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Good functional outcomes expected after shoulder arthroplasty irrespective of body mass index

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Background: This study evaluated how body mass index (BMI) factors into functional outcomes and complications after shoulder arthroplasty.
Methods: A retrospective analysis was performed of age-matched patients with a minimum 2-year follow-up after total shoulder arthroplasty (TSA), reverse total shoulder arthroplasty (RTSA), or hemiarthroplasty (HA). Patient-reported outcome (PRO) scores, range of motion (ROM), and complications were assessed. Forty-nine patients were classified into the following groups: normal (BMI <24.9 kg/m^2), overweight (BMI 25-29.9 kg/m^2), class I obese (BMI 30-34.9 kg/m2), class II obese (BMI 35-39.9 kg/m^2), and class III morbid obese (BMI ≥40 kg/m^2).
Results: A total of 245 patients (134 women, 111 men; average age, 64 ± 8 years) were evaluated at an average follow-up of 48 ± 18 months. TSA was performed in 122 patients (50%), RTSA was performed in 103 (42%), and HA was performed in 20 (8%). No significant difference was found among the 5 BMI groups in arthroplasty type ($P = .108$) or in complications, including reoperations ($P = .27$). All groups had significant postoperative improvements in PROs and ROM ($P < .001$ for both). There were no significant differences among the BMI groups in postoperative ROM or PROs.
Discussion: This study demonstrates that patients undergoing TSA, RTSA, and HA can expect good functional outcomes, with improvements in pain, function and outcome scores, irrespective of BMI.
Levels of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Shoulder arthroplasty; obesity; outcomes; complications; BMI; body mass index

The management of glenohumeral arthritis in patients with an intact rotator cuff with total shoulder arthroplasty (TSA) results in excellent pain relief and significantly improved functional outcomes.[5,7,31] Patients with cuff tear arthropathy, fracture sequelae, inflammatory arthropathy, and failed prior anatomic shoulder arthroplasty have achieved significant improvements in pain and functional outcomes with the reverse TSA (RTSA).[3,9,11,26] As indications for shoulder arthroplasty continue to expand, its use in the United States continues to increase.[20,29] Furthermore, as the aging population continues to grow, the burden of patients needing a shoulder arthroplasty is expected to increase.

Obesity presents a significant health issue throughout the world. The World Health Organization reported the

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rate of obesity with a body mass index (BMI) >30 kg/m^2 in 2009 to 2010 was 36% for men and women.[6] Minorities and the elderly are especially prone to being overweight or obese, with rates up to 70%.[18,27] In the hip and knee arthroplasty literature, increased complication and revision rates are strongly correlated with obesity.[1,4,15,16] Despite this, functional outcomes are still expected to significantly improve after knee arthroplasty in the obese patient population.[23]

Most studies to date that have evaluated the effects of obesity on shoulder arthroplasty are insurance and health care database studies. Werner et al[28] found that a BMI >50 kg/m^2 was associated with a significant increased rate of surgical and postoperative complications for patients after shoulder arthroplasty. Gupta et al[10] found increased complication rates in patients undergoing RTSA with a BMI >35 kg/m^2. In contrast, Anakwenze et al[2] found no significant increase in the deep infection rate, aseptic revision rate, or 1-year mortality after shoulder arthroplasty with higher BMI groups. Similar to Anakwenze et al, Jiang et al[12] reported increased surgical times with increasing BMI levels but found no increase in short-term complications between the different obesity classes. Most recently, Wagner et al[25] reported significantly increased rates of revision surgery, superficial wound infection, and postoperative complications in the higher BMI groups. Regarding patient satisfaction and functional outcomes, TSA and RTSA both demonstrated good pain relief and functional outcome scores in obese patients.[13,14,17,19,21,24]

Thus, the effect of patient BMI status on outcomes after shoulder arthroplasty is unclear due to differing study designs and differing databases. The purpose of this study was to stratify clinical outcomes and complication rates among differing BMI groups in patients who undergo TSA, RTSA, or hemiarthroplasty (HA) from a single-institution with high-volume fellowship-trained surgeons, with a minimum 2-year follow-up. We hypothesized that patients in all BMI groups would have a significant improvement in clinical outcome scores and similar complication rates.

