BJO

ARTHROPLASTY

Should isolated morbid obesity influence the decision to operate in hip and knee arthroplasty?

P. F. Crookes,
R. S. Cassidy,
A. Machowicz,
J. C. Hill,
J. McCaffrey,
G. Turner,
D. Beverland

From Musgrave Park Hospital, Belfast Health & Social Care Trust, Belfast, UK

Aims

We studied the outcomes of hip and knee arthroplasties in a high-volume arthroplasty centre to determine if patients with morbid obesity (BMI ≥ 40 kg/m²) had unacceptably worse outcomes as compared to those with BMI < 40 kg/m².

Methods

In a two-year period, 4,711 patients had either total hip arthroplasty (THA; n = 2,370), total knee arthroplasty (TKA; n = 2,109), or unicompartmental knee arthroplasty (UKA; n = 232). Of these patients, 392 (8.3%) had morbid obesity. We compared duration of operation, anaesthetic time, length of stay (LOS), LOS > three days, out of hours attendance, emergency department attendance, readmission to hospital, return to theatre, and venous thromboembolism up to 90 days. Readmission for wound infection was recorded to one year. Oxford scores were recorded preoperatively and at one year postoperatively.

Results

On average, the morbidly obese had longer operating times (63 vs 58 minutes), longer anaesthetic times (31 vs 28 minutes), increased LOS (3.7 vs 3.5 days), and significantly more readmissions for wound infection (1.0% vs 0.3%). There were no statistically significant differences in either suspected or confirmed venous thromboembolism. Improvement in Oxford scores were equivalent.

Conclusion

Although morbidly obese patients had less favourable outcomes, we do not feel that the magnitude of difference is clinically significant when applied to an individual, particularly when improvement in Oxford scores were unrelated to BMI.

Cite this article: *Bone Jt Open* 2021;2-7:515–521.

Keywords: arthroplasty, hip, knee, Morbid Obesity

Introduction

Together, hip and knee arthroplasties represent a significant proportion of healthcare spending in every developed country,[1] with significant projected increases in the incidence of surgery in the USA, UK, and Australia in the next decade.[2-4] These projected increases are based on many factors, such as increasing prosperity, altered age demographics, and increasing levels of obesity.

In any healthcare system deploying scarce or expensive technology in those whose outcome is likely to be poor would generally be regarded as a wasteful use of limited resources. This concept is applied in other fields of medicine, such as transplant surgery where, for example, a recent survey confirmed that 27% of responding programmes limited listing for kidney transplantation to those with BMI ≤ 30 kg/m², and 29% had a cutoff point at BMI 35 kg/m².[5] Furthermore, obese patients spend longer on transplant waiting lists.[6]

Obesity, generally defined as having BMI ≥ 30 kg/m², is now a common feature of most high-income countries and increasingly in low-income countries. There is an even greater rise in prevalence of more severe forms of obesity (class II obesity BMI ≥ 35 kg/m², and class III or morbid obesity BMI ≥ 40 kg/m²). Obesity is associated with an increased prevalence of osteoarthritis (OA),

Correspondence should be sent to Roslyn S Cassidy; email: roslyn.cassidy@belfasttrust.hscni.net

doi: 10.1302/2633-1462.27.BJO-2021-0062.R1

Bone Jt Open 2021;2-7:515–521.

with a lifetime risk of 60%.[7] Obese patients present a challenge to healthcare providers because of the comorbidities to which they are subject, and the difficulties that they pose in caring for them. These difficulties include the need for equipment capable of bearing the additional weight, such as hospital beds and chairs, transport trolleys, tables in operating theatres, radiograph or scanning suites, as well as specially modified instruments to perform operative procedures.

Studies of complex and resource-intensive operations, such as heart, liver, or kidney transplantation, have reported outcomes where length of hospital stay, surgical site infections, and other complications requiring additional treatment, and long-term failure of the procedure, tend to be greater in the obese.[8]

Similar arguments have been advanced for limiting the use of total hip arthroplasty (THA) and total knee arthroplasty (TKA) in the obese. The incidence of deep infection has been estimated to be 1.3-times higher, and the need for revision almost twice as high in obese patients compared with normal weight patients undergoing TKA.[9-13] Many of these meta-analytic studies have small numbers and incomplete follow-up and may not be applicable to good contemporary practice. In addition, lessons learned by surgeons and the associated teams for preoperative, intraoperative, and postoperative care have made substantial improvements in the outcomes for obese patients.[14]

In countries with nationalized healthcare services, the decision of whether to offer arthroplasty to an obese individual may be dictated by a commissioning policy focused on the population and not the individual. In the UK, some Clinical Commissioning Groups have been refusing hip and knee arthroplasty to patients with BMIs greater than 35 kg/m^2.[15,16] Therefore, accurate and timely data on the outcomes of these procedures in obese compared with normal weight patients are essential if we are to make choices based on science, not just for the morbidly obese population, but also the individual patient.

The aim of the current study was to compare the results of total or partial joint arthroplasty in the morbidly obese (BMI ≥ 40 kg/m^2) as compared to all other BMI groups (BMI < 40 kg/m^2) using routinely collected data in a large cohort of patients in a high volume arthroplasty centre.

