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Long-Term Postoperative Total Knee Arthroplasty Flexion Scores in Relation to Body Mass Index

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Abstract

Knee range of motion (ROM) is an important postoperative measure of total knee arthroplasty (TKA). There is conflicting literature whether patients who are obese have worse absolute ROM outcomes than patients who are not obese. This study analyzed whether preoperative body mass index (BMI) influences knee ROM after patients' primary TKA. A retrospective investigation was performed on patients, who underwent primary TKA at an academic institution, by one of three fellowship-trained adult reconstruction surgeons. Patients were stratified according to their preoperative BMI into nonobese (BMI < 30.0 kg/m^2) and obese (BMI ≥ 30.0 kg/m^2) classifications. Passive ROM was assessed preoperatively as well as postoperatively at patients' most recent follow-up visit that was greater than 2 years. Mann–Whitney U tests were performed to determine statistical significance at p-value <0.05 for ROM outcomes. No statistically significant differences were observed when ROM in the nonobese group was compared with ROM in the obese group both preoperatively (105.73 ± 11.58 vs. 104.14 ± 13.58 degrees, p-value $= 0.417$) and postoperatively (105.83 ± 14.19 vs. 104.49 ± 13.52 degrees, p-value $= 0.777$). Mean follow-up time for all patients was 4.49 ± 1.92 years. In conclusion, long-term postoperative ROM outcomes were similar between patients who were nonobese and patients who were obese.

Keywords
- body mass index
- range of motion
- obesity
- total knee arthroplasty
- joint replacement

Obesity is a national epidemic that creates a multitude of challenges for patients and physicians.[1] It is well described in literature that increases in body mass cause substantial increases in load on weight-bearing joints. Obesity, defined as body mass index (BMI) $\geq$30.0 kg/m^2, has especially been linked to joint degeneration, osteoarthritis, and a higher incidence of total knee arthroplasty (TKA).[2,3] Additionally, patients with higher BMIs tend to have more postoperative complications, including longer length of hospital stay, higher 30-day readmission rate, and increased reoperation rate.[2,4–11]

Increases in postoperative range of motion (ROM) have been shown to be an important measure of a successful TKA procedure and patient satisfaction.[12–16] ROM has a significant impact on activities of daily living, where basic activities require 5 to 95 degrees of flexion. Interactions with flat ground, using a chair, descending stairs, and kneeling require knee flexion of approximately 0 to 65, 0 to 70, 0 to 90, and 0 to 125 degrees, respectively.[17–19] The 95 degrees of flexion mark is clinically significant for this reason. Below this point, patients experienced lower functionality as measured by the Western Ontario and McMaster Universities Osteoarthritis Index function scores.[12] Furthermore, literature also testifies that better ROM directly correlated with increased functionality and satisfaction, regardless if the patient reports

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symptoms.[15,20,21] Up to approximately one in ten to one in five patients may report dissatisfaction post-TKA.[15,22] Matsuda et al observed that limited postoperative ROM may be a main contributor to this dissatisfaction, significantly contributing to low functional activities scores and unfulfilled patient expectations.[15] Bourne et al reported that 16 to 30% of patients were dissatisfied with their knee function in relation to achieving activities of daily living.[22] These described failures were main reasons to perform this study to further delineate limitations in postoperative ROM.

Currently, the TKA prevalence in the United States population is 10.38%, and the incidence rate is 1.52%;[23] however, projections have estimated an increase of 1.5 million cases per year by 2050 with many of these patients being overweight and obese.[24] The current prevalence of obesity in the United States in adults aged 20 or older has been estimated to be 34.5%,[25] and more recent data showed a greater than 4% increase and a statistically significant rise in the number of people who are morbidly obese.[1,26,27] Thus, it is important to understand the relationship between BMI and final ROM. Current literature reports conflicting data and lacks an established long-term relationship between obesity and ROM following primary TKA.[4,16,20,21,28–32] The purpose of this study is to add to the current evidence to determine if there is a correlation between increasing BMI and poorer long-term ROM outcomes several years after patients' initial surgery.

Materials and Methods

Data Collection, Inclusion Criteria, and Classification

A total of 1,397 patients who underwent TKA by one of three fellowship-trained orthopedic adult reconstruction surgeons from 2009 to 2018 were retrospectively identified using current procedural terminology codes (►**Fig. 1**). Formal review and approval were conducted by the institutional review board at an academic institution from the Office for the Protection of Research Subjects. Patients were excluded if they received knee revision surgery, incision and drainage, infection spacers, or polyethylene liner replacements. This narrowed the cohort to 973 patients. Patients were then also excluded if they had less than 2-year follow-up data, resulting in a final cohort of 205 patients.

