Five- and ten-year follow-up of medial unicompartmental knee arthroplasties in obese and non-obese patients

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Aims

The aim of this study was to determine whether obesity had a detrimental effect on the long-term performance and survival of medial unicompartmental knee arthroplasties (UKAs).

Methods

This study reviewed prospectively collected functional outcome scores and revision rates of all medial UKA patients with recorded BMI performed in Christchurch, New Zealand, from January 2011 to September 2021. Patient-reported outcome measures (PROMs) were the primary outcome of this study, with all-cause revision rate analyzed as a secondary outcome. PROMs were taken preoperatively, at six months, one year, five years, and ten years postoperatively. There were 873 patients who had functional scores recorded at five years and 164 patients had scores recorded at ten years. Further sub-group analysis was performed based on the patient's BMI. Revision data were available through the New Zealand Joint Registry for 2,323 UKAs performed during this time period.

Results

Obese patients (BMI > 30 kg/m^2) were 3.1 years younger than non-obese patients (BMI < 30 kg/m^2) at the time of surgery (mean age of obese patients 65.5 years (SD 9.7) and mean age of non-obese patients 68.6 years (SD 10.1)). Preoperatively, obese patients tended to have significantly lower functional scores than non-obese patients, which continued at five and ten years postoperatively. At these timepoints, obese patients had significantly lower scores for most PROMs measured compared to non-obese patients. However, there was no significant difference in the improvement of any of these scores after surgery between obese and non-obese patients. There was no significant difference in revision rates between obese and non-obese patients at any time. All-cause revision rate for obese patients was 0.73 per 100 observed component years compared to 0.67 in non-obese patients at ten years. There was also no significant difference in the aseptic loosening rate between groups.

Conclusion

Our study supports the use of UKAs in obese patients, with similar benefit and survival compared to non-obese patients at ten years.

Take home message

- Obese patients receive equivalent long-term benefit from unicompartmental knee arthroplasty compared to non-obese patients, with no difference in long-term implant survival.

Introduction

Evidence suggests that unicompartmental knee arthroplasty (UKA) is more cost-effective than total knee arthroplasty (TKA) due to shorter hospital stays, fewer readmissions, and faster rehabilitation.[1–3] This is despite the established higher revision rate associated with UKA compared to TKA.[2,4–7] UKA is associated with fewer major surgical and medical complications, such as deep infection, intraoperative blood loss, and the need for transfusion.[8] Obesity is clearly a risk factor for knee arthritis, and New Zealand

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is now one of the most obese countries in the world.[9] The proportion of New Zealanders with a BMI greater than 30 kg/m^2 is increasing each year, and this now makes up over one-third of the adult population.[9] In combination with a growing and ageing population, obesity is leading to a rapidly increasing demand for knee arthroplasty surgery. Traditionally, obesity has been thought of as a contraindication for UKA due to an unproven theoretical concern of early failure.[10] In recent years, UKA has continued to increase in popularity, but in 2022, only 9.3% of knee arthroplasties performed in New Zealand were UKAs.[4] In the UK, in the three years across 2020 to 2022, only 13.5% of knee arthroplasties were UKAs, despite an estimated 48% of patients meeting candidacy based on clinical and radiograph appearance.[5,11] Obesity, as a contraindication, is potentially a major contributing factor to the underutilization of UKA, despite several recent studies demonstrating that UKA in obese patients have equivalent longevity and performance to non-obese patients.[12–15] Many of these studies, however, have either had short follow-up, low patient numbers, or have failed to address implant performance based on functional outcome scores.[12,15–23] The aim of our study was to further investigate the association between obesity, clinical outcomes, and implant survival following UKA. We hypothesize that UKA in obese patients results in equivalent long-term implant survival and postoperative improvement in pain and function compared to non-obese patients.

Methods

The study included all patients with recorded BMIs who received a primary medial UKA in Christchurch, New Zealand, from January 2011 to December 2021. The patients who were included received their surgery in three different hospitals performed by 19 different surgeons. During this time period, no surgeries were performed with navigation or robotic arm assistance. There was no consensus on contraindications for UKA between these surgeons. Specifically, there was no agreed cut-off for BMI with regard to obesity. The majority of these cases (68.2%, n = 1,586) were performed at Burwood Public Hospital. The remainder were performed at St George's Hospital (22.7%, n = 527) and Southern Cross Hospital (8.7%, n = 203), both private hospitals in Christchurch. BMI measurements were taken and recorded by a trained registered nurse on the day of their preoperative anaesthetic assessment. The BMI was then entered into the standardized joint registry form on the day of surgery, which is checked and signed by the responsible surgeon. BMI data were then accessed via the New Zealand Joint Registry (NZJR) at the time of analysis. Patients were classified as obese if their preoperative BMI was > 30 kg/m^2, and non-obese if their BMI was < 30 kg/m^2. There was further subgroup analysis classifying patients into normal (BMI < 25 kg/m^2), overweight (BMI 25 to 29.9 kg/m^2), obese class I (BMI 30 to 34.9 kg/m^2), and obese class II and III (BMI > 35 kg/m^2).

