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The Effect of Obesity on Distal Radius Fractures: An Analysis from the NSQIP Database

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Introduction: The rate and severity of obesity has risen over the past 40 years, and class III (formerly morbid) obesity presents additional sequelae. The effect of obesity on the incidence and recovery of hand and wrist fractures remains unclear. We sought to quantify the relationship between class III obesity and postoperative distal radius fracture (DRF) complications.

Methods: We performed a retrospective analysis of the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) database for surgical DRF patients more than 50 years old from 2015 to 2020. We then stratified patients into class III obese (BMI > 40) and compared the rates of postoperative complications to a control group with BMI less than 40.

Results: We included 10,022 patients (570 class III obese vs. 9,452 not class III obese). Patients with class III obesity had significantly increased odds of experiencing any complication (OR 1.906, $p<0.001$), adverse discharge (OR 2.618, $p<0.001$), delayed hospital stay of longer than three days (OR 1.91, $p<0.001$), and longer than seven days (OR 2.943, $p<0.001$) than controls. They also had increased odds of unplanned reoperation (OR 2.138, $p=0.026$) and readmission (OR 2.814, $p < 0.001$) than non–class III obese patients. Class III obese patients had a significantly longer average operation time (79.5 min vs. 72.2 min, $p < 0.001$). They also spent more time in the hospital postoperatively (0.86 days vs. 0.57 days, $p = 0.001$).

Conclusion: Class III obese patients undergoing DRF repair are more likely to experience postoperative complications than non–class III obese patients. *(Plast Reconstr Surg Glob Open 2023; 11:e5049; doi: 10.1097/GOX.0000000000005049; Published online 9 June 2023.)*

INTRODUCTION

Obesity is a complex, multifactorial disease that is increasingly prevalent.[1] Obesity is defined by the Centers for Disease Control and Prevention (CDC) as a body mass index (BMI) over 30 kg/m^2 and is associated with severe and complicated comorbidities.[2,3] Obesity is further differentiated into class I (BMI 30 to <35), class II (BMI 35 to <40), and class III (BMI >40).[2] Worldwide, obesity has tripled since 1975, with more than 650 million obese adults living today, and incidence rates have steadily increased in the United States.[4] The age-adjusted prevalence of obesity was 42.4% in 2018, whereas severe obesity has nearly doubled since 2000.[2] Additionally, the severely obese population is growing even more quickly than the moderately obese population.[5] An increasingly obese population contributes to the rising prevalence of diabetes and cardiovascular disease and the growing strain on healthcare systems.[6,7]

Although obesity may lead to an increased risk of many diseases, obesity's relationship to bone health and predisposition to fractures is mixed. Obesity has long been thought to have a protective effect against fractures because it generally increases bone mineral density.[8,9] More recent studies have drawn similar conclusions, with one study finding a 15% lower risk of wrist fracture in obese postmenopausal women.[10] Other recent epidemiological studies have suggested the opposite, naming obesity as either nonprotective or as a significant risk factor for fractures.[11–14] The literature is split on the role of obesity as a protective factor against or a risk factor for

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fractures.[15] Despite the debate on the effects of obesity on fracture risk, many studies have found that obese patients experience more complications during and after surgical fracture repair.[16–19]

Radius fractures are the most frequent long bone fractures, and forearm fractures have an annual incidence of over 640,000 in the United States.[20,21] Distal radius fractures (DRFs) are especially common, and usually result from a fall onto an outstretched, pronated hand.[22] Many factors, such as age, sex, lifestyle, and other health conditions, have been shown to increase the frequency of DRFs.[23–25] Obesity has been shown to increase risk of DRF, but obesity's effects on fracture complexity are less clear. There remains significant debate on the effects of obesity on DRFs.

Although many studies have focused on obesity and its effects on fracture risk and surgical complications, these studies did not focus on any single operation and were limited in their sample size. In this study, we investigate the effects of class III obesity on a population of over 10,000 patients undergoing open reduction-internal fixation of a DRF. We hypothesize that class III obesity correlates to increased risk of postoperative complications and reoperation rates.

METHODS

We performed a retrospective analysis using the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) database between 2015 and 2020. The ACS-NSQIP is a multi-institution and multicenter database that collects patient variables from over 500 hospitals. Patient variables are extracted via trained clinical reviewers at each site. They match each patient with their respective Current Procedural Terminology code, preoperative, intraoperative, 30 day postoperative and discharge data. The database undergoes various levels of audits and periodic quality checks. Patients were included if they were older than 50 years, had a BMI more than 18, and sustained a DRF.

