An Original Study

Obesity Has Minimal Impact on Short-Term Functional Scores After Reverse Shoulder Arthroplasty for Rotator Cuff Tear Arthropathy

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Abstract

The potential adverse effect of body mass index (BMI) on shoulder function scores after reverse shoulder arthroplasty (RSA) has not been investigated.

We conducted a study to examine outcomes of RSA performed for rotator cuff tear arthropathy (RCTA) across BMI categories (normal weight, overweight, obese). We hypothesized that, compared with normal-weight patients, obese patients would have worse shoulder function scores, worse mobility, and more complications.

Using a prospective shoulder arthroplasty registry, we identified 77 primary RSAs performed for RCTA with minimum 2-year follow-up. Thirty-four patients had normal weight (BMI <25 kg/m^2), 21 were overweight (BMI 25-30 kg/m^2), and 22 were obese (BMI >30 kg/m^2). Shoulder function scores, mobility, and satisfaction were evaluated before surgery and at final follow-up.

The 3 BMI groups were not significantly different on demographic factors, preoperative shoulder function scores, or preoperative mobility ($P > .05$). For each group, shoulder function scores and mobility significantly improved between the preoperative and final follow-up assessments ($P < .001$). Patient satisfaction was similar between groups ($P = .967$).

Improved shoulder function scores, mobility, and patient satisfaction can be expected after RSA for RCTA in patients regardless of BMI.

Body mass index (BMI) is thought to be a predictor of body composition, with higher values indicating more adipose tissue. BMI is a measure of mass with respect to height. The World Health Organization[1] has established health categories based on BMI measurements. Values from 18.5 to 24.9 kg/m^2 are deemed to represent normal weight; those from 25 to 30 kg/m^2, overweight; and those higher than 30 kg/m^2, obesity. BMI is not a perfect tool, but it is the most widely used tool in clinical and research practice because of its relative reliability and ease of use.[2] Being overweight or obese (according to BMI) is increasingly common among adults worldwide, and particularly in the United States. An estimated 39% of adults worldwide are overweight, and 13% are obese.[1] An estimated 69% of US adults are overweight, including 35.1% who are obese.[2]

Various pathologies have been treated with reverse shoulder arthroplasty (RSA), and results have been promising,[3-9] but little is known about patient demographic and clinical factors that may adversely affect outcomes. Recent work suggests younger age[7] and failed prior arthroplasty may adversely affect RSA outcomes.[10] Higher BMI has also been implicated as a cause of increased perioperative and immediate postoperative complications of RSA with minimum 90-day follow-up, but no one has

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examined shoulder function scores at minimum 2-year follow-up.[11,12]

We conducted a study to examine shoulder function scores, mobility, patient satisfaction, and complications at minimum 2-year follow-up in normal-weight, overweight, and obese patients who underwent RSA. We hypothesized that, compared with normal-weight patients, obese patients would have worse shoulder function scores, worse mobility, and more complications.

Materials and Methods

Inclusion Criteria and Demographics

After obtaining Institutional Review Board approval for this study, we used a prospective shoulder arthroplasty registry to identify patients (N = 77) who had rotator cuff tear arthropathy (RCTA) treated with primary RSA and then had minimum 2-year follow-up. The study period was 2004-2011. All patients had RCTA diagnosed with physical examination findings and anteroposterior, scapular Y, and axillary radiographs. RCTA was graded 1 to 5 using the classification system of Hamada and colleagues.[13] Rotator cuff status was determined with preoperative computed tomography arthrogram (CTA) or magnetic resonance imaging (MRI) and confirmed at time of surgery. BMI calculations were based on height and weight measured at initial office visit. Thirty-four patients had normal weight (BMI <25 kg/m^2), 21 were overweight (BMI 25-30 kg/m^2), and 22 were obese (BMI >30 kg/m^2). Patient demographic and clinical characteristics reviewed also included age, sex, follow-up duration, arm dominance, complications, prevalence of depression, and prevalence of diabetes. All RSAs were performed by the same surgeon (Dr. Edwards) at a single high-volume shoulder arthroplasty center.

Shoulder function scores evaluated before surgery and at final follow-up included Constant score,[14] American Shoulder and Elbow Surgeons (ASES) score,[15] Western Ontario Osteoarthritis Shoulder (WOOS) index,[16] Single Assessment Numeric Evaluation (SANE),[17] and mobility. Satisfaction was assessed by having patients describe themselves as *very dissatisfied*, *dissatisfied*, *satisfied*, or *very satisfied*. All intraoperative and postoperative complications were recorded.

