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Original Research

Impact of body mass index on robotic-assisted total knee arthroplasty outcomes: A retrospective cohort analysis

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ABSTRACT

Introduction: Obesity is a growing global health concern and a known risk factor in total knee arthroplasty (TKA). With an increasing number of obese patients requiring TKA, it is essential to understand how obesity influences clinical outcomes and complication rates. The objective of this study is to investigate the impact of obesity on clinical outcomes and complications in patients undergoing robotic-assisted TKA (RA-TKA).

Methods: A retrospective cohort study was conducted on 216 patients aged ≥18 years who underwent RA-TKA between 2019 and 2023, with a minimum postoperative follow-up of one year. Patients were stratified into three body mass index (BMI) categories: <25, 25–29, and ≥30 kg/m^2. Demographic, intraoperative, and postoperative variables—including tourniquet use and time, implant type, hospital stay, and complications—were compared. Statistical analysis was performed ($p < 0.05$).

Results: Two hundred sixteen patients (91.5% follow-up rate) were evaluated at a mean of 34 months, postoperatively. No statistically significantly difference was found among the BMI groups in terms of age, sex, use of tourniquet, hospital stay, or use of stem implants. A statistically significant difference was observed only in the group of BMI <25 kg/m^2 regarding arthrofibrosis. When patients were grouped as a BMI <35 vs a BMI ≥ 35 kg/m^2, a higher complication rate was noted in the ≥35 kg/m^2 group (18.2% versus 7.2%), though the difference was not statistically significant ($p = 0.09$).

Conclusions: This study found that the difference was not statistically significant in the overall rate of postoperative complications among patients with obesity undergoing RA-TKA. However, a nonsignificant trend toward a higher complication rate was observed in patients with severe obesity (BMI ≥35 kg/m^2). Interestingly, a statistically significant increase in arthrofibrosis was found in patients with BMI <25 kg/m^2, a finding that contrasts with the current literature.

Level of Evidence: Level III.

What are the new findings?

- Although not statistically significant ($p = 0.09$), a higher frequency of postoperative complications was observed in patients with severe obesity.
- Higher incidence of arthrofibrosis in patients with body mass index <25 kg/m^2, this finding was statistically significant ($p = 0.003$) and contrasts with the previous literature.
- Robotic-assisted surgery enabled a consistent technique across all patients, which may have minimized outcome differences among body mass index groups and highlights its value in anatomically complex populations such as obese patients.

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INTRODUCTION

Total knee arthroplasty (TKA) is a commonly performed surgical procedure aimed at relieving pain and improving function in patients with degenerative knee joint diseases [1,2]. However, obesity, defined by an elevated body mass index (BMI), has been identified as a factor that may influence postoperative outcomes.

Several studies have examined the relationship between high BMI and the incidence of perioperative complications in patients undergoing TKA. For instance, patients with a BMI exceeding 35 kg/m^2 have been shown to have a higher likelihood of postoperative complications, including infections and wound healing issues [3,4].

Nevertheless, the evidence remains inconclusive. Some studies have found no significant association between high BMI and an increased frequency of perioperative adverse events in knee arthroplasty [5,6].

Given the increasing global prevalence of obesity and the rising demand for knee arthroplasty, it is essential to understand how a BMI above 30 kg/m^2 affects postoperative outcomes. It has been observed that more than 40% of adults in the United States are obese [7–9]. According to a recently published article, by the year 2029, it is estimated that ≥69% of primary total knee arthroplasties in the United States will involve patients with obesity or morbid obesity [10]. This global increase in obesity prevalence coincides with a shift in the demographics of patients requiring total knee arthroplasty [11].

For the above reasons, and considering the challenges associated with performing total knee arthroplasty in this type of patient, robotic-assisted surgery may prove more beneficial and yield good outcomes in this patient subgroup [29]. Both computer navigation systems and robotic-assisted technologies may be beneficial in TKA, offering improved implant positioning, reduced trauma to soft tissues, and consequently, decreased postoperative pain compared with conventional approaches guided by intramedullary femoral and extramedullary tibial references [12–16]. Therefore, robotic-assisted TKA (RA-TKA) or navigation-guided TKA could be especially valuable in obese patients, including those with morbid obesity (BMI > 40 kg/m^2).

The objective of this retrospective cohort study is to investigate the impact of obesity and its severity on clinical outcomes and complications in patients undergoing RA-TKA. The goal is to provide a comprehensive perspective that contributes to informed clinical decision-making.

METHODS

Ethical review was undertaken by the Health and Disability Ethics Committee of our center, ethics approval number 2013-01. Informed consent was taken from all patients for use of data. No funding was required for this study.