Materials and methods

Consecutive patients undergoing shoulder arthroplasty by 2 high-volume fellowship-trained surgeons (G.P.N. and A.A.R.) were retrospectively reviewed from a prospectively maintained shoulder arthroplasty database. All patients who underwent a nonrevision arthroplasty, including TSA, RTSA, or HA, and had minimum 2-year clinical follow-up were identified. The study excluded patients with incomplete medical records, including preoperative patient-reported outcomes (PROs), those undergoing revision arthroplasty surgery, and those with less than 2 years of follow-up.

Patient BMI grouping

Patients were classified according to the World Health Organization BMI classification[30] as normal (BMI <24.9 kg/m^2), overweight (BMI 25-29.9 kg/m^2), class I obese (BMI 30-34.9 kg/m^2), class II obese (BMI 35-39.9 kg/m^2), and class III morbid obese (BMI ≥40 kg/m^2). Patients who met the inclusion criterion were age matched with 49 patients in each BMI group. Patient demographics and type of surgery are reported in Table I.

Outcomes measures

All patients included in this study completed the following PRO scores preoperatively and postoperatively: Single Assessment Numeric Evaluation, American Shoulder and Elbow Surgeons (ASES) Standardized Shoulder Assessment Form, Western Ontario Osteoarthritis of the Shoulder index, visual analog scale (VAS), and Simple Shoulder Test (SST). Range of motion (ROM), including forward elevation, external rotation at the side, and abduction internal rotation, was measured by the treating physician during the patient's preoperative visit and at the final follow-up. Complications, including persistent pain, poor range of motion, superficial and deep infections, fractures, and all reoperations were recorded.

Statistical analyses

The statistical tests were computed with SPSS 22.0 software (IBM, Armonk, NY, USA). Statistical analysis was performed using 1-way univariate and multivariate analysis of covariates adjusting for BMI

Table I Demographic data of study population by body mass index group

Variable	Body mass index group (kg/m^2)				
	<25 (n = 49)	25-29.9 (n = 49)	30-34.9 (n = 49)	35-39.9 (n = 49)	>40 (n = 49)
Sex					
Female	33	19	24	29	29
Male	16	30	25	20	20
Diabetes	5	7	6	12	17
TSA	19	27	30	19	27
RTSA	24	19	16	28	16
Hemiarthroplasty	6	3	3	2	6

TSA, total shoulder arthroplasty; *RTSA*, reverse total shoulder arthroplasty.
Data are presented as number of patients.

groups, and the χ^2 or Fisher exact test. A P value of <.05 was considered significant.

Results

There were 245 patients (134 women and 11 men) selected for this study, with 49 patients age matched to each BMI group. Patients were a mean age of 64 ± 8 years, and mean clinical follow-up was 48 ± 17.9 months. TSA was performed in 122 patients (50%), RTSA was performed in 103 (42%), and HA was performed in 20 (8%). There was no significant difference in arthroplasty types between allocated BMI groups ($P = .108$). Female patients were more likely to be in the higher BMI groups ($P = .047$). Higher BMI groups were significantly more likely to have diabetes ($P = .01$).

Functional outcomes

Mean ROM and functional outcome scores significantly improved from preoperative values to postoperative values, regardless of BMI status (Table II). There was a significant preoperative difference in functional scores between normal BMI and overweight groups compared with class II obese patients ($P = .018$). A preoperative difference was also identified for the SST in the overweight cohort compared with the class II obese ($P = .006$). No other preoperative difference between BMI groups in ROM, SST, ASES, and VAS scores was identified.

There was no significant difference in postoperative ROM or functional scores between the BMI class groups. The magnitude of change from preoperative ROM and functional scores to postoperative values was analyzed across the BMI groups. A 1-way analysis of variance found a significantly larger magnitude of change in forward elevation in the class II obese group (63.8° ± 31.3°) over the normal BMI group (44.0° ± 30.40°; $P = .05$). No significant differences were seen in external rotation, functional scores, ASES, SST, and VAS scores.

