patients had a height and weight recorded at least 12 months after their primary SA.

We identified 789 unique patients that had undergone primary SA during the study period and 469 (59%) met inclusion criteria. Baseline demographics were recorded for all patients including age, sex, current tobacco use, type of arthroplasty performed, as well as postoperative BMI changes. Follow-up period (months) was determined by the most recent weight recorded in the medical record. Obesity was defined as a preoperative BMI of $\geq$ 30 and further subclassified as obesity class I (BMI 30.0-34.9), obesity class II (BMI 35-39.9), and obesity class 3 (BMI $\geq$ 40). Clinically meaningful weight loss was defined as a $\geq$ 5% reduction in body weight postoperative compared with a preoperative baseline measurement.[8,18,22] We also recorded preoperative and postoperative glycemic control (hemoglobin A1C) when available, and changes in glycemic control were compared between patients with obesity and without obesity.

Statistics

Descriptive statistics were used for patient characteristics such as, age, gender, tobacco use, obesity class, and type of SA. In addition, descriptive statistics were used for preoperative and postoperative weight characteristics, stratified by patients with obesity and without obesity. Frequency and percentages were reported for categorical variables and the mean, and standard deviation was reported for continuous variables. Furthermore, chi-square and Fisher's exact test, Student t-test, and ANOVA, where appropriate, were performed to compare patient characteristics among the two groups of patients with obesity and without obesity and across obesity classifications. A chi-square test was also performed to examine the association between preoperative and postoperative hemoglobin A1C with comparisons between obese and nonobese groups. A scatterplot and a generalized linear model were generated to test significance in the association between change in hemoglobin A1C and change in weight.

An a priori sample size calculation was not performed at the start of this retrospective investigation. A post hoc power analysis was conducted to determine what minimum detectable mean weight change would have had 80% statistical power to be detected with the sample size when comparing obese and nonobese groups. The post hoc power analysis demonstrated that with the sample size for this investigation (N = 469), there was 99% power to detect the observed mean difference of 4.7 kg in weight between patients with obesity and without obesity, and there would have been 80% power to detect a minimum mean difference of 2.2 kg. All analyses were performed in SAS Enterprise Guide v8.2 (SAS, Inc., Cary, NC, USA), with $P < .05$ considered statistically significant.

Results

During the study period, 789 patients underwent primary SA. Of these patients, 469 (59%) had their height and weight measured

Table I
Baseline demographics and body weight outcomes for all patients.

Characteristic	All patients (n = 469)
Mo follow-up, mean (range)	40 (12-135)
Age in yr, mean (SD)	70 (9.9)
Male, n (%)	182 (39%)
Current tobacco use, n (%)	63 (13%)
Type of shoulder arthroplasty, n (%)	210 (45%)
TSA	259 (55%)
RTSA	
Preoperative BMI, mean (SD)	32.9 (7.5)
Obesity class, n (%)	
Nonobese	164 (35%)
Class I	138 (29%)
Class II	80 (17%)
Class III	87 (19%)
BMI change in kg/m^2, mean (SD)	−3.4 (3.5)
Weight change in kg, mean (SD)	−8.8 (9.3)
Patients with weight loss $\geq$5%, n (%)	321 (68%)
Patients with weight gain $\geq$5%, n (%)	17 (4%)

BMI, body mass index; *RTSA*, reverse total shoulder arthroplasty; *SD*, standard deviation; *TSA*, total shoulder arthroplasty.

preoperative and postoperatively in accordance with our inclusion criteria.

Table I presents characteristics and baseline demographics for all included patients. The mean preoperative BMI for all patients was 33 with 65% of patients meeting the definition of obesity (BMI $\geq$30). In addition, 87 patients (19%) had a BMI of $\geq$40 (class III obesity). With a mean follow-up of 40 months, 70% of patients demonstrated clinically significant weight loss, defined as a postoperative weight decrease of $\geq$ 5 % preoperative body weight. Patients lost an average of 8.6 kg after SA and decreased their BMI by an average of 3.4 postoperatively.

Table II includes a comparison of baseline demographics and body weight changes after SA for patients with obesity and without obesity. Compared with patients without obesity, patients with obesity lost significantly more weight (10.4 vs. 5.9 kg, $P < .0001$) and demonstrated significantly greater postoperative BMI reductions (4 vs. 2, $P < .0001$). Overall, 72% of patients with obesity demonstrated clinically significant postoperative weight loss of $\geq$5% body weight. Table III represents a comparison of baseline demographics and body weight changes after SA relative to the three obesity classifications (classes I, II, III). While there were no statistically significant differences with respect to the percentage of patients that demonstrated clinically significant postoperative weight loss of $\geq$5% body weight between the three obesity classes, 70% or more of patients in each group showed postoperative reductions of $\geq$5% body weight.

