JB&JS OPEN ACCESS

The Influence of Obesity on Outcomes Following Arthroscopic Rotator Cuff Repair

A Systematic Review and Meta-Analysis of 118,331 Patients Internationally

Alexis B. Sandler, MD, Clare K. Green, BS, John P. Scanaliato, MD, Austin B. Fares, MD, John C. Dunn, MD, and Nata Parnes, MD

Background: Given the rising prevalence of obesity, the number of patients with obesity undergoing arthroscopic rotator cuff repair (RCR) will likely increase; however, there have been mixed results in the existing literature with regard to the effect of elevated body mass index (BMI) on functional outcomes and complications.

Methods: The patient-reported outcome measures included the visual analog scale (VAS) pain score, the American Shoulder and Elbow Surgeons (ASES) score, range of motion, and adverse events.

Results: Fourteen studies (118,331 patients) were included. There were significant decreases in VAS pain scores for both patients with obesity (mean difference, −3.8 [95% confidence interval (CI), −3.9 to −3.7]; $p < 0.001$) and patients without obesity (mean difference, −3.2 [95% CI, −3.3 to −3.1]; $p < 0.001$). There were also significant increases in ASES scores for both patients with obesity (mean difference, 24.3 [95% CI, 22.5 to 26.1]; $p < 0.001$) and patients without obesity (mean difference, 24.3 [95% CI, 21.4 to 26.0]; $p < 0.001$). There were also significant increases in ASES scores for both patients with obesity (mean difference, 24.3 [95% CI, 22.5 to 26.1]; $p < 0.001$) and patients without obesity (mean difference, 24.3 [95% CI, 21.4 to 26.0]; $p < 0.001$). However, there were no significant differences in final VAS pain scores, ASES scores, or range of motion between the groups. The mean rates of complications were higher among patients with obesity (1.2% ± 1.7%) than among patients without obesity (0.59% ± 0.11%) ($p < 0.0001$), and the mean rates of postoperative admissions were also higher among patients with obesity (5.9%) than patients without obesity (3.7%) ($p < 0.0001$). Although the mean rates of reoperation were similar between groups (5.2% ± 2.8% compared with 5.2% ± 4.2%), the meta-analysis revealed lower odds of reoperation in patients without obesity (odds ratio [OR], 0.76 [95% CI, 0.71 to 0.82]).

Conclusions: No significant or clinically important differences in postoperative pain, ASES scores, or range of motion were found between patients with and without obesity following arthroscopic RCR. However, populations with obesity had higher rates of complications, postoperative admissions, and reoperation following arthroscopic RCR.

Level of Evidence: Prognostic Level II. See Instructions for Authors for a complete description of levels of evidence.

Rotator cuff tears comprise a substantial proportion of shoulder pathology worldwide: according to studies from the United Kingdom, the United States, and Japan, rotator cuff tears are present in up to 20% of the general population, with increasing prevalence among geriatric patients, reportedly as high as 70% in those ≥80 years of age[1-5]. Arthroscopic rotator cuff repair (RCR) is currently considered the gold standard for surgical management of symptomatic tears warranting operative management and has been shown to consistently produce excellent functional outcomes[6-8].

Internationally, the prevalence of obesity continues to increase. The World Health Organization has estimated that, in 2016, >1.9 billion adults (39% of men and 40% of women) met the criteria for being overweight, with >650 million (11% of men and 15% of women) meeting the criteria for being obese, rates that have tripled since 1975[9]. Although many chronic diseases and comorbidities arise from obesity, the effect of obesity on the musculoskeletal system is an increasingly recognized manifestation of the disease[10,11], and obesity is known to be an independent risk factor for the occurrence and severity of rotator cuff pathology[12]. Obesity is known to increase

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A620).

complication rates following shoulder, hip, and knee arthroplasty[13-17], but the effects of obesity on outcomes following arthroscopic RCR have been less clearly elucidated. Several studies investigating arthroscopic RCR internationally have demonstrated no significant differences in patient-reported outcome scores between patients with a body mass index (BMI) of ≥30 kg/m^2 compared with patients with a BMI of <30 kg/m^2, whereas other studies have found patients with obesity to have inferior functional outcomes and increased complication rates[12,18-22].

Given the high burden of rotator cuff tears and the growing prevalence of obesity, as well as predicted increases in arthroscopic RCRs among an aging population, it is important that physicians understand the impact of elevated BMI on outcomes following arthroscopic RCR. The purpose of this study was to compare short-term outcomes after arthroscopic RCR in patients with and without obesity from the existing literature worldwide. We hypothesized that patients with a BMI of ≥30 kg/m^2 will have comparable patient-reported outcome scores, but will experience higher rates of complications following arthroscopic RCR compared with patients without obesity.

Materials and Methods

Search Strategy and Study Selection

The systematic review and meta-analysis were performed on the basis of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

An unfiltered search of Embase and PubMed (MEDLINE) databases was conducted on July 24, 2022, with the following search terms: "(((rotator cuff) OR (shoulder) OR (rotator cuff tear arthropathy) OR (rotator cuff injur*) OR (massive rotator cuff tear) OR (cuff tear)) AND ((arthroscop*) OR (ARCR) OR (arthroscopic rotator cuff repair*) OR (arthroscopic partial repair*) OR (shoulder arthroscopy)) AND ((body mass index) OR (overweight) OR (BMI) OR (obesity) OR (weight)))." Three investigators (1 of the authors of this study [A.B.S.] and 2 non-authors [J.A.D. and W.H.D.]) independently screened abstracts and performed full-text review. The inclusion criteria for screening selected studies were studies that discussed adults who were ≥18 years of age and underwent arthroscopic RCR; showed functional outcomes, range of motion, and/or adverse events; and had comparator groups defined on the basis of the BMI classification that permitted separating patients with and without obesity. Studies with a minimal follow-up time of at least 6 months were eligible for inclusion in the calculations of functional outcomes, whereas there were no requirements for minimal follow-up time in the assessment of postoperative complications. Exclusion criteria disqualified studies that discussed open or mini-open RCR or the use of additional postoperative treatments after arthroscopic RCR (such as platelet-rich plasma injections) that could serve as confounders. The Methodological Index for Non-Randomized Studies (MINORS) criteria, manually assessed by 1 author (A.B.S.), were used for quality assessment[23].

