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CLINICAL RESEARCH

Bariatric Orthopaedics: Total Knee Arthroplasty in Super-obese Patients (BMI > 50 kg/m^2). Survivorship and Complications

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Abstract

Background Some studies have suggested that patients who are super obese (BMI > 50 kg/m^2) may have poorer outcomes and more frequent complications when undergoing TKA compared with those who have lower BMI, however, the literature on this is scant.

Questions/purposes The purpose of this study was to compare a group of super-obese patients undergoing TKA with a matched group of patients with BMI less than 30 kg/m^2 in terms of (1) implant survivorship, (2) complications, (3) functional parameters, and (4) intraoperative variables (including operative time and estimated blood loss).

Methods One-hundred one knees in 95 patients (21 men, 74 women) who had a minimum BMI of 50 kg/m^2 and who had undergone a primary TKA at one of the four high-volume institutions were compared with a group of patients who had a BMI less than 30 kg/m^2 who were matched by age, gender, preoperative clinical scores, and mean followup. End points evaluated by chart review included implant survivorship, medical and surgical complications, functional parameters (The Knee Society outcome scores

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research.
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and ROM), and intraoperative variables at a mean followup of 62 months (range, 36–85 months).

Results With the numbers available, there were no differences in aseptic implant survivorship (94% versus 98%, p = 0.28), however, medical and surgical complication rates (14% versus 5%, OR: 3.1, 95% CI=1.07–8.9; p = 0.037) were significantly higher in the super-obese patients compared with the nonobese matching group, respectively. Super-obese patients also achieved lower mean Knee Society functional scores (82 versus 90 points, p = 0.004) and smaller gains in flexion arc ROM (14° versus 21°, p = 0.009); they also lost more blood during surgery and experienced longer surgical anesthesia times compared with the matched group, respectively.

Conclusions With the numbers available, we could not identify what might have been modest differences in implant survivorship, however, complications were more frequent and functional outcomes were significantly lower in super-obese patients. Other studies similarly have found inferior outcomes in this challenging group of patients. Our data may be considered pilot data for future prospective studies with longer followup.

Level of Evidence Level III, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Obesity (BMI $\geq$ 30 kg/m^2 or approximately 20% higher than ideal body weight) is an epidemic [18] that affects approximately one-third of the adults and one-fifth of the adolescents and children in the United States [27]. It is associated with an increase in medical comorbidities including hypertension, coronary artery disease, diabetes, and degenerative joint disease [7, 32]. These patients potentially may be at increased risk for having osteoarthritis develop, and may need TKA at an earlier age [6, 26]. However, surgical interventions in these patients may be associated with more technically demanding procedures and higher complication rates [3].

Numerous studies have reported on the outcomes of TKA in obese and morbidly obese patients [1, 4, 9, 12, 14–16, 20–22, 25, 26, 31, 33, 36], and numerous studies of patients whose threshold for obesity and morbid obesity have varied (generally $>$ 30 or $>$ 40 kg/m^2) have shown disparate outcomes [2, 3, 5, 8–11, 24, 33, 34, 36], although several more recent reports with larger numbers of patients have consistently tended to identify more inferior outcomes in patients with higher BMI [16, 19, 20, 35]. However, only a couple recent reports evaluated TKA outcomes in super-obese patients (BMI $\geq$ 50 kg/m^2, or those exceeding estimated ideal body weight by approximately 225%, such as a 6-feet tall individual who is approximately 200 pounds overweight) [3, 31]. Those studies reported a higher rate of medical and surgical complications. However, they had short-term followups (less than mean 3 years) and neither specifically evaluated methods of implant failure, Knee Society scores, and intraoperative variables between super-obese patients and their comparison cohorts. Accordingly, we sought to compare a group of super-obese patients (BMI $>$ 50 kg/m^2) undergoing TKA with a matched group of patients with BMI less than 30 kg/m^2 in terms of (1) implant survivorship, (2) complications, (3) functional parameters, and (4) intraoperative variables (including operative time and estimated blood loss).