A retrospective cohort study was conducted on a cohort of patients aged ≥18 years who underwent RA-TKA between 2019 and 2023. Patients with a minimum postoperative follow-up of one year were included. Patients who underwent revision TKA, bilateral TKA, and those who had incomplete data and contact information were excluded from the study. The groups were retrospectively classified according to their weight.

The primary outcome was intraoperative and postoperative characteristics according to World Health Organization's classification of BMI criteria, patients were divided into three groups: underweight/normal weight (<25 kg/m^2), overweight (25–29 kg/m^2), and obesity (≥30 kg/m^2). The variables evaluated were sex, age, laterality, use of tourniquet, presence of stem, days of hospitalization, follow-up time, presence of complications, and type of complications. Comorbidities assessed included hypertension, dyslipidemia, arthritis, cardiac diseases, respiratory conditions, depression, and anxiety.

RA-TKA operative technique

Surgeries were performed by experienced knee surgeons (10+ years of experience), all patients underwent general anesthesia (combining inhalation and intravenous methods). A tourniquet was used to induce ischemia at the start of the surgery. The robotic system (MAKO®, Stryker, MI, USA) was calibrated and configured following a standardized protocol before surgery. Preoperative computed tomography scans of the hip, knee, and ankle were obtained using the TKA application platform to create a patient-specific three-dimensional model. Regarding the implants, all patients received a Triathlon® total knee system (Stryker, MI, USA) with Posterior Stabilized implant with posterior cruciate ligament sacrifice, and both the femoral and tibial components were cemented.

Patient rehabilitation was conducted by physical therapists at our center following a standardized protocol. This included immediate postoperative rehabilitation, starting with the use of a continuous passive motion machine from recovery, direct mobilization, and immediate full weight-bearing with the aid of crutches.

The use of orthopaedic canes was recommended for at least the first two weeks. All patients received routine prophylaxis with oral anticoagulation for three weeks following surgery. The first postoperative appointment at the outpatient clinic occurred at two weeks. Clinical follow-up was conducted at 2 weeks, 4 weeks, 2 months, 3 months, 6 months, and 1 year, postoperatively.

For statistical analysis, categorical variables were calculated with the chi-square test and Fisher's exact test. Continuous variables were analyzed using the Student's t-test or the Mann–Whitney U test for two group comparisons, and ANOVA or the Kruskal–Wallis test for multiple-group comparisons, according to the distribution of data verified with the Shapiro–Wilk test. Post hoc analysis was conducted when statistically significant differences were detected. Logistic regressions models were adjusted for age and sex. A statistically significant difference was considered with a $p < 0.05$. in Stata v.18.5 software.

RESULTS

A total of 236 patients underwent RA-TKA surgery between 2019 and 2023. All patients were contacted between January and March 2025 for a review. At follow-up, 216 patients were available, giving a follow-up rate of 91.5% at a mean follow-up time of 34 months after surgery (standard deviation [SD]: 10.29, range: 24–63 months). Most patients were female (65.7%), with a median age of 71.8 years (SD: 8.5) and a median BMI of 28.4 kg/m^2 (interquartile range [IQR]: 25.6–31.9). Regarding the characteristics of the surgery, surgery was performed on the left knee in 45.8% of cases (n = 99), use of tourniquet was performed in 89.8% of surgeries with a median of 69.5 min (IQR: 60–82), and the median hospital stay was 3 days (IQR: 3–4). After a median postoperative follow-up of 2.8 years, 8.3% of procedures had complications, with arthrofibrosis being the most prevalent [Table 1].

There was a statistically significant difference in the presence of comorbidities among patients with a BMI of 30 or higher compared with those with a BMI below 30 (52.4% versus 32.6%, p = 0.034) [Table 2]. When comparing RA-TKA between BMI groups, no statistically significant differences were observed in demographic characteristics or in surgery characteristics; among the intraoperative complications, one patient in the group with a BMI greater than 30 experienced an intraoperative fracture, which was managed with osteosynthesis. No statistically significant differences in post-follow-up complications were observed across BMI groups, even after adjustments for age and sex [Table 2]. However, the most prevalent post-follow-up complication, arthrofibrosis, was concentrated in the BMI <25 kg/m^2 group (p = 0.003), accounting for 80% of all complications evidenced in this group

Table 1
Patient characteristics.

