The impact of obesity on the mid-term outcome of cementless total knee replacement

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We evaluated 535 consecutive primary cementless total knee replacements (TKR). The mean follow-up was 9.2 years (0.3 to 12.9) and information on implant survival was available for all patients. Patients were divided into two groups: 153 obese patients (BMI ≥ 30) and 382 non-obese (BMI < 30). A case-matched study was performed on the clinical and radiological outcome, comparing 50 knees in each group. We found significantly lower mean improvements in the clinical score ($p = 0.044$) and lower post-operative total clinical scores in the obese group ($p = 0.041$). There was no difference in the rate of radiological osteolysis or lucent lines, and no difference in alignment. Log rank test for survival showed no significant differences between the groups ($p = 0.167$), with a ten-year survival rate of 96.4% (95% confidence interval (CI) 92 to 99) in the obese and 98% (95% CI 96 to 99) in the non-obese.

The mid-term survival of TKR in the obese and the non-obese are comparable, but obesity appears to have a negative effect on the clinical outcome. However, good results and high patient satisfaction are still to be expected, and it would seem unreasonable to deny patients a TKR simply on the basis of a BMI indicating obesity.

Obesity has been shown to be an independent risk factor for the development of osteoarthritis, particularly in the knee.¹⁻³ With the rising demand for total knee replacement (TKR)^{4,5} and the increase in obesity levels,⁶⁻⁸ it is important to determine whether obese patients have inferior or equivalent outcomes compared with the non-obese. It is also assumed that the increased load causing greater peak contact stresses in the polyethylene and greater forces across the implant-bone interface could lead to premature wear, loosening and increased failure rates. The current literature has divided opinion, with some studies finding little difference in outcomes^{9,10} and others showing inferior results.^{11,12} However, there is still limited information for this group of patients. The aim of this study was to evaluate implant survival and review the mid-term clinical and radiological outcome of patients who had undergone primary TKR and assess the effect of obesity.

culated for each patient using a standardised formula at their pre-operative assessment, which typically occurred within two weeks of surgery. It is our practice not to defer knee replacement surgery because of obesity, and there were no pre-operative selection criteria. Obesity has been defined by the World Health Organisation as a BMI > 30 ,¹³ and we therefore grouped the patients as obese (BMI ≥ 30) or non-obese (BMI < 30).

In our unit, all demographic and clinical information for arthroplasty patients is anonymously recorded prospectively in a database by the surgeons (WLW, WKW, BAZ). Patient consent is obtained for ongoing research purposes and the data are collected with the assessors blinded to any particular future study. Post-operative radiographs were sequentially examined by an orthopaedic surgeon blinded to the patient's BMI, and who was not involved in their operation or routine follow-up. Standard anteroposterior, lateral, patellar and weight-bearing knee radiographs were obtained pre- and post-operatively, and evaluated for the presence of osteolysis, radiolucent lines and alignment using the Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System.¹⁴ Clinical outcome was assessed using The Hospital for Special Surgery (HSS)

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Patients and Methods

Between 1995 and 2001, 535 consecutive primary cementless AMK (Depuy, Warsaw, Indiana) TKRs were performed in 481 patients at our hospital. All were available for survival analysis. The body mass index (BMI) was cal-

Table I. Demographics of the knee cohort for survival analysis

	All	Obese	Non-obese	Significance (p)
Number (%)	535	153 (29)	382 (71)	
Male (%)	208	46 (22)	162 (78)	< 0.01
Female (%)	327	107 (33)	220 (67)	
Mean age (SD, range)	71 (9.0, 41 to 89)	67 (9.6, 54 to 87)	72 (8.4, 41 to 89)	< 0.001
Mean follow-up (SD, range)	9.2 (2.5, 0.3 to 12.9)	9.4 (2.6, 0.3 to 12.9)	9.2 (2.4, 0.8 to 12.9)	0.88
Mean BMI* (SD, range)	28.0 (5.2, 18 to 46.7)	34.5 (4.0, 30 to 46.7)	25.2 (2.7, 18 to 29.9)	< 0.01

* BMI, body mass index

Table II. Demographics of the case-matched knee replacements

	Obese	Non-obese	Significance (p)
Number	50	50	-
Male	12	12	NS*
Female	38	38	
Mean age (SD, range)	69 (5.9, 55 to 81)	69 (5.5, 51 to 81)	0.66
Mean follow-up (SD, range)	7.2 (1.9, 3.1 to 11.5)	7.4 (1.9, 3.5 to 12.0)	0.67
Mean BMI† (SD, range)	34.1 (3.8, 30 to 46.7)	25.2 (3.2, 18 to 29.9)	< 0.01

* NS, not significant

† BMI, body mass index

Knee Rating Score,¹⁵ which is calculated from a maximum of 100 points, composed of pain (30), range of movement (18), function (22), muscle strength, flexion deformity and instability (10 each), with deductions for the use of walking aids, extensor lag and residual coronal malalignment. Post-operative range of movement was also assessed separately, along with an overall satisfaction with surgery question using a visual analogue scale (maximum of 10).