Data Collection and Analysis

Data collection and extraction were performed independently by 3 investigators (1 of the authors of this study [A.B.S.] and 2 non-authors [J.A.D., and W.H.D.]), with discrepancies assessed and resolution determined by the most senior investigator (A.B.S.). In accordance with the World Health Organization guidelines[9], patients with obesity were defined as those with a BMI of ≥30 kg/m^2, whereas patients without obesity were defined as those with a BMI of <30 kg/m^2. Patients were defined as overweight if they had a BMI of ≥25 kg/m^2 but <30 kg/m^2. Data with regard to functional outcomes, range of motion, and adverse events were collected and pooled for analysis. Functional outcomes included the visual analog scale (VAS) pain score, reported in 3 studies[19,21,24], and American Shoulder and Elbow Surgeons Standardized Shoulder Assessment (ASES) score, reported in 4 studies[19-21,24]. Range-of-motion measures included forward elevation and external rotation.

Statistical Analysis

Two-tailed t tests were used to evaluate significant changes between means based on the calculations of weighted means with standard deviations. Studies that did not report a specific outcome of interest were excluded from the analysis of that outcome. Minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient acceptable symptom state (PASS) values for VAS pain and ASES scores were obtained from the existing literature[25,26]. The rates of achieving MCID, SCB, and PASS thresholds were assessed at the study level rather than at the patient level. For assessing adverse events with meta-analysis, odds ratios (ORs) of events were determined and p values for the I^2 and Cochran Q statistics were used to assess between-study heterogeneity and variance. The Mantel-Haenszel method with a random effects model was used in the meta-analysis of adverse events, given that all adverse event variables were considered dichotomous. Significance was set at $p \leq 0.05$. Review Manager software (version 5; Nordic Cochrane Centre, The Cochrane Collaboration) was used for analysis and forest plot generation.

Source of Funding

There was no source of funding for this study.

Results

In total, 1,313 abstracts were screened, 66 studies were reviewed, and 14 studies with Level-II to IV evidence (118,331 patients) were determined eligible for inclusion (Fig. 1). BMI distributions are presented in Table I. In total, 56.4% (66,716) of the patients were male, and the mean age (and standard deviation) of 3,300 patients between studies was 59.2 ± 2.29 years (range of means, 57 to 66 years). On average, patients with obesity were younger (49.4 years) than patients without obesity (60.5 years). Using weighted means, diabetes was a known risk factor in 22.5% (26,343 patients [omitting the patients from the studies by Chalmers et al.[27] and Audigé et al.[28]]), and tobacco use was a known risk factor in 15.5%

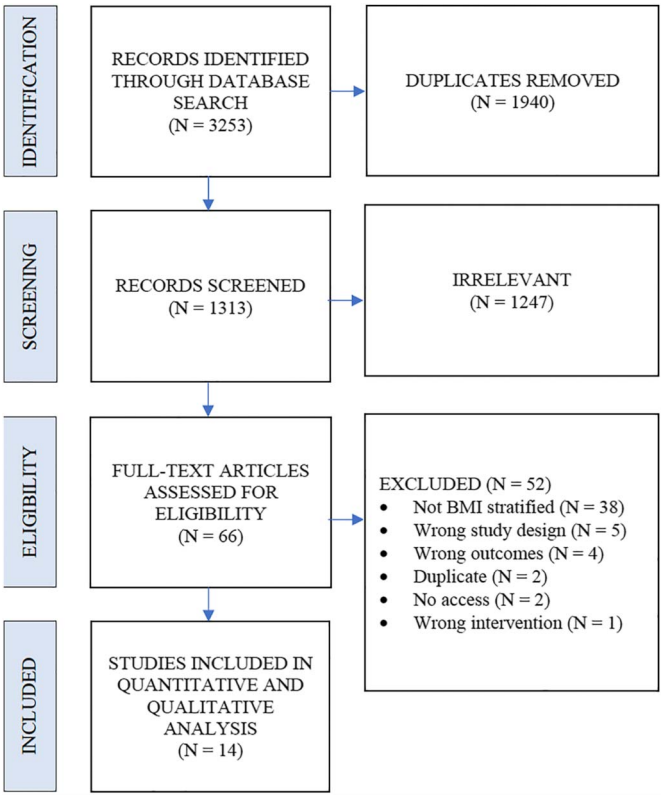

Fig. 1
PRISMA flow diagram.

(15,901 patients [omitting the patients from the studies by McGlone et al.[29] and Fares et al.[21]]).

Pain

Among patients without obesity, VAS pain scores decreased from 5.6 preoperatively to 2.4 postoperatively (mean difference, −3.2 [95% confidence interval (CI), −3.3 to −3.1]; $p < 0.001$), whereas, among patients with obesity, VAS pain scores decreased from 6.2 preoperatively to 2.4 postoperatively (mean difference, −3.8 [95% CI, −3.9 to −3.7]; $p < 0.001$) (Table II). There were no significant differences ($p = 1.000$) between the final VAS pain scores in patients without obesity (2.4 ± 0.5) and patients with obesity (2.4 ± 0.4). All mean improvements in VAS pain scores within studies met the MCID and SCB thresholds, whereas only 6.2% met the PASS threshold in both groups.