Table IV presents a comparison of preoperative and postoperative hemoglobin A1C values between the non-obese and obese (BMI $\geq$ 30) patient groups that underwent SA. Overall, preoperative and postoperative glycemic control as measured by hemoglobin A1C appeared similar. However, patients with obesity who lost weight also saw a decrease in their postoperative hemoglobin A1C (Fig. 1). For every 10 pounds of weight loss, A1C significantly decreased by 0.08 units, as noted in Figure 1 ($P = .004$, 95% confidence interval [0.03-0.13]).

Discussion

These data indicate that 73% of patients with obesity undergoing primary SA achieve clinically meaningful weight loss with a mean follow-up of more than 3 years. While patients with obesity were significantly more likely to achieve postoperative weight loss, 64% of patients without obesity also demonstrated a postoperative

Table II
Comparison of baseline demographics and body weight changes after shoulder arthroplasty for patients with and without obesity (BMI ≥ 30).

Characteristic	Patients without obesity (n = 164)	Patients with obesity (n = 305)	P value
Months follow-up, mean (range)	41 (12-135)	39 (12-124)	.36
Age in yr, mean (SD)	71 (10.7)	68 (9.4)	**.004**
Male, n (%)	70 (43%)	112 (37%)	.21
Current tobacco use, n (%)	28 (17%)	35 (11%)	.09
Type of shoulder arthroplasty, n (%)			.10
TSA	65 (40%)	145 (48%)	
RTSA	99(60%)	160 (52%)	
BMI change in kg/m^2, mean (SD)	−2.0 (2.5)	−4.1 (3.7)	**<.0001**
Weight change in kg, mean (SD)	−5.7 (7.2)	−10.4 (9.9)	**<.0001**
Patients with weight loss ≥5%, n%	101 (62%)	220 (72%)	**.02**
Patients with weight gain ≥5%, n%	11 (7%)	6 (2%)	**.01**

BMI, body mass index; RTSA, reverse total shoulder arthroplasty; SD, standard deviation; TSA, total shoulder arthroplasty.
Bold indicates P values of <.05.

Table III
Comparison of baseline demographics and body weight changes after shoulder arthroplasty relative to obesity classification.

Characteristic	Class I obesity N = 138	Class II obesity N = 80	Class III obesity N = 87	P value
Mo follow-up, mean (range)	38 (12-124)	46 (14-115)	35 (12-93)	
Age in yr, mean (SD)	70 (9.0)	67 (8.6)	65 (9.9)	**.001**
Male, n (%)	57 (41%)	30 (38%)	25 (29%)	.16
Current tobacco use, n (%)	12 (9%)	9 (11%)	14 (16%)	.24
Type of shoulder arthroplasty, n (%)				.19
TSA	58 (42%)	40 (50%)	47 (54%)	
RTSA	80 (58%)	40 (50%)	40 (46%)	
BMI change in kg/m^2, mean (SD)	−3.2 (2.9)	−4.3 (3.2)	−5.6 (4.6)	**<.0001**
Weight change in kg, mean (SD)	−8.3 (8.0)	−10.5 (8.5)	−13.7 (12.7)	**.0003**
Patients with weight loss ≥5%, n%	96 (70%)	61 (76%)	63 (72%)	.57
Patients with weight gain ≥5%, n%	3 (2%)	2 (3%)	1 (1%)	.88

BMI, body mass index; RTSA, reverse total shoulder arthroplasty; SD, standard deviation; TSA, total shoulder arthroplasty.
Bold indicates P values of <.05.

Table IV
Comparison of preoperative and postoperative hemoglobin A1C values between patients with and without obesity (BMI ≥ 30) who underwent shoulder arthroplasty.

Characteristic	All patients (n = 469)	Patients without obesity	Patients with obesity	P value
Patients with pre and postoperative A1C, n (%)	365 (78%)	108 (100%)	257 (100%)	–
Months between A1C values, mean (SD)	66.6 (43.3)	68.0 (44.9)	66.1 (42.7)	.69
Preoperative A1C in mg/dL, mean (SD)	6.4 (1.1)	6.2 (0.9)	6.4 (1.1)	.06
Patients with preoperative A1C ≥ 6.5, n (%)	137 (29%)	36 (33%)	101 (39%)	.28
Postoperative A1C in mg/dL, mean (SD)	6.5 (1.2)	6.5 (1.3)	6.5 (1.2)	.79
Patients with postoperative A1C ≥ 6.5, n (%)	146 (31%)	39 (36%)	107 (42%)	.33
A1C change in mg/dL, mean (SD)	0.1 (1.1)	0.2 (1.0)	0.1 (1.1)	.15

BMI, body mass index; SD, standard deviation.