This study only included medial UKAs and excluded all lateral UKAs and patellofemoral arthroplasties. Both mobile and fixed-bearing, cemented, and uncemented implants were included. Of the patients included, 82.7% (n = 1,941) were Oxford phase 3 uncemented (Zimmer Biomet, UK), 14% (n = 329) Physica ZUK (LimaCorporate, Italy), with the remaining 3.3% (n = 53) of implants consisting of Miller Galante (Zimmer Biomet, USA), Oxford phase 3 cemented, and Persona Partial Knee (Zimmer Biomet, USA). In the non-obese group, Oxford phase 3 uncemented comprised 83.4% (n = 977) of patients, compared to 83.8% (n = 964) in the obese group.

All patients were followed prospectively with a variety of PROMs recorded preoperatively, at six months, one year, five years, and ten years postoperatively. Patients were contacted at these time intervals by medical staff working for the University of Otago's Department of Musculoskeletal Medicine and filled out forms in person. The scores included the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC),[24] Oxford Knee Score (OKS),[25,26] High Activity Arthroplasty Score (HAAS),[27] University of California and Los Angeles (UCLA) activity score,[28] World Health Organization (WHO) quality of life (WHOQoL) score,[29] and a visual analogue scale (VAS) pain score and patient satisfaction score (0 to 10). Preoperative functional scores were recorded in 1,588 patients, postoperative scores were recorded in 873 patients at five years, and 164 patients at ten years. Patient written consent and formal ethics approval were obtained from the New Zealand Health Research Council (HRC) Ethic Committee. All-cause revision data were available for all 2,323 patients during this ten-year period through the NZJR.[4] Revision rate was measured as the number of revisions per 100 observed component years.[4] Revision was defined as any further surgery where implant components were changed, including exchange of dislocated mobile bearings. Revision also included prosthesis implantation in previously unreplaced compartments, such as in the addition of a lateral UKA.

Statistical analysis

Statistical comparisons of age and PROM values and changes between the two BMI groups were undertaken using independent-samples *t*-tests. The data were confirmed to be of a normal distribution. The association between sex and BMI group was tested using a chi-squared test. Changes over time within BMI groups were tested using paired *t*-tests, and revision rates were compared using log-rank tests and Kaplan-Meier survival analysis. A two-tailed p-value < 0.05 was taken to indicate statistical significance, and all analyses were undertaken using SPSS v.28 (IBM, USA).

Results

There were 2,323 patients in the study cohort, with an equal distribution between obese and non-obese (49.5% and 50.5%, respectively). The mean age for all patients was 67.1 years (SD 10.0) with 48.7% (n = 1,132) of them female (Table I). Obese patients had surgery 3.1 years earlier than non-obese patients (p < 0.001, independent-samples *t*-test). There was a direct relationship with increasing BMI and decreasing age at time of surgery (Figure 1). On average, patients with a BMI > 35 kg/m^2 had surgery 5.7 years earlier than those with a BMI < 25 kg/m^2. In obese patients, the proportion of females increased with increasing BMI (50.5% vs 60.6%, obese class I vs obese class II and III, respectively).

Functional results

Obese patients had significantly lower preoperative functional scores compared to non-obese patients (p < 0.001,

