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REVERSE SHOULDER ARTHROPLASTY (E CRAIG, SECTION EDITOR)

Obesity and Reverse Total Shoulder Arthroplasty

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Abstract

Purpose of Review Rates of obesity and reverse total shoulder arthroplasty (rTSA) in the USA have both escalated with time. Obese patients experience arthritis at higher rates than normal weight patients; therefore, these numbers go hand in hand. Obesity has been correlated with health comorbidities such as anxiety, cardiovascular disease, diabetes, and metabolic syndrome as well as poorer outcomes and higher complication rates following lower extremity arthroplasty. The current review investigates these comorbidities as they relate to obese patients undergoing rTSA.

Recent Findings Functional outcomes are similar to normal weight counterparts. Although longer operative times and a large soft tissue envelope would intuitively predispose these patients to higher risk for infection or other complications, this has not been reliably demonstrated. Technical considerations and awareness of potential risks in the obese patient demographic may aid the surgeon in preoperative planning and counseling of their patient.

Summary Obese patients undergoing rTSA have been shown to have higher risks specifically for infection, revision, and medical complications; however, this has not been consistently demonstrated in the single surgeon series where, more often, no difference in these metrics has been found. Outcomes measures and satisfaction are reliably improved, even when considering superobese patients, and majority of studies find their improvements and absolute values to be in line with their normal weight counterparts. Thus, rTSA does not seem to carry the same level of adverse risk associated with lower joint arthroplasty but potential for higher risk still bears consideration when counseling obese patients. Attention to factors that may negatively affect prosthesis positioning may optimize retention rates and limit early failure.

Keywords Obesity · Reverse total shoulder arthroplasty · Rotator cuff

Introduction

Reverse total shoulder arthroplasty (rTSA) has been a reliable treatment for patients with a variety of shoulder conditions with rapid utilization growth since its approval in the United States of America (USA) in 2004 [1,2]. Indications for rTSA include osteoarthritis with rotator cuff tear, irreparable rotator cuff tear, rotator cuff arthropathy, and proximal humerus fracture. Additionally, it has served as a useful revision operation for patients with history of failed arthroplasty [1].

Rates of obesity have continued to climb and impact health care in multiple capacities. Its influence on outcome and complication rates within the arthroplasty population has been of great interest to the orthopedic community, with significant research efforts within the lower extremity. Obesity as it relates to rTSA has been examined albeit to a lesser degree than lower extremity arthroplasty. This review aims to summarize

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the effects of obesity on health as it relates to orthopedic care and examine the literature specifically highlighting outcomes and complications specific to rTSA.

Obesity Background

Body mass index (BMI) (weight in kilograms divided by the square of height in meters) is a common method to measure obesity levels. It has been adopted as surrogate for body fatness due to its ease of calculation. It is moderately correlated with more direct measures of body fat [3–5]. A BMI greater than 30 signifies obesity while a BMI of 40 or greater implies morbid obesity [6]. Percentage of obese individuals has trended up with projections to rise to 48.9% of adults within the USA by 2030 [7]. Adults aged 40–59, being female, or being a non-Hispanic black adult have the greatest prevalence of obesity [6].

Within the literature, significant associations have been demonstrated between total body fat mass and widespread pain [8]. Pain-relieving treatments are less effective in obese patients even though they report higher pain intensities than patients of healthy weight [26]. This is likely multifactorial as chemical mediators due to fat accumulation and psychiatric diagnoses impact health condition and specifically pain perception.

Increases in adipocytes further increase production of peptides, cytokines, and metabolites while adiponectin levels decrease leading to a pro-inflammatory state [9, 10]. Chemical mediators such as these contribute to joint pain and development of joint pathology, such as osteoarthritis [11, 12]. The pro-inflammatory state may also contribute to finding that obesity is a risk factor to occurrence and severity of rotator cuff tears [13]. Systemic inflammations induced with excess fat accumulation have additionally been strong risk factors for developing cardiovascular disease, metabolic syndrome, diabetes, and cancer. Ultimately, obese patients may experience poor outcomes or complications may arise [14].

