



EVALUATION OF EFFECTS OF BMI ON FUNCTIONAL RECOVERY FOLLOWING TOTAL KNEE ARTHROPLASTY SURGERY

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ABSTRACT

Background: Obesity is a well known risk factor for complications following total knee arthroplasty, various data is available on the impact of the degree of obesity on patient-reported outcomes following total knee arthroplasty.

In our study we tried to determine the extent to which obesity level affects the recovery as well as patient-reported pain, function, and satisfaction with after total knee arthroplasty surgery.

Methods: We followed a cohort of patients who underwent total knee arthroplasty at our medical centre. Patients included were +40 years of age with a primary diagnosis of osteoarthritis. Patients were classified into 5 groups according to the World Health Organization classification of body mass index (BMI). Assessment was done between BMI group and pain and function over the time intervals of 0 to 3, 3 to 6, and 6 to 12 months using a piecewise linear model. Multivariable models adjusted for age, sex, diabetes, musculoskeletal functional limitations index and pain medication use.

Results: Of the 150 participants included in our analysis, 19% were normal weight (BMI of <25 kg/m²), 32% overweight (BMI of 25 to 29.9 kg/m²), 27% class-I obese (BMI of 30 to 34.9 kg/m²), 12% class-II obese (BMI of 35 to 39.9 kg/m²), and 9% class-III obese (BMI of +40 kg/m²). Study participants with worse preoperative WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) had a higher BMI, pain and function scores and had greater improvement from baseline to 3 months. Across all BMI groups the mean change in pain and function from 3 to 6 and from 6 to 12 months was similar. At 12 months, participants in all BMI groups had similar levels of pain, function, and satisfaction.

Conclusions: The variability of recovery in the first 3 months following total knee arthroplasty, the participants in the higher BMI groups were able to attain absolute pain and function scores similar to those in the non obese and class-I obese groups. The available data can be helpful for surgeons to discuss with the patients about their demands and functional recovery following Total knee Arthroplasty surgery,

KEYWORDS :

The most common disabling joint disease Osteoarthritis of knee affects almost 4% of the worldwide population^{1,2}. Osteoarthritis of knee is seen more commonly in obese individuals, and increased body mass index (BMI) has been established as a risk factor for the disease^{3,4}. This number is expected to increase in the coming years as the prevalence of obesity among adults is on rise⁵. Patients with advanced knee osteoarthritis are typically offered total knee arthroplasty, as a to relieve pain and restoring function^{6,7}.

Some patients experience complications or less improvement than expected despite the overall success of total knee arthroplasty; obese individuals are at higher risk for such outcomes⁸⁻¹⁶ that calls for revision surgery¹⁷. It is necessary to understand the benefits these patients can expect from the procedure¹⁸ because majority of total knee arthroplasties are performed in obese individuals. Some authors have found that obesity is associated with worse improvement in functional outcomes, such as pain¹⁹⁻²¹. Others have reported no such association²²⁻²⁴. Many previous studies have evaluated this association between obesity and overall improvements following total knee arthroplasty, the recovery patterns are not clear. These changes are important to better understand the point in the recovery process at which outcomes diverge; this point presents a potent target for intervention. There remains a flaw in our understanding of the extent of recovery following total knee arthroplasty is influenced by BMI.

For this question, we used patient-reported data to measure patients' function, pain, and satisfaction after total knee arthroplasty. Our objective was to assess the extent to which BMI category affects the trajectory of recovery over 12 months following total knee arthroplasty as well as the resulting patient-reported outcomes at 12 months.

Materials and Methods

Sample Participants were enrolled in studies assessing out- comes of total knee arthroplasty: the AViKA cohort study, the AViKA Care Navigator randomized controlled trial, and STARS³⁰⁻³². Participants were

enrolled at medical centre: a tertiary academic medical centre in Jawaharlal nehru medical college, Sawangi (Meghe), Wardha, Maharashtra. Included were English and local language-speaking adults who lived in the community, were ≥40 years of age, for the primary diagnosis of osteoarthritis were undergoing total knee arthroplasty. Exclusion criteria included other conditions (e.g., inflammatory arthritis), traumatic knee, uni- compartmental knee arthroplasty, and bilateral total knee arthroplasty.