Table II Preoperative to postoperative comparison of functional outcomes

Functional outcome	Preoperative	Postoperative	*P* value
Functional score	9.56	22.32	<.001
VAS	5.39	1.43	<.001
SST	3.43	8.78	<.001
ASES	40.42	80.43	<.001
Forward elevation	90.84	138.26	<.001
External rotation	27.54	52.82	<.001

VAS, visual analog scale; *SST*, Simple Shoulder Test; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form.

Table III Complications by body mass index

Complication	BMI category (kg/m²)	Total patients (No.)	*P* value
Infection*			.016
	<25	0	
	25-29.9	0	
	30-34.9	0	
	35-39.9	3	
	>40	0	
Complications			.272
	<25	5	
	25-29.9	2	
	30-34.9	3	
	35-39.9	8	
	>40	3	
Reoperation*			.009
	<25	1	
	25-29.9	1	
	30-34.9	1	
	35-39.9	7	
	>40	1	

BMI, body mass index.
* Identifies the group with a significant difference.

Complications

There were 21 complications, including 3 superficial infections, all of which were treated with irrigation and débridement and component retention (Table III). There were 3 revision operations (2 RTSA instabilities treated with liner exchange and 1 HA revised to RTSA). There were 4 periprosthetic fractures: 2 scapular spine fractures treated with open reduction and internal fixation, and 2 traumatic periprosthetic humeral fractures (1 treated with open reduction and internal fixation and other treated nonoperatively). There were 2 identified early subscapularis repair failures (1 treated operatively and 1 treated nonoperatively) and 9 patients with persistent pain or stiffness (2 treated with arthroscopic débridement/release).

The difference in the total number of postoperative complications, including reoperations across the BMI groups, was not significant ($P = .27$). No significant correlation was found between patients who had diabetes and had a complication ($P = .89$). There were 3 superficial infections (1.2%), and all were in the class II obese group ($P = .016$). There were 11 reoperations, with a significantly higher rate seen in the class II obese group ($P = .009$).

Discussion

The primary goal of this study was to evaluate functional outcomes after shoulder arthroplasty between all BMI groups. The secondary goal was to evaluate whether there was a difference in complication rates among BMI groups. Our data show that all BMI groups can achieve significant improvements in clinical outcomes. This was at a mean follow-up of 4 years

Table IV Review of recent clinical outcome studies on obesity and relevant body mass index registry database studies

Author, year	Study design	Comparison groups	Outcomes
Anakwenze et al, 2017[2]	• Shoulder arthroplasty registry retrospective review • Identify the effects of BMI on long-term outcomes: revision rate, 1-year-mortality rate, 3-year surgical site infection rate, and 90-day in-patient all-cause readmission rate after TSA and RTSA	• 4630 patients who underwent TSA and RTSA between 2007 and 2013 (75% TSA, 25% RTSA) • BMI categories were stratified by 5 kg/m^2 increments	• Overall combined revision rate was 1.7% • Higher BMI was not associated with higher risk of aseptic revision, 1-year-mortality rate, or 3-year deep infection • In TSA only, every 5 kg/m^2 increase in BMI was associated with a 16% in the likelihood of 90-day readmission • BMI has different outcomes on TSA and RTSA
Jiang et al, 2016[12]	• The American College of Surgeons National Surgical Quality Improvement Program database for 2006 to 2012 • Queried for patients who underwent a primary TSA for OA • Perioperative hospitalization data and 30-day postoperative complications were compared among different BMI classes	• 4796 patients underwent a primary TSA for OA • Patients were classified into 4 BMI categories: normal BMI (18.5-25 kg/m^2), overweight (25-30 kg/m^2), obesity class I (30-35 kg/m^2), and obesity class II or greater (>35 kg/m^2)	• There was no association between BMI and 30-day complications after surgery • Surgical time increased for patients with greater BMI • No difference in 30-day complications and perioperative hospitalization data after TSA in patients with increased BMI
Werner et al, 2015[28]	• PearlDiver* registry retrospective review • Postoperative complication rate including infection, dislocation, component loosening, and revision surgery	• 144,239 shoulder arthroplasties • 13,759 obese • 955 super obese	• BMI >50 kg/m^2 (super obese) had significantly higher rates of infection, dislocation component loosening, revision surgery, 90-day DVT, and, medical complications • No difference in risk for periprosthetic fracture