ASES Score

Similarly, ASES scores increased significantly among both patients with obesity (mean difference, 23.7 [95% CI, 22.5 to 26.1]; $p < 0.001$) and patients without obesity (mean difference, 24.3 [95% CI, 21.4 to 26.0]; $p < 0.001$), and there were no significant differences between the final ASES scores ($p = 0.434$). Although all studies showed mean ASES changes that met the MCID and SCB thresholds, on average, only 9.5% of the patients with obesity and 18.8% of the patients without obesity ultimately reached the PASS threshold (Table II).

Range of Motion

Among patients without obesity, forward elevation increased from 129.6° ± 12.0° to 139.8° ± 5.2° (569 patients), whereas, among patients without obesity, forward elevation increased from 123.6° ± 20.3° to 138.6° ± 7.8° (296 patients) (Table III). Although there were significant differences between the initial and final forward elevation measurements in patients with and without obesity ($p < 0.001$ for both), the mean difference between final postoperative measurements was only 1.2° ($p = 0.008$). External rotation decreased by 2.0° among patients without obesity (47.0° ± 12.9° to 45.1° ± 7.2° [569 patients]), whereas it started significantly lower in the patients with obesity ($p < 0.001$) but increased 2.3° following the surgical procedure (42.2° ± 12.1° to 44.5° ± 8.0° [296 patients]; $p = 0.128$). There was no significant difference between final external rotation values ($p = 0.264$).

Adverse Events

Specific complications and corresponding rates are presented in Table IV as well as in the corresponding forest plots in Figure 2. Patients with obesity, when compared with patients without obesity, had higher mean rates of complications (1.2% compared with 0.59%) and postoperative admissions (5.9% compared with 3.7%). Although the simple mean rates of reoperation were similar between patients without and with obesity when pooled from all studies included in the systematic review (5.2% ± 2.8% [2,046 of 39,115] compared with 5.2% ± 4.2% [1,089 of 21,053]), meta-analysis of the comparative studies revealed that the adjusted odds of reoperation were significantly lower in the patients without obesity (OR, 0.76 [95% CI, 0.71 to 0.82]). There were significantly higher complication rates, postoperative admission rates, and reoperation rates among patients with obesity (Fig. 2).

Discussion

Despite an increasing prevalence of obesity worldwide, the effect of elevated BMI on outcomes following surgical management of rotator cuff pathology remains controversial. The present study demonstrates that the existing orthopaedic literature is frequently heterogenous in data reporting, with only occasional stratification of outcomes by BMI categories. Despite these challenges, the results of the present study suggest that there are no significant or clinically important differences in postoperative pain, ASES scores, or range of motion between patients with and without obesity after arthroscopic RCR; however, our findings indicate that patients with obesity have higher rates of complications and postoperative admissions as well as slightly higher rates of reoperation following arthroscopic RCR. Further research will be critical in comparing outcomes between different levels and classes of obesity to further clarify the degree to which body weight and BMI classes affect postoperative outcomes after arthroscopic RCR.

The etiology of rotator cuff tears is especially complex among patients with obesity. Although obesity has been identified as a key modifiable risk factor that impacts both the occurrence and severity of rotator cuff tears[12,20,30], the effects of

JBJS Open Access • 2024:e23.00047.

TABLE I BMI Distributions*

Study	LOE	Follow-up† *(mo)*	MINORS Score	BMI in kg/m²†			
				<18.5	18.5 to <25	25 to <30	≥30
Warrender[20] (2011)	III	Without obesity: 15.3 ± 3.7, with obesity: 16.7 ± 4.3	17 of 24	56	—§	34	59
Berglund[24] (2018)	III	12#	15 of 24	427	—**	—**	200
Chalmers[27] (2018)	IV	14.4	12 of 16	21	—§	35	29
Heyer[41] (2018)	IV	1#	9 of 16	3,755	—§	7,643	9,745
Kessler[19] (2018)	III	36#	19 of 24	3	43	84	93
Audigé[28] (2021)	III	6#	16 of 24	564	—§	766	—††
O'Donnell[40] (2020)	IV	NR; assessed primary RCRs that required revision	9 of 16	29,477	—**	—**	11,990
Daumillare[42] (2023)	IV	12.3 ± 3.6	12 of 16	72	—**	—**	18
Gagnier[45] (2021)	II	6# (range, 6 to 60)	22 of 24	122	—§	225	221
Kashanchi[43] (2021)	IV	1#	16 of 24	9,548	—**	—**	8,973
McGlone[29] (2021)	III	NR; assessed postoperative admission	16 of 24	67	2,652	5,762	7,365
Fares[21] (2022)	III	Without obesity: 52.4 ± 10.2, with obesity: 47.9 ± 21.2	19 of 24	52	—§	37	—††
Gambhir[46] (2022)	III	28 ± 9	19 of 24	86	—§	127	100
Plantz[47] (2022)	IV	1#	16 of 24	167	2,714	6,341	8,658

*LOE = Level of Evidence, and NR = not reported. †In total, of 33,949 patients, 237 (0.7%) had a BMI of <18.5 kg/m² and 33,712 (99.3%) had a BMI of ≥18.5 kg/m²; of 57,626 patients, 10,302 (17.9%) had a BMI of <25 kg/m² and 47,324 (82.1%) had a BMI of ≥25 kg/m²; and of 117,001 patients, 69,513 (59.4%) had a BMI of <30 kg/m² and 47,488 (40.6%) had a BMI of ≥30 kg/m². ‡Of note, a minimal follow-up time of at least 6 months was needed to be eligible for inclusion in calculations of functional outcomes, whereas there were no requirements for minimal follow-up time in the assessment of postoperative complications. The values are given as the mean with or without the standard deviation or the range in parentheses. §This study combined patients with BMIs of <18.5 and 18.5 to <25 kg/m². #This is the minimal follow-up time required; no mean was reported. **This study combined patients with BMIs of <18.5, 18.5 to <25, and 25 to <30 kg/m². ††This study combined patients with BMIs of 25 to <30 and ≥30 kg/m².