Patients and Methods

After reviewing the records of four fellowship-trained adult reconstruction surgeons (ALM, PMB, SFH, MAM) at four high-volume arthroplasty institutions, 99 patients (105 knees) who had a minimum BMI of 50 kg/m^2 and who had undergone a primary TKA between 1999 and 2009 were identified. Four patients (four TKAs) were lost to followup before their 36-month followup, and although all had well-fixed implants at latest followup (12 to 30 months) and had achieved Knee Society scores greater than 80 points, they were not included in this study. The remaining 95 patients (101 TKAs; 21 men and 74 women) had a mean age at surgery of 60 years (range, 43–74 years), mean BMI of 54 kg/m^2 (range, 50–66 kg/m^2), and mean followup of 62 months (range, 36–85 months). There were no significant differences in followup duration among the different institutions. All available medical records including preoperative and postoperative studies, radiographs, surgical and anesthesia notes, estimated blood loss, surgical and anesthesia times, and clinic visits and notes were reviewed. Appropriate institutional review board approvals for the study of these patients were obtained at all four institutions.

Aseptic implant survivorship (defined as failure owing to revision of tibial or femoral components for any aseptic reason), surgical complications, Knee Society objective and functional scores, flexion ROM, estimated intraoperative blood loss, surgical time, anesthesia time, and radiographic outcomes in super-obese patients were compared with those of a group of patients who had a BMI less 30 kg/m^2 (mean, 28 kg/m^2; range, 25–29.9 kg/m^2) and who

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were matched by mean age (within 2 years), sex, procedure (unilateral versus bilateral), followup time (within 4 months), and preoperative Knee Society objective and functional scores (within 5 points) who had undergone TKA by the same surgeons during the same period. The matching group was selected in a 1:1 ratio and as a series of consecutive patients who had met the matching criteria from each institution.

For super-obese patients, a standard medial parapatellar or midvastus approach was performed in 78 and 23 TKAs, respectively. Sixty-three knees were implanted with Triathlon® prostheses (Stryker Orthopedics, Mahwah, NJ, USA), 32 with Osteonics Scorpio® prostheses (Stryker Orthopedics), and six with Kinemax® prostheses (Stryker Orthopedics) with the use of standard universal cutting blocks. For the matching cohort, a standard medial parapatellar or midvastus approach was performed in 85 and 16 TKAs, respectively. In this cohort, 78 knees were implanted with the Triathlon® prostheses (Stryker Orthopedics), 20 with Osteonics Scorpio® prostheses (Stryker Orthopedics), and three with Kinemax® prostheses (Stryker Orthopedics) with the use of standard universal cutting blocks. There were no significant differences in type of approach ($p = 0.28$) or prostheses types between the two cohorts ($p = 0.21$). In all centers the tibial trays were cemented around the stem. An intentional tibial cement mantle of at least 2 mm was used around the stem in all cases. Although tibial stem extensions were not used routinely, the decision to use them was based on the amount of proximal bone stock and not the level of obesity, therefore, a similar amount of stem extensions were used in both groups. Nevertheless, in nine super-obese patients and six patients in the matching group, these tibial stem extensions were used ($p = 0.42$).

When evaluating comorbidities based on the American Society of Anesthesiologists (ASA) comorbidity index, in the super-obese cohort, four patients had Class I, 21 had Class II, 58 had Class III, and 12 had Class IV ASA comorbidity indices. In the comparison cohort, 15 patients had Class I, 35 had Class II, 44 had Class III, and eight had Class IV ASA comorbidity indices. Super-obese patients had a 2.3 times higher odds ratio of having Classes III and IV comorbidities compared with the matching group (95% CI, 1.3 to 4.3; $p = 0.005$). In the super-obese cohort, the most common comorbidities included hypertension and cardiovascular disorders (73.7%), multiple joint musculoskeletal disorders (62.1%), diabetes (45.2%), tobacco smoking (36.8%), and gastrointestinal disorders (30.5%). In the matching group the most common comorbidities included, hypertension and cardiovascular disorders (53.6%), multiple joint musculoskeletal disorders (43.2%), diabetes (22.1%), gastrointestinal disorders (18.5%), and tobacco smoking (13.6%).

All patients received preoperative antibiotics and deep venous thrombosis prophylaxis as the standard of care. Tourniquets were applied during all procedures and were released during approximately the last 30 minutes of surgery and before case closure. During rehabilitation, all patients were encouraged to fully weightbear immediately in the postoperative period with the use of ambulatory aids. Patients also were allowed to discontinue the use of ambulatory aids when they could walk with no substantial limp, usually at approximately 2 weeks after their surgery. Standard postoperative rehabilitation protocols were used for all patients, which included ROM exercises, quadriceps muscle strengthening, and gait.