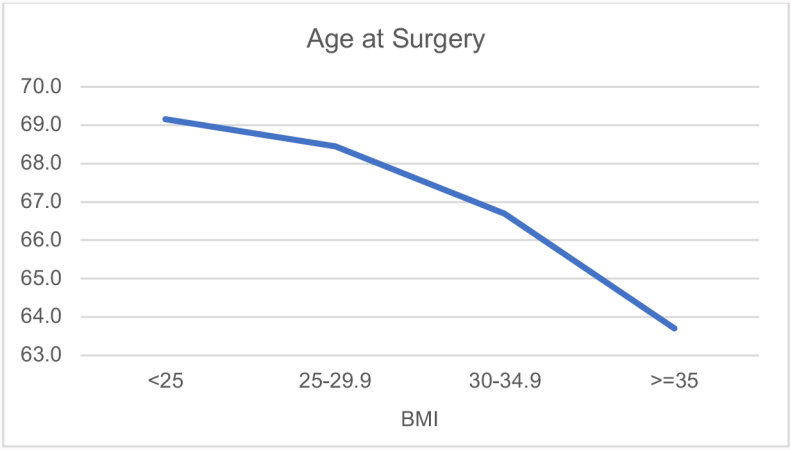

Fig. 1
The relationship between escalating obesity and age at time of surgery.

Table I. Patient demographic data.

Variable	Total	Non-obese (BMI < 30 kg/m²)	Obese (BMI > 30 kg/m²)	p-value
Patients, n (%)	2,323	1,172 (50.5)	1,151 (49.5)	
Mean age, yrs (SD)	67.1 (10.0)	68.6 (10.1)	65.5 (9.7)	< 0.001
Female, n (%)	1,132 (48.7)	507 (43.6)	625 (54.8)	< 0.001

independent-samples *t*-test), except for pain and UCLA activity score. For obese patients, preoperative scores deteriorated with increasing BMI (obese class II and III were worse than obese class I), except for pain and UCLA activity score. Both obese and non-obese patients had significant improvement in all postoperative scores ($p < 0.001$, paired *t*-test). At five years, the non-obese group had better postoperative scores for all PROMs compared to the obese group (highest p-value = 0.012, independent-samples *t*-test). Although statistically significant, ($p < 0.001$, independent-samples *t*-test) these differences did not meet the minimal clinically important difference (MCID) for the OKS (4.7) and WOMAC (20.5).[30] Importantly, there was no significant difference in the improvement from preoperative scores in both groups at five years (highest p-value = 0.120, independent-samples *t*-test). Subgroup analysis showed that for obese patients, there were significantly lower OKS, WOMAC, HAAS, and UCLA activity scores with increasing BMI at five years (obese class II and III group worse than obese class I, $p < 0.001$). However, again, this did not meet MCID for OKS and WOMAC. These results are shown in Figures 2 to 7.

At ten years, the difference in functional scores between obese and non-obese patients remained, except for pain ($p = 0.360$, independent-samples *t*-test), OKS ($p = 0.062$, independent-samples *t*-test), and WHOQoL score ($p = 0.133$, independent-samples *t*-test). The difference in mean WOMAC scores between the two groups (6.3, $p = 0.028$, independent-samples *t*-test) did not meet the MCID (20.5).[30] Other scores showed some small deterioration in function for the obese patients but, again, there was no significant difference in the improvement from preoperative scores between obese and non-obese patients at ten years (highest p-value = 0.091, independent-samples *t*-test). For obese patients at ten years, there were progressively poorer HAAS, WOMAC, and OKS with increasing BMI (obese class II and III group worse than obese class I) but this did not meet the MCID for OKS and WOMAC. There was also no difference in the improvement from preoperative scores in the subgroup analysis at five or ten years (highest p-value = 0.093, independent-samples *t*-test). There was no association between increasing BMI and lower improvement with surgery at any time for any score.

Revision rates

There were 97 revisions (4.18%) during this time period, equating to a revision rate of 0.70 per 100 observed component years. Although the overall revision rate was higher in obese compared to non-obese patients (0.73 vs 0.67, respectively), this was not statistically significant ($p = 0.744$, log-rank test) (Table II). There was also no significant difference in survival with increasing BMI in the subgroup analysis ($p = 0.878$, log-rank test) (Table II).

The proportion of patients who were revision-free was slightly higher in the obese group at ten years, but this was not statistically significant ($p = 0.744$, log-rank test) (Figure 8). In 2,323 patients, there were only four revisions for deep infection, equating to 0.17% of all patients, two being in the obese group and two in the non-obese group. The revision rate for infection included debridement, antibiotics, and implant retention (DAIR), if the bearing was exchanged. "Ongoing pain" as a reason for revision was much higher in the obese group, with 14 patients out of the total 17 revisions being obese (82.4%). This did not increase with BMI, with 12 revisions in the obese class I group and only two revisions for ongoing pain in the obese class II and III group. There was no difference in mean VAS pain score for this group compared to other BMI sub-categories. The study is not powered to come to any statistically robust conclusion on this finding. We believe "pain" as a reason for revision may have been inconsistently