obesity on tendon structure are complex and not yet fully understood, although they are likely related to peripheral vascular deficiencies secondary to increased production of adipokines leading to increased oxidative stress, cellular apoptosis, and the subsequent intracellular release of pro-inflammatory molecules[12,31,32]. Additionally, associations with diabetes, atherosclerosis, hypertension, hyperlipidemia, and metabolic syndrome likely contribute to both relative hypoxia and increased tendinous inflammation in these populations[12,31]. Furthermore, rat models demonstrate that obesity impairs enthesis healing following RCR, leading to inferior biomechanical and histological outcomes[33].

Despite the acknowledgment of pathophysiological risk factors, the results of clinical studies with regard to the degree to which elevated BMI affects outcomes after arthroscopic RCR remain controversial[19-21]. In their retrospective comparative study, Fares et al.[21] reported no differences in postoperative outcomes among normal-weight patients without obesity compared with patients with severe obesity (BMI, ≥40 kg/m²); however, in a related study, Parnes et al.[22] described greater improvements in VAS pain scores and internal rotation as well as shorter operative times and fewer comorbidities among normal-weight patients compared with patients with non-severe obesity (BMI, 30 to 39.9 kg/m²). Fermont et al. reported the absence of obesity to be a favorable prognostic factor following arthroscopic RCR[34], and Kluczynski et al. found obesity to be associated with inferior clinical outcome scores and an extended hospital stay following RCR in their analysis of outcomes after ambulatory shoulder surgery, albeit with only 2 included studies in which the authors reported on arthroscopic RCR[35]. The findings of the present study indicate that patients with obesity have comparable VAS pain and ASES scores with those of patients without obesity, suggesting that patients with obesity may achieve noninferior clinical outcomes following arthroscopic RCR compared with patients without obesity.

Despite the promising functional outcomes observed in the present analysis, the presence of obesity was associated with higher rates of complications and postoperative admissions. Patients with elevated BMI are known to be more medically complex with regard to perioperative management[36], aligning with high rates of comorbid conditions that increase the risk of perioperative and postoperative complications in the present study, including diabetes mellitus (22.5%), hypercholesterolemia (52.8%), and tobacco use (15.5%), among patients with

JBJS Open Access • 2024:e23.00047.

TABLE II VAS Pain and ASES Scores*

Outcome and Study	BMI < 30 kg/m²						BMI ≥ 30 kg/m²					
	No. of Patients	Preop. Score	Postop. Score	MCID Met	SCB Met	PASS Met	No. of Patients	Preop. Score	Postop. Score	MCID Met	SCB Met	PASS Met
VAS pain†												
Berglund[24] (2018)	427	5.4	2.5	Y	Y	N	200	6.1	2.3	Y	Y	N
Kessler[19] (2018)	130	5.5	2.8	Y	Y	N	93	5.7	2.8	Y	Y	N
Fares[21] (2022)	37	8.3	0.6	Y	Y	Y	37	7.9	1.5	Y	Y	Y
Total or weighted mean ± SD	594	5.6 ± 0.70	2.4 ± 0.49	100%	100%	6.2%	330	6.2 ± 0.63	2.4 ± 0.38	100%	100%	6.2%
ASES†												
Warrender[20] (2011)	90	52.0	90.0	Y	Y	Y	59	50.0	81.0	Y	Y	N
Berglund[24] (2018)	427	22.9	41.9	Y	Y	N	200	22.0	39.4	Y	Y	N
Kessler[19] (2018)	130	47.9	72.2	Y	Y	N	93	46.4	70.4	Y	Y	N
Fares[21] (2022)	37	42.8	96.1	Y	Y	Y	37	44.6	89.6	Y	Y	Y
Total or weighted mean ± SD	684	32.6 ± 12.6	56.9 ± 20.3	100%	100%	18.6%	389	34.2 ± 12.7	57.9 ± 19.8	100%	100%	9.5%

*Y = yes, N = no, and SD = standard deviation. The threshold being met in a study means that the mean measurement of the study's participants met the threshold rather than an individual patient on the patient level met the threshold. †The VAS pain score thresholds for RCR are 1.5 for the MCID, 2.5 for SCB, and 1.7 for the PASS. ‡The ASES score thresholds for RCR are 11.1 for the MCID, 17.5 for SCB, and 86.7 for the PASS.

obesity. Additionally, arthroscopic RCR is generally performed on an outpatient basis; however, it has been reported that up to one-quarter of patients considered ineligible for an ambulatory procedure are deemed ineligible because of obesity[37]. The higher rates of complications and postoperative admissions observed in the present study highlight the importance of considering obesity and related comorbidities when evaluating a patient's candidacy for outpatient procedures, as many ambulatory centers may not be equipped to handle higher-risk patients. Furthermore, studies of costs associated with total shoulder arthroplasty have demonstrated sizeable discrepancies associated with treating patients with obesity, totaling thousands of dollars[38,39]; however, these differences are infrequently described in existing arthroscopic RCR literature and will require further research to define specific associated costs.