TSA, total shoulder arthroplasty; *RTSA*, reverse total shoulder arthroplasty; *BMI*, body mass index; *OA*, osteoarthritis; *DVT*, deep venous thrombosis.
* PearlDiver Technologies, Inc., Ft. Wayne, IN, USA.

in this series. Furthermore, when evaluating the magnitude of change from preoperative ROM and functional scores to postoperative values, the only significant difference between the groups was in forward elevation. This was seen with the class II obese group having a larger improvement in active forward elevation than in the normal BMI groups. The class II obese group had poorer preoperative forward elevation, yet the mean active forward elevation was nearly 15° higher at the final follow-up. Thus, this group had a lower "floor" value for active elevation preoperatively but achieved a higher "ceiling" postoperatively. The factors contributing to this improvement compared with the other BMI groups cannot be discerned by our data. It is interesting that this same group also had the highest complication rate and reoperation rate.

Although shoulder arthroplasty has demonstrated excellent outcomes,[5,7,31] patient factors that can affect clinical outcomes need to be thoroughly evaluated. Obesity is one of those patient factors, and its effect on shoulder arthroplasty outcome is not yet fully understood.[22] In patients with a higher BMI, there have been reported excellent satisfaction and clinical outcomes with shoulder arthroplasty (Tables IV and V).[8,10,12-14,17,19,21,24,28] Unfortunately, data evaluating functional results between all BMI class groups are limited.

There is concern shoulder arthroplasty in obese patients may have an increased risk of complications that will increase the health care burden and patient morbidity.[25] Wagner et al[25] recently reported in a large shoulder arthroplasty institutional joint registry that increased BMI is associated with increased complications such as revision surgery, reoperation, mechanical failure, and superficial wound infection. Some authors similarly have found increased rates of complications with shoulder arthroplasty in higher BMI patients.[10,28] Other authors argue that surgical complications are similar when compared with control cohorts.[2,12]

Our data showed an overall complication rate of 8.6%, a reoperation rate of 4.5%, and a revision rate of 1.2%. Although not statistically significant, 8 of the 11 reoperations were in patients with a BMI >35 kg/m^2. This group also had a significantly increased risk of superficial wound infections, although we did not report any deep wound infections. This is similar to the recently reported results from Wagner et al,[25] where patients with a BMI >35 kg/m^2 had a statistically

Table V Review of recent clinical outcomes studies on obesity and body mass index