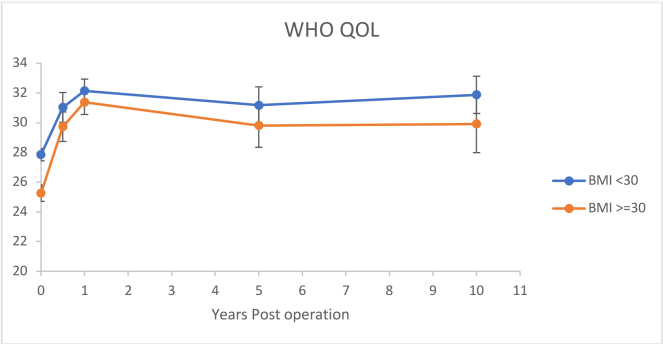

Fig. 2
Preoperative and postoperative World Health Organization (WHO) quality of life score for unicompartmental knee arthroplasty patients with BMI over and under 30 kg/m^2.

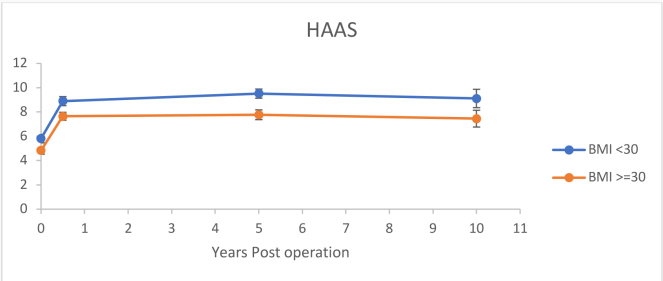

Fig. 4
Preoperative and postoperative High Activity Arthroplasty Scores (HAAS) for unicompartmental knee arthroplasty patient with BMI over and under 30 kg/m^2.

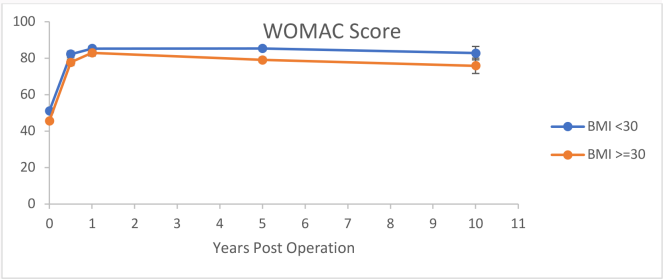

Fig. 6
Preoperative and postoperative Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores for unicompartmental knee arthroplasty patients with BMI over and under 30 kg/m^2.

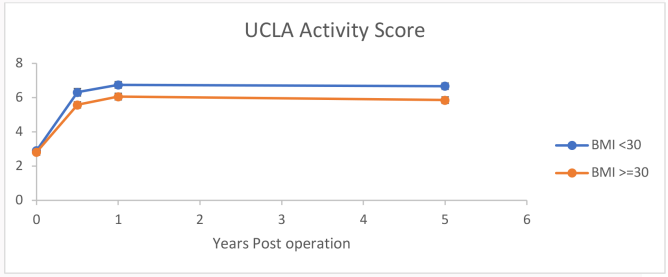

Fig. 3
Preoperative and postoperative University of California, Los Angeles (UCLA) Activity scores for unicompartmental knee arthroplasty patients with BMI over and under 30 kg/m^2.

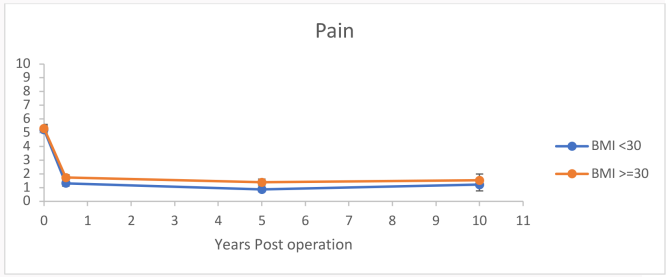

Fig. 5
Preoperative and postoperative visual analogue pain scores for unicompartmental knee arthroplasty patients with BMI over and under 30 kg/m^2.