Although simple mean rates of reoperation were similar between patients with and without obesity in the studies included in the systematic review, the meta-analysis demonstrated significantly higher rates of reoperation among patients with obesity; however, the difference in reoperation rates between the 2 populations was <1% and likely was skewed by the presence of large database studies. The discrepancy between the systematic review and the meta-analysis may suggest that reoperation rate differences likely are small and do not contribute as much to the higher rates of pooled adverse events as other outcomes. Nevertheless, these results highlight the importance of disclosing potentially higher risk of adverse events or reoperation in patients with obesity, especially with higher rates of revision noted among patients with other comorbidities such as diabetes mellitus, tobacco use, and osteoporosis[40].

The present study had notable major limitations, which primarily stemmed from the nature of a systematic review with regard to heterogeneity among the inclusion and exclusion criteria in individual studies, disparate data

TABLE III Range of Motion

	BMI < 30 kg/m²				BMI ≥ 30 kg/m²				P Value Comparing Final Postop. Measurements
	No. of Patients	Preop. Measurement*	Postop. Measurement*	P Value	No. of Patients	Preop. Measurement*	Postop. Measurement*	P Value	
Forward elevation	569	129.6° ± 13.0°	139.8° ± 5.3°	<0.001	296	123.6° ± 20.3°	138.6° ± 7.8°	<0.001	0.008
External rotation	569	47.0° ± 12.9°	45.1° ± 7.2°	0.002	93	42.2° ± 12.1°	44.5° ± 8.0°	0.128	0.264

*The values are given as the mean and the standard deviation.

TABLE IV Complications, Admissions, and Reoperations*

	BMI < 30 kg/m^2				BMI ≥ 30 kg/m^2			
Study	No. of Patients	Complications	Admissions	Reoperations	No. of Patients	Complications	Admissions	Reoperations
Warrender[20] (2011)	90	0	0	5 (5.6%) retears	90	1 (1.1%) superficial skin infection that resolved with oral antibiotics	23 (25.6%) monitor sleep apnea	5 (5.6%) retears
Heyer[41] (2018)	11,398	58 (0.5%); NS: cardiac (MI, cardiac arrest), wound (deep SSI, superficial SSI, organ and/or space SSI, wound disruption), renal (progressive renal insufficiency, acute renal failure), pulmonary (unplanned intubation, ventilator >48 hr, VTE)	NR	NR	9,745	89 (0.9%); NS: cardiac (MI, cardiac arrest), wound (deep SSI, superficial SSI, organ/space SSI, wound disruption), renal (progressive renal insufficiency, acute renal failure), pulmonary (unplanned intubation, ventilator >48 hr, VTE)	NR	NR
Kessler[19] (2018)	130	8 (6.2%); NS: return to ED for pain, dizziness, difficulty with urination, or superficial infection	5 (3.8%); NS	NR	93	5 (5.4%); NS: return to ED for pain, dizziness, difficulty with urination, or superficial infection	15 (16.1%); NS: 10 admitted preop., 3 UTI, 2 deoxygenation	NR
O'Donnell[40] (2020)	29,477	NR	NR	2,018 (6.8%)	11,990	NR	NR	1,054 (8.8%)
Daumillare[42] (2023)	72	22 (30.5%) retear (Sugaya 4-5)	NR	NR	18	10 (55.6%) retear (Sugaya 4-5)	NR	NR
Kashanchi[43] (2021)	9,548	67 (0.7%): VTE (24), UTI (12), pulmonary (9), SSI (9), cardiac arrest and/or MI (6), sepsis (6), wound dehiscence (1)	42 (0.4%)	23 (0.2%)	8,973	125 (1.4%): VTE (34), pulmonary (27), UTI (20), cardiac arrest/ MI (16), SSI (14), renal (7), sepsis (6), wound dehiscence (1)	55 (0.6%)	30 (0.3%)
McGlone[29] (2021)	8,481	NR	640 (7.5%)	NR	7,365	NR	891 (12.0%)	NR
Weighted mean ± SD	59,196	0.73% ± 1.8% (155 of 21,238)	3.8% ± 3.5% (687 of 18,249)	5.2% ± 2.8% (2,046 of 39,115)	38,274	1.2% ± 1.7% (230 of 18,919)	5.9% ± 5.9% (974 of 16,521)	5.2% ± 4.2% (1,089 of 21,053)

*NS = not specified, MI = myocardial infarction, SSI = surgical site infection, VTE = venous thromboembolism, NR = not reported, ED = emergency department, UTI = urinary tract infection, and SD = standard deviation.

collected between studies, and discrepancies in reporting between studies. Few studies successfully controlled for confounding variables such as tobacco use and the presence of diabetes mellitus in gauging outcomes, although certain studies excluded active tobacco users and others performed comparative analyses to assess differences in outcomes[19,20,29,40-43]. Shorter follow-up times may have resulted in artificially low rates of MCID, SCB, and PASS achievement. A limited number of studies showed comparative outcomes in patients with different weight classifications, so not all studies included in the systematic review were eligible for meta-analysis. Additionally, the pooled nature of the data reported by the studies prohibited the assessment of outcomes on an individualized patient basis. Unfortunately, there is a major disparity in the existing literature with respect to reporting outcomes by BMI class[44], with many studies classifying patients as with or without obesity, limiting the differentiation of patients without obesity who are classified as overweight from those classified as not overweight. Furthermore, the presence of several large database studies that met the inclusion criteria but dominated the available patient populations in the meta-analysis may have further skewed the data, given the potential for studies referencing large databases to statistically overwhelm smaller analyses and the potential for patient overlap between databases. Despite major heterogeneity among the included studies, however, we elected to include these studies to fully assess the existing literature in an attempt to better reflect the current understanding of how the presence of obesity impacts outcomes after arthroscopic RCR in a time where understanding these differences is increasingly critical to providing individualized patient care.