We collected preoperative patient characteristics such as demographics, smoking history, American Society of Anesthesiologists class, patient functional status, and medical comorbidities. Medical comorbidities included diabetes, chronic obstructive pulmonary disorder, liver disease with ascites, congestive heart failure, hypertension, osteoporosis, and dialysis-dependent kidney disease. BMI was calculated from each patient's height and weight. We also collected data on postoperative medical complications within 30 days of the surgery. Postoperative complications included occurrence of pneumonia, pulmonary embolism, unplanned intubation, ventilator more than 48 hours, ventilator dependent, cardiac arrest requiring CPR, myocardial infarction, dirty or contaminated wound, superficial surgical site infection, deep incisional SSI, wound dehiscence, DVT/thrombophlebitis, transfusion, acute renal failure, progressive renal insufficiency, septic shock, and CVA/Stroke. We also collected information on reoperation within 30 days, operative time, length of hospital stay, and discharge destination.

Takeaways

Question: What is the relationship between class III obesity and complications after distal radius fracture repair?

Findings: In our retrospective cohort analysis of 10,022 patients comparing postoperative outcomes after distal radius fracture repair, class III obesity patients were 1.906 times more likely to experience any complication, and 2.138 times more likely to undergo unplanned reoperation than non–class III obesity patients.

Meaning: After repair of a distal radius fracture, class III obesity patients were more likely than non–class III obese patients to experience any complication, and have unplanned reoperation.

Demographic and Historical Data

Our study identified 10,022 patients who met inclusion criteria. An estimated 84.1% of the patients were women, and there was no significant difference in gender between the two groups ($P = 0.759$). The lower-BMI group included all patients who were not classified as class III obese. All patients considered were over the age of 50 because very few patients below the age of 50 were in the database and including these patients may reduce the external validity of our study. Additionally, all patients had a BMI more than 18 kg/m^2 because of the potential for patients with a lower BMI to have complications that may be attributable to malnutrition confounding our results. Finally, all patients had undergone surgical repair of DRF (Table 1).

Statistical Analysis

After exclusion of incomplete, and missing variables, the patient cohort was divided into those with a BMI more than 40, and those with a BMI less than 40. Next, International Business Machines Statistical Package for the Social Sciences suite was utilized to analyze data. Finally, University of California Los Angeles's Advanced Research Computing Statistical Methods and Data Analysis G*Power Statistics tool was used to perform power analysis. Confidence intervals were set at

Table 1. Base Demographics of Cohort of Patients Who Underwent Surgical Repair of a DRF

Demographics	Not Morbidly Obese	Morbidly Obese
Age, y (mean ± SD)	65.8 ± 9.11	63.1 ± 7.6
Body mass index (mean ± SD)	27.37 ± 5	45.32 ± 5.15
Hispanic, N (%)	786 (8.3)	43 (7.5)
Black, N (%)	284 (3.0)	31 (5.4)
Gender		
Women	7947 (84.1)	482 (84.6)
Men	1505 (15.9)	88 (15.4)

95%, with a P value of 0.05 being considered statistically significant.

Each group then underwent analysis to compare complication rates, and means of various variables. Further, multiple linear and logistic regression models were created to elucidate the connection between obesity and various linear and categorical complications and variables. These regression models controlled for age, sex, ethnicity, race, and BMI.

All data was initially analyzed to ensure a correct statistical assessment was chosen and that the variables met the requirements and assumptions for each statistical test. Comparison of normally distributed data was performed with independent sample t tests. For nonnormally distributed data, the Wilcoxon rank-sum test was performed. Categorical variables were assessed with Fisher exact test or chi square with Kendall Tau. Both multiple linear and logistic regression models were analyzed to ensure all assumptions were met. Where appropriate, residuals were assessed for normal distribution.

RESULTS

The average BMI and age in the lower-BMI group was 27.3 kg/m^2 (SD = 4.9) and 65.7 years (SD = 9.1), and 45.3 kg/m^2 (SD = 5.15) and 63.13 years (SD = 7.6) in the class III obesity group (Table 1). Logistic regression was used to calculate ORs for different complications following the ORIF operations (Fig. 1). Class III obese patients were found to have increased odds of experiencing any complication [OR 1.906, 95% CI (1.371–2.65), P < 0.001], adverse discharge [OR 2.618, 95% CI (1.809–3.791), P < 0.001], delayed hospital stay of longer than 3 days [OR 1.91, 95% CI (1.397–2.612), P < 0.001], and longer than 7 days [OR 2.943, 95% CI (1.809–3.791), P < 0.001](Fig. 2). They also had increased odds of unplanned reoperation [OR 2.138, 95% CI (1.096–4.169), P = 0.026] and readmission [OR 2.814, 95% CI (1.755–4.51), P < 0.001] when compared with the lower-BMI group (Fig. 3).