Methods

We audited the outcomes of 4,711 patients undergoing THA (2,370; 50.3%), TKA (2,109; 44.8%), and unicompartmental knee arthroplasty (UKA, 232; 4.9%) for two BMI categories – those with a BMI less than 40 kg/m^2 (4,319; 91.6%) and those with a BMI equal to or greater than 40 kg/m^2 (392; 8.4%). The audit was registered with the standard, quality and audit department in our institution (Belfast Heath and Social Care Trust, UK) (audit number: 6090). The setting was a high-volume arthroplasty centre with a total of 22 orthopaedic surgeons undertaking at least one of the three procedures. The patients were managed on a common pathway including routine preoperative assessment (POA). The data were collected routinely by a team of arthroplasty care practitioners and a data analyst (RSC) from a hospital maintained database and the Northern Ireland Electronic Care Record (NIECR) database. All patients undergoing any of these three procedures between January 2017 and December 2018 were included.

Patients were referred by their GP based on symptoms and radiological findings. Most patients were then seen by an orthopaedic integrated clinical assessment and treatment service triage service.[17] There were no referral restrictions based on BMI. Patients were then seen at an orthopaedic consultant-based clinic before being added to an inpatient waiting list. Prior to admission, all patients were seen at a POA clinic, irrespective of comorbidities. Height, weight, and BMI, along with Oxford hip or knee score, were recorded at this POA appointment.[18,19] Only those considered to be higher risk were seen by an anaesthetist, the remainder being screened by a preoperative clinic nurse. Although no protocols were in place, one surgeon did have a cut off BMI of 40 kg/m^2 when listing for surgery. This surgeon carried out 11/2,090 (0.5%) TKAs within the time frame of this audit, with BMI ranging from 25 kg/m^2 to 38 kg/m^2.

Anaesthetic technique. The default in all cases was spinal anaesthesia with or without nerve blocks in TKAs and UKAs, but not THAs. General anaesthesia was only used in the case of a failed spinal, or with specific pathologies.

Operative technique. All THAs were carried out using a posterolateral approach with either hybrid, reverse hybrid, cemented, or cementless components based on surgeon choice. TKAs and UKAs were cemented or cementless, again based on surgeon choice. No major changes in technique were required for obese patients.

Postoperatively, at that time, patients were generally mobilized by a physiotherapist on the day following surgery with an expected postoperative stay of two days for THA and UKA and three days for TKA. Postoperative review was scheduled for between six and 12 weeks following surgery.

All patients had their height and weight measured at their POA appointment, with the values being added to the hospital information system which calculated BMI. For simplicity, patients were then stratified into two categories: those with a BMI less than 40 kg/m^2, and those with a BMI of 40 kg/m^2 and above. Then the following outcome measures were compared:

- Perioperative: Anaesthetic time and operative time. Anaesthetic time was defined as the arrival time in theatre until time patient was anaesthetised,

positioned and ready. Operative time was defined as time from incision to skin closure.

- Postoperative length of stay (LOS) and percentage of patients with LOS > three days.
- Following discharge: All out of hours GP contacts (OOH), all Emergency Department (ED) attendances and readmission for any reason up to day 90 following surgery.
- Oxford hip or knee scores (if recorded) both at POA and one-year review.
- The following complications were recorded out to 90 days:
  - Request for doppler ultrasound scans (USSs) with suspected deep vein thrombosis (DVT).
  - Computed tomography pulmonary angiography (CTPA) with suspected pulmonary embolism (PE).
  - All returns to theatre for any reason linked to the primary surgery.
  - Wound infection requiring readmission up to one year.

Statistical analysis. Statistical analysis was carried out using SPSS version 26 software (IBM, USA). All data were assessed for normality using the Shapiro-Wilk test. Categorical variables were compared and odds ratio calculated using the chi-squared test or Fisher's exact test. Non-parametric continuous variables were assessed with Mann-Whitney U test or Kruskal-Wallis test where appropriate. The principal comparisons were the outcomes in patients with morbid obesity compared with those having BMI < 40 kg/m^2. Statistical significance was set at a p-value < 0.05.

Results

A total of 4,711 patients underwent THA, TKA, or UKA between 1 January 2017 and 31 December 2018 with a BMI being available for every patient: 8.3% (392/4,711) were morbidly obese (BMI ≥ 40 kg/m^2).

Morbidly obese patients were more likely to be female (9.9% (263/2,625) for females vs 6.3% (129/2,059) for males, p < 0.001, Fisher's exact test) and require a TKA (11.3%, 241/2109) rather than THA (5.8%; 134/2370) or UKA (7.5%; 17/232) (Table I). They were also significantly younger by approximately five years than those with BMI < 40 kg/m^2 (Table II). The difference was greatest for THA (median 63 years (interquartile range (IQR) 56 to 69) vs median 69 years (IQR 60 to 76), p < 0.001, Mann-Whitney U test), and TKA (median 66 years (IQR 59 to 71) vs median 70 years (IQR 64 to 76), p < 0.001, Mann-Whitney U test), but insignificant for UKA (median 66 yrs. (IQR 60 to 70) vs median 66 years (IQR 60 to 73), p = 0.542, Mann-Whitney U test) (Table II).

