Review Article

Morbid Obesity and Total Knee Arthroplasty: A Growing Problem

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Abstract

Obesity is an epidemic, with approximately 35% of the US population affected. This rate is unlikely to decline and may increase the demand for total knee arthroplasty (TKA). Data regarding the risks, benefits, and potential complications of TKA in this patient population are conflicting. Preoperative considerations are optimization of nutritional status, safe weight loss strategies, and bariatric surgery. Intraoperative concerns unique to this population include inadequate exposure, implant alignment, and durable implant fixation; postoperative issues include tibial loosening, wound complications, cardiovascular events, and respiratory complications. A thorough understanding of the medical and surgical complications associated with TKA in the obese patient will facilitate research efforts and improve outcomes.

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Obesity is prevalent in the United States, affecting approximately 35% of the adult population.[1] Obesity is generally defined as a body mass index (BMI) of ≥30 kg/m^2, although the World Health Organization (WHO) uses three categories: class I, 30.0 to 34.9 kg/m^2; class II, 35.0 to 39.9 kg/m^2; and class III, ≥40.0 kg/m^2. Use of BMI versus percentage of body fat to determine weight status is controversial.[2] Percentage of body fat may be a better representation because it measures adipose tissue more accurately than does BMI.

Regardless of the criterion used, obesity can substantially alter the results of total knee arthroplasty (TKA).[3] Obesity disproportionately affects knees more than hips, leading to an unequal increase in the number of primary TKAs performed relative to the number of total hip arthroplasties.[4]

The demographics of patients undergoing TKA have also changed drastically over the last few decades. For example, the average BMI of patients undergoing the procedure has increased incrementally during that time.[5] In addition, a recent study showed that obese patients required TKA at a younger age than did patients of normal weight.[6] As a result of these changes, research on the obese TKA patient has also intensified. Most of these studies have retrospectively identified adverse outcomes associated with obesity, with very few prospective studies pinpointing methods for optimizing TKA in the obese patient.

Preoperative Considerations

Medical Comorbidities

Obese patients often have multiple medical comorbidities, such as diabetes mellitus and cardiopulmonary disease, which can negatively affect the results of TKA. The Mayo Clinic reviewed insulin dependence as an independent risk factor in obese

patients undergoing the procedure.[7] Three cohorts of morbidly obese patients (ie, WHO class III) were evaluated: patients without diabetes (n = 1,284), patients with type 2 diabetes who did not require insulin (n = 530), and patients with type 2 diabetes who required insulin (n = 164). The insulin-dependent cohort had increased risks of reoperation ($P = 0.005$), revision ($P = 0.02$), and periprosthetic joint infection ($P = 0.03$), as well as decreased 10-year implant survivorship ($P = 0.01$) compared with the nondiabetic cohort. However, no statistically significant differences were noted in outcomes between the non–insulin-dependent type 2 diabetic and nondiabetic cohorts.

Obesity, diabetes, and metabolic syndrome (ie, central obesity, hypertension, glucose intolerance, and hypercholesterolemia) are also closely related. Patients with metabolic syndrome undergoing primary total joint arthroplasty had a statistically significant increase in perioperative complications, with an elevated BMI being the greatest risk factor of the comorbid features of this syndrome ($P = 0.0028$).[8]

Nutrition

Contrary to perceptions, a large percentage of obese patients are malnourished. When evaluating patients for malnutrition, we commonly screen for the following values: albumin <3.5 g/dL; transferrin <200 mg/dL; and total lymphocyte count <1,500/mm^3. A recent study involving 58 obese patients (ie, WHO class III) who were scheduled to undergo bariatric surgery found substantial nutritional deficiencies in vitamin D (92.9%) and iron (36.2% to 56.9%).[9] In addition, 15.6% of patients who underwent a preoperative evaluation before gastric bypass surgery were diagnosed as having hypoalbuminemia.

Nelson et al[10] used the National Surgical Quality Improvement Program database to analyze a cohort of 77,785 patients who underwent TKA. They divided the cohort according to BMI and preoperative albumin level. A multivariate analysis determined that morbid obesity (ie, WHO class III) was not independently associated with most complications. However, morbid obesity was directly associated with renal insufficiency, superficial surgical site infection, and sepsis. Interestingly, a low serum albumin level (ie, <3.5 mg/dL) was associated with increased mortality as well as several other perioperative complications.

Given demonstrated nutritive deficiencies in obese patients, a thorough preoperative nutritional workup is advocated to medically optimize their status before TKA. It appears that some major complications associated with obesity are confounded by concomitant nutritional deficiencies. Further research is needed to determine whether preoperative optimization of nutrition decreases postoperative morbidity in the obese population.