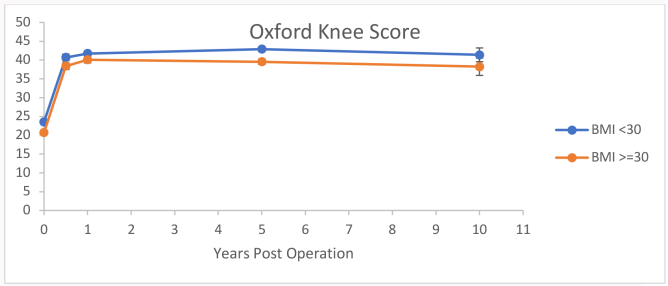

Fig. 7
Preoperative and postoperative Oxford Knee Scores for unicompartmental knee arthroplasty patients with BMI over and under 30 kg/m^2.

interpreted and selected by surgeons, and believe these data are best ignored. Only ten revisions were done for aseptic loosening of either femoral or tibial components, five in the obese group and five in the non-obese group. There was no notable difference in complication profile according to BMI sub-categories other than revision for "pain" in the obese class I group, as stated above.

Discussion

This study adds to the recent growing body of evidence supporting the performance of UKAs in obese patients. Obesity should not be considered a contraindication for UKA. Obese patients can be expected to experience an equivalent long-term benefit from UKA, with no reduction in implant survival. In addition to several other recent studies, we have demonstrated that obesity is not a risk factor for periprosthetic joint infection or early UKA implant failure.[12–15]

UKA is more cost-effective than TKA, which is clearly relevant in a public health system.[7] This is true even when considering its accepted higher revision rate.[1,5,6] UKA is also associated with a faster rehabilitation, fewer major complications including deep infection, fewer outpatient visits, and lower transfusions rates and mortality.[1,3,8] We have demonstrated a very low revision rate for infection in this study of 0.17%. New Zealand hospitals are overcrowded and struggling to meet the current arthroplasty demands of an ageing obese population.[9] Cancellation of elective surgery due to shortage of hospital beds is a frequent occurrence. UKA could pose a potential solution by providing a cost-effective option that

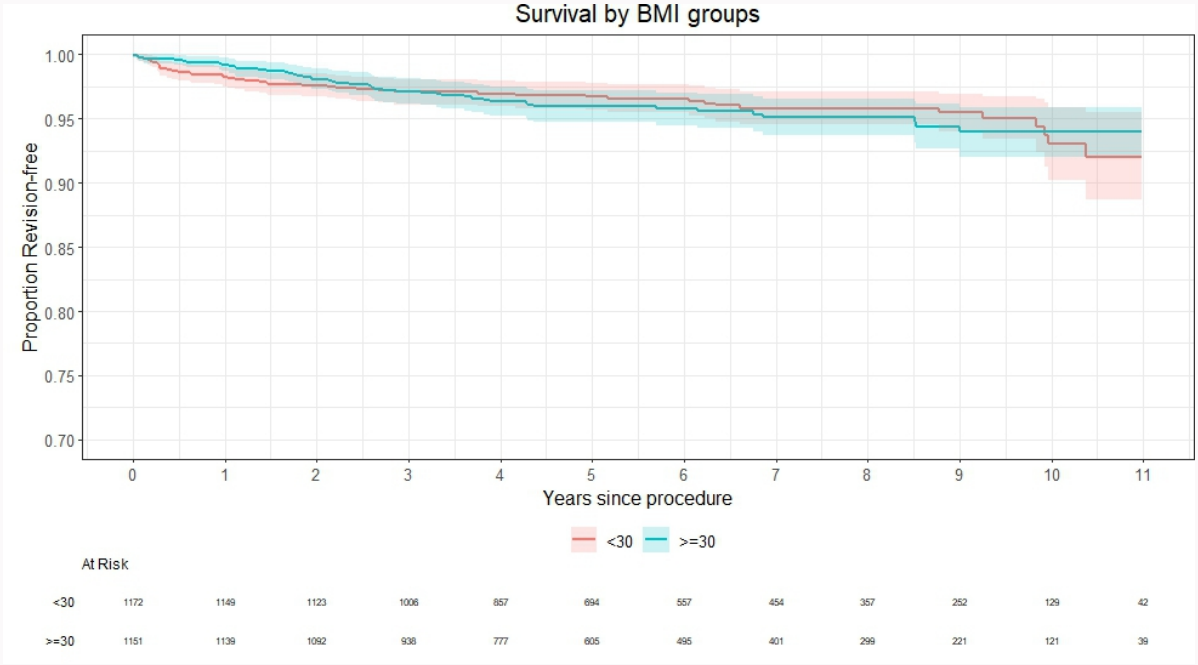

Fig. 8
Kaplan-Meier curve - proportion of revision-free patients.