A case-matched study was performed retrospectively on the prospectively collected data, comparing 50 TKRs in 50 obese patients with 50 matched replacements in 50 patients from the non-obese group. All surviving unilateral TKRs in the obese group with more than three years' follow-up and which had a suitable match were selected. They were individually matched on the database for age (within five years), gender, pre-operative diagnosis, side, surgeon and time to follow-up (within one year). Surgery was performed in a high air flow environment by one of two experienced arthroplasty surgeons (WKW, BAZ) using comparable techniques which were maintained throughout the study. The prosthesis in all cases was a cementless AMK using a fixed-bearing insert with selective resurfacing of the patella. The post-operative protocols were standardised for all patients, and included venous thromboembolic prophylaxis with subcutaneous heparin and 48 hours of intravenous antibiotics. A continuous passive movement device was used while the patient was in bed during the first two days. Patients were encouraged to mobilise fully weight-bearing as tolerated, with supervision from a physiotherapist.

Statistical analysis. Data analysis was performed using the SPSS software (SPSS Inc., Chicago, Illinois). Results were

compared using a combination of the paired two-tailed *t*-tests, Fisher's exact test and the chi-squared test, with a significance level set at 0.05. Survival data were investigated with a log rank test for equality of survival and a Kaplan-Meier curve generated using revision for any reason as the end-point. A *post hoc* power analysis was performed with the α and β levels set at 0.05 and 0.2, respectively.

Results

The demographic details of all patients are shown in Table I. The mean age of obese patients was significantly lower than that of the non-obese. There was a significantly higher proportion of women in the obese group ($p = 0.01$). The mean follow-up was 9.2 years (0.3 to 12.9) and was not significantly different between the groups. The demographics of patients for the subsequent case controlled study are shown in Table II.

There was no difference in the overall pre-operative mean HSS clinical scores but post-operatively they were significantly lower in the obese group (Table III). Post-operatively, range of movement and maximum knee flexion were significantly worse in the obese group. There were no differences in the occurrence of fixed flexion post-operatively with only one knee in each group having more than a 5° extension deficit. The overall satisfaction with surgery scores were not significantly different between the groups.

When we considered any difference in relative improvement from the mean pre-operative to post-operative HSS scores there was significantly less improvement in the obese ($p = 0.04$, two-tailed paired *t*-test). Improvements in the individual parameters of the knee score were not significantly different between the groups, although there was a trend for all to be greater in the non-obese (Table IV).

Table III. Pre- and post-operative clinical results for the case-matched knees

	Obese	Non-obese	Significance (p)
Mean total HSS* (SD)			
Pre-	56.5 (10.9)	54.1 (12.0)	0.30
Post	83.8 (9.3)	87.4 (8.6)	< 0.05
Pain (SD)			
Pre-operative	9.9 (7.0)	8.1 (7.3)	0.21
Post-operative	26.8 (6.8)	27.3 (5.1)	0.68
Function (SD)			
Pre-operative	12.3 (1.8)	13.0 (2.3)	0.10
Post-operative	15 (3.2)	16.7 (3.5)	< 0.01
Examination† (SD)			
Pre-operative	25 (4.4)	23.8 (3.9)	0.13
Post-operative	29.1 (1.9)	29.2 (1.8)	0.78
Range of movement (SD)			
Pre-operative	11.7 (2.2)	11.9 (2.5)	0.55
Post-operative	13.4 (2.1)	14.6 (2.0)	< 0.01
Maximum knee flexion achieved post surgery (°) (SD)	112 (17.1)	120 (15.5)	< 0.05
Satisfaction with surgery/10 (SD)	8.8 (2.2)	9.4 (1.2)	0.17

* HSS, Hospital for Special Surgery score

† examination: muscle strength, flexion deformity, instability; 10 points each

Table IV. Mean HSS* score improvements for the case-matched knees

	Obese	Non-obese	Significance (p)
Total score (SD)	27.3 (15.8)	33.3 (14.8)	< 0.05
Pain (SD)	16.9 (10.7)	19.2 (8.5)	0.24
Function (SD)	2.7 (3.4)	3.7 (4.1)	0.18
Examination (SD)	4.0 (4.9)	5.4 (4.6)	0.16
Range of movement (SD)	1.8 (2.8)	2.6 (3.0)	0.14

* HSS, Hospital for Special Surgery

Radiological assessment revealed no significant differences in femoral or tibial component alignment in the coronal and sagittal planes. There were four lucent lines and 12 osteolytic lesions identified in seven patients (1.3%), with no significant difference between the obese and the non-obese. All patients had evidence of radiological bony ingrowth on the femoral and tibial components.