Weight Loss

We encourage weight loss in obese patients (ie, WHO classes II and III) before TKA. We typically advocate diet and exercise and, if necessary, refer patients to an appropriate specialist to facilitate these goals. However, data on the outcomes of patients who have significant weight loss preceding TKA are limited. One study examined a patient cohort undergoing 10,718 TKAs to determine the effect of meaningful weight loss (ie, a 5% decrease in body weight) on surgical site infection and postoperative hospital readmission.[11] Approximately 12.4% of TKA patients had meaningful weight loss within the year before surgery. There was no statistically significant difference in surgical site infection or readmission rate in the weight loss cohort. However, the authors were unable to correlate this finding with the nutritional status of the patients in each cohort. This is an important consideration because patients partaking in a hypocaloric diet are most likely in a catabolic state.[12] These patients may be at risk for poor wound healing and infection, the same complications seen in obese patients.

Bariatric Surgery

Bariatric surgery is often performed in obese patients to reliably facilitate weight loss.[13] Werner et al[14] evaluated three large cohorts 90 days after TKA: nonobese patients (n = 66,523), morbidly obese patients (ie, WHO class III) who did not undergo bariatric surgery (n = 11,294), and morbidly obese patients (ie, WHO class III) who underwent bariatric surgery before TKA (n = 219). The authors found reduced rates of both major complications (odds ratio [OR], 0.45; $P = 0.001$) and minor complications (OR, 0.61; $P = 0.01$) in the bariatric cohort compared with the morbidly obese cohort who did not undergo bariatric surgery.

It is difficult to infer a direct relationship between obesity and outcomes secondary to bariatric surgery because of the lack of a matched cohort controlling for many of the comorbidities. Nevertheless, others have noted either no difference or worse outcomes in patients who underwent bariatric surgery before TKA.[15,16] Martin et al[17] identified a cohort of 91 patients who had undergone bariatric surgery before TKA (mean BMI before bariatric surgery, 51.1 kg/m^2; mean BMI at the time of TKA, 37.3 kg/m^2). This cohort was then matched with two groups that did not undergo bariatric surgery before TKA: a cohort matched to the bariatric cohorts

pre-bariatric BMI of 51 kg/m^2 before TKA (1:1 match; n = 91) and a cohort matched to the bariatric cohorts post-bariatric BMI of 37 kg/m^2 before TKA (1:2 match; n = 182). The bariatric cohort had a higher risk of reoperation (hazards ratio [HR], 2.6; P = 0.02) than did the high BMI control cohort, and higher risk of reoperation (HR, 2.4; P = 0.2) and revision (HR, 2.2; P = 0.04) than did the lower BMI cohort. One possible explanation for worse outcomes in bariatric patients undergoing TKA is concomitant malnutrition in this population;[9] patients may remain in a catabolic state for 2 years following these procedures.[18]

Intraoperative Considerations

Exposure

The distribution of increased soft-tissue mass in obese patients undergoing TKA can be important. Lozano et al[19] measured limb length versus suprapatellar and infrapatellar limb girths in a group of TKA candidates with a BMI ≥35 kg/m^2 (ie, WHO classes II and III). They observed that BMI was not associated with tourniquet time, whereas a short limb with increased suprapatellar girth (ie, a short, stocky limb) increased tourniquet time and surgical complexity. According to In et al,[20] exposure often takes longer in this patient population, and the patella can be difficult to subluxate or evert. In their study, high girth was a significant risk factor for inability to evert the patella; the risk was 27.2 greater when thigh girth was >55 cm. In contrast, a more recent study reported no difficulty in everting the patella in obese patients undergoing TKA.[21] The average surgical time was approximately 90 minutes in this cohort. The prolonged surgical time and a 2% intraoperative complication rate were most likely the result of inadequate visualization related to difficulty obtaining exposure.

We advocate a standard medial parapatellar arthrotomy in obese patients. Minimally invasive approaches may substantially increase surgical times and cause injury to the extensor mechanism, collateral ligaments, or cutaneous blood supply. Regardless of approach, however, adequate visualization is key to decreasing intraoperative and postoperative complications in this patient population.

Alignment

Obtaining appropriate alignment can be challenging in the obese patient because of adipose tissue obstructing bony landmarks, limited visualization, and decreased flexion secondary to soft-tissue constraints. For this reason, some surgeons advocate the use of computer navigation.[22] Kamat et al[22] retrospectively studied 287 TKAs, 133 with computer-assisted alignment and 154 with non-navigated alignment. Approximately half of the patients were obese (ie, WHO class I). Alignment was better and surgical times were faster in the computer alignment cohort than in the standard alignment cohort.