Table II. The revision rates of medial unicompartmental knee arthroplasty according to BMI as per 100 observed component years.

BMI, kg/m²	Procedures	Component years	Revised	Revision rate	95% CI	p-value*
< 30	1,172	7,180.80	48	0.668	0.493 to 0.886	0.744
≥ 30	1,151	6,718.70	49	0.729	0.533 to 0.956	
Total	2,323	13,899.50	97	0.698	0.563 to 0.847	
< 25	286	1,773.57	13	0.733	0.390 to 1.253	0.878
25 to 29.9	886	5,407.23	35	0.647	0.443 to 0.889	
30 to 34.9	715	4,260.14	33	0.775	0.533 to 1.088	
≥ 35	436	2,458.55	16	0.651	0.372 to 1.057	

*Log-rank test.

results in fewer major complications and shorter hospital stays.[1,2] UKA is still underutilized as a treatment option for isolated medial compartment osteoarthritis of the knee.[4,5,11] One explanation might be a reluctance of surgeons to perform UKA in obese patients. Until recently, the majority of studies investigating the safety of UKA in obese patients have been limited by small study populations[22,31–33] and short follow-up.[22,23,31,32,34–36]

In 2013, Murray et al[37] showed no difference in revision rates between obese and non-obese patients in 2,438 medial Oxford phase 3 (Zimmer Biomet) UKAs at average follow-up of five years. They also showed no difference in the objective American Knee Society Score (KSS) between the two groups.[37] Obese patients had significantly lower preoperative scores and postoperative OKS and functional KSS. Like our study, the importance lies in the lack of difference in the improvement from preoperative scores.[37] In the same year, a retrospective study by Cavaignac et al[38] showed no difference in functional or objective KSS at a minimum follow-up of seven years. They also showed no significant difference in ten-year survival rate. However, the study was not well powered to detect a difference between the two groups, with only 212 UKAs included.[38]

Molloy et al[13] in 2019 showed no difference in overall ten-year survival rates for obese patients in 956 UKAs, including sub-group analysis of BMI groups. The overall survival for obese patients was over 94% at ten years. There was no difference in OKS or Tegner activity scores between the groups. In contrast to our study, patients with BMI > 35 kg/m² demonstrated the largest improvement in OKS.[13] Mushabi et al[14] in 2020 published a systematic review of nine studies,[17–20,22,37,39–41] including 4,621 UKAs, and concluded that higher BMI does not lead to significantly worse outcomes in patients treated with UKA. They reported a trend of increased revision

rates with increasing BMI with an odds ratio (OR) of 0.33, but again, this was not clinically significant.[14] Importantly, seven of the included studies were on fixed bearing prostheses and therefore may not be comparable to this study.[18–20,22,39–41]

In 2020, Agarwal et al[42] published a meta-analysis of 30 studies with 80,798 patients treated with UKAs, with a mean follow-up of five years.[13,16–23,31,33,34,36,37,40,41] They identified no difference in minor or major complications, and/or number of revisions, between obese and non-obese patients. There was no increased rate in septic or aseptic loosening between obese and non-obese patients.[42] Campi et al[12] published a systematic review and meta-analysis reporting a higher all-cause revision rate for patients with a BMI > 30 kg/m^2 from 11 studies, including 40,753 patients, with an OR of 1.42 (95% CI 1.05 to 1.92).[13,17–19,38–41,43,44] There was no increased risk of periprosthetic joint infection as a cause of revision between the two groups.[12] Again, obese patients were shown to have lower postoperative functional KSS and OKS, but experienced similar improvements from preoperative scores.[12]

Some of the limitations of this study include its lack of randomization, lack of blinding, retrospective grouping of patients based on BMI, possible inaccuracies of BMI recording at the time of surgery, reliance on the joint registry for revision data, and lack of objective assessment. Of note, the "reason for revision" data from the NZJR should be questioned. Pain as a reason for revision may be inconsistently selected by surgeons as almost all patients undergoing revision would have pain. The NZJR fails to detect revisions surgeries performed outside of New Zealand. The 2,323 surgeries were performed by 19 different surgeons. There was no formal consensus on the appropriate indications and contraindications among them. The most common implant by a large margin was the uncemented Oxford phase 3 uncemented mobile bearing UKA, and therefore, these results may not be applicable to cemented fixed-bearing implants.

The key take home point is that obese and non-obese patients can be expected to benefit equally from UKA. Obesity is not a risk factor for early revision of UKA, and therefore obesity should not be considered a contraindication.

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