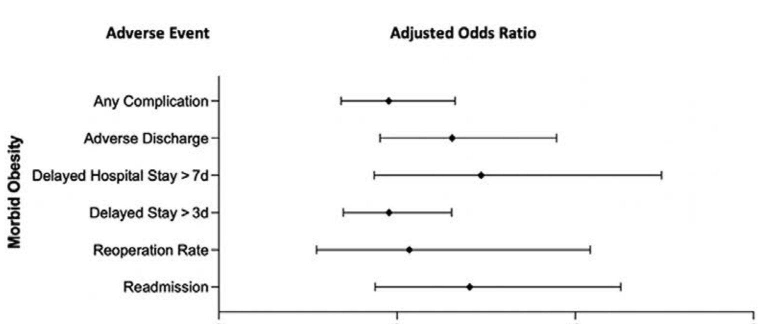
Class III obese patients had both a significantly longer average operation time than the lower-BMI group by 6.68 minutes [95% CI (3.408–9.951); P < 0.001]. Class III obese patients also had a significantly longer hospital stay, spending 0.354 more days [95% CI (0.141–0.568); P < 0.001] in the hospital than the lower-BMI group (Fig. 3).

DISCUSSION

Our study about the effect of class III obesity on complications in 10,022 DRFs demonstrated that (1) class III obese patients had higher odds of any complication, (2) class III obese patients had higher odds of unplanned reoperation than non–class III obese patients, and (3) class III obese patients had longer total operation times and higher likelihoods to remain in the hospital for longer than one day postoperation than non–class III obese patients.

There are many mechanisms through which obesity can either increase or decrease both the frequency and complexity of DRFs. The most common mechanism for DRFs in older adults is a fall from standing height onto an outstretched arm, and obese individuals falling onto an outstretched arm have been shown to generate greater force across the wrist than normal BMI individuals.[23,26] This suggests that obesity might be a risk factor for both frequency and complexity of DRFs.[27] Additionally, obesity is associated with a chronic inflammatory state, and the upregulation of receptor activator on NF-KB ligand, and cytokines in the TNF family may enhance osteoclast activity leading to increased bone resorption.[27] However, obesity may have a protective effect from a metabolic standpoint as it is associated with increased bone mineral density and decreased rates of osteoporosis in obese women.[28,29] Although these are potential mechanisms for the protective effect of obesity against fractures, obesity is not correlated to lower fracture incidence.[30] Surgeons should consider the interplay of these mechanisms when considering patient risk for sustaining DRFs.

The literature generally supports that obesity is positively associated with fracture severity. Ebinger et al reviewed radiographs from 423 patients with DRFs and found that patients with obese BMI was significantly associated with increasing fracture severity, per the OTA classification (P = 0.039).[19] Ebinger et al did not stratify patient fracture severity by BMI, whereas our study further stratified patients into class III obesity.[19] Montague et al also performed a retrospective review of 132 post-DRF radiographs stratified by BMI and found a positive



	OR	95% CI L	95% CI U	P
Any Complication	1.906	1.371	2.65	<.001
Adverse Discharge	2.618	1.809	3.791	<.001
Delayed Hospital Stay > 7d	2.943	1.744	4.968	<.001
Delayed Stay > 3d	1.91	1.397	2.612	<.001
Reoperation Rate	2.138	1.096	4.169	0.026
Readmission	2.814	1.755	4.51	<.001

Fig. 1. Multivariate regression model with adjusted OR for the class III obese group. Postoperative adjusted OR of complications for class III obese patients undergoing ORIF of DRF.