Length of operation was longer in the morbidly obese patients, by four minutes for TKA (p = 0.009, Mann-Whitney U test) and ten minutes for THA (p < 0.001, Mann-Whitney U test) (Table II). UKA operative time did not differ between the BMI groups (p = 0.552, Mann-Whitney U test) (Table II). Anaesthetic time was longer by three to four minutes in the morbidly obese (p < 0.001, Kruskal-Wallis test) (Table II), with both morbidly obese THA and TKA patients taking longer to anaesthetise. THA anaesthetic time was approximately four minutes longer in the morbidly obese (p < 0.001, Mann-Whitney U test) (Table II), with TKA anaesthetic time in the morbidly obese being approximately three minutes longer (p = 0.009, Mann-Whitney U test (Table II). Anaesthetic time in UKA patients was not significantly different between the BMI groups (p = 0.074, Mann-Whitney U test) (Table II).

Overall postoperative LOS was significantly longer by 0.2 days in morbidly obese patients (p = 0.008, Kruskal-Wallis test) (Table II). However, when looking at THA, TKA, and UKA individually, there were no significant differences in LOS, p = 0.511, p = 0.184, and p = 0.917, respectively, all Mann-Whitney U test (Table II). Prolonged LOS (PLOS), as defined by a postoperative LOS greater than three days, occurred in a total of 1,361 patients, equating to 28.9% of the total patient cohort (Table III). A significantly greater proportion of morbidly obese TKA patients had a PLOS (p < 0.001, Fisher's exact test), attended OOH (p = 0.019, Fisher's exact test), attended ED (p = 0.006, Fisher's exact test), and had a general readmission (p = 0.011, Fisher's exact test) compared to TKA patients with a BMI < 40 kg/m^2 (Table III). THA and UKA patients showed no significant differences in PLOS, attendance at OOH, attendance at ED, or had a readmission when comparing morbidly obese and BMI < 40 kg/m^2 patients.

In total, 66 patients were readmitted to our unit within one year of their primary surgery and had a return to theatre for either a reoperation or revision. Reoperations were carried out in 44 patients (0.9%); 39 (0.9%) had a BMI < 40 kg/m^2, and five (1.3%) were morbidly obese patients (p = 0.629, Fisher's exact test). Reoperations were carried out for stiffness (0.6%), infection (0.1%),

Table I. Patient demographics according to BMI category.

Demographic	BMI < 40 kg/m^2, n (%)	Morbidly obese, n (%)	p-value*
Female (n = 2,652)	2,389 (90.1)	263 (9.9)	< 0.001†
Male (n = 2,059)	1,930 (93.7)	129 (6.3)	
THA (n = 2,370)	2,236 (94.3)	134 (5.7)	< 0.001‡
TKA (n = 2,109)	1,868 (88.6)	241 (11.4)	< 0.001§
UKA (n = 232)	215 (92.7)	17 (7.3)	0.714
Total (n = 4,711)	4,319 (91.6)	392 (8.4)	N/A

*Fisher's exact test.
†A significantly greater proportion of female patients (263/2,652; 9.9%) were morbidly obese compared to male patients (129/2059; 6.3%); Odds ratio 1.6 (95% confidence interval (CI) 1.3 to 1.9), p < 0.001.
‡A significantly smaller proportion of Hip patients (134/2,370; 5.7%) were morbidly obese compared to all other patients (258/2,341; 11.0%); Odds ratio 0.5 (95% CI 0.4 to 0.6), p < 0.001.
§A significantly greater proportion of Knee patients (241/2,109; 11.4%) were morbidly obese compared to all other patients (151/2,602; 5.8%); Odds ratio 2.1 (95% CI 1.7 to 2.6), p < 0.001.
N/A, not applicable; THA, total hip arthroplasty; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty.

Table II. Patient age, length of operation, length of anaesthetic, postoperative length of stay, and change in Oxford scores according to BMI category.

