Obesity and total knee and hip replacement

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Summary
As the prevalence of obesity rises, the number of hip and knee replacements performed on obese patients will rise. This article reviews the correlation between obesity and the development of osteoarthritis in the hip and knee, and outcomes.

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Introduction
The Body Mass Index (BMI) is an individual’s weight divided by height squared; this ratio correlates with the amount of total body fat.1 The normal