Patients were divided into nonobese and obese groups based on the World Health Organization strata of obesity[33]: patients who resided in the normal and overweight classification (BMI < 30.0 kg/m^2, $n = 48$) and patients who resided in obesity class I and higher (BMI ≥ 30.0 kg/m^2, $n = 157$). Values of passive knee ROM were used to determine the range of knee flexion and were obtained from the electronic medical record (EMR) at preoperative and postoperative clinic visits. All demographic and outcome data were also collected from the EMR. Diabetic status was assessed, as past literature demonstrated significantly less ROM post-TKA in diabetic patients when compared with matched controls.[34]

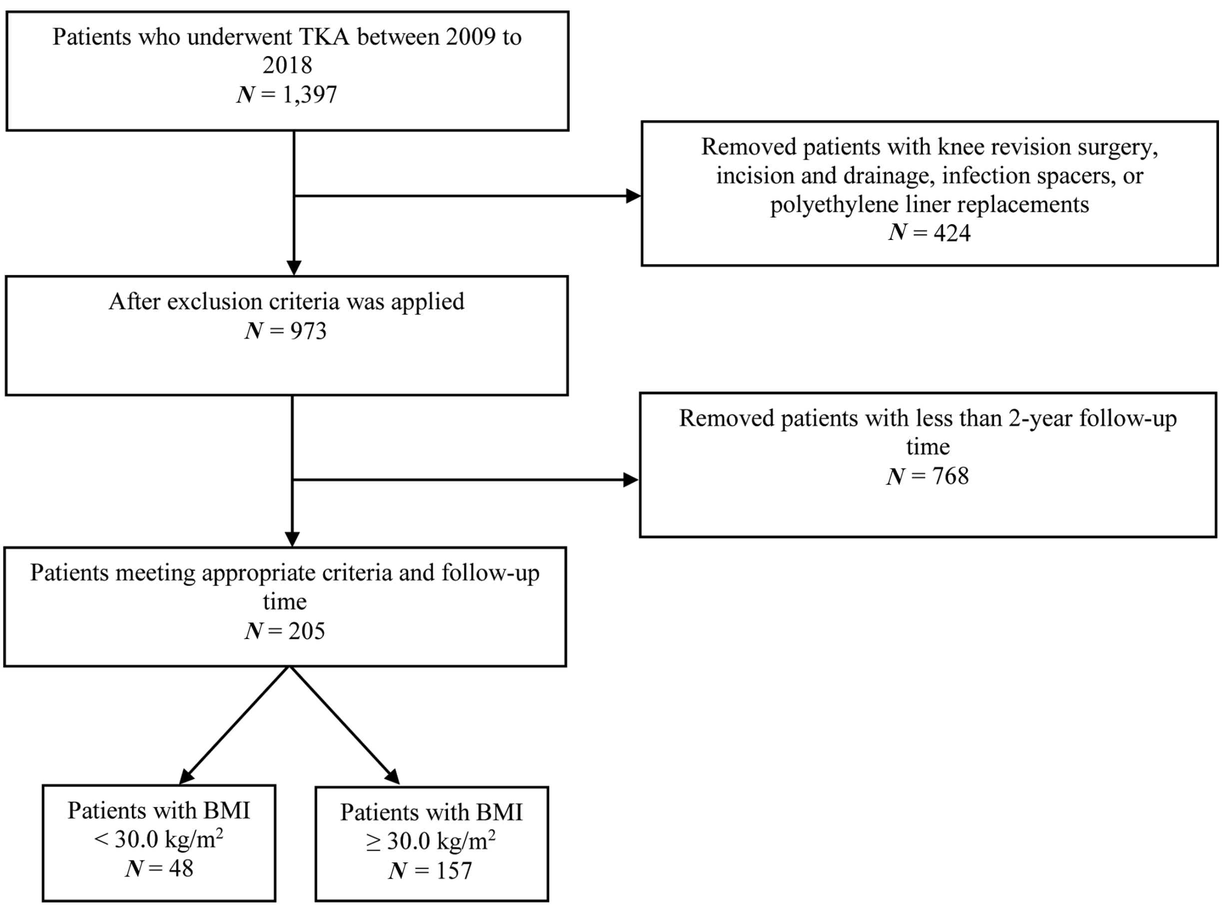

Fig. 1 Exclusion criteria and classification.