All participants completed a baseline questionnaire within 6 weeks prior to surgery and were evaluated at 3, 6, and 12 months postoperatively. The AViKA Care Navigator randomized controlled trial and STARS cohorts had an additional follow-up at 12 months. (While the primary end point of the Care Navigator randomized controlled trial was 6 months, patients were also evaluated at 12 and 24 months postoperatively.) Our analytic cohort consisted of participants who provided height and weight information on the baseline questionnaire and who completed #1 follow-up questionnaire. We also compared the baseline and clinical characteristics of participants who were included in our analytic cohort with those who were excluded.

All participants provided signed informed consent, and study was approved by the Partners Healthcare institutional review board.

Data Elements

Pain and functional status was measured with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). It uses a 5-point Likert scale to assess pain according to 5 items and function according to 17 items. For ease of interpretation, these scores were converted to a scale of 0 to 100 (with 100 being the worst) by dividing the sub-scale score by the total possible score and multiplying by 100. We assessed the level of overall satisfaction with the surgery following total knee arthroplasty with the question, "How satisfied are you with the results of your surgery?" Overall satisfaction was categorised as "very satisfied" or "not very satisfied".

Covariates

BMI was calculated from height and weight. We divided BMI into 5 groups, on the basis of the WHO classification: BMI of $<25.0 \text{ kg/m}^2$ (normal weight), 25.0 to 29.9 kg/m^2 (overweight), 30.0 to 34.9 kg/m^2 (class-I obese), 35.0 to 39.9 kg/m^2 (class-II obese), and $\geq 40.0 \text{ kg/m}^2$ (class-III obese). Small number of participants who were underweight (BMI of $<18.5 \text{ kg/m}^2$), were included in the "normal weight" category (BMI of $<25 \text{ kg/m}^2$). Other data was collected regarding diabetes status, use of medication for knee pain (categorized as no use, occasional use, or almost daily use), and the musculoskeletal functional limitations index³³. This index measures the aggregation of musculoskeletal problems in 6 anatomic regions that limit a patient's ability to perform daily activities; it is scored on a scale of 0 to 12, with 12 being the worst. Demographic data included age, sex, education, and surgeon.

Statistical Analysis

To investigate the association between time trend in WOMAC pain and function over 12 months and BMI group, we used a piecewise linear mixed-effects model. Piecewise linear models, also called spline models, work well to describe nonlinear longitudinal trends in which a mean response changes rapidly for some duration and more slowly thereafter (or vice versa)³⁴. These models are thus well suited to describe total knee arthroplasty recovery, in which we expect rapid improvement over the first 3 to 6 months, followed by slower improvement^{35,36}. Points at which the slope changes are referred as "knots." For pain and function separately, 3 different models were evaluated—1 knot at 3 months, 1 knot at 6 months, and knots at both 3 and 6 months—and selected the best-fit, most parsimonious model based on r^2 and the Bayesian information criterion (BIC)³⁴.

To investigate the association between the final WOMAC score at 12 months and BMI group, we used linear mixed-effects models. WOMAC pain and function was taken separately. Linear mixed-effects models take into account all available data and thus allow for missing data; therefore, we included all participants in the analysis regardless of month-12 visit completion.

Finally, we used a mixed-effects logistic regression model to examine the effect of BMI group on patient satisfaction at 12 months. As a sensitivity analysis for missing 12 month data, we used a last observation carried forward (LOCF) approach by creating a satisfaction score based on the final satisfaction response recorded (that is, from 12 months if available; otherwise, from 12 months; otherwise, from 6 months; otherwise, satisfaction data missing).

All models were adjusted for age, sex, diabetes, musculoskeletal functional limitations index and pain medication use. We accounted for clustering by surgeon by including a random effect in the mixed model.