	BMI < 40 kg/m²	Morbidly obese	
Demographic	**Median; IQR (range)**	**Median; IQR (range)**	**p-value***
Age at operation, yrs			
THA	69.0; 60.0 to 76.0 (16 to 97)	63.0; 56.0 to 69.0 (25 to 82)	< 0.001
TKA	70.0; 64.0 to 76.0 (25 to 94)	66.0; 59.0 to 71.0 (40 to 83)	< 0.001
UKA	66.0; 60.0 to 73.0 (46 to 90)	66.0; 59.5 to 70.0 (49 to 79)	0.542
Total	69.0; 62.0 to 76.0 (16 to 97)	65.0; 58.0 to 70.0 (25 to 83)	< 0.001
Length of operation, mins			
THA	59.0; 47.0 to 73.0 (30 to 175)	68.0; 56.0 to 85.0 (34 to 125)	< 0.001
TKA	58.0; 47.0 to 73.0 (30 to 168)	60.0; 50.0 to 77.0 (34 to 150)	0.009
UKA	48.0; 41.0 to 56.3 (31 to 118)	51.0; 47.7 to 58.0 (42 to 85)	0.074
Total	58.0; 46.0 to 72.0 (30 to 175)	63.0; 51.0 to 78.0 (34 to 150)	< 0.001
Length of anaesthetic, mins			
THA	25.0; 20.0 to 32.0 (10 to 130)	26.0; 20.0 to 35.0 (10 to 82)	< 0.001
TKA	30.0; 24.0 to 38.0 (10 to 110)	33.0; 25.0 to 40.0 (10 to 102)	0.009
UKA	30.0; 24.8 to 39.0 (10 to 65)	32.0; 23.5 to 38.5 (15 to 64)	0.074
Total	28.0; 21.0 to 35.0 (10 to 130)	31.0; 24.0 to 40.0 (10 to 102)	< 0.001
Postoperative length of stay, days (mean; standard deviation (range))			
THA	3.4; 3.0 (1 to 56)	3.6; 2.9 (1 to 16)	0.511
TKA	3.8; 3.0 (0 to 44)	3.9; 3.0 (0 to 30)	0.184
UKA	2.6; 1.8 (1 to 20)	2.7; 2.0 (1 to 10)	0.917
Total	3.5; 3.0 (0 to 56)	3.7; 2.9 (0 to 30)	0.008
Change in Oxford Pain Score			
THA	3.0; 2.0 to 4.0 (-2 to 4)	3.0; 2.0 to 4.0 (0 to 4)	0.358
TKA	2.0; 1.0 to3.0 (-2 to 4)	2.0; 1.0 to 3.0 (-1 to 4)	0.912
UKA	3.0; 1.3 to 4.0 (0 to 4)	3.0; 1.0 to 3.0 (1 to 4)	0.689
Total	3.0; 2.0 to 4.0 (-2 to 4)	3.0; 1.0 to 4.0 (-1 to 4)	0.413
Change in Oxford Score			
THA	26.0; 17.0 to 32.0 (-20 to 47)	27.0; 18.0 to 33.0 (-3 to 44)	0.741
TKA	20.0; 11.0 to 26.8 (-18 to 44)	18.0; 10.0 to 26.0 (-6 to 43)	0.489
UKA	23.0; 16.3 to 29.0 (-9 to 41)	24.0; 13.5 to 30.5 (8 to 33)	0.790
Total	23.0; 14.0 to 30.0 (-20 to 47)	21.0; 12.0 to 30.0 (-6 to 44)	0.076

*Mann-Whitney U test.
IQR, interquartile range; THA, total hip arthroplasty; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty.

Table III. Postoperative outcomes following primary joint arthroplasty.

	BMI < 40 kg/m²						Morbidly obese					
Joint	**Total**	**PLOS, n (%)**	**OOH, n (%)**	**ED, n (%)**	**Gen re-ad, n (%)**	**WI re-ad, n (%)**	**Total**	**PLOS, n (%)**	**OOH, n (%)**	**ED, n (%)**	**Gen re-ad, n (%)**	**WI re-ad, n (%)**
THA	2,236	562 (25.1)	282 (12.6)	357 (16.0)	175 (7.8)	7 (0.3)	134	38 (28.4)	17 (12.7)	23 (17.2)	8 (6.0)	2 (1.5)
TKA	1,868	643 (34.4)	251 (13.4)	296 (15.8)	122 (6.5)	5 (0.3)	241	92* (38.2)	32† (13.3)	40‡ (16.6)	17§ (7.0)	2 (0.8)
UKA	215	25 (11.6)	17 (7.9)	24 (11.2)	10 (4.6)	0 (0.0)	17	1 (5.9)	2 (11.8)	2 (11.8)	1 (5.9)	0 (0.0)
Total	4,319	1,230 (28.5)	550 (12.7)	677 (15.7)	307 (7.1)	12 (0.3)	392	131¶ (33.4)	51 (13.0)	65 (16.6)	26 (6.6)	4** (1.0)

Data presented as a percentage of the total number of joints within each BMI category.
*Of the patients who had a prolonged length of stay (LOS), a significantly greater proportion were total knee arthroplasty (TKA) patients with a BMI ≥ 40 kg/m² (70.2%; 92/131) compared to those TKA patients with a BMI < 40 kg/m² (52.3%; 643/1,230): Odds ratio 2.2 (95% confidence interval (CI) 1.5 to 3.2); p < 0.001, Fisher's exact test.
†Of the patients who attended out of hour attendance, a significantly greater proportion were TKA patients with a BMI ≥ 40 kg/m² (63.7%; 32/51) compared to TKA patients with a BMI < 40 kg/m² (45.6%; 251/550): Odds ratio 2.0 (95% CI 1.1 to 3.6); p = 0.019, Fisher's exact test.
‡Of the patients who attended the emergency department, a significantly greater proportion were TKA patients with a BMI ≥ 40 kg/m² (61.5%; 40/65) compared to TKA patients with a BMI < 40 kg/m² (43.7%; 296/677): Odds ratio 2.1 (95% CI 1.2 to 3.5); p = 0.006, Fisher's exact test.
§Of the patients who had a general readmission, a significantly greater proportion were TKA patients with a BMI ≥ 40 kg/m² (65.4%; 17/26) compared to BMI < 40 kg/m² TKA patients (38.5%; 122/307): Odds ratio 2.9 (95% CI 1.2 to 6.6); p = 0.011, Fisher's exact test.
¶Overall, a significantly greater proportion of patients with a BMI ≥ 40 kg/m² (131/392; 33.4%) had a prolonged LOS compared to patients with a BMI < 40 kg/m² (1,230/4,319; 28.5%); Odds ratio 1.3 (95% CI 1.0 to 1.6); p = 0.045, Fisher's exact test.
**A significantly greater proportion of BMI ≥ 40 kg/m² patients (1.0%, 4/392) were readmitted due to a wound infection within 12 months of their index surgery compared to BMI < 40 kg/m² patients (0.3% 12/4,319); Odds ratio 3.70 (95% CI 1.2 to 11.5); p = 0.049, Fisher's exact test.
ED, emergency department attendance within 90 days; OOH, out of hour attendance within 90 days; PLOS, prolonged length of stay; WI Re-ad, wound infection readmission within 12 months.; Gen Re-ad, general readmission within 90 days