Table 1 Patient demographics

	Nonobese (BMI < 30.0 kg/m^2) Mean (SD)	Obese (BMI ≥ 30.0 kg/m^2) Mean (SD)	*p*-Value
n	48	157	
BMI	26.21 (2.87)	38.15 (5.23)	
Age	62.71 (9.62)	57.62 (8.47)	0.001
Sex	14 Males (29.17%) 34 Females (70.83%)	32 Males (20.38%) 125 Females (79.62%)	0.202
Race/ethnicity	2 Caucasian (4.17%) 29 African American (60.42%) 2 Asian (4.17%) 1 Hispanic (2.08%) 14 Unspecified (29.17%)	14 Caucasian (8.92%) 105 African American (66.88%) 1 Asian (0.64%) 10 Hispanic (6.37%) 27 Unspecified (17.20%)	0.081
HTN	36 (75.00%)	131 (83.44%)	0.188
CVD	8 (16.67%)	23 (14.65%)	0.733
Smoking status	29 (60.42%) Never 9 (18.75%) Former 10 (20.83%) Current	95 (60.51%) Never 28 (17.83%) Former 34 (21.66%) Current	0.986
Diabetic status	39 (81.25%) None 7 (14.58%) Noninsulin dependent 2 (4.17%) Insulin dependent	109 (69.43%) None 40 (25.48%) Noninsulin dependent 8 (5.10%) Insulin dependent	0.262
Laterality	23 Left (47.92%) 25 Right (52.08%)	81 Left (51.59%) 76 Right (48.40%)	0.656

Abbreviations: BMI, body mass index; CVD, cardiovascular disease; HTN, hypertension; SD, standard deviation.

Similarly, sex was assessed because it has been demonstrated that men have greater postoperative ROM.[30]

Statistical Analysis

Data were statistically analyzed with IBM SPSS 26.0.0.1 (Statistical Package for Social Sciences). The α value was set to 0.05. Patient demographics were compared between obese and nonobese groups to evaluate for any preoperative differences. Categorical data such as sex, race/ethnicity, hypertension, cardiovascular disease, smoking status, diabetic status, and laterality were analyzed via Chi-squared testing, while descriptive statistics and Shapiro–Wilk tests for normality were explored for all appropriate scaled variables. Age met expectations for normality, and therefore, a Student's *t*-test was performed, while nonparametric Mann–Whitney U testing was conducted for preoperative flexion, postoperative flexion, and follow-up time for nonobese and obese groups. Furthermore, stepwise multiple linear regression analysis was performed on all preoperative variables to determine their independent predictive values for postoperative ROM. As a secondary analysis, we analyzed differences in postoperative flexion when stratifying patients based on high-grade obesity. These groups included patients with BMI $<35.0\,kg/m^2$ ($n = 104$) and BMI $\geq 35.0\,kg/m^2$ ($n = 101$).

Results

Patient age ranged from 39 to 83 years old, and BMIs ranged from 19.78 to 55.95 kg/m^2. Patients in the nonobese group had TKA procedures performed at a significantly later age (62.71 ± 9.62 vs. 57.62 ± 8.47 years, *p*-value = 0.001) than the obese cohort. No other demographic factor displayed a significant difference between the two study groups (►**Table 1**). Evaluation of mean follow-up time also showed no discernable difference between groups (4.37 ± 1.95 vs. 4.53 ± 1.91 years, *p*-value = 0.519) and ranged from 2.00 to 10.05 years (►**Table 2**).

Table 2 Patients' knee range of motion at preoperative and postoperative clinic visits after a minimum follow-up of 2 years

	Nonobese (BMI < 30.0 kg/m^2) Mean (SD)	Obese (BMI ≥ 30.0 kg/m^2) Mean (SD)	*p*-Value
n	48	157	
Preoperative flexion	105.73 (11.58)	104.14 (13.58)	0.417
Postoperative flexion	105.83 (14.19)	104.49 (13.52)	0.777
Follow-up (y)	4.37 (1.95)	4.53 (1.91)	0.519
Postoperative-preoperative	0.104 (14.53)	0.350 (18.29)	0.729

Abbreviations: BMI, body mass index; SD, standard deviation.

Table 3 Stepwise multiple linear regression analysis of all preoperative variables for 2-year flexion range of motion

Independent variable[a]	*p*-Value
Preoperative flexion	0.030
Body mass index	0.835
Age	0.094
Sex	0.858
Race/ethnicity	0.226
Hypertension	0.182
Cardiovascular disease	0.282
Smoking status	0.795
Diabetic status	0.144
Laterality	0.273

[a]The variables of body mass index, age, sex, diabetic status, laterality, race/ethnicity, hypertension, cardiovascular disease, and smoking status were not associated with a change in postoperative range of motion.

Nonobese and obese groups had no statistical difference in both preoperative flexion and postoperative flexion, with *p*-values of 0.417 and 0.777, respectively. Stepwise multiple linear regression analysis determined that only preoperative flexion featured an independent predictive value on postoperative flexion (*p*-value = 0.030, 95% confidence interval [CI]: 0.015–0.300) (►**Table 3**).

High-grade obesity stratification also did not show any postoperative differences in ROM (104.71 ± 13.31 vs. 104.90 ± 14.07 degrees, *p*-value = 0.497).