For all patients with higher BMIs (> 30 kg/m^2), the senior authors (MAM, SFH, PMB, ALM) recommend that patients lose weight, with nonoperative measures such as life-style modifications and increasing exercise. Patients with a BMI of 40 kg/m^2 or greater (including super-obese patients) are advised to discuss, with their primary care providers, the possibility of undergoing bariatric surgery before TKA, if they meet medical eligibility. However, in our institutions, weight loss is not a requirement and BMI is not an exclusion criterion to perform a TKA. Although, in nine super-obese patients, the procedures were delayed between 2 to 12 weeks until these patients were cleared by their primary care physicians, no patient was denied a TKA solely because of their BMI. If patients had end-stage knee arthritis, were medically stable, and appropriate nonoperative management had failed to treat the arthritis problem, they were offered a knee arthroplasty.

Patients returned for followups at approximately 6 weeks, 6 months, 12 months, and then yearly thereafter. Clinical outcomes were assessed by evaluating The Knee Society objective and function scores. All patient records were reviewed by the senior authors (ALM, PMB, SFH, MAM) for complications or for the need for further surgical interventions such as arthrofibrosis, wound hematoma, lysis of adhesions, polyethylene spacer exchange, or revision.

AP and lateral view radiographs of the knees were obtained for all patients and reviewed at each postoperative visit by one of the senior authors (MAM, SFH, PMB, ALM). In all centers, similar standard protocols were used to obtain AP and lateral knee views. For AP radiographs, all patients were placed in the upright position and with their back toward the vertical grid device, knees positioned to the center of the cassette, and feet adequately separated for good balance. While shielding the reproductive organs, patients were asked to stand straight with fully extended knees and weight distributed equally on the feet. Radiographs were taken by placing the cassette centered approximately ½ inch below the apices of the patellae. For lateral radiographs, patients were asked to turn to the affected side, bring the affected knee forward, and extend the other knee behind it. The affected knee was flexed to

the desired angle and the cassette was placed perpendicular to the epicondyles, while the patella also was perpendicular to the plane of the cassette. The reproductive organs were shielded as the radiographs were taken. These radiographic images were assessed for fixation, progressive radiolucencies around the prosthetic components, malalignment, or component failure.

All data were recorded using an Excel spreadsheet (Microsoft Corporation, Redmond, WA, USA). Implant survivorship was analyzed by defining failure as revision of tibial or femoral components for any aseptic cause. Statistical analysis was performed by Student's t-test and Fisher's exact test to analyze implant survivorship and clinical and radiographic outcomes between the super-obese and the matching group. A p value less than 0.05 was used as a threshold for significance. A post hoc a priori retrospective power analysis with the numbers available using survivorship and complications (our primary study end points) found that we had 36% power to detect a difference in survivorship of 4%, and 58% power to detect a threefold (5% to 14%) difference in complications between the matching and super-obese groups.

Results

There were no significant differences in implant survivorship using aseptic loosening as the end point between the super obese and the matching group ($p = 0.28$). In the super-obese group, the aseptic implant survivorship was 94% with six patients undergoing revision surgery. In the matching group, the aseptic implant survivorship was 98% with two patients undergoing revision surgery. With the numbers available, there also was no difference between groups in terms of survivorship for reoperation for any reason ($p = 0.33$). In the super-obese group, overall, there were seven revisions. Four patients underwent revision surgery resulting from component loosening, two other patients underwent revision surgery as a result of pain and instability, and another patient had revision surgery as a result of a deep periprosthetic infection. In the matching group, overall there were three revisions. Two patients underwent revision surgery resulting from pain and instability and one patient underwent two-stage revision surgery as a result of periprosthetic infection (Table 1). When comparing revisions attributable to implant loosening, the super-obese cohort had an approximately 9.4 times higher odds ratio (95% CI, 0.49–176.6) of loosening compared with the matching group and this trended toward significance ($p = 0.13$). When revisions were substratified based on medical comorbidities, diabetes (OR, 1.7; $p = 0.51$) and tobacco smoking (OR, 2.1; $p = 0.45$) were correlated with higher odds ratio of failure. On radiographic review of patients in both groups, except for the patients who had undergone revision surgery for any reason, radiographic evaluation of prosthetic components in all remaining patients showed no evidence of progressive radiolucencies, subsidence, or loosening.