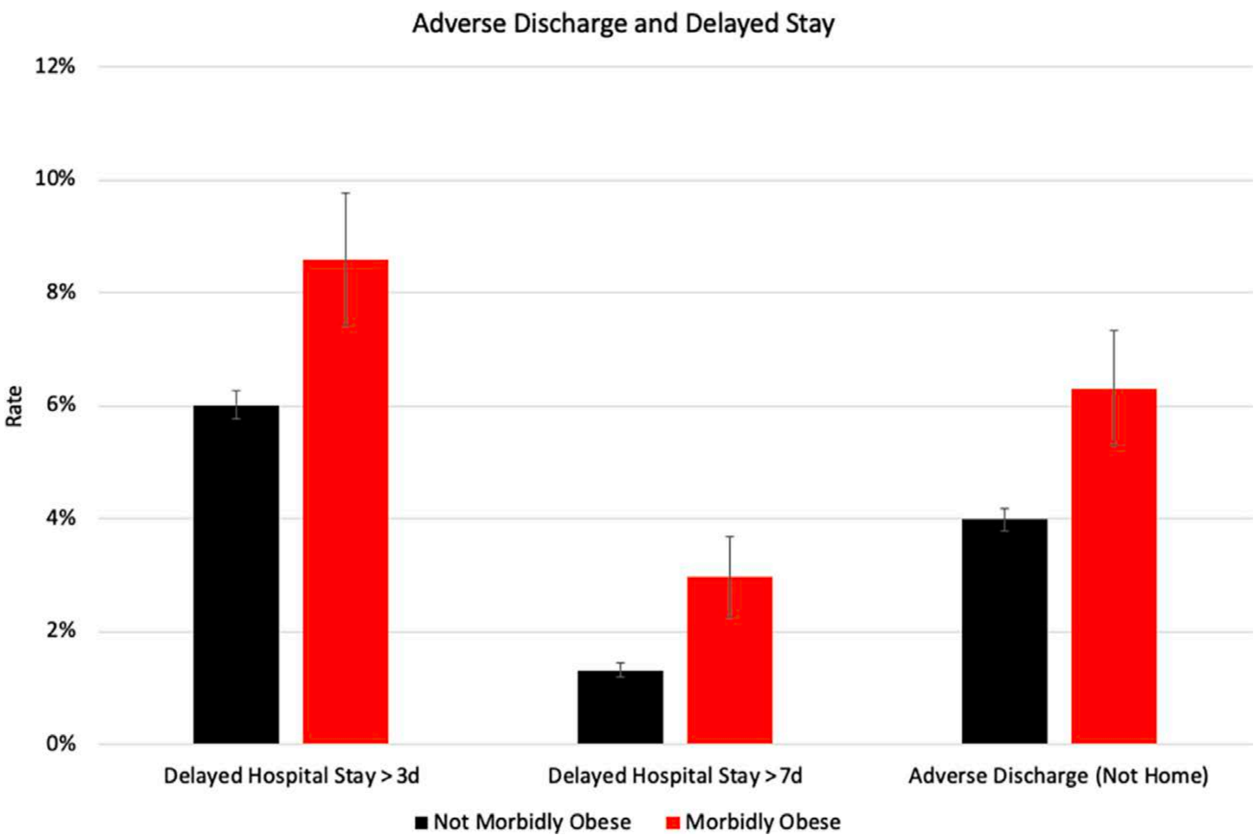


Fig. 2. Rates of delayed hospital stay and adverse discharge, according to BMI group. Rates of hospital stays lasting longer than 3 days, stays longer than 7 days, as well as adverse discharge.

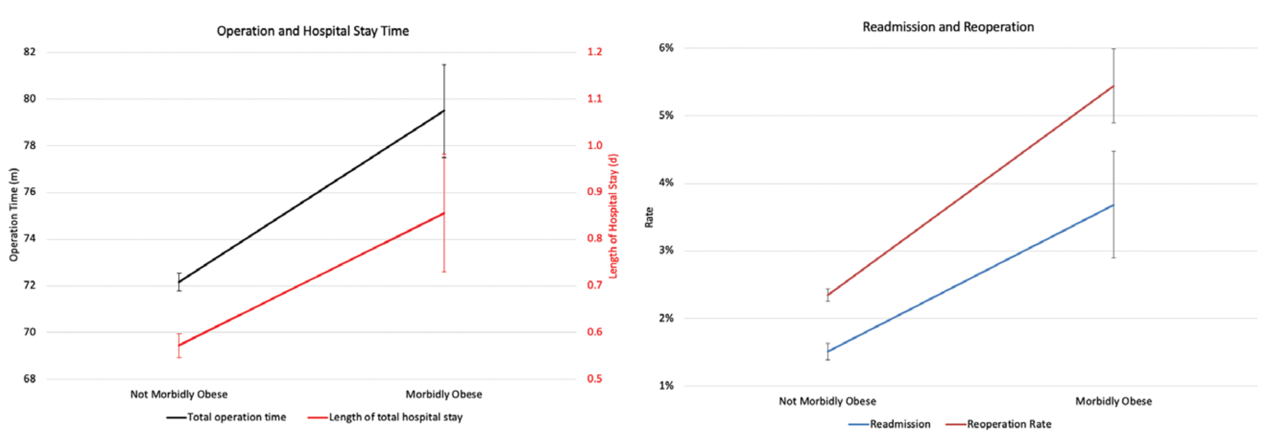


Fig. 3. Differences in operation time and hospital stay, as well as rates of readmission and reoperation, according to BMI group. Total operation time, hospital length of stay, rates of readmission, and reoperation shown from top to bottom for each BMI group. Error bars represent the 95% CI.