	N = 216 (100%)
Patient medical history	
Female	142 (65.7%)
Age, years (SD)	71.8 (8.5%)
BMI, kg/m^2 (IQR)	28.4 (25.6–31.9)
BMI category	
• Underweight	1 (0.5%)
• Normal weight	42 (19.4%)
• Overweight	89 (41.2%)
• Obesity	84 (38.89%)
Surgical characteristics	
Left laterality	99 (45.8%)
Use of tourniquet	194 (89.8%)
Tourniquet time, minutes (IQR)	69.5 (60–82)
Stem	12 (5.6%)
Hospital stay, days (IQR)	3 (3–4)
Postoperative follow-up	
Follow-up duration, days (IQR)	1035 (723–1935)
Post-follow-up complications	18 (8.3%)

SD = standard deviation; IQR = interquartile range; BMI = body mass index.

[Fig. 1]. Post hoc analysis showed that the BMI <25 kg/m^2 group differed from both the 25 ≤ BMI < 30 kg/m^2 group (p = 0.002) and the BMI ≥30 kg/m^2 group (p = 0.01). Having a BMI <25 kg/m^2 was associated with 17.64-fold increased odds of developing arthrofibrosis compared with individuals with a BMI ≥25 kg/m^2 (odd ratio [OR] = 17.64, 95% confidence interval [CI]: 1.91–162.21). Even after adjusting for sex and age, the association remained significant (adjusted OR = 19.85, 95% CI: 2.07–189.93). There were no differences in post-follow-up complications in the remaining complications by BMI group.

In a second analysis, we divided the patients into two groups according to their BMI and complications [Table 3]. Complications (prosthesis infection/aseptic prosthesis loosening) were observed in 3 (1.38%) of 216 patients included in the study. Complications were encountered in 14 (7.2%) patients in the group with BMI <35 kg/m^2 and in 4 (18.2%) patients in the group with BMI ≥35 kg/m^2 (p = 0.09).

Regarding postoperative complications, a higher frequency was observed in the group with BMI ≥35 compared with the other group, although this difference was not statistically significant (p = 0.09). The revision rate was 1.38% (3/216 patients).

DISCUSSION

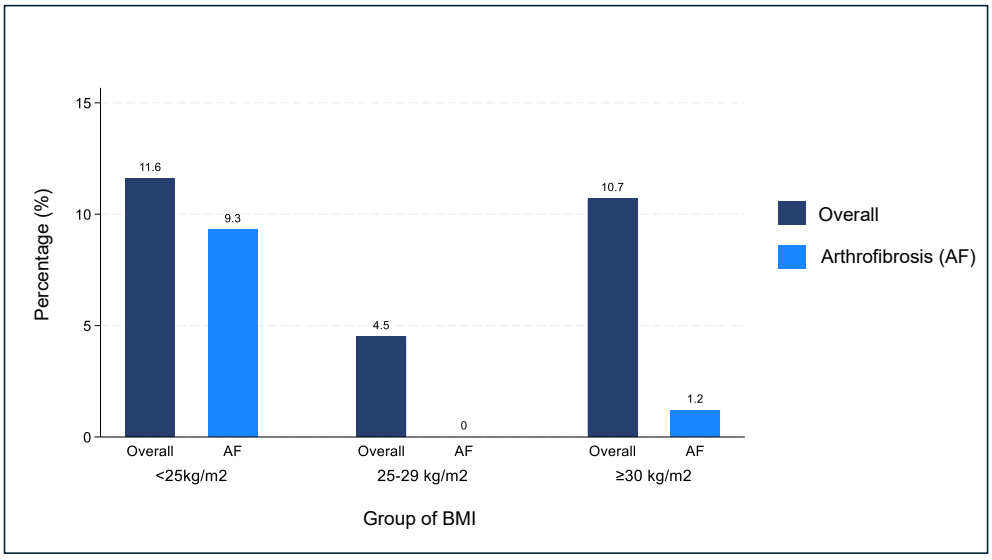
The most significant finding of this study is the absence of major differences in the incidence of complications among obese patients (BMI ≥30 kg/m^2) undergoing total knee arthroplasty compared with those with a BMI <30 kg/m^2 at a minimun 1-year follow-up. However, when analyzing the data by dividing patients into two groups (BMI ≥35 kg/m^2 versus <35 kg/m^2), a trend toward a higher proportion of complications was observed in the group with severe obesity (18.2% versus 7.2%). Although this difference was not statistically significant, it may have clinical relevance. These findings are consistent with the previous literature, which has reported a higher incidence of postoperative complications in obese patients, attributed to factors such as longer surgical time, mechanical overload, and increased risk of infection or implant failure [17–21]. We believe that the lack of a statistically significant difference between these two groups may be related to the type of patients treated at our institution, the strict preoperative, intraoperative, and postoperative protocols followed, as well as the use of robotic assistance. This result holds particular relevance in countries such as ours, where the prevalence of obesity and life expectancy are both on the rise—factors closely associated with an increased burden of degenerative joint diseases. Consequently, the coexistence of these conditions is expected to become increasingly prevalent in clinical practice. Although there may be a perception that performing surgery in obese patients is more challenging and costly, this scenario is likely to become more common, highlighting the need for ongoing research and adaptation in surgical strategies and perioperative management [22,23].