With the numbers available, super-obese patients had approximately 3.1 times higher odds ratio (95% CI, 1.07–8.9) of complications (14 versus 5%) compared with the matching group and this was statistically significant ($p = 0.037$). There were no intraoperative complications in the super-obese group. However, the surgical complication rate was 6% (six of 101), which included three patients who had wound necrosis develop, one of whom was returned to the operating room for revision of the scar and the other two underwent superficial débridement in the outpatient setting. Another patient had a superficial infection that was treated nonoperatively with oral and topical antibiotics and two patients had wound hematoma, which were treated with evacuation, irrigation, and débridement. The medical complication rate in this cohort was 8% (eight of 101) which included two urinary tract infections, two acute renal failures, two acute respiratory complications, one delayed wound healing, and one postoperative ileus. In the matching group, there were no intraoperative complications. The surgical complication rate in the matching group was 2% (two of 101), which included a wound hematoma and a suture abscess, both of which were treated with evacuation, irrigation, and débridement. The medical complication rate was 3% (three of 101) which included one urinary tract infection, one respiratory complication, and one metabolic alkalosis. All patients in both groups who had complications were treated successfully and had achieved The Knee Society objective and functional scores greater than 80 points at latest followup. Medical and surgical complications were spread equally among the four centers with a range of four to six complications per center ($p = 0.52$) with a similar amount of patients from each center.

Super-obese patients achieved significantly lower postoperative Knee Society functional scores ($p = 0.004$), however, there were no differences in The Knee Society objective scores between the two groups The mean Knee Society function scores in the super-obese group improved from a mean preoperative score of 52 points (range, 0–85 points) to a postoperative mean of 82 points (range, 30–100 points), respectively. This was significantly lower than the matching group that had improved from a mean preoperative score of 54 points (range, 35–70 points) to a postoperative mean of 90 points (range, 64–100 points), respectively (Table 2). A significantly lower gain in flexion ROM also was achieved in the super-obese group compared with the matching group ($p = 0.009$). The mean gain in flexion arc in the super-obese group was 14° (range,

Table 1. Summary of the revisions at the postoperative clinical outcomes

Revision	Patient age (years)	Sex	BMI (kg/m^2)	Time to revision (months)	Reason for revision/ treatment course	Postoperative Knee Society objective and function scores (points)	Followup (months)
BMI > 50 kg/m^2 group							
1	60	F	53	6	Loosening	69 and 75	24
2	52	M	52	7	Loosening	68 and 60	37
3	63	M	53	26	Infection	86 and 30	11
4	46	F	52	33	Pain/instability	70 and 65	23
5	55	F	55	34	Loosening	87 and 85	6
6	43	F	56	39	Pain/instability	94 and 65	42
7	59	F	59	42	Loosening	95 and 66	19
Matching group							
1	63	M	26	4	Infection	91 and 90	31
2	58	F	25	9	Pain/instability	99 and 80	16
3	53	M	30	13	Pain/instability	85 and 90	26

F = female; M = male; KSS = The Knee Society score.

10°–100°), which was significantly lower than 21° (range, 5°–90°) in the matching group.

Super-obese patients lost more blood during surgery ($p = 0.001$), and had longer surgical and anesthesia times ($p = 0.001$, $p = 0.009$, respectively), when compared with the matching group (which may point to more technically demanding procedures). In the super-obese group, the mean estimated blood loss, surgical time, and anesthesia time were 274 mL (range, 75–500 mL), 98 minutes (range, 72–120 minutes), and 153 minutes (range, 125–205 minutes), respectively, which were significantly higher than 121 mL (range, 50–300 mL), 90 minutes (range, 62–134 minutes), and 135 minutes (range, 110–189 minutes) in the matching group, respectively.