dislocation (0.1%), and wound dehiscence (0.08%). Revisions were carried out in 22 (0.5%) patients; 19

Table IV. Number of venous thromboembolism examinations according to BMI category and joint replaced.

	BMI < 40 kg/m²					BMI ≥ 40 kg/m²				
		Doppler USS		CTPA			Doppler USS		CTPA	
Joint	Total	Requested, n (%)*	Positive, n (%)	Requested, n (%)	Positive, n (%)	Total	Requested, n (%)	Positive, n (%)	Requested, n (%)	Positive, n (%)
THA	2,236	165 (7.4)	19 (0.8)	68 (3.0)	15 (0.7)	134	12 (9.0)	0 (0.0)	3 (2.2)	0 (0.0)
TKA	1,868	175 (9.4)	9 (0.5)	81 (4.3)	21 (1.1)	241	19 (7.9)	0 (0.0)	15 (6.2)	5 (2.1)
UKA	215	13 (6.0)	1 (0.5)	9 (4.2)	2 (0.9)	17	0 (0.0)	0 (0.0)	2 (11.8)	0 (0.0)
Total	4,319	353 (8.2)	29 (0.7)	158 (3.7)	38 (0.9)	392	31 (7.9)	0 (0.0)	20 (5.1)	5 (1.3)

*Data presented as a percentage of the total number of joints within each BMI category. No difference was observed in the proportion of Doppler ultrasound scans (USS) requested in patients with BMI < 40 kg/m² compared to morbidly obese patients; p = 0.314 (chi-squared analysis). All positive Doppler USS were in patients with BMI < 40 kg/m². No difference was observed in the proportion of computed tomography pulmonary angiography (CPTA) requested in patients with BMI < 40 kg/m² compared to morbidly obese patients; p = 0.081, chi-squared analysis. When comparing the number of positive CTPA between BMI < 40 kg/m² and morbidly obese patients, no statistical difference was observed; p = 0.157, chi-squared analysis.
CPTA, computed tomography pulmonary angiography; THA, total hip arthroplasty; TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty; USS, ultrasound scans.

(0.4%) BMI < 40 kg/m² and three (0.8%) morbidly obese patients (p = 0.593, Fisher's exact test). Revisions were carried out for infection (0.2%), dislocation (0.2%), and for other reasons including periprosthetic fracture, cup failure and stem loosening (0.1%). Of the sixteen (0.3%) who had a return to theatre for wound infection; 12 were within 90 days (6 to 51) and four from day 99 to 361.

Table IV outlines the number of Doppler ultrasound scans (USS) requested within the patient group, 384 (8.2%) in total. There was no significant difference observed between the proportion of patients who had a Doppler USS within each BMI category (8.2% (353/4,318) BMI < 40 kg/m² compared to 7.9% (31/392) morbidly obese (p = 0.314, chi-squared analysis). Of the Doppler USS that were positive, all were in the BMI < 40 kg/m² category, 0.7% (29/4,318) of the group. Of the 29 positive Doppler USS, 0.2% (10/4,318) had distal, 0.2% (8/4,318) had proximal, 0.02% (1/4,318) had both distal and proximal DVT detected.

There were no significant differences seen in the number of CTPA examinations requested between BMI categories (Table IV); 3.7% (158/4,318) BMI < 40 kg/m² compared to 5.1% (20/392) morbidly obese (p = 0.081, chi-squared analysis). The number of positive CTPA exams between BMI categories did not differ; 0.9% (38/4,318) BMI < 40 kg/m² compared to 1.3% (5/392) morbidly obese (p = 0.401, Fisher's exact test). As a point of interest, positive CTPA exams were only observed in the morbidly obese patients who had undergone a TKA. Looking specifically at TKA patients, there was no difference in the number of positive CTPA exams between BMI categories; 1.1% (21/1,868) BMI < 40 kg/m² compared to 2.1% (5/241) morbidly obese (p = 0.210, Fisher's exact test).