Results

Sample Description

Of 150 enrolled participants, (92%) had baseline BMI data and completed ± 1 follow up questionnaire. Fifty-eight participants were excluded: 16 on the basis of missing BMI data, 39 for missing all follow-up questionnaires, and 3 for missing both BMI data and all follow-up questionnaires. The excluded participants reported, on average, worse preoperative WOMAC scores for pain and function (mean [and standard deviation], 48.3 ± 19.2 and 50.4 ± 18.6 , respectively) compared with those in the analytic cohort (40.8 ± 17.9 and 42.5 ± 17.0). The excluded participants were more likely to be using medication almost daily for knee pain (62% compared with 43%). There were also differences between the included and excluded groups with respect to race and study site (see Appendix). However, there did not appear to be an association between BMI group and exclusion due to missing all follow-up questionnaires.

In the analytic cohort, the average age was 65.9 ± 8.5 years. Fifty-nine percent of the participants were female, and 93% were white.

The average BMI was $30.8 \pm 6.6 \text{ kg/m}^2$ (Table I). On the basis of BMI, 120 (19%) of the participants were categorized as normal weight; 203 (32%), overweight; 174 (27%), class-I obese; 79 (12%), class-II obese; and 57 (9%), class-III obese. The normal-weight group included 2 participants with a BMI of $<18.5 \text{ kg/m}^2$. The mean musculoskeletal functional limitations index was 3.3 ± 2.1 . Thirteen percent of the participants had diabetes, and 43% reported taking medication for knee pain almost every day. The overall mean pre-operative WOMAC pain and function scores were 40.8 ± 17.9 and 42.5 ± 17.0 , respectively.

BMI Groups and Preoperative Characteristics

The BMI groups differed with respect to baseline characteristics. Heavier participants tended to be younger; the mean age at surgery ranged from 68.0 years in the normal-weight group to 62.6 years in the class-III obese group (Table I). Heavier participants were more likely to be female, to be non-white, and to have diabetes, and had, on average, greater musculoskeletal functional limitations.

The heavier BMI groups had, on average, worse preoperative WOMAC pain and function scores; the mean preoperative pain score ranged from 33.7 ± 15.9 in the normal-weight group to 49.7 ± 17.3 in the class-III obese group, and the mean preoperative function score ranged from 34.7 ± 16.3 in the normal-weight group to 50.5 ± 16.6 in the class-III obese group.

BMI Groups and Outcomes

All BMI groups showed improvement in both pain (Fig. 1) and function (Fig. 2). The mean adjusted WOMAC pain and function scores at 24 months were 11.0 (standard error of the mean [SE], 1.3) and 13.9 (SE, 1.5), respectively.

The piecewise linear model identified 3 distinct pain-improvement periods: from baseline to 3 months (postoperative days 0 to 90), 3 to 6 months (days 90 to 183), and 6 to 24 months (days 183 to 730). For WOMAC pain, in the unadjusted model, patients improved, on average, by 25.0 points in the interval of baseline to 3 months (days 0 to 90), 4.9 points in the interval of 3 to 6 months (days 90 to 183), and 2.9 points in the interval of 6 to 12 months, which translates to 0.48 points per 3-month interval over months 6 to 12. On average, patients in the higher BMI groups experienced greater pain improvement during the interval of 0 to 3 months than did patients in the lower BMI groups (adjusted $p < 0.0001$). The mean adjusted change in pain for the interval of baseline to 3 months ranged from 18.1 points in the lowest BMI group (BMI of $<25 \text{ kg/m}^2$) to 32.2 points in the highest BMI group (BMI of $\geq 40 \text{ kg/m}^2$) (Table II). During the intervals of 3 to 6 months and 6 to 12 months, all BMI groups experienced similar improvement in pain. We observed similar results for WOMAC function; the higher BMI groups experienced greater improvement in function from baseline to 3 months (adjusted $p < 0.0001$), while functional improvements did not differ by BMI group during the intervals of 3 to 6 months or 6 to 12 months.