Discussion

Obese patients appear to undergo TKAs at younger ages, and those reconstructions may be associated with lower implant survivorship [6, 36]. In addition, arthroplasties may be more technically demanding in these patients as a result of difficulty in identifying the anatomic landmarks. A couple studies included outcomes and complications of TKAs in super-obese patients, however, these studies have short followups (less than mean 3 years) and none evaluated methods of implant failure, Knee Society scores, and intraoperative variables between super-obese and matching cohorts. Therefore, as a result of the paucity of reports regarding TKAs in super-obese patients, we evaluated the clinical and radiographic outcomes of this procedure in a group of patients who had a minimum BMI of 50 kg/m^2 compared with a nonobese matching group who had a BMI less than 30 kg/m^2 at a mean followup of 5 years. With the numbers available, we found similar implant survivorship at short-term, but we did observe significantly higher complications, lower Knee Society functional scores, and decreased postoperative ROM in the super-obese group compared with the nonobese matching group.

There are several limitations of this study including its small sample size. An a priori retrospective power analysis based on the numbers available in our study showed lower power and insufficient sample size to detect differences in implant survivorship. Since our study includes only the early outcomes of TKA in super-obese patients, implant survivorship at 5 to 10 years or longer followup may change. The retrospective design of the study might have introduced selection bias. In addition, four patients were lost to followup and were excluded from this study. The chart review was performed by surgeons involved with the care of the patients. Because radiographic images were not obtained under fluoroscopic guidance, it might have been hard to get good x-ray penetration or consistently get acceptable AP or lateral films owing to the physical size of these patients; thus, some radiolucent lines may have been missed. Furthermore, coronal and sagittal limb alignment parameters were not evaluated. Because it has been shown that more varus alignment (> 3° varus from neutral mechanical axis) may lead to higher loosening rates [30], such radiographic alignment analysis potentially could have been valuable to further analyze the early loosening rate of our super-obese patients. Future studies should look at potential correlations of alignment parameters to aseptic loosening in these patients. In addition, broader quality-of-

Table 2. Summary of the demographic and clinical findings

Demographics and clinical findings	Super-obese group (BMI > 50 kg/m^2)	Matching group (BMI < 30 kg/m^2)	p value
Number of patients (number of knees)	95 (101)	95 (101)	1
Age (years; range)	60 (43–74)	59 (45–75)	0.3727
Men:women	21:74	21:74	1
BMI (kg/m^2; range)	54 (50–66)	28 (24–30)	< 0.001
Preoperative Knee Society objective score (points; range)	53 (23–78)	50 (35–69)	0.0899
Preoperative Knee Society function score (points; range)	52 (0–85)	54 (35–70)	0.1589
Postoperative Knee Society objective score (points; range)	91 (58–100)	94 (66–100)	0.1161
Postoperative Knee Society function score (points; range)	82 (30–100)	90 (64–100)	0.004
Preoperative range of flexion arc (degrees; range)	84 (15–120)	98 (70–130)	0.001
Postoperative range of flexion arc (degrees; range)	109 (90–125)	122 (95–130)	0.001
Gain of flexion arc (degrees; range)	14 (10–100)	21 (5–90)	0.009
Estimated blood loss (mL; range)	174 (75–500)	121 (50–300)	0.001
Surgical time (minutes; range)	98 (72–120)	90 (62–134)	0.009
Anesthesia time (minutes; range)	153 (125–205)	135 (110–189)	0.001
Aseptic implant survivorship	94	98	0.3313
Percent complications	14	5	0.037

life measures (such as WOMAC or SF-36) were not evaluated. All senior authors involved in this study were high-volume surgeons, therefore our results might not generalize well to the practices of lower-volume or less-experienced surgeons. In addition, all surgeons followed Surgical Care Improvement Projects (SCIP) guidelines [28] for antibiotic prophylaxis, American Academy of Orthopaedic Surgeons (AAOS) recommendations concerning venous thromboembolic prevention [17, 23], weight reduction recommendations before TKA, and early and extended postoperative rehabilitation for all patients. Nevertheless, we believe that these results are valuable to evaluate clinical outcomes of primary TKA in this difficult-to-treat patient population. Prospective multicenter studies with longer followup are needed to further evaluate outcomes of TKA in this patient population.