Awareness of the difficulty of identifying bony landmarks and the potential for malalignment of a TKA are important when treating this patient population. Thus, we have a low threshold for the use of computer navigation in these patients.

Fixation

Component fixation is a potential concern when planning TKA in an obese patient. From a biomechanical perspective, increasing patient weight proportionally raises the stress transmitted to the fixation interface. In one study, patients with a BMI ≥35 kg/m^2 had increased risk of tibial component loosening.[23] Additional fixation should be considered in obese patients to potentially decrease the risk of aseptic tibial loosening. However, reports are conflicting on the effects of obesity on implant survivorship and, more specifically, aseptic loosening. Cherian et al[24] performed a literature review and identified five TKA studies involving 288 patients with a BMI ≥30 kg/m^2. No statistically significant increase in aseptic loosening was found in these patients (OR, 2.28; P = 0.22), although the study may have been underpowered to identify a statistically significant difference.

We are unaware of any literature on femoral or patellar component loosening, but loosening may be a concern, as well. We believe the use of stemmed implants may promote improved fixation and may decrease stresses on the tibial base plate.

Blood Loss

Hrnack et al[25] evaluated a cohort of patients with varying BMIs (ie, WHO classes I–III) undergoing 94 primary TKAs to determine the effect on surgical blood loss. They performed a regression analysis and were unable to correlate obesity with increased blood loss. However, surgical time did correlate with the amount of blood loss. This study may have been underpowered to identify a difference in perioperative blood loss. In addition, evaluation of perioperative hemoglobin values and perioperative fluid management would have been beneficial given the inherent inaccuracies of estimated intraoperative blood loss. To our knowledge, no studies on tranexamic acid and blood loss have been conducted in the obese population.

Anesthesia Considerations

Ventilation can be problematic in obese patients given their propensity for restrictive lung disease from decreased airway compliance and

increased incidence of concomitant sleep apnea. Restrictive lung disease can lead to a ventilation-perfusion mismatch and subsequent shunting of blood. The resulting increase in P_{CO_2} and decrease in P_{O_2} is known as Pickwickian syndrome.

A recent study evaluated 26 obese patients scheduled to undergo bariatric surgery.[26] Patients were randomly assigned to one of three intraoperative positions to determine the effect of each on oxygen saturation: 30° reverse Trendelenburg, supine horizontal, and 30° back up Fowler position. Of the three groups, patients in the reverse Trendelenburg position had the lowest change in oxygen saturation at the time of intubation as well as the shortest recovery to baseline oxygen saturation level. Reverse Trendelenburg positioning can be easily incorporated into TKA to optimize ventilation in obese patients.

In addition, some anesthesiologists have advocated the use of peripheral blocks and/or spinal anesthetics to avoid many cardiopulmonary and systemic opioid complications associated with general anesthesia.[27] These authors noted that although regional blocks can be more difficult to perform in obese patients, the blocks can be optimized with ultrasonographic guidance.

Postoperative Considerations

Body Mass Index

Multiple studies have shown that outcomes after TKA were worse in obese patients than in nonobese patients.[3,23,28] As BMI level rises into morbidly and super-obese categories, complication rates also climb.[29] The super-obese (ie, BMI >50 kg/m^2) had a statistically significant increase in both medical ($P < 0.0001$) and surgical complications ($P < 0.0001$). Furthermore, Wagner et al[30] recently evaluated BMI as a continuous variable in a series of 21,361 consecutive TKAs. BMI was significantly associated with increased rates of reoperation ($P < 0.001$) and revision surgery ($P < 0.002$). In addition, they found a statistically significant increase in the incidence of wound infections (HR, 1.08; $P < 0.001$) and deep infections (HR, 1.08; $P < 0.001$). Of note, the risk of most complications increased at a BMI between 30 and 35 kg/m^2 and continued to increase with rising BMI level.

Medical Complications

Thromboembolic Events

Obese patients are considered susceptible to thrombosis after TKA. A study of 32,485 patients undergoing TKAs examined the impact of obesity (ie, WHO classes I–III) on deep vein thrombosis (DVT) and pulmonary embolism (PE).[31] The risk of DVT/PE increased significantly in the obese population (from 2.0% to 3.3%; adjusted $P < 0.01$). Despite this finding, the authors noted that the absolute risk was low. Another study of more than 12,000 patients found no statistically significant difference in rates of asymptomatic DVT ($P = 0.9475$), symptomatic DVT ($P = 0.4260$), and symptomatic PE ($P = 0.9275$) in patients with a BMI ≥40 kg/m^2 versus those with a lower BMI.[32]

Studies evaluating anticoagulation modalities are needed to provide a definitive recommendation on preventing DVT/PE risks. Although rates of DVT/PE may be increasing, adjustments in the anticoagulation regimen may be unnecessary, given the low absolute risk. The shift to spinal and regional blocks by many physicians over the past decade may further decrease this risk.