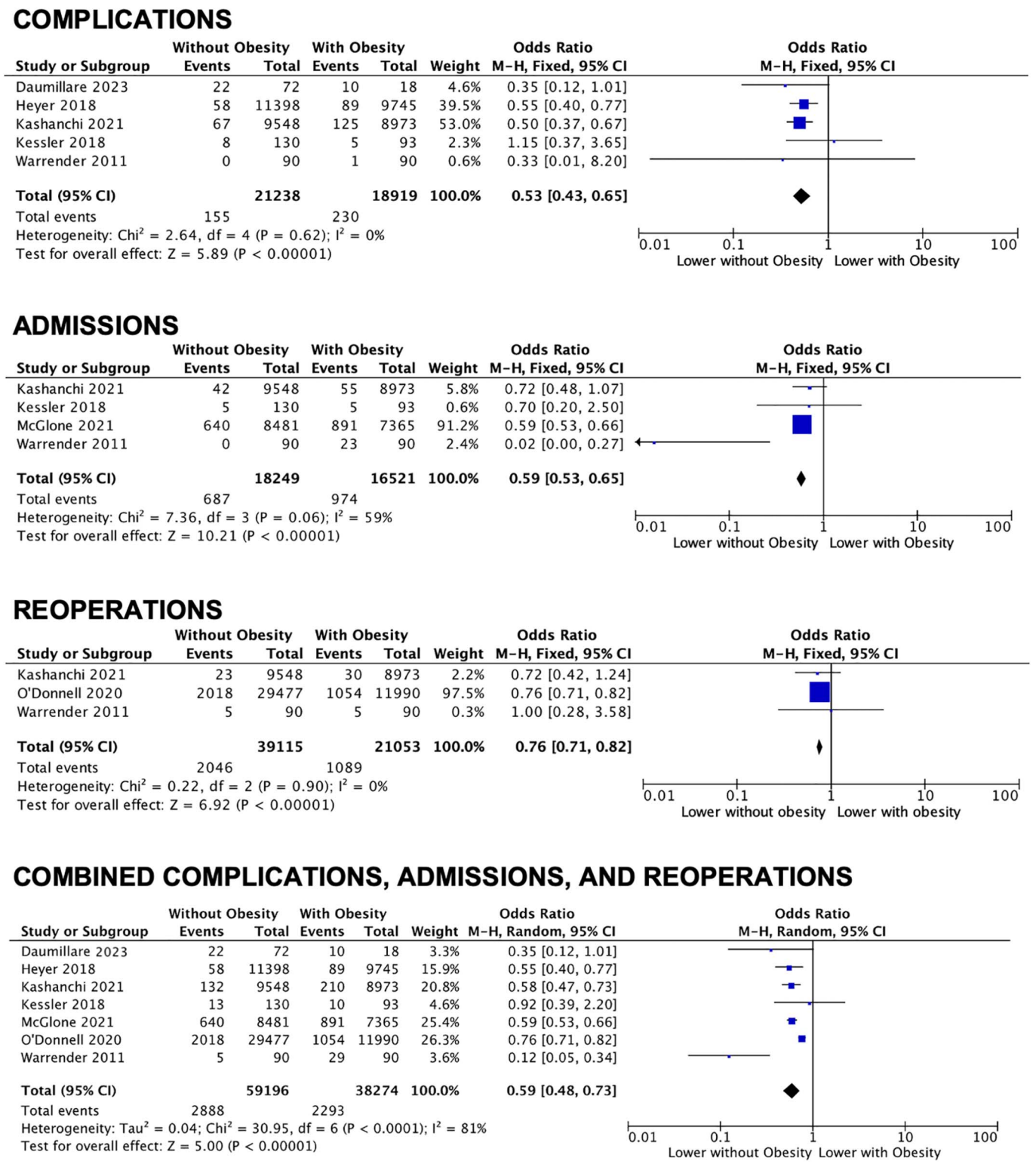

Fig. 2

Forest plots for complications, admissions, and reoperations. M-H = Mantel-Haenszel, and df = degrees of freedom.

In conclusion, the results of this meta-analysis based on a systematic review of >100,000 patients suggest that there are no significant or clinically important differences in postoperative pain, ASES scores, or range of motion between patients with and without obesity following arthroscopic RCR. However, the findings of this study

indicate that populations with obesity have higher rates of complications, postoperative admissions, and reoperation following arthroscopic RCR compared with patients without obesity. ■

NOTE: The authors acknowledge Jake A. DiPasquale, MS, and William H. Davis, PharmD, for their participation in the formulation of this work.

Alexis B. Sandler, MD[1,2]
Clare K. Green, BS[3]
John P. Scanaliato, MD[4]
Austin B. Fares, MD[1,2]
John C. Dunn, MD[1,2]
Nata Parnes, MD[5,6]

[1]Department of Orthopaedic Surgery, William Beaumont Army Medical Center, El Paso County, Texas

[2]Department of Orthopaedic Surgery, Texas Tech University Health Sciences Center, Lubbock, Texas

[3]School of Medicine and Health Sciences, The George Washington University, Washington, DC

[4]Midwest Orthopaedics at Rush University Medical Center, Chicago, Illinois

[5]Department of Orthopaedic Surgery, Carthage Area Hospital, Carthage, New York

[6]Department of Orthopaedic Surgery, Claxton-Hepburn Medical Center, Ogdensburg, New York

Email for corresponding author: ckgreen@gwu.edu

References

1. MacDermid JC, Bryant D, Holtby R, Razmjou H, Faber K, Balyk R, Boorman R, Sheps D, McCormack R, Athwal G, Hollinshead R, Lo I, Bicknell R, Mohtadi N, Bouliane M, Glasgow D, Lebel ME, Lalani A, Moola FO, Litchfield R, Moro J, MacDonald P, Bergman JW, Bury J, Drosdowech D; JOINTS Canada. Arthroscopic versus mini-open rotator cuff repair: a randomized trial and meta-analysis. Am J Sports Med. 2021 Oct;49(12):3184-95.