Anxiety occurs more frequently in obese individuals than individuals that are at a healthy weight. Furthermore, chronic anxiety in conjunction with type II diabetes increases the risk for developing chronic heart disease [15–18]. Insulin resistance is greater in obese individuals while anxiety compounds this to further increase insulin resistance [19]. This is complicated as, in turn, experiencing a cardiovascular event may cause anxiety levels to increase and exacerbate this vicious cycle [20, 21]. Therefore, acknowledgement of comorbid conditions and how they influence one another is a valuable insight to the complex medical condition of obesity which orthopedic surgeons commonly see in their patient populations.

Technical Considerations for rTSA in the Obese Patient

Obesity influences how orthopedic surgeons approach rTSA. For example, bony detail from radiographs may be obscured due to overlying soft tissue. Obscurities can be overcome by use of advanced imaging techniques by enhancing understanding of joint geometry. To assist, medical device companies offer preoperative planning software and patient-specific navigation based on these modalities (Blueprint, Tornier, Edina MN; Match Point System, DJO, Lewisville TX; Zimmer PSI Shoulder System, Zimmer, Warsaw IN; Signature Personalized Patient Care Glenoid System, Zimmer BIOMET, Warsaw IN). Within the literature specifically examining use of guided implant placement, reports suggest that placement of implants is accurate, specifically the glenoid, but functional outcomes or longevity of the implants may not be affected [22•, 23, 24, 25]. Thus use of these intraoperative aids is a consideration when landmarks are less easily identified.

Exposure of the shoulder is more challenging with a greater soft tissue envelope due to depth of the glenoid. Additionally, positioning the arm in adequate adduction to expose the humerus may be difficult due to the size of the arm and torso. As a result, operative times can increase [26•, 27•, 28]. Greater operative time has been associated with higher infection rates in other joint arthroplasties [29, 30]. Thus, preoperative planning and optimization of surgical time may be instrumental in minimizing risk for the obese patient population. Table 1 outlines investigations that specifically evaluated outcomes and complications after reverse TSA impacted by BMI.

Weight of the arm requires consideration as it may place greater demands upon the prosthesis. Early wear or aseptic loosening is a potential concern, although there is a lack of long-term studies to support this [31]. There is a possibility that the weight of the arm following surgery may incite a distraction force causing dislocation. And unfortunately, many larger patients rely on their arms in assisting mobility; thus, risk for injury due to instability or early use of the extremity is a concern. Preoperative therapy services may enhance a patient's ability to mobilize without the use of their upper extremity or consult on the accessibility of their home to improve their independence postoperatively.

Outcomes of rTSA in the Obese Patient

The application of rTSA to a variety of shoulder pathologies has been successful in significantly improving pain and function in vast majority of patients. Compared to their preoperative state, obese patients consistently experience improvements postoperatively [32, 28, 33, 34•, 35, 36]. However, absolute outcome scores may not reach the same level of

Table 1 Investigations that specifically evaluated outcomes and complications after reverse TSA impacted by BMI

Study	Length of follow-up	Sample size of reverse TSAs	Outcomes	Complications
Anakwenze et al. [41]	1 and 3 years; 2.6 years average	1147: 304 (BMI <25) 422 (BMI 25–29) 267 (BMI 30–34) 110 (BMI 35–39) 44 (BMI >40)		5 kg/m^2 marginally associated with increased risk of 3-year deep infection p=0.064
Morris et al. [35]	2 years minimum	77: 34 (BMI<25) 21 (BMI 25–30) 22 (BMI >30)	Constant-strength higher in the obese group. No difference in other patient-reported outcome measures between groups.	No statistical difference in complications between groups.
Wiater et al. [27]	2 years minimum	130: 29 (BMI<25) 50 (BMI 25–30) 51 (BMI >30)	Longer surgical times for overweight and obese patients compared to normal weight. No difference in other patient-reported outcome measures, range of motion, and x-ray findings between groups.	No statistical difference in complications between groups.
Izquierdo-Fenandez et al. [31]	4 years	29: 21 (BMI <35) 8 (BMI >35)	Divided into 2 groups above and below BMI of 35. ASES was significantly higher in the below 35 group (75.3 vs 63.4)	No difference in complications or x-ray findings.
Kusin et al. [49]	Not stated	9382: 50 (BMI <18.5) 1452 (BMI 18–24) 3069 (BMI 25–29) 2491 (BMI 30–34) 1331 (BMI 35–39) 962 (BMI >40)		Dislocation was higher in the BMI <18.5 and BMI >40 groups. Lowest in the overweight group (BMI 25–30).
Eichinger et al. [37]	2 years minimum; 3 years average (2–7 years)	1171: 348 (BMI 20–25) 438 (BMI 25–30) 334 (BMI 30–39) 51 (BMI >40)	Significantly greater internal rotation for normal BMI than overweight, obese, and morbidly obese	
Statz et al. [32]	2 years minimum; 3.2 years average (2–7.36 years)	40 BMI >40	ASES 71.1, simple shoulder test 6.8, shoulder subjective test 67.5. 93% satisfaction	2% revision rate
Pappou et al. [28]	2 years minimum	21 (BMI>40) 63 (BMI<30)	Morbidly obese group had more comorbidities excluding obesity (6 vs 4). Longer operative time by 13 min. Blood loss 40 mL greater. Six-fold higher rate of discharge to rehabilitation facilities rather than home. Higher hospital costs by $2974. Similar outcomes between groups for ASES, range of motion, scapular notching, and major and minor complications.	Similar rate of major and minor complications