Preoperative and one year Oxford scores were only available for 2,654 patients (56.3%). Overall, there were no differences in either Oxford pain scores or total Oxford scores between morbidly obese patients and those with BMI < 40 kg/m² (p = 0.413 and p = 0.076 respectively, Kruskal-Wallis test). For all patients the median improvements in Oxford scores for THAs, TKAs, and UKAs were 26.0, 20.0, and 23.0, respectively. No significant differences were observed in each joint group when comparing change in score for morbidly obese patients to patients with BMI < 40 kg/m² (THA p = 0.741, TKA p = 0.489, and UKA p = 0.790) (Table II).

Discussion

We have shown that, overall, in the morbidly obese, median anaesthetic and surgical times were increased by no more than five and ten minutes respectively, and LOS was significantly increased by 0.2 days. For morbidly obese patients undergoing TKA, there were significant increases in rates of 90 days OOH attendance, ED attendance, and wound infection (Table III). Also, the one-year infection rate in morbidly obese patients was 1%, as compared with 0.3% for those with BMI < 40 kg/m². Although significant, this represented only four patients out of 392 morbidly obese patients (two THAs and two TKAs). This observation is in line with other studies, including that of Davies et al,[20] who found that patients with BMI > 35 kg/m² had a threefold higher rate of infection at five years than patients with BMI < 35 kg/m², but in that study of 1,689 patients there was no indication of how many patients fell into the obese category. A systematic review involving a total of 13,722 patients after THA reported that three of the studies showed an adverse effect of obesity defined as BMI ≥ 30 kg/m², but that eight studies showed no effect.[21] It is nevertheless widely agreed, both among surgeons and referring doctors, that obesity has an adverse effect on outcome.[22] The pathophysiology of the increased incidence is not understood and is likely multifactorial in aetiology. A recent publication from this unit (Musgrave Park Hospital, Belfast, UK) looking at subcutaneous fat depth over the greater trochanter in THA found no relation between this factor and infection but infection rate was higher in the morbidly obese.[23] That study concurs with the findings in this present study and further adds to the evidence for increased postoperative infection rate in the morbidly

obese following hip and knee arthroplasty. However, in the context of informed consent, and particularly in light of the recommendations of the UK Supreme Court decision in Montgomery versus Lanarkshire Health Board,[24] many morbidly obese patients would choose to proceed to surgery particularly when informed of the absence of any convincing evidence that weight loss prior to surgery can influence outcome.[25]

The topic has been much discussed recently, most notably by Leopold,[26] who argues persuasively that simply dichotomizing patients into categories (e.g. smoker/non-smoker, normal weight/obese, or HbA1c levels) and comparing the outcomes in the two groups is an incorrect way to make a clinical judgement in an individual patient. A small but significant difference in the statistical likelihood of a particular outcome has very little relevance to what will happen to an individual patient even if average costs increase. In principle, healthcare systems should balance what is best for the individual with what is best for the population as a whole.

Furthermore, even if weight loss was proven to be beneficial the chances of successful weight loss by an arthritic patient with a BMI of 40 kg/m^2 is extremely low. A comprehensive study by Tomiyama et al[27] surveyed 21 randomized trials of weight loss by dietary means and found that the average weight loss maintained by obese subjects two to five years after initial weight loss is 1 kg. This is much lower than the eventual remission rate of opiate addiction.[28] The decision to offer or withhold joint arthroplasty in obese patients must be considered in the light of the alternative therapies to which they would necessarily be consigned if joint arthroplasty were not offered. With respect to outcome, the documented results of joint arthroplasty in patients with severe arthritis of the hip and knee are so much better than any alternative therapy and in our morbidly obese patient group the improvement in Oxford scores was unrelated to BMI.

It has been proposed that morbidly obese patients may benefit from undergoing bariatric surgery to bring their weight down into a lower category of obesity before undertaking arthroplasty. This suggestion is even more controversial and underestimates the complex effect that bariatric surgery may have on factors such as wound healing and tissue repair. Bariatric surgery does carry many benefits in reduction of pain in OA of the hip, knee, and spine after successful weight loss, but these are quite separate from improvements in outcomes after total joint arthroplasty.[29,30] Although bariatric surgery is provided by the NHS and approved by the National Institute for Health and Clinical Excellence,[31] it is not universally available in all parts of the UK.

This study has limitations, in particular uncontrolled variables that cannot be accounted for in a retrospective analysis. For example, no comorbidities were recorded in these patients and, as such, there may have been morbidly obese patients who failed their POA because of significant comorbidities. Another limitation is the use multiple surgical techniques; therefore, no direct comparison could be made between operative techniques. Also, the follow-up is relatively short, just 90 days for issues other than wound infection, with the latter only being for one year. Other authors have published longer-term (up to five- and ten-year) revision rates in the morbidly obese after TKA.[20,32] We also acknowledge the limitations of any study from a single centre, and the fact that even with 388 morbidly obese patients the low rate of complications in these procedures may conceal a type II error. Nevertheless, we believe that our study shows what can be accomplished by a single centre with a large number of surgeons, and hence may be of relevance to those responsible for prioritizing public health policies.

The ethical issues raised by decision-making in relation to joint arthroplasty in the morbidly obese are complex. They involve both utilitarian arguments (the right thing to do is the measure that maximizes the happiness for the greatest number), as well as arguments of justice-as-fairness where whatever solution is chosen, it should not work to the detriment of those least well off. Ethical issues, however, must take as a starting point the empirical data currently available.