We identified two previous studies that have included clinical outcomes of TKA in super-obese patients [3, 31]. Schwarzkopf et al. [31] evaluated outcomes of 137 THAs or TKAs in patients with BMIs of 45 to 70 kg/m^2 compared with 63 patients who had BMIs less than 25 kg/m^2. Although they did not specify how many patients who had TKAs were super obese (BMI > 50 kg/m^2), they reported an 8.44 higher odds of postoperative complications while the patients were hospitalized (p = 0.05) and a 1.61 increase in odds of having postoperative complications within the first year when their morbidly obese and super-obese patients were compared with the matching group. Similarly, Baker et al. [3] retrospectively reviewed 1018 TKAs in patients who had BMIs of 40 to 60 kg/m^2 compared with 12,655 TKAs in overweight and obese patients. Although, they did not specify how many patients were super-obese (BMI > 50 kg/m^2), they reported significantly higher wound complications (17% versus 9%; p = 0.001) in the morbidly and super-obese patients compared with the patients who were overweight. Similar to these studies, we also observed significantly higher complications in our super-obese patients.

When evaluating functional outcomes, we did not find any previous study that had evaluated The Knee Society objective and functional scores or ROM in super-obese patients. However, Baker et al. [3] evaluated patient-reported outcomes between overweight and morbidly or super-obese patients and reported no significant differences in Oxford Knee Score (mean difference, 0.5 point [95% CI, −0.5 to 1.5 points]; p = 0.78), EuroQol-5D index (mean difference, 0.014 point [95% CI, −0.021 to 0.048 point]; p = 1.00), and EuroQol-5D VAS (mean difference, 1.9 points [95% CI, −0.4 to 4.1 points]; p = 0.13) between the two cohorts. They concluded that the improvements in patient-reported outcome measures experienced by all patients were similar, regardless of BMI and that obese patients should not be excluded from the benefit of a TKA, given that their overall improvements were equivalent to those of patients with a lower BMI. Similarly, although our super-obese patients had achieved comparable Knee Society objective scores compared with the matching group (potentially proposing similar pain relief advantage of the procedure), they achieved significantly lower functional outcomes, which may be concerning.

When evaluating operative complexity, operation time, and blood loss in super-obese patients, we did not find any study that had evaluated these metrics in this patient population, and overall there is a paucity of reports on this topic. However, Gadinsky et al. [13] evaluated 454 unilateral primary TKAs and categorized them based on BMI (normal weight, 18.5–25 kg/m^2; overweight, 25–30 kg/m^2; obese Class I, 30– < 35 kg/m^2; Class II, 35–40 kg/m^2; Class III, > 40 kg/m^2). Comparing normal weight with obese Class

III, time differences were significant in total room time (24 minutes, $p < .01$), surgery time (16 minutes, $p < .01$), tourniquet time (7.5 minutes, $p < .01$), and closure time (8 minutes, $p < .01$). Raphael et al. [29] evaluated operative time in 100 consecutive patients undergoing primary total joint arthroplasties who were divided into four groups depending on their BMI: the normal group (BMI, 18 to 24.9 kg/m^2), the overweight group (BMI, 25–29.9 kg/m^2), the obese group (BMI, 30–39.9 kg/m^2), and the morbidly obese group (BMI $\geq$ 40 kg/m^2). They reported that the mean operative time for THA ($R2 = 0.197$, $p = 0.003$) and mean scrubbing time for TKA varied with BMI ($p = 0.028$). The time to administer spinal anesthesia ($R2 = 0.1466$, $p = 0.018$) was significantly increased in morbidly obese patients. Nevertheless, our results showed that TKA may be more technically demanding in super-obese patients compared with nonobese patients.

We found no differences in implant survivorship between super-obese patients undergoing TKA compared with a matching cohort of nonobese patients. We suspect that this may have been a function of a relatively small sample size and short followup duration. However, the higher rates of early aseptic loosening that we found in our super-obese cohort compared with the matching group, especially in younger super-obese patients, may be concerning (potentially more than other metrics). In addition, we observed significantly higher complications and lower functional outcomes in super-obese patients. Other studies [3, 31] have found similar differences, and we suspect that the super-obese patient undergoing a TKA may be at greater risk for complications with decreased implant survivorship. Furthermore, the longer and bloodier operations in our super-obese cohort reflect on the high degree of difficulty in these procedures. Longer followup and larger (perhaps multicenter) studies are needed.

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