Table 1 (continued)

Study	Length of follow-up	Sample size of reverse TSAs	Outcomes	Complications
Werner et al. [45]	Up to 8 years	30,217: 5036 (BMI 30–40) 3230 (BMI >40)		Risk factors for early revision. Obesity (OR 1.4), morbid obesity (OR 1.8)
Beck et al. [44]		76: 23 (BMI<25) 36 (BMI 25–30) 17 (BMI >30)	No difference in scapular notching, surgical time, length of hospitalization, humeral component loosening, postoperative range of motion, pain relief, or instability between groups.	Complication rate in the obese group was 35% compared to 4% in the normal weight group.

BMI, body mass index; *TSA*, total shoulder arthroplasty: *ASES*, American Shoulder and Elbow Surgeons score; *OR*, odds ratio

normal weight comparisons [31, 36]. Eichinger et al. reported that postoperative internal rotation is poorer in patients with higher BMIs which corresponded to poorer ability to perform activities of daily living that rely on internal rotation motion and strength [37]. Statz et al. found higher BMI patients have less elevation and lower simple shoulder test scores [32]. The finding of less forward elevation was supported by a meta-analysis with similar abduction and external rotation compared to normal weight. It is worth noting that this study reported worse pain in obese following rTSA but this may not be a clinically important difference [38••]. Klein et al. report only slightly lower ASES scores in those with BMI greater than 40 [33]. Yet other studies yield similar improvements across all measured outcomes including range of motion and functional scores [34, 27, 39].

Complications of rTSA in the Obese Patient

Conflicting research exists regarding complications following rTSA. Patients categorized morbidly obese or superobese often have more medical comorbidities and are often nutritionally deficient [40]. This intuitively increases the risk for postoperative complications. However, there are conflicting reports within the literature. Some studies have reported that no significant differences exist in complication rates between BMI categories undergoing rTSA [1, 33, 35, 39, 41, 27, 42]. Conversely, other researches suggest that complication rates following rTSA are greater for obese than nonobese patients [43, 44]. Potential complications include medical, infectious, and mechanical such as prosthetic instability, periprosthetic fracture, or premature loosening. Indeed, obesity has been associated with early revision after rTSA [45].

Time and hospitalization factors may predispose obese patients to a greater frequency of complications. In regard to rTSA, obese patients require longer operative times [27, 28, 38]. Longer operative times have been associated with a higher risk for infection in other surgical procedures, although this was not found in studies relating specifically to rTSA [46]. Obese patients may require longer hospitalizations [38] and have higher likelihood of requiring discharge to location other than home [28]. Reviews and meta-analyses have found a higher risk for venous thromboembolism (VTE) in obese patients [38, 47•] but risk of many other potential medical complications, such as myocardial infarction or urinary tract infection, has not been found to be increased [36, 38]. Fortunately, this does not seem to drive patient outcomes when specifically examining rTSA patients but serves as valuable insights to orthopedic surgeons treating these patients.

Hypothetically, obese individuals are at higher risk for developing a postoperative infection due to nutritional status, comorbidities, and poor vascularity of adipose tissue. Rates of periprosthetic shoulder infection range from 1 to 10% and

can be due to less virulent organisms [39]. Furthermore, rTSA patients may be at higher risk for developing infection due to the greater dead space created with this operation compared to anatomic TSA [41]. In a series of 301 rTSA, Morris et al. note that BMI is not a significant risk factor for developing periprosthetic infection (overall rate of 5% at a minimum of 1 year of follow-up) [39]. Conversely, larger database-derived studies utilizing Kaiser, Mayo, and PearlDiver have shown a trend bordering on significance that increasing BMI correlated with higher risk for periprosthetic infection [41, 48••, 50]. Examining available evidence, there is a lack of consistent findings that obesity correlates to increased risk for periprosthetic shoulder infection. However, there are few long-term studies available and potential correlation of infection to obesity may be underappreciated.