In conclusion, this study questions whether morbid obesity on its own should be used as a factor to deny hip or knee arthroplasty to an otherwise suitable patient.

Take home message

- Morbidly obese patients can expect a comparable improvement in Oxford score following total joint replacement.
- This paper questions whether total joint replacement should be denied to an uncomplicated morbidly obese patient.

References

1. **Singh JA**, **Yu S**, **Chen L**, **Cleveland JD**. Rates of total joint replacement in the United States: future projections to 2020-2040 using the National inpatient sample. *J Rheumatol*. 2019;46(9):1134–1140.
2. **Chen A**, **Gupte C**, **Akhtar K**, **Smith P**, **Cobb J**. The global economic cost of osteoarthritis: how the UK compares. *Arthritis*. 2012;2012:1–6.
3. **Culliford D**, **Maskell J**, **Judge A**, **et al**. Future projections of total hip and knee arthroplasty in the UK: results from the UK clinical practice research Datalink. *Osteoarthritis Cartilage*. 2015;23(4):594–600.
4. **Ackerman IN**, **Bohensky MA**, **Zomer E**, **et al**. The projected burden of primary total knee and hip replacement for osteoarthritis in Australia to the year 2030. *BMC Musculoskelet Disord*. 2019;20(1):90.
5. **Hossain M**, **Woywodt A**, **Augustine T**, **Sharma V**. Obesity and listing for renal transplantation: weighing the evidence for a growing problem. *Clin Kidney J*. 2017;10(5):703–708.
6. **Segev DL**, **Simpkins CE**, **Thompson RE**, **Locke JE**, **Warren DS**, **Montgomery RA**. Obesity impacts access to kidney transplantation. *J Am Soc Nephrol*. 2008;19(2):349–355.
7. **Murphy L**, **Schwartz TA**, **Helmick CG**, **et al**. Lifetime risk of symptomatic knee osteoarthritis. *Arthritis Rheum*. 2008;59(9):1207–1213.
8. **Spengler EK**, **O'Leary JG**, **Te HS**, **et al**. Liver transplantation in the obese cirrhotic patient. *Transplantation*. 2017;101(10):2288–2296.
9. **Kerkhoffs GM**, **Servien E**, **Dunn W**, **Dahm D**, **Bramer JA**, **Haverkamp D**. The influence of obesity on the complication rate and outcome of total knee arthroplasty: a meta-analysis and systematic literature review. *J Bone Joint Surg Am*. 2012;94-A(20):1839–1844.