Surgical Technique and Postoperative Rehabilitation

The Aequalis RSA system (Tornier) was used for all patients during the study period. The RSA technique used has been well described.[18,19] A standard postoperative rehabilitation protocol was followed.[19,20]

Clinical and Radiographic Assessment

Patients were prospectively enrolled in a shoulder arthroplasty outcomes registry and followed clinically. Mean follow-up was 3.16 years (range, 2-8 years). Before surgery, patients were examined by the surgeon. Examinations were repeated 1 week, 6 weeks, 3 months, 6 months, and 12 months after surgery and annually thereafter. Mobility (active range of motion) was determined with a handheld goniometer. Strength of abduction was measured with a handheld digital dynamometer (Chatillon digital force gauge, 200 lbf; Ametek). Anteroposterior in plane of scapula, scapular Y, and axillary radiographs were obtained at each clinic appointment.

Before surgery, the surgeon reviewed all radiographs. Each RCTA was given a Hamada grade (1-5).[13] Glenoid erosion in the coronal plane was classified (E0, E1, E2, E3) according to Sirveaux and colleagues.[21] Hamada grades and glenoid erosion types are listed in **Table 1**. The overall trend in classification by BMI group was statistically significant for Hamada grade (P = .004) but not glenoid erosion type (P = .153).

Before surgery, the surgeon also evaluated rotator cuff status using CTA or MRI. All patients

Table 1. **Hamada Grades and Glenoid Erosion Types**[a]

	BMI <25 (n = 34)	BMI 25-30 (n = 21)	BMI >30 (n = 22)
Hamada grade[13]			
1	0 (0%)	0 (0%)	5 (22.7%)
2	6 (17.7%)	2 (9.5%)	3 (13.6%)
3	2 (5.9%)	0 (0%)	1 (4.6%)
4	25 (73.5%)	18 (85.7%)	9 (40.9%)
5	1 (2.9%)	1 (4.8%)	4 (18.2%)
Glenoid erosion type[21]			
E0	25 (73.5%)	13 (61.9%)	10 (45.5%)
E1	0 (0%)	1 (4.8%)	3 (13.6%)
E2	2 (5.9%)	4 (19.0%)	3 (13.6%)
E3	7 (20.6%)	3 (14.3%)	6 (27.3%)

Abbreviation: BMI, body mass index (kg/m^2).
[a]Overall trend in classification by BMI group was statistically significant for Hamada grade (P = .004) but not glenoid erosion type (P = .153).

had full-thickness tears of the supraspinatus and infraspinatus. The subscapularis was variably present, and subscapularis repair was performed when the subscapularis was intact. Rotator cuff status is listed in **Table 2**. There were no significant differences in the distribution of intact subscapularis ($P = .402$) or teres minor ($P = .188$) among the normal-weight, overweight, and obese groups. No patient had a latissimus dorsi transfer at time of RSA.

Statistical Analysis

Independent-samples *t* tests assuming unequal variances were used to compare the 3 BMI groups on age, follow-up duration, preoperative shoulder function scores, and mobility. Chi-square tests were used to identify any significant group differences in comorbidities (eg, complications, arm dominance, prevalence of depression, prevalence of diabetes) and patient satisfaction. Repeated-measures analysis of variance was used to evaluate main effects, changes from before surgery to final follow-up, and BMI group differences, as well as differences in changes from before surgery to final follow-up among the 3 BMI groups.

Results

Among BMI groups (<25 kg/m^2, 25-30 kg/m^2, >30 kg/m^2), there were no statistically significant preoperative differences in age, sex, follow-up duration, complications, arm dominance, prevalence of depression, or prevalence of diabetes ($P > .05$) (**Table 3**). **Table 4** lists the groups' preoperative and final follow-up data (Constant score, ASES score, WOOS index, SANE, mobility). There were no statistically significant preoperative group differences in Constant score, ASES score, WOOS index, SANE, mobility, or patient satisfaction ($P > .05$) (**Tables 5, 6**).

All groups' shoulder function scores and mobility improved significantly from before surgery to final follow-up ($P < .001$) (Table 5). The groups' magnitudes of change (improvement) from before

Table 2. **Rotator Cuff Status**

Status	BMI <25 (n = 34)	BMI 25-30 (n = 21)	BMI >30 (n = 22)	*P*
Full-thickness supraspinatus tear	34 (100%)	21 (100%)	22 (100%)	—
Full-thickness infraspinatus tear	34 (100%)	21 (100%)	22 (100%)	—
Full-thickness subscapularis tear	20 (59%)	10 (48%)	9 (41%)	.402
Intact teres minor	34 (100%)	19 (90%)	20 (91%)	.188

Abbreviation: BMI, body mass index (kg/m^2).