At 12 months, the adjusted mean WOMAC pain score ranged from 9.1 (95% confidence interval [CI], 5.8 to 12.5) in the normal-weight group to 13.6 (95% CI, 9.4 to 17.7) in the class-III obese group (adjusted $p = 0.2996$). The mean adjusted WOMAC function score ranged from 12.2 (95% CI, 8.4 to 15.9) in the normal-weight group to 16.5 (95% CI, 11.9 to 21.0) in the class-III obese group (adjusted $p = 0.2153$). Eighty-one percent of the participants reported that they were "very satisfied" with the surgery: 80% in the normal-weight group, 80% in the overweight group, 82% in the class-I obese group, 80% in the class-II obese group, and 83% in the class-III obese group reported high satisfaction (adjusted $p = 0.8246$). Results were similar after using the LOCF approach response at 24 months.

Discussion

From a cohort of >150 total knee arthroplasty patients, we assessed whether BMI group was associated with patient-reported outcomes, including the time trend of recovery. Our results showed

that, while a higher BMI was associated with worse preoperative pain and function, by 12 months postoperatively, there were no significant differences in pain or function across the BMI groups. The piecewise linear model demonstrated that the higher BMI groups experienced greater improvement in the first 3 months postoperatively compared with the lower BMI groups, and afterward, the trend over time was similar across all BMI groups. Patients reported a similar level of high satisfaction across all BMI groups.

The findings of previous studies of obesity and recovery following total knee arthroplasty have been mixed, with some studies suggesting that obesity is associated with worse pain and function and lower satisfaction following total knee arthroplasty, and others finding no association, or even that obese patients are more likely to be satisfied with their surgery^{19,24,26,37,38}. This variability may be due to differences in the health status of the cohorts or differences in the cutoffs used to define categories of obesity. Baker and colleagues found that a higher BMI (assessed in groups of BMI of <25, 25 to 39.9, and ≥ 40 kg/m²) was associated with worse baseline values for the Oxford Knee Score and EuroQol-5 Dimensions

(EQ-5D) but that the average change from baseline to 6 cannot determine if study participation was associated with 12 months following total knee arthroplasty was similar across the BMI distribution³⁹. Jiang et al. found that patients with a BMI of >35 kg/m² started with worse Oxford Knee Score values compared with normal-weight patients and that differences between BMI groups persisted at 1, 5, and 10 years after total knee arthroplasty⁴⁰. We also found that patients in the higher BMI groups had worse pain and function preoperatively, and we found that patients in the higher BMI groups had more change. The studies of both Baker et al. and Jiang et al. involved patients in the U.K., and the average baseline scores were substantially worse than in our study. It is possible that differences between the U.S. and U.K. health-care systems result in different indications for total knee arthroplasty; a recent review found that, in 2011, the U.S. had an incidence rate of 235 total knee arthroplasties per 100,000 population compared with 140 per 100,000 in the U.K.⁴¹. We examined both short-term and long-term (up to 24-month) changes in pain and function, and our findings offer insight into the association between obesity and total knee arthroplasty recovery in a U.S. population with moderate pain and functional limitations prior to the procedure. It is also possible that, by using the 5-level WHO classification for BMI, we were better able to elucidate distinct patterns within each group.

A major strength of our study was the ability to evaluate different recovery periods following total knee arthroplasty. The recovery trend over time for total knee arthroplasty is nonlinear³⁶, and our piecewise linear model uncovered 3 distinct recovery periods: baseline to 3 months (postoperative days 0 to 90), 3 to 6 months (days 90 to 183), and 6 to 12 months (days 183 to 730). This allowed us to assess the effect of the BMI group separately in early recovery and in later recovery. Participants in the higher BMI groups experienced greater improvement during the first 3 months postoperatively. In fact, the average change in pain among class-II and class-III obese participants over the first 3 postoperative months (30.6 and 32.2 points, respectively) was more than 40% greater than that for normal-weight participants (18.1 points). Improvements did not differ statistically by BMI group in the interval of 3 to 6 months or 6 to 12 months. All BMI groups experienced improvement in pain and function by 12 months. In particular, we noted that mean 12-month WOMAC scores differed at most by 4 to 5 points across the BMI groups, a difference that was neither significant nor regarded as clinically meaningful^{42,43}.