Wagner et al. [24] recently analyzed BMI as a continuous variable in a cohort of 21,361 consecutive TKAs. Their findings demonstrated a statistically significant different association between higher BMI and increased rates of reoperation (p < 0.001) and revision procedures (p < 0.002). Furthermore, a higher BMI was significantly correlated with elevated risks of wound infections (hazard ratio [HR]: 1.08; p < 0.001) and deep infections (HR: 1.08; p < 0.001). Notably, the risk for most complications began to rise at a BMI between 30 and 35 kg/m^2 and continued to escalate with increasing BMI values. Although there is a group of patients with a BMI >40 in our cohort, this group is small. This is attributed to the fact that, although we do not have a strict BMI >40 cutoff, the population of morbidly obese patients at our center is limited.

Table 2
Characteristics by BMI category.

	BMI < 25	25 ≤ BMI < 30	BMI ≥30	p
	N = 43 (19.9%)	n = 89 (41.2%)	n = 84 (38.9%)	
Patient medical history				
Female	33 (76.7%)	52 (58.4%)	57 (67.9%)	0.10
Age, years (SD)	71.7 (±8.9)	71.7 (±8.7)	72.0 (±8.1)	0.97
Comorbidities	14 (32.6%)	29 (32.6%)	44 (52.4%)	**0.034**
Surgical characteristics				
Left laterality	21 (48.8%)	37 (41.6%)	41 (48.8%)	0.58
Use of tourniquet	38 (88.4%)	79 (88.8%)	77 (91.7%)	0.76
Tourniquet time, minutes (IQR)	67 (57–79)	70 (60–80)	70 (60–85)	0.43
Stem	2 (4.7%)	5 (5.6%)	5 (6.0%)	0.95
Hospital stay, days (IQR)	3 (3–4)	3 (3–4)	3 (3–4)	0.43
Complications	0 (0%)	0 (0%)	1 (1.2%)	0.15
Postoperative follow-up				
Post-follow-up complications (n = 18)	5 (11.6%)	4 (4.5%)	9 (10.7%)	0.2
• Arthrofibrosis (n = 5)	4 (9.3%)	0 (0%)	1 (1.2%)	**0.003**
• Fracture (n = 4)	1 (2.3%)	0 (0%)	3 (3.6%)	0.19
• Surgical wound dehiscence (n = 4)	0 (0%)	2 (2.3%)	2 (2.3%)	1.00
• Infection (n = 2)	0 (0%)	1 (1.1%)	1 (1.2%)	1.00

SD = standard deviation; IQR = interquartile range; BMI = body mass index.



BMI: Body mass index, AF: Arthrofibrosis

Fig. 1. Prevalence of complications and arthrofibrosis after surgical follow-up, by BMI group. BMI = body mass index; AF = arthrofibrosis.

Table 3
Complications by BMI category.

	BMI < 35	BMI ≥ 35	p
	N = 194 (89.8%)	n = 22 (10.2%)	
Age, years (SD)	71.7 ± 8.4	72.5 ± 9.8	0.67
Hospital stay, days (IQR)	3 (3–4)	4 (3–5)	0.22
Complications	14 (7.2%)	4 (18.2%)	0.07
• Arthrofibrosis (n = 5)	5 (2.57%)	0 (0%)	0.44
• Fracture (n = 4)	3 (1.54%)	1 (4.54%)	0.32
• Surgical wound dehiscence (n = 4)	4 (2.06%)	0 (0%)	0.55
• Aseptic loosening (n = 1)	0 (0%)	1 (4.54%)	0.1
• Infection (n = 1)	1 (0.51%)	1 (4.54%)	0.63

SD = standard deviation; IQR = interquartile range; BMI = body mass index.

The previous reports have documented the growing incidence of obesity in TKA utilization. A study of the 2002 to 2009 NIS by Odum et al. [25] assessed 753,268 TKA patients, finding 114,396 patients (15%) with a BMI greater than 30 kg/m^2. They noted a doubling of obese patients over their study period ($p < 0.001$).