Table 3. **Patients**

	BMI <25	BMI 25-30	BMI >30	*P*
Patients, n (male, female)	34 (11M, 23F)	21 (10M, 11F)	22 (10M, 12F)	—
Mean (SD) age at surgery, y Range, y	73.2 (7.6) 61-89	69.4 (9.8) 43-82	69.5 (8.0) 52-84	.151
Mean (SD) follow-up, y Range, y	3.2 (1.7) 2.0-8.3	3.3 (2.0) 2.0-7.7	3.6 (1.7) 2.0-8.4	.722
Bilaterality	11 (32.4%)	3 (14.3%)	5 (22.7%)	.310
Complications	4 (11.8%)	1 (4.8%)	1 (4.4%)	.512
Dominant arm	22 (64.7%)	15 (71.4%)	15 (68.2%)	.872
Depression	6 (17.6%)	6 (28.6%)	4 (18.2%)	.587
Diabetes	1 (2.9%)	4 (19.0%)	3 (13.6%)	.138

Abbreviation: BMI, body mass index (kg/m^2).

surgery to final follow-up were almost identical, with no significant differences in shoulder function scores or mobility (Table 5). The only significant difference was in Constant–Strength, which was higher in the obese group ($P = .017$) (Table 5). Patient satisfaction ratings improved after surgery, with 79% of the normal-weight group reporting being *satisfied* or *very satisfied* with their shoulders (Table 6). The overweight and obese groups gave similar *satisfied* (81%) and *very satisfied* (82%) ratings. The small differences between group satisfaction scores were nonsignificant ($P = .967$).

Complications

The normal-weight group had 4 complications: periprosthetic infection (2 cases), intraoperative humeral fracture (1), and scapular spine stress fracture (1). The overweight group had 1 complication, an acromial stress fracture that was successfully treated with conservative measures. The obese group had 1 patient with 2 postoperative dislocations. The first dislocation was treated with closed reduction and bracing, and the second required revision surgery. There was no statistical difference in complications among the groups ($P = .680$).

Discussion

To our knowledge, this is the first study of the effects of varying BMI on functional outcomes of RSA with minimum 2-year follow-up. There appears to be minimal impact on shoulder function scores, complications, and patient satisfaction among normal-weight, overweight, and obese patients with RCTA treated by the same surgeon using similar techniques.

The relationship between obesity and increased perioperative risks or poorer surgical outcomes has been well established in orthopedic surgery. In a systematic review, Falagas and Kompoti[22] found increased risk for perioperative and nosocomial infections in obese patients. Schoenfeld and colleagues[23] and Jiang and colleagues[24] reported increased risk for complications in spinal surgery. The total joint arthroplasty literature is rife with evidence suggesting higher BMI leads to increased risk for complications, including infection and deep venous thrombosis, as well as decreased functional outcome scores.[25-29] Recent studies on shoulder surgery have shown worse outcomes in rotator cuff repair[30] and a higher revision rate in hemiarthroplasy.[31]

Table 4. **Shoulder Function Scores and Mobility, Mean (SD)**

	BMI, <25		BMI, 25-30		BMI, >30	
Measure	**Before Surgery**	**Final Follow-Up**	**Before Surgery**	**Final Follow-Up**	**Before Surgery**	**Final Follow-Up**
Constant–Pain	4.0 (3.3)	12.0 (4.5)	3.6 (2.4)	11.5 (4.3)	3.5 (2.3)	11.1 (4.8)
Constant–Activity	5.1 (3.0)	15.0 (5.3)	6.9 (3.2)	14.3 (5.2)	5.5 (3.5)	14.5 (5.7)
Constant–Mobility	6.8 (7.1)	29.5 (9.1)	7.7 (7.7)	25.0 (10.4)	8.0 (8.1)	29.1 (9.5)
Constant–Strength	0.3 (0.9)	7.7 (4.0)	0.8 (2.7)	7.6 (6.4)	1.6 (3.7)	12.2 (7.3)
Constant–Total	16.0 (9.6)	64.2 (16.9)	19.0 (11.0)	58.3 (21.1)	18.7 (13.4)	66.9 (23.0)
Constant–Adjusted	22.4 (13.2)	93.2 (25.2)	25.0 (13.6)	80.0 (27.7)	25.7 (18.8)	93.9 (33.8)
ASES score	31.2 (19.8)	75.2 (25.7)	30.8 (13.9)	69.4 (22.4)	32.6 (16.1)	70.5 (24.4)
ASES Pain score	6.1 (3.2)	1.4 (2.6)	6.3 (2.3)	1.4 (2.3)	5.5 (2.6)	1.4 (2.0)
WOOS index	72.5 (20.2)	25.5 (28.4)	72.2 (14.5)	27.8 (25.9)	74.8 (15.9)	25.4 (25.0)
SANE	25.7 (26.3)	56.9 (38.6)	36.1 (23.2)	63.7 (33.1)	26.6 (26.1)	72.9 (26.8)
Flexion	32° (40°)	146° (30°)	47° (40°)	134° (37°)	52° (48°)	142° (29°)
Abduction	30° (38°)	142° (37°)	44° (39°)	131° (38°)	50° (46°)	139° (32°)
External rotation	13° (14°)	30° (17°)	5° (11°)	31° (15°)	8° (12°)	26° (16°)

Abbreviations: ASES, American Shoulder and Elbow Surgeons; BMI, body mass index (kg/m^2); SANE, Single Assessment Numeric Evaluation; WOOS, Western Ontario Osteoarthritis Shoulder.