Our analysis had several limitations. Eight percent of the participants were excluded from the analytic cohort, the majority because of missing follow-up questionnaires. Linear mixed-effects models take into account all available data and thus allow for missing data, and therefore, we included all patients who had at least 1 follow-up visit. While the excluded participants had worse

preoperative pain and function, there did not appear to be an association between BMI group and exclusion due to missing follow-up questionnaires. The inclusion and exclusion criteria were not based on BMI value; however, BMI data were only available for those patients who completed a baseline questionnaire, and thus we were not able to determine if study participation was associated with BMI. Bilateral and uni-compartmental surgeries were excluded, limiting the generalized ability of the results to unilateral total knee arthroplasty. Comorbidities were not assessed in a uniform manner across studies and thus could not be adjusted for, the exception being diabetes, which was similarly assessed across studies and, therefore, was included in our analysis. It is possible that differences in baseline comorbidities could explain some of the differences in baseline pain and function among the BMI groups. Finally, BMI calculations were based on self-reported height and weight, and BMI was missing for 3% of the cohort, who were excluded.

Overall, we found that participants across all BMI groups achieved similar outcomes with respect to self-reported pain, function, and satisfaction at 12 months following total knee arthroplasty. Because of the differential trajectory of recovery in the first 3 months postoperatively, participants in the class-II and class-III groups were able to reach absolute pain and function scores similar to those in the non obese and class-I obese groups. We believe that our research contributes important data regarding the trajectory of patient-reported pain and functional recovery for obese patients after total knee arthroplasty; such research can provide critical insight as surgeons discuss the expectations of surgery with the growing numbers of total knee arthroplasty candidates with higher BMI.

Fig 1: Pain

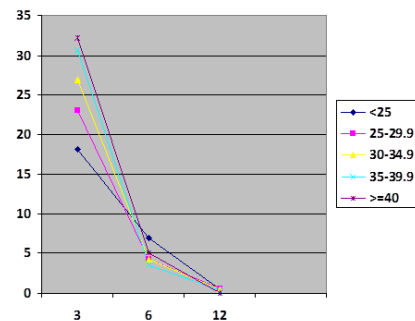


Fig 2: Function

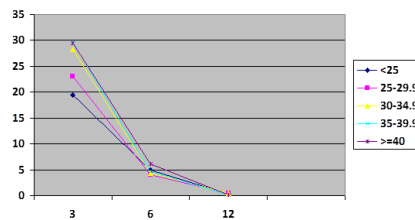


Fig 3: Age group

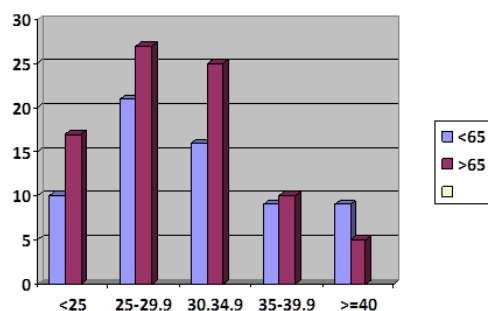


Fig:Sex

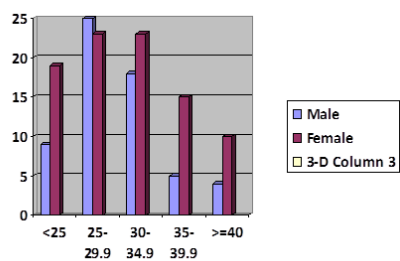


Fig:Pain medication