Cardiovascular Events

Obese patients often have comorbid conditions that increase their risk of perioperative complications.[33] A review of Danish registries revealed a U-shaped distribution of ischemic stroke, acute myocardial infarction, and/or cardiovascular death based on BMI (ie, WHO classes I–III) at the time of primary total hip or knee arthroplasty.[34] The U-shaped curve demonstrates that patients with the highest and lowest BMIs are increasingly at risk for perioperative cardiovascular complications. Once again, no direct conclusion can be drawn from this study; however, patient status should be properly optimized preoperatively and carefully monitored postoperatively to avoid cardiovascular complications.

Respiratory Complications

Respiratory complications, including respiratory tract and lung infections, are more common in obese patients than in nonobese patients undergoing TKA. In their study, Friedman et al[32] categorized patients according to BMI: 24.3% with a BMI <25 kg/m^2; 39.8% with a BMI from 25 to 29 kg/m^2; 32.3% with a BMI from 30 to 39 kg/m^2; and 3.6% with a BMI ≥40 kg/m^2. Patients with a BMI ≥40 kg/m^2 had a statistically significant increase in respiratory tract and lung infections compared with the pooled cohort of patients with a BMI <40 kg/m^2 ($P = 0.0391$). The authors did not speculate on the reason for this finding. It is likely multifactorial, given that this patient population has a higher incidence of medical comorbidities, nutritional deficiencies, and increased immobility than does the nonobese patient population.

Surgical Complications

Infection

In a prospective study of 1,214 consecutive patients undergoing TKA, Dowsey and Choong[35] noted an overall infection rate of 1.5% (n = 18). The deep prosthetic infection

rate in the morbidly obese cohort (ie, WHO classes I–III) was significantly greater than the rate in the nonobese cohort (OR, 8.96; 95% confidence interval [CI], 1.59 to 50.63). Several recent studies have shown similar results.[36,37]

Interestingly, not only is obesity associated with an increased risk of periprosthetic infection, but two-staged reimplantation is also more likely to fail in obese patients treated for infection than in nonobese patients.[38] Watts et al[38] retrospectively evaluated morbidly obese patients (ie, BMI ≥40 kg/m^2) who underwent a two-stage revision for infection. This cohort was matched 2:1 to a control group of nonobese patients who underwent a two-stage revision for infection. The morbidly obese cohort had statistically significant increased risks for revision surgery (32% compared with 11%; $P < 0.01$), reinfection (22% compared with 4%; $P < 0.01$), and reoperation (51% compared with 16%; $P < 0.01$). Currently, no study has evaluated methods for decreasing the infection rates in the obese population; however, the preoperative, intraoperative, and postoperative modes of medical and surgical optimization discussed previously should be employed.

Implant Survivorship

Multiple studies have shown worse implant survivorship in the obese TKA population.[23,39] As previously discussed, Abdel et al[23] reported that patients with a BMI ≥35 kg/m^2 had a significantly increased risk of tibial loosening ($P < 0.05$). In addition, multiple studies have shown a statistically higher risk of revision for deep infection.[28,38] To date, no study has specifically evaluated modalities to improve implant survivorship, although stemmed implants have been recommended to prevent aseptic tibial loosening. Methods for decreasing the risk of deep infection in obese patients warrant further investigation. Eliminating or substantially decreasing the risk of aseptic and septic loosening would most likely increase implant survivorship.

Interestingly, the implant survival rate is even lower in obese patients who undergo revision for aseptic loosening.[40] In a recent retrospective study of patients who underwent revision TKA for aseptic loosening, patients with a BMI ≥40 kg/m^2 who underwent 120 revisions were matched 1:1 with nonobese patients on the basis of sex, age, and date of surgery.[40] The implant survival rate was significantly lower at 10 years in the morbidly obese cohort than in the nonobese cohort (81% versus 93%, respectively; $P = 0.02$). Obese patients should be counseled at the time of primary and revision surgery that the rate of implant survival is reduced in their population.