Other RSA studies have examined short-term complications or perioperative risk factors associated with BMI. In a study using slightly different BMI groupings, Gupta and colleagues[12] reported significantly higher complication rates for RSA patients with BMI higher than 35 kg/m^2 compared to patients with BMI of 25 to 35 kg/m^2 and compared to patients with BMI lower than 25 kg/m^2. Their study highlighted medical and surgical complications and used a short follow-up period (minimum, 90 days). It did not assess shoulder function scores, and included multiple indications for RSA (eg, RCTA, proximal humerus fracture, inflammatory arthropathy). In another study, higher BMI was reported as a risk factor for early dislocation after RSA, but only 11 patients with a history of dislocation were assessed, and minimum follow-up was 6 months.[32] We know of only one study that addressed RSA outcomes in obese patients and used minimum 2-year follow-up, but its primary endpoint was rate of complications, and it did not report shoulder function scores.[11] Li and colleagues[33] conducted

Table 5. ***P* Values for Select Comparisons**[a]

Measure	BMI Group	Preoperative to Final Follow-Up Changes Between BMI Groups
Constant–Pain	.711	.942
Constant–Activity	.841	.315
Constant–Mobility	.467	.256
Constant–Strength	.013	.027
Constant–Total	.528	.259
Constant–Adjusted	.371	.147
ASES score	.786	.657
ASES Pain score	.770	.745
WOOS index	.968	.847
SANE	.224	.301
Flexion	.504	.102
Abduction	.510	.155
External rotation	.341	.181

Abbreviations: ASES, American Shoulder and Elbow Surgeons; BMI, body mass index (kg/m^2); SANE, Single Assessment Numeric Evaluation; WOOS, Western Ontario Osteoarthritis Shoulder.

[a]$P < .001$ for all preoperative vs final follow-up comparisons.

Table 6. **Patient Satisfaction Ratings**[a]

	BMI, <25		BMI, 25-30		BMI, >30	
Rating	Before Surgery	Final Follow-Up	Before Surgery	Final Follow-Up	Before Surgery	Final Follow-Up
Very dissatisfied	28 (82.4%)	5 (14.7%)	20 (95.2%)	1 (4.7%)	20 (90.9%)	1 (4.6%)
Dissatisfied	6 (17.6%)	2 (5.9%)	1 (4.8%)	3 (14.3%)	2 (9.1%)	3 (13.6%)
Satisfied	0 (0%)	7 (20.6%)	0 (0%)	11 (52.4%)	0 (0%)	5 (22.7%)
Very satisfied	0 (0%)	20 (58.8%)	0 (0%)	6 (28.6%)	0 (0%)	13 (59.1%)

Abbreviation: BMI, body mass index (kg/m^2).

[a]Ratings improved at final follow-up, with 79% of normal-weight (BMI <25) patients reporting they were *satisfied* or *very satisfied* with their shoulders. Overweight (BMI 25-30) and obese (BMI >30) patients reported similar *satisfied* and *very satisfied* ratings of 81% and 82%, respectively. The small differences between groups were nonsignificant ($P = .967$).

a study similar to ours, but with primary total shoulder arthroplasty (TSA) patients, and reported similar results. Relative to normal BMI, higher BMI did not have a detrimental effect on short-term improvement in shoulder function after TSA.

Given the US obesity epidemic, our study results are encouraging. Depending on many factors, obesity remains a risk factor for poor outcomes in patients who undergo orthopedic surgery. As our results show, however, patients with higher BMI can obtain functional outcomes similar to those experienced by patients with normal-weight BMI after RSA for RCTA.

The primary limitation of this study was its retrospective design. Strengths of the study included its having a single surgeon and a single diagnosis: RCTA. In addition, each group was robust in size, a standard operative/postoperative protocol was used, and clinical results were measured with multiple validated shoulder function scores.

Conclusion

Improved shoulder function scores, mobility, and patient satisfaction can be expected after RSA for RCTA in patients with BMI higher than 30 kg/m^2. These patients did not exhibit an increase in complications at short-term follow-up.

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