Discussion

More postoperative ROM is essential for favorable patient outcomes and to complete activities of daily living. With a heavier, aging United States population, it is vital to understand the role if any that obesity plays in determining a patient's final ROM. Our study found no significant association between BMI and long-term post-TKA ROM. Mean postoperative flexion measurements between nonobese and obese groups at 2 years follow-up were nearly identical, with less than 2 degrees of difference. This study indicates that when considering final ROM, TKAs may be effective long-term solutions for patients in all weight classes.

There are conflicting literature reports regarding an association between obesity and final ROM. Sun and Li performed a meta-analysis showing that patients with higher BMIs had more absolute decreases in their ROM.[4] Additionally, Liao et al reported that patients in the obese group featured worse absolute ROM outcomes at their 6-month follow-up visit when compared with preoperative scores.[28]

Several other studies also describe how patients in obese groups have a relatively greater increase in flexion between their preoperative and postoperative ROM, but still featured worse absolute ROM scores when compared with patients with lower BMIs.[4,16,28–31] The overall sample of 391 patients in the study by Gadinsky et al demonstrated a 4.0- to 11.9-degree mean difference between patients with normal BMI and patients in higher BMI classifications 3 years after their respective TKAs.[30] Moreover, Maniar et al reported that patients in obesity class III had a significantly decreased motion arc when compared with patients in the nonobese group during preoperative as well as postoperative 3-month and 1-year measurements.[31] It is important to note, however, that other factors—such as greater relative thigh fat in the female gender—as well fat distribution behind the knee in high BMI patients may provide a mechanical block when measuring postoperative ROM[35,36] and therefore could have confounded results.

Finally, there is a depth of literature reporting no difference in long-term postoperative ROM between patients in obese and nonobese groups, which parallel the findings of this study.[20,21,32] Importantly, many of these studies featured similar follow-up times to our study, often at 2 years[20,32] and 5 years[21] postoperatively.

Our study also explored long-term postoperative ROM results comparing high-grade obesity categories (obesity II and obesity III) to the remainder of the study population by classifying two new groups using a BMI cut-off of 35.0 kg/m^2. This secondary analysis mirrored our primary results and also did not show any postoperative differences between groups (high-grade obesity classification: 104.71 ± 13.31 degrees vs. low-grade obesity, overweight, and normal classification: 104.90 ± 14.07 degrees, *p*-value = 0.497).

This study demonstrated a statistically significant difference between patient age at the time of TKA between nonobese and obese groups (*p*-value = 0.001). This relationship between age at TKA and BMI is well observed in the literature.[3,28] The phenomenon of patients with higher BMIs needing to receive a TKA at a significantly younger age is likely secondary to the chronic effects of extra weight contributing to higher mechanical loading, pain, and a greater loss of knee function.

Stepwise multiple linear regression model results, however, allowed our study to nullify this difference in age between the preoperative groups' demographics. The analysis also showed no association between sex, diabetic status, laterality, race/ethnicity, hypertension, cardiovascular disease, and smoking status as independent contributors to final ROM (►**Table 3**). Importantly, the regression model also excluded BMI, which further supports the conclusions of this study that patients with higher BMIs have similar long-term postoperative flexion as patients with lower BMIs. Finally, the model successfully showed the only preoperative variable that had predictive value on postoperative flexion was preoperative flexion (*p*-value = 0.030; 95% CI: 0.015–0.300), a well-known finding in orthopedic literature.[14,37,38] Based on our results and accordance to the literature,[14,37,38] patients should expect a correlation between their preoperative flexion and postoperative flexion.

The primary limitations of this study occurred as a consequence of its retrospective nature. Due to the fact that three different fellowship-trained orthopedic surgeons performed the measurements, there may have been differences in their measurement accuracy. Furthermore, after extensive exclusion criteria were applied, only 21.07% of the sample population had sufficient electronic medical records at their 2-year follow-up clinic visit or beyond. Future studies would benefit from a larger sample size and better patient follow-up. Finally, there is potential for a selection bias and confounding health factors, asides from the variables analyzed in this study, that could have influenced final ROM.

In accordance with the current literature, our analysis demonstrated that only preoperative flexion is an appropriate predictor of final ROM. However, the relationship between BMI and final ROM may be more complex than a linear relationship, so other modeling methods could be explored. Future studies also need to examine the impact of other variables as independent predictors of final ROM, including rheumatoid arthritis, osteoarthritis, socioeconomic status, anxiety, and depression.

Conclusion

In general, patients with obesity undergo longer operation times, experience more hardware failure, and receive higher rates of wound infection.[39] Consequently, physicians need to evaluate all potential risks and benefits when making decisions of whether or not to perform elective cases. While obesity can be a barrier to success, this study demonstrates that BMI has no impact on postoperative ROM. Thus, BMI should not be a deterrent to total knee arthroplasty for fear of limited postoperative ROM.

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Conflict of Interest
None declared.

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