Wound Healing

Wound healing is a common concern in obese patients undergoing TKA. Often, there is substantial adipose tissue between the skin and the extensor mechanism. Fluid can collect in this space at the time of closure, which may complicate wound healing in this population. One study evaluated 50 primary TKAs performed in 40 obese patients (ie, WHO class III) and compared the results with those of 1,768 TKAs in nonobese patients performed during the same period by one surgeon.[41] The risk of perioperative complications was significantly increased in the obese population ($P < 0.00005$). Specifically, wound complications were observed in 22% of knees in the obese patients compared with 2% of knees in the comparison group. The authors recommended altering the wound closure to limit complications. In addition, we typically apply negative-pressure wound vacuum therapy in at-risk areas. Specifically, attempts should be made to eliminate dead space between the arthrotomy and the skin layers. This space allows fluid to collect, which may place additional pressure on the skin closure, thereby increasing wound complications.

Costs

The previously noted increased complication and revision rates and the time required to perform a TKA in obese patients may contribute to increased healthcare expenditures in this patient population. At the Mayo Clinic, Kremers et al[42] evaluated length of stay and direct medical costs in obese patients undergoing TKA and reported that costs were lowest for patients in the normal and overweight BMI categories; there was a statistically significant increase in costs in the obese patient population. For every 5-kg/m^2 elevation in BMI above 30 kg/m^2, there was an increase of approximately $250 to $300 in hospitalization costs ($P < 0.0001$). The increase was closer to $600 to $650 for revision TKA ($P < 0.0001$). An association was seen with an increase in the length of stay for obese patients. The expansion in direct hospitalization costs was likely multifactorial.

Weight Loss After Total Knee Arthroplasty

It is commonly believed that TKA will allow obese patients to be more active and subsequently experience substantial postoperative weight loss. However, most patients who undergo TKA do not lose weight postoperatively. Ast et al[43] evaluated 3,893 total hip arthroplasties and 3,036 TKAs over a 2-year postoperative interval to determine whether patients had meaningful weight loss, defined as a 5% change in BMI. Among patients who underwent TKA, 69% had no meaningful change in BMI. Higher

preoperative BMI level, female sex, and TKA correlated strongly with weight loss. Another study indicated that obese patients may be more likely to maintain or even gain weight after TKA.[44]

Summary

Obesity is an epidemic, with a substantial percentage of the US population considered obese or overweight. In addition, the average BMI of patients undergoing TKA has increased each decade, contributing to poorer patient outcomes. For this reason, a comprehensive treatment plan should be used with this population. To optimize outcomes preoperatively, patients should be screened to determine their nutritional status. Obese patients are often malnourished and are specifically prone to hypoalbuminemia, an independent risk factor for poor outcomes after TKA. At this time, we are unable to recommend for or against preoperative bariatric surgery. However, nutritional laboratory tests may improve outcomes in patients who choose this option.

Intraoperatively, the obese patient poses several challenges. Because of excessive soft tissue, exposure may be problematic. Use of minimally invasive exposures is difficult and may be associated with increased ligamentous injury and longer surgical time. Component placement is also a challenge in this patient population, although some authors have shown improved placement with computer navigation. Tibial loosening is also increased in obese patients, and stemmed implants should be considered to improve fixation.

Finally, postoperative complications are a concern in obese patients. Medically, cardiovascular risks are nearly doubled in this patient population, and the risk of VTE is high. Surgically, the risk of periprosthetic and superficial infections is increased in obese patients, and implant longevity is decreased. Of note, most obese patients who undergo TKA are unlikely to lose weight and may actually gain weight postoperatively. Overall costs of performing TKAs are also higher in obese patients than in nonobese patients.

Over the last decade, numerous studies have demonstrated increased adverse outcomes after TKA in the obese population. However, few studies have examined ways to optimize and improve these results. Further research is warranted in this area. In some centers, patients whose BMI exceeds a set limit (ie, >35 kg/m^2) are required to lose weight before qualifying for TKA. However, information is limited on long-term outcomes in subjects with morbid obesity and advanced knee arthritis who do not undergo a TKA. For this reason, it is difficult to determine if a weight limit should be enforced when evaluating candidacy for TKA. Nevertheless, with the expanding epidemic of obesity and the known association between obesity and knee osteoarthritis, the percentage of TKAs performed in obese patients is likely to increase.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, reference 13 is a level I study. References 3, 19, 21, 28, and 35 are level II studies. References 4-7, 10, 14-17, 22, 23, 26, 29, 30, 32, 37, 38, 40-42, and 44 are level III references. References 2, 9, 11, 12, 18, 20, 24, 25, 27, 31, 33, 34, 36, 39, and 43 are level IV studies. Reference 1 is level V expert opinion.

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