Author, year	Study design	Comparison groups	Outcomes
Gupta et al, 2014[10]	• Retrospective review of primary RTSAs with a minimum of 90-day follow-up • Level III	• Patients were classified into 3 groups by BMI: normal (<25 kg/m^2), overweight or mildly obese (25-35 kg/m^2), and moderately or severely obese (>35 kg/m^2)	• Patients with a BMI >35 kg/m^2 or <25 kg/m^2 have higher complication rates after RTSA
Li et at, 2013[13]	• Case-control study of functional outcomes after TSA in obese patients • Preoperative demographics, and perioperative and postoperative complications were recorded • ASES, SF-36, VAS, and fatigue scores were evaluated at baseline and 2-year follow-up • Prognostic Level II	• 76 patients were grouped according to BMI: normal (<25 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥30 kg/m^2)	• Obesity did not have a detrimental effect on the improvement of short-term shoulder function • Overall physical function of obese and overweight patients does not significantly improve after TSA • Patients in normal BMI group did not improve overall physical function after TSA
Linberg et al, 2009[14]	• Case series • Complications, results, and failure rates for shoulder arthroplasty in morbidly obese patients was examined • Level IV	• 41 shoulders were monitored for a minimum of 2 years or until revision	• Shoulder arthroplasty in morbidly obese patients is associated with long-term improvement in pain and function • Intraoperative and postoperative care for these patients is more complex, and patients seem to have a higher rate of unsatisfactory results
Morris et al, 2016[17]	• Prospective study • Examined outcomes of RSA performed for RCTA across BMI categories (normal weight, overweight, obese)	• 77 primary RSAs performed for RCTA with minimum 2-year follow-up • 34 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)	• The 3 BMI groups were not significantly different on demographic factors, preoperative shoulder function scores, or preoperative mobility
Pappou et al, 2014[19]	• Retrospective case-series • Outcome measures, complications, discharge dispositions, costs in patients undergoing RSA • Minimum 24-month follow-up • Prognostic Level III	• 21 patients with a BMI of ≥40 kg/m^2 • Matched with 63 control patients with a BMI of <30 kg/m^2	• RSA is as safe and effective in morbidly obese patients; however, it has an increased cost and patients have a lower rate of discharge to home and greater care needs after discharge
Statz et al, 2016[21]	• Retrospective case-series of all patients receiving a primary RSA • Minimum 2-year follow-up • Shoulder abduction, external rotation, and ASES were evaluated	• 41 patients with mean BMI of 44 kg/m^2	• RSA is a successful procedures in morbidly obese patients (BMI ≥40 kg/m^2)
Vincent et al, 2016[24]	• Prospective cohort study • ASES, Shoulder Pain and Disability Index, UCLA, SF-12, ROM, and strength • Preoperative, 2-year and final follow-up visits were included • Level II study	• 310 patients with a TSA or RSA were longitudinally compared in patients with low and high BMI after a TSA or a RSA	• TSA and RSA both result in positive functional outcomes in patients irrespective of BMI • Morbidly obese patients do not attain the same gains in SF-12 scores compared with nonmorbidly obese patients
Wagner et al, 2017[25]	• Case series • Complication, reoperation, and revision rates	• 4567 shoulder arthroplasties • 302 revisions	• Increasing BMI associated with increased complication risk, reoperation, revision for mechanical failure, and overall revision rates • Highest association seen with BMI and superficial wound infection

RTSA, reverse total shoulder arthroplasty; *BMI*, body mass index; *TSA*, total shoulder arthroplasty; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *SF-36*, 36-Item Short Form Health Survey; *VAS*, visual analog scale; *RSA*, reverse shoulder arthroplasty; *RCTA*, rotator cuff tear arthropathy; *UCLA*, University of California, Los Angeles Shoulder Rating scale; *SF-12*, 12-Item Short Form Health Survey *ROM*, range of motion.

significant increased risk of superficial wound infection and reoperation. Interestingly, although the higher BMI group also had a higher incidence of diabetes, it did not correlate with a complication in our patient cohort. Our overall low complication, revision, and infection rate may not be representative of what is seen in the general population.

This study has limitations that should be taken into account when interpreting our data. First, this study includes a heterogenous set of procedures, including RTSA, TSA, and HA, performed by 2 surgeons, although the rates of these procedures did not differ significantly between each BMI group. Furthermore, we did not categorize based on the design or manufacturer of the shoulder arthroplasty implant.

Second, despite matching by patient age and sex in our retrospective case-control design, other differences between the BMI groups are potential sources of error or bias, including insurance status, medical comorbidities, activity level, and prior surgical interventions.

Third, our overall complication, revision, and infection rate is lower than historical controls; thus, our patient population may not accurately reflect the general population.

Fourth, although the main purpose of this study was to evaluate functional outcomes between BMI groups, our relatively large patient population of 245 patients with 49 in each group may be underpowered to identify a significant difference in complications between groups.

Lastly, a mean follow-up of 48 months may not be sufficient to identify long-term complications that may be more likely to occur in obese patients, including, but not limited to, mechanical failure.

The strengths are the study's prospective and continuous data collection from a shoulder arthroplasty database at a single institution. Furthermore, to our knowledge, this is the largest study to evaluate functional results and outcomes based on each BMI class group. The results of this study will contribute to our understanding of how increasing BMI can affect functional outcomes after shoulder arthroplasty.

Conclusion

Our results demonstrate that for TSA, RTSA, and HA, irrespective of BMI class groups, patients can expect good functional outcomes with improvements in pain, ROM, function, and outcome scores. Similar to previous studies, complication rates tend to be higher in the higher BMI groups, particularly superficial infections and reoperation rates. Longer follow-up is needed to determine whether these excellent functional results persist over time.

Disclaimer

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