10. **McElroy MJ**, **Pivec R**, **Issa K**, **Harwin SF**, **Mont MA**. The effects of obesity and morbid obesity on outcomes in TKA. *J Knee Surg*. 2013;26(2):083–088.
11. **Boyce L**, **Prasad A**, **Barrett M**, **et al**. The outcomes of total knee arthroplasty in morbidly obese patients: a systematic review of the literature. *Arch Orthop Trauma Surg*. 2019;139(4):553–560.
12. **Pozzobon D**, **Ferreira PH**, **Blyth FM**, **Machado GC**, **Ferreira ML**. Can obesity and physical activity predict outcomes of elective knee or hip surgery due to osteoarthritis? A meta-analysis of cohort studies. *BMJ Open*. 2018;8(2):e017689.
13. **Samson AJ**, **Mercer GE**, **Campbell DG**. Total knee replacement in the morbidly obese: a literature review. *ANZ J Surg*. 2010;80(9):595–599.
14. **Pratt GM**, **McLees B**, **Pories WJ**. The ASBS bariatric surgery centers of excellence program: a blueprint for quality improvement. *Surg Obes Relat Dis*. 2006;2(5):497–503.
15. **ABHI**. Hip and knee replacement – the hidden barriers. https://www.abhi.org.uk/media/1379/hip-and-knee-replacement-the-hidden-barriers.pdf (date last accessed 14 June 2021).
16. **Pillutla V**, **Maslen H**, **Savalescu J**. Rationing elective surgery for smokers and obese patients: responsibility or prognosis? *BMC Med Ethics*. 2018;19(1):28.
17. **Feist-Wilson S**, **Heron N**. An evaluation of the clinical skills and experience within an orthopaedic integrated clinical assessment and treatment service. *BJGP Open*. 2018;1(4):bjgpopen17X101217.
18. **Dawson J**, **Fitzpatrick R**, **Carr A**, **Murray D**. Questionnaire on the perceptions of patients about total hip replacement. *J Bone Joint Surg Br*. 1996;78-B(2):185–190.
19. **Dawson J**, **Fitzpatrick R**, **Murray D**, **Carr A**. Questionnaire on the perceptions of patients about total knee replacement. *J Bone Joint Surg Br*. 1998;80-B(1):63–69.
20. **Davis AM**, **Wood AM**, **Keenan AC**, **Brenkel IJ**, **Ballantyne JA**. Does body mass index affect clinical outcome post-operatively and at five years after primary unilateral total hip replacement performed for osteoarthritis? A multivariate analysis of prospective data. *J Bone Joint Surg Br*. 2011;93-B(9):1178–1182.
21. **Haynes J**, **Nam D**, **Barrack RL**. Obesity in total hip arthroplasty. *Bone Joint J*. 2017;99-B(1_Supple_A):31–36.
22. **Stürmer T**, **Dreinhöfer K**, **Gröber-Grätz D**, **et al**. Differences in the views of orthopaedic surgeons and referring practitioners on the determinants of outcome after total hip replacement. *J Bone Joint Surg Br*. 2005;87-B(10):1416–1419.
23. **Mayne AIW**, **Cassidy RS**, **Magill P**, **Diamond OJ**, **Beverland DE**. Increased fat depth is not associated with increased risk of surgical complications following total hip arthroplasty. *Bone Joint J*. 2020;102-B(9):1146–1150.
24. **Montgomery v**. Lanarkshire Health Board [2015] UKSC 11. 11AD. http://www.bailii.org/uk/cases/UKSC/2015/11.html (date last accessed 14 June 2021).
25. **Inacio MC**, **Kritz-Silverstein D**, **Raman R**, **et al**. The impact of pre-operative weight loss on incidence of surgical site infection and readmission rates after total joint arthroplasty. *J Arthroplasty*. 2014;29(3):458–464.
26. **Leopold SS**. Editorial: the shortcomings and harms of using hard cutoffs for BMI, hemoglobin A1c, and smoking cessation as conditions for elective orthopaedic surgery. *Clin Orthop Relat Res*. 2019;477(11):2391–2394.
27. **Tomiyama AJ**, **Ahlstrom B**, **Mann T**. Long-Term effects of dieting: is weight loss related to health? *Soc Personal Psychol Compass*. 2013;7(12):861–877.
28. **Hser YI**, **Evans E**, **Grella C**, **Ling W**, **Anglin D**. Long-term course of opioid addiction. *Harv Rev Psychiatry*. 2015;23(2):76–89.
29. **Hamdi A**, **Albaghdadi AT**, **Ghalimah B**, **Alnowiser A**, **Ahmad A**, **Altaf A**. Bariatric surgery improves knee function and not knee pain in the early postoperative period. *J Orthop Surg Res*. 2018;13(1):82.
30. **Gu A**, **Cohen JS**, **Malahias MA**, **Lee D**, **Sculco PK**, **McLawhorn AS**. The effect of bariatric surgery prior to lower-extremity total joint arthroplasty: a systematic review. *Hss J*. 2019;15(2):190–200.
31. **National Institute for Clinical Excellence (NICE)**. Guidelines for surgery in obese adults:-NICE Pathway. http://pathways.nice.org.uk/pathways/obesity (date last accessed 14 June 2021).
32. **Sisko ZW**, **Vasarhelyi EM**, **Somerville LE**, **Naudie DD**, **MacDonald SJ**, **McCalden RW**. Morbid obesity in revision total knee arthroplasty: a significant risk factor for Re-Operation. *J Arthroplasty*. 2019;34(5):932–938.

Author information:
- P. F. Crookes, MD, FRCS, Consultant Bariatric Surgeon
- R. S. Cassidy, BSc (Hons), MMedSci, PhD, Data Analyst
- A. Machowicz, BSc, Medical Student
- J. C. Hill, MEng, MSc, PhD, Research Manager
- D. Beverland, MD, FRCS, Consultant Orthopaedic Surgeon
  Outcomes Unit, Primary Joint Unit, Musgrave Park Hospital, Belfast, UK.
- J. McCaffrey, MB, BchBAo, FCARCSi, FCICMI FCICM, Consultant Anaesthetist
- G. Turner, MB, BChBAo, FFARCSi, Consultant Anaesthetist
  Department of Anaesthetics, Musgrave Park Hospital, Belfast, UK.

Author contributions:
- P. F. Crookes: Contributed to the writing and editing of the manuscript.
- R. S. Cassidy: Analyzed the data, Contributed to the writing and editing of the manuscript.
- A. Machowicz: Contributed to the writing and editing of the manuscript.
- J. C. Hill: Contributed to the writing and editing of the manuscript.
- J. McCaffrey: Contributed to the writing and editing of the manuscript.
- G. Turner: Contributed to the writing and editing of the manuscript.
- D. Beverland: Contributed to the writing and editing of the manuscript.

Funding statement:
- Although none of the authors has received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article, benefits have been or will be received but will be directed solely to a research fund, foundation, educational institution, or other non- profit organization with which one or more of the authors are associated.

ICMJE COI statement:
- D. Beverland reports consultancy, payment for lectures, and payment for development of educational presentations from Depuy International, which are unrelated to this work.

Acknowledgements:
- The authors would like to thank the Outcomes department Artrhoplasty Care Practitioners at Musgrave Park Hospital for their contribution to patient data collection. The authors would also like to thank the Trauma & Orthopaedics Research Charity Northern Ireland (www.TORCNI.org) for their support in producing this paper (Charity no. NIC105791).

Ethical review statement:
- This was an audit; therefore, IRB approval was not required according to the guidelines at our institution (Belfast Health & Social Care Trust)