Body habitus due to obesity hypothetically may impact how the prosthesis functions and wears for obese individuals. The weight of the arm, motion limitations, or levering against the torso as well as deconditioning raise concerns that dislocation or premature wear may occur at higher rates in obese individuals. Kusin et al. who examined risk for early dislocation found highest rates of this occurring in underweight and >40 BMI patients, however noted this was an uncommon complication and did not reach statistical significance [49]. In an investigation by Wagner, the risk for dislocation was not affected [48]. Intraoperative fracture or periprosthetic fracture rates have not been found to occur more frequently [37, 39]. Likewise, postoperative radiolucencies have not been consistently reported as higher in the obese population [27, 31] and higher rates of aseptic revision have not invariably been found [36, 41, 48]. Perhaps body habitus does not deserve the prejudiced fear for mechanical failure or studies have simply not followed these patients for adequate time to parcel out if this becomes more of a factor with longer term follow-up [48].

It is worth noting that superobese patients, with BMI greater than 50, may represent a subset of patients with increased risk compared to nonobese counterparts. Few studies have examined this specifically with most grouping all patients with BMI greater than 40 within the same cohort and none to our knowledge has further stratified to examining rTSA in isolation. Werner et al., in their database study examining superobesity in anatomic and reverse total shoulder arthroplasty, reported higher rates of infection, dislocation, component loosening, and postoperative venous thromboembolism (VTE) in superobese cohort compared to nonobese cohort [47]. Many of these measures ceased to reach significance when comparing to obese (BMI 30–40) and morbid obese (BMI 40–50) groups [47]. Thus, there may be a yet undefined threshold at which patients consistently assume greater risk for adverse event following shoulder arthroplasty.

Limitations of Available Research

The literature regarding obesity and rTSA is early in study and at times heterogenous. The relatively smaller case series tended to find comparable complication rates and favorable outcomes regarding obese patients. Larger database studies and meta-analyses do identify that obesity can be associated with greater infection rates and medical complications but often do not separate out their patient cohorts by type of shoulder arthroplasty performed. Thus, their results may not completely represent findings specific to rTSA. Discrepancy between large databases is present and may be due to inconsistencies in coding [50]. Hip arthroscopy large database investigations have found greater incidence of femoral neck fractures, hip dislocation, re-operation, and revision to total hip arthroplasty compared to original research [51]. The finding is partially explained by the surgical learning curve, as experts tend to publish original research and large databases capture all surgeons regardless of surgical volume [52]. Similar phenomena may be present within rTSA literature. Available studies are also limited in their follow-up with only a small number following patients beyond 3 years postoperatively. BMI in literature has become synonymous with obesity, however is not a true representation of body fat nor is the manner in which this is considered across studies consistent, with different cutoffs considered relevant between studies. These factors limit definitive conclusions that can be drawn about which patients are considered in the "obese" category and what complications, if any, they may be at higher risk of experiencing.

Conclusions

As obesity rates continue to increase, demand for orthopedic procedures in this population will grow. Obesity is correlated with other medical comorbidities. Obese patients undergoing rTSA have been shown in large database studies to have higher risks specifically for infection, revision, and medical complications; however, this has not been consistently demonstrated in the single surgeon series where, more often, no difference in these metrics has been found. Outcomes measures and satisfaction are reliably improved, even when considering superobese patients, and majority of studies find their improvements and absolute values to be in line with their normal weight counterparts. Thus, rTSA does not seem to carry the same level of adverse risk associated with lower joint arthroplasty but potential for higher risk still bears consideration when counseling obese patients. Attention to factors that may negatively affect prosthesis positioning may optimize retention rates and limit early failure.

Declarations

Conflict of Interest Emily Monroe, Richard Hardy, and James Holmquist declare that they have no conflict of interest. Jefferson Brand is Assistant Editor-in-Chief of Arthroscopy Journal as employee of Arthroscopy Association of North America.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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