2. Littlewood C, May S, Walters S. Epidemiology of rotator cuff tendinopathy: a systematic review. Shoulder Elbow. 2013;5(4):256-65.

3. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, Shitara H, Kobayashi T. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg. 2010 Jan;19(1):116-20.

4. Hinsley H, Ganderton C, Arden NK, Carr AJ. Prevalence of rotator cuff tendon tears and symptoms in a Chingford general population cohort, and the resultant impact on UK health services: a cross-sectional observational study. BMJ Open. 2022 Sep 13;12(9):e059175.

5. Minagawa H, Yamamoto N, Abe H, Fukuda M, Seki N, Kikuchi K, Kijima H, Itoi E. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: from mass-screening in one village. J Orthop. 2013 Feb 26;10(1):8-12.

6. Davey MS, Hurley ET, Carroll PJ, Galbraith JG, Shannon F, Kaar K, Mullett H. Arthroscopic rotator cuff repair results in improved clinical outcomes and low revision rates at 10-year follow-up: a systematic review. Arthroscopy. 2023 Feb;39(2):452-8.

7. Green CK, Scanaliato JP, Dunn JC, Rosner RS, Parnes N. Rates of return to manual labor after arthroscopic rotator cuff repair. Am J Sports Med. 2022 Jul;50(8):2227-33.

8. Plachel F, Jo OI, Rüttershoff K, Andronic O, Ernstbrunner L. A systematic review of long-term clinical and radiological outcomes of arthroscopic and open/mini-open rotator cuff repairs. Am J Sports Med. 2023 Jun;51(7):1904-13.

9. World Health Organization. Obesity and overweight. 2021 Jun 9. Accessed 2023 Jun 12. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

10. Gregg EW, Shaw JE. Global health effects of overweight and obesity. N Engl J Med. 2017 Jul 6;377(1):80-1.

11. Anandacoomarasamy A, Fransen M, March L. Obesity and the musculoskeletal system. Curr Opin Rheumatol. 2009 Jan;21(1):71-7.

12. Gumina S, Candela V, Passaretti D, Latino G, Venditto T, Mariani L, Santilli V. The association between body fat and rotator cuff tear: the influence on rotator cuff tear sizes. J Shoulder Elbow Surg. 2014 Nov;23(11):1669-74.

13. Rodriguez-Merchan EC, Delgado-Martinez AD. Risk factors for periprosthetic joint infection after primary total knee arthroplasty. J Clin Med. 2022 Oct 18;11(20):6128.

14. Gurunathan U, Barras M, McDougall C, Nandurkar H, Eley V. Obesity and the risk of venous thromboembolism after major lower limb orthopaedic surgery: a literature review. Thromb Haemost. 2022 Dec;122(12):1969-79.

15. Walocha D, Bogdan P, Gordon AM, Magruder ML, Conway CA, Razi AE, Choueka J. Risk factors for the development of a peri-prosthetic joint infection up to 2 years following primary reverse shoulder arthroplasty. J Orthop. 2022 Nov 9;35:69-73.

16. Jan K, Dadhania A, Foy M, Sood A, Gonzalez M. Risk factors for wound complication following primary total hip arthroplasty. J Surg Orthop Adv. 2022 Winter;31(4):242-7.

17. De Oliveira GS Jr, McCarthy RJ, Davignon K, Chen H, Panaro H, Cioffi WG. Predictors of 30-day pulmonary complications after outpatient surgery: relative importance of body mass index weight classifications in risk assessment. J Am Coll Surg. 2017 Aug;225(2):312-323.e7.

18. Ateschrang A, Eggensperger F, Ahrend MD, Schröter S, Stöckle U, Kraus TM. Obesity causes poorer clinical results and higher re-tear rates in rotator cuff repair. Arch Orthop Trauma Surg. 2018 Jun;138(6):835-42.

19. Kessler KE, Robbins CB, Bedi A, Carpenter JE, Gagnier JJ, Miller BS. Does increased body mass index influence outcomes after rotator cuff repair? Arthroscopy. 2018 Mar;34(3):754-61.

20. Warrender WJ, Brown OL, Abboud JA. Outcomes of arthroscopic rotator cuff repairs in obese patients. J Shoulder Elbow Surg. 2011 Sep;20(6):961-7.

21. Fares AB, Scanaliato JP, Gavalas A, Dunn JC, Czajkowski H, Parnes N. Severe obesity is not associated with worse functional outcomes following arthroscopic rotator cuff repair. Arthroscopy. 2022 Sep;38(9):2602-8.

22. Parnes N, Scanaliato J, Dunn J, Fink W, Sandler A, Fares A. Obesity negatively affects outcomes following arthroscopic rotator cuff repair at four-year follow-up. Shoulder & Elbow. 2022 Apr 24.

23. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological Index for Non-Randomized Studies (MINORS): development and validation of a new instrument. ANZ J Surg. 2003 Sep;73(9):712-6.

24. Berglund DD, Kurowicki J, Giveans MR, Horn B, Levy JC. Comorbidity effect on speed of recovery after arthroscopic rotator cuff repair. JSES Open Access. 2018 Jan 8;2(1):60-8.

25. Cvetanovich GL, Gowd AK, Liu JN, Nwachukwu BU, Cabarcas BC, Cole BJ, Forsythe B, Romeo AA, Verma NN. Establishing clinically significant outcome after arthroscopic rotator cuff repair. J Shoulder Elbow Surg. 2019 May;28(5):939-48.