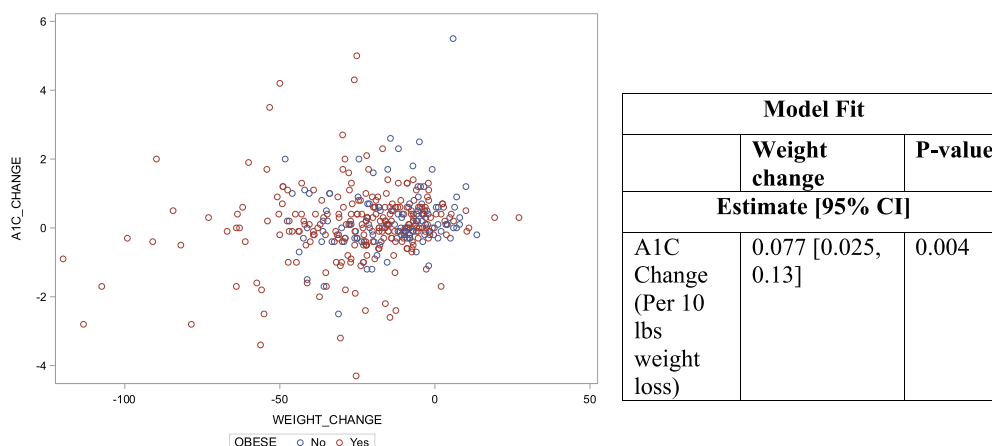| Model Fit		
	Weight change	**P-value**
Estimate [95% CI]		
A1C Change (Per 10 lbs weight loss)	0.077 [0.025, 0.13]	0.004

Figure 1 Scatterplot of hemoglobin A1C change vs. weight change, by obesity.

weight loss of $\geq 5\%$ body weight. Similar investigations analyzing weight loss after hip and knee arthroplasty have demonstrated conflicting results.[1,5,13,16,23] Similar to our findings, Ast et al[1] demonstrated that patients with higher preoperative body weights were more likely to lose weight after lower-extremity arthroplasty. The reasons for our observed weight loss are likely multifactorial. SA results in substantial improvement in not only shoulder specific outcome scores but also in generic health and quality of life scores as well.[2-3] In addition, measures of psychological status (including anxiety and depression) have been shown to improve for patients undergoing SA.[4] It is possible that these improvements in non–shoulder-related metrics after SA aid in postoperative weight loss.

We note that across all three obesity classes, $\geq 70\%$ of patients maintained clinically meaningful weight loss at a mean follow-up of more than 3 years. These results are encouraging, especially considering that average adult gains approximately two pounds per year.[9] This may be of particular interest for patients with severe class III obesity (BMI ≥ 40), as they are at higher risk for severe health issues.[6] While there is conflicting information with respect to outcomes of SA in patients with obesity compared with patients without obesity, there is some evidence to suggest that obesity is associated with higher complication rates.[11,14,19-20] These data may provide some additional insight for patients who cite activity limiting shoulder pain as a reason for their inability to participate in exercise components of weight loss programs. For patients with obesity with functionally limiting shoulder arthritis, the benefit of possible postoperative weight loss should be carefully weighed against the risks inherent to SA.

When looking at all patients, there did not appear to be much of a change with respect to preoperative and postoperative glycemic control as measured by hemoglobin A1C. However, patients with obesity who lost weight also saw a decrease in their postoperative hemoglobin A1C. Similar to the previous investigations regarding weight loss after hip or knee arthroplasty, studies analyzing the relationship between glycemic control and compilations after SA have demonstrated conflicting results.[12,15] While it is not surprising that patients who lose wight after SA demonstrate improve glycemic control, patients should still be counseled preoperatively regarding health optimization before surgery, particularly in the cases where patients have multiple potential risk factors for infection.

This investigation has a number of limitations. There are inherent limitations associated with any retrospective investigation. An a priori sample size calculation was not used in this retrospective study. Only 59% of patients who underwent SA during the study period had sufficient follow-up to meet inclusion criteria, and it is uncertain how the results of these excluded patients would have impacted our results. These data are from a single institution which is part of a rural, academic, level I trauma center and may not be generalizable to other practices. In addition, while the obesity rate for US adults is 42%, 65% of patients in our series were obese which may introduce a component of selection bias.[7]

Conclusion

In our series, 73% of patients with obesity undergoing primary SA achieved clinically meaningful weight loss (defined as a reduction of $\geq 5\%$ body weight postoperatively), with a mean follow-up of more than 3 years. Patients who lose weight after SA additionally demonstrate improved glycemic control. Surgeons and patients should balance the association between postoperative weight loss after SA with the potential increased risks of operative complications, particularly for patients with severe obesity.

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