The *post hoc* power analysis of the case-matched study revealed that we will have detected with 80% certainty what we believe to be a clinically significant difference in the means of the total HHS (five points), the derivative HSS parameters (three points), knee flexion (9°), patient satisfaction score (< 1) and radiological measurements (2.5°).

There were 82 deaths (92 knees) during the follow-up period and 13 revision procedures for all reasons representing 2.4% (13/535) overall, 3.92% (6/153) in the obese and 1.83% (7/382) in the non-obese group. Kaplan-Meier survival analysis, with revision for any reasons as the endpoint showed no significant difference between the groups (log rank test, $p = 0.167$, Fig. 1). The

cumulative survival rate at ten years was 96.4% in the obese (standard error 0.16 and 95% confidence interval (CI) 92 to 99) and 98% in the non-obese (standard error 0.07 and 95% CI 95.9 to 99). The number of knees remaining at risk at ten years was 68 in the obese group and 154 in the non-obese.

Discussion

There is much interest in the role of BMI on the outcome of hip and knee arthroplasty,^{16,17} leading to some public health systems in the United Kingdom trying to use a raised BMI as a means of rationing of arthroplasty services.¹⁸ However, we propose there is little to suggest that this is justified. We found no significant difference in the mid-term survival of knee replacements between obese and non-obese patients, with revision for any reason as the endpoint. Other studies looking at implant survival have had differing findings. Spicer et al¹⁰ found similar ten-year survival figures and rates of revision between obese and non-obese, whereas a demographic study with a ten-year follow-up

Fig. 1

Kaplan-Meier survival curve comparing total knee replacement in obese and non-obese patients.

found a significant decrease in survival in an obese group.¹² Foran et al¹¹ revealed similar survival figures until 14 years after surgery, when there were more failures in the obese group; however, this was not statistically significant. The same group, in a separate study, suggested that survival in the obese group decreased significantly after 60 to 80 months,¹⁹ whereas survival analysis of our groups showed no statistically significant difference between them. As none of our patients was lost to follow-up due to a regular review of patient deaths and excellent communication within a small referral base and a localised arthroplasty community, we are confident that this is an accurate picture of the rate of revision and mid-term implant survival in a large group of patients. Radiological analysis showed no difference between the groups with regard to findings suggestive of impending implant failure or malalignment, which is claimed to predispose to aseptic loosening.²⁰ This should mean that continuing survival remains similar between the groups. We may see more revisions in the obese group secondary to polyethylene wear. However, as it has been suggested that there is increased wear in the non-obese owing to their tendency towards higher activity levels,²¹ this may counteract the higher loading in the obese.

Our findings differ from others who found little difference in the overall clinical outcome scores between the obese and non-obese.^{9,10,22,23} We found that there was a significantly better range of movement in the non-obese group. We feel that this is to be expected, given the apposition of soft tissue which occurs at higher flexion angles. This is also likely to affect the function score, which was also found to be significantly lower. Our finding that the relative improvement in the score in the non-obese was

significantly better is interesting, and in agreement with the Foran study.¹⁹ Score improvements have often not been commented upon by researchers, and therefore limit some of their conclusions.^{9,11,22,23} All the individual parameters of the overall score also showed a trend towards greater relative improvement in the non-obese, although this was not significant, all suggesting that non-obese gain more from their operation. BMI has been identified as a marker of several medical conditions, chronic health problems and mortality.^{24,25} Obesity has also been shown to have broad associations with factors detrimental to health, which may adversely influence the knee score. These include depression, chronic fatigue, insomnia²⁶ and the self-reporting of pain.²⁷ The reasons for the effect on the knee score following surgery are therefore not entirely clear, and there is likely to be a complex relationship between them.

It is possible that our obese group lost weight post-operatively, and therefore the differences in BMI are not sustained. However, several studies have investigated weight change post arthroplasty and, despite the intentions of many patients, there is evidence that the BMI remains static or increases.^{28,29} We are therefore confident that the BMI of our patients will not have changed during follow-up.

Specific focus evaluation of morbidly obese patients (BMI > 40) suggests that they have poorer outcomes.³⁰ Unfortunately, we only had a small number (15) of such patients and were therefore unable to evaluate them meaningfully. However, so far none has required a revision operation.

In conclusion, the obese patient can be informed that their mid-term implant survival is comparable with that of the non-obese, and that their overall clinical result and satisfaction with surgery should be excellent. However, they should be counselled that their post-operative flexion may be less than in the non-obese patient, and that their overall improvement *versus* the non-obese group could be reduced. We advise that a patient requiring a TKR should not be denied the potential benefits of this operation purely on the grounds that their BMI indicates obesity.

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