linear correlation between increasing BMI and fracture complexity.[31] They found that each point increase in BMI increased the chance of having a complex DRF with an odds ratios (OR) of 1.07.[31] The observed correlation between obesity and fracture complexity in these two studies, combined with our findings of increasing odds of reoperation and increased operation time and length of hospital stay with a high BMI, points to a potential relationship between obesity-related fracture complexity and postoperative complications. Utilizing the NSQIP database, we did not have access to radiographs and could not determine fracture severity using the OTA classification. Other studies have confirmed that obese orthopedic surgery patients experience increased length of stay after surgery. These studies, however, point to the chronic comorbidities and medical complexities of obese patients as the reason for the longer stays in the hospital. Further research to explore a relationship between fracture and surgical complexity of DRFs with obese individuals and length of stay would assist surgeons' surgical decision-making and managing patient expectations when operating on obese patients. Wei et al conducted a retrospective review of 11,272 patients and found that increased operation time was associated with increased risk of reoperation following DRF repair ($P <$ 0.001).[32] They suggested that resident training and inexperience was the main catalyst for this effect. Our study suggests that BMI is associated with this phenomenon, as increased BMI was associated with both longer operation times and increased reoperation rates in our analysis. In our clinical experience, the soft tissue burden in obese patients increases operation time for fracture visualization, reduction, and closure. This could potentially account for the observed longer operation times in obese patients.

Few studies have been conducted on the healing rate and complication rates following DRFs by BMI. Hall et al's retrospective analysis of 200 patients found that patients with BMI more than 30 had similar fractures and similar functional outcomes both three months and one year after volar plate fixation of fractures in patients with BMI less than 30.[33] The similar healing rates seen in the BMI less than 30 and BMI more than 30 groups in Hall et al may be due to a lack of stratification of the BMI more than 30 group into class II or class III obese groups, as our study found that patients with class III obesity had significantly higher odds of reoperation than non–class III obese patients ($P < 0.001$). Meanwhile, DeGeorge et al conducted a retrospective analysis of 647 patients and found that BMI more than 35 was associated with a significantly increased rate of major and minor complications following volar plate fixation of DRF.[34] The significant increase in complications that was observed in patients with the BMI more than 35 comorbidity follows the findings of our study, and indicates that it is not sufficient to simply classify patients as obese or nonobese. It is necessary to stratify patients with obesity into separate groups to determine specific risks for comorbidities. Our methodology follows the obesity classification scheme from the CDC.[35] Additional studies have been conducted on the effect of BMI on complications in upper extremity fractures. For example, London et al's case-control study of 436 patients found that among obese patients undergoing hand, forearm, or elbow surgeries, patients with higher BMI had significantly increased rates of complications, including infection, delayed healing, nerve injury, dehiscence, hematoma, and reoperation.[36] They observed that the higher risk of complications was especially salient at a BMImore than 45. This reinforces the need for future studies to further stratify BMI beyond simply obesity.

LIMITATIONS

This study is inherently limited due to its retrospective design. Although using the ACS-NSQIP database is a strength of the study because of the volume of cases it allows us to analyze, it also limits our access to patient and fracture information that is not recorded in the database, such as radiographs of DRFs or detailed personal medical history of the patients. It would be insightful to separate the different DRFs based on fracture pattern or specific fixation method used to correct the deformity. Additionally, this database does not contain details about the treatment, approach, rehabilitation protocol, or patient-reported outcomes measures, such as the Disabilities of the Arm, Shoulder, and Hand score, which are important for determining which methods are most effective for treating these injuries. Furthermore, this database does not include length of follow-up, nor does it include radiographs pre- and postsurgery, which obscures the severity of injuries that were included in the database. Finally, insurance status and other socioeconomic factors are not included in this database, which decreases the ability of this study to determine if external factors influence rates of complications.

CONCLUSIONS

As the rate of global obesity increases, further research is required to solidify our understanding of the influence that obesity has on bone health, fracture risk, and fracture complexity. Additionally, as a greater percentage of the population begins to record a BMI substantially higher than the cutoff for obesity, it is critical that we understand what complications these individuals are at risk for when undergoing orthopedic surgery. This study found that class III obesity is correlated to increased odds ratio of any complication, including delayed hospital stay, unplanned reoperation, longer operation times, and readmission than patients with BMI less than 40. These findings suggest that further stratification of obese BMI into class II and class III obesity can elucidate essential trends that would be hidden if all obese individuals were considered in a single group.

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DISCLOSURE

The authors have no financial interests to declare in relation to the content of this article.

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