The second finding of our study, whose difference was statistically significant , is that in the group with a BMI <25 kg/m^2, a higher number of patients developed arthrofibrosis requiring a second arthroscopic procedure for joint release. This result's difference was statistically significant and contrasts with what has been described in much of the literature, where obesity and overweight have traditionally been associated with a higher risk of joint stiffness [26–28]. Although scientific evidence suggests that obese patients may have an increased risk of stiffness due to factors such as chronic inflammation, intra-articular fat tissue, or lower adherence to rehabilitation, our finding opens the door to exploring alternative hypotheses that could explain the higher incidence of arthrofibrosis in leaner patients.

Diagnosing arthrofibrosis remains challenging due to a lack of consensus among surgeons. Patients typically present with limited range of motion, tenderness, and knee swelling [29,30]. Initial treatment is conservative, including anti-inflammatory medications, rest, elevation, and physical therapy focused on mobility and quadriceps strengthening. If symptoms persist and interfere with daily activities, surgical intervention may be warranted. Manipulation under anesthesia is most effective when performed within 12 weeks of the index procedure, though recent studies question the traditional view that outcomes worsen beyond this window [31]. Arthroscopic lysis of adhesions may be considered a treatment option for patients with persistent stiffness beyond 12 weeks after the index procedure who have not responded to conservative management [32,33].

We believe there are several hypotheses that could explain this finding. First, patients with a low BMI typically have less muscle mass and reduced periarticular soft tissue volume, which may favor a stiffer scarring response to surgical trauma. It is also possible that these patients, who are often older or more frail, may have lower adherence to or tolerance for intensive postoperative rehabilitation, increasing the risk of joint stiffness. Lastly, although a standardized robotic-assisted surgical protocol was used, the lack of personalization according to body composition may have influenced the outcomes in this subgroup. Taken together, these factors could explain the higher incidence of arthrofibrosis observed in patients with low BMI. Although unexpected, this finding highlights the importance of considering obesity not only as a risk factor but also low body weight, and suggests the need to tailor perioperative management strategies to the individual characteristics of each patient.

The recent literature has highlighted the benefits of robotic-assisted TKA in obese patients, particularly regarding postoperative alignment. Richardson et al. [34] in a retrospective study compared RA-TKA with conventional instrumentation in patients with a BMI ≥35 kg/m^2, no significant differences were found in terms of age, BMI, or estimated blood loss between groups. However, patients in the robotic-assisted cohort demonstrated significantly better postoperative mechanical alignment, with fewer radiographic outliers compared with the conventional group. These findings suggest that robotic systems may enhance surgical precision, especially in anatomically challenging populations, and it may have some implications in terms of complication rates [35,36]. Although our study did not assess postoperative alignment in order to draw definitive conclusions about the advantages of robotic assistance, it could be one of the factors contributing to the low incidence of early aseptic loosening. Worsened limb alignment, particularly coronal plane malalignment (varus or valgus) greater than 3°, has been associated with an increased risk of aseptic loosening [37,38]. This situation may be further exacerbated in patients with elevated BMI as this population experiences greater overload or stress on the prosthetic components [39,40].

There are several limitations to the present study. The use of robotic assistance ensures a certain degree of consistency in the surgical

technique, which reduces variability and allows for a more accurate assessment of the impact of obesity. However, the study is limited by its design and a relatively short follow-up period of nearly 3 years. Another limitation of our study is that the evaluation being centered in a single institution may increase susceptibility to institutional biases, such as having a relatively small population of patients with a BMI greater than 40. We have very few patients classified as "super-obese," a group in which complications and mortality-related issues may be significantly more pronounced. This could therefore limit the applicability of our findings.

CONCLUSION

This study found the differences not statistically significant in the overall rate of postoperative complications among patients with obesity undergoing RA-TKA. However, a nonsignificant trend toward a higher complication rate was observed in patients with severe obesity (BMI $\geq$35 kg/m^2), underscoring the potential clinical relevance of this subgroup. Interestingly, a statistically significant increase in arthrofibrosis was found in patients with BMI <25 kg/m^2, a finding that contrasts with the current literature and suggests the need to consider low BMI as a potential risk factor for joint stiffness following TKA.

Author contributions

All the authors contributed to the design, analyses and reporting for this manuscript. Both authors read and approved the final submitted manuscript.

Informed consent

Informed consent was obtained from all patients for the use of their data or photos.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institution.

Ethical consideration

The study received approval from the Health and Disability Ethics Committee of Clinica Alemana Center, ethics approval number 2013-01.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

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