26. Kim DM, Kim TH, Kholinne E, Park JH, Shin MJ, Kim H, Park D, Jeon IH, Koh KH. Minimal clinically important difference, substantial clinical benefit, and patient acceptable symptomatic state after arthroscopic rotator cuff repair. Am J Sports Med. 2020 Sep;48(11):2650-9.

27. Chalmers PN, Granger E, Nelson R, Yoo M, Tashjian RZ. Factors affecting cost, outcomes, and tendon healing after arthroscopic rotator cuff repair. Arthroscopy. 2018 May;34(5):1393-400.

28. Audigé L, Aghlmandi S, Grobet C, Stojanov T, Müller AM, Felsch Q, Gleich J, Flury M, Scheibel M. Prediction of shoulder stiffness after arthroscopic rotator cuff repair. Am J Sports Med. 2021 Sep;49(11):3030-9.

29. McGlone PJ, Li LT, Bokshan SL, O'Donnell R, Owens BD. Preoperative malnutrition increases odds of hospital admission and extended length of stay following arthroscopic rotator cuff repair. Phys Sportsmed. 2021 May;49(2):236-40.

30. Macchi M, Spezia M, Elli S, Schiaffini G, Chisari E. Obesity increases the risk of tendinopathy, tendon tear and rupture, and postoperative complications: a systematic review of clinical studies. Clin Orthop Relat Res. 2020 Aug;478(8):1839-47.

31. Dandona P, Aljada A, Chaudhuri A, Mohanty P, Garg R. Metabolic syndrome: a comprehensive perspective based on interactions between obesity, diabetes, and inflammation. Circulation. 2005 Mar 22;111(11):1448-54.

32. Blevins FT, Djurasovic M, Flatow EL, Vogel KG. Biology of the rotator cuff tendon. Orthop Clin North Am. 1997 Jan;28(1):1-16.

33. Bolam SM, Park YE, Konar S, Callon KE, Workman J, Monk AP, Coleman B, Cornish J, Vickers MH, Munro JT, Musson DS. Obesity impairs enthesis healing after rotator cuff repair in a rat model. Am J Sports Med. 2021 Dec;49(14):3959-69.

34. Fermont AJM, Wolterbeek N, Wessel RN, Baeyens JP, de Bie RA. Prognostic factors for successful recovery after arthroscopic rotator cuff repair: a systematic literature review. J Orthop Sports Phys Ther. 2014 Mar;44(3):153-63.

35. Kluczynski MA, Bisson LJ, Marzo JM. Does body mass index affect outcomes of ambulatory knee and shoulder surgery? Arthroscopy. 2014 Jul;30(7):856-65.

36. Bazurro S, Ball L, Pelosi P. Perioperative management of obese patient. Curr Opin Crit Care. 2018 Dec;24(6):560-7.

37. Siow M, Cuff G, Popovic J, Bosco J. An evaluation of patient risk factors to determine eligibility to undergo orthopaedic surgery in a freestanding ambulatory center: a survey of 4,242 consecutive patients. Bull Hosp Joint Dis (2013). 2017 May;75(3):201-6.

38. Griffin JW, Novicoff WM, Browne JA, Brockmeier SF. Morbid obesity in total shoulder arthroplasty: risk, outcomes, and cost analysis. J Shoulder Elbow Surg. 2014 Oct;23(10):1444-8.

39. Burns KA, Robbins LM, LeMarr AR, Fortune K, Morton DJ, Wilson ML. Modifiable risk factors increase length of stay and 90-day cost of care after shoulder arthroplasty. J Shoulder Elbow Surg. 2022 Jan;31(1):2-7.

40. O'Donnell EA, Fu MC, White AE, Taylor SA, Dines JS, Dines DM, Warren RF, Gulotta LV. The effect of patient characteristics and comorbidities on the rate of revision rotator cuff repair. Arthroscopy. 2020 Sep;36(9):2380-8.

41. Heyer JH, Kuang X, Amdur RL, Pandarinath R. Identifiable risk factors for thirty-day complications following arthroscopic rotator cuff repair. Phys Sportsmed. 2018 Feb;46(1):56-60.

42. Daumillare A, Carré R, Thouvenin Y, Chammas M, Lazerges C, Coulet B. Prospective study of 90 arthroscopic rotator cuff repairs for isolated distal supraspinatus tear, assessing the impact of cardiovascular risk factors on tendon healing. Orthop Traumatol Surg Res. 2023 Apr;109(2):103244.

43. Kashanchi KI, Nazemi AK, Komatsu DE, Wang ED. Level of obesity is directly associated with complications following arthroscopic rotator cuff repair. J Shoulder Elbow Surg. 2021 Jul;30(7):1581-7.

44. Weir CB, Jan A. BMI classification percentile and cut off points. In: StatPearls. Treasure Island: StatPearls Publishing; 2023.

45. Gagnier J, Bedi A, Carpenter J, Robbins C, Miller B. A 5-year follow-up of patients treated for full-thickness rotator cuff tears: a prospective cohort study. Orthop J Sports Med. 2021 Sep 7;9(9):23259671211021589.

46. Gambhir N, Shankar D, Alben M, Kwon Y, Rokito A, Virk MS. The effects of obesity on 1-year functional outcomes after arthroscopic rotator cuff tear repair. JSES Int. 2022 May 5;6(4):631-7.

47. Plantz MA, Wu SA, Gerlach EB, Arpey NC, Swiatek PR, Carney JJ, Tjong VK. Increased 30-day postoperative readmission and medical complication rates among patients 65 years and older following arthroscopic rotator cuff repair. Arthrosc Sports Med Rehabil. 2022 May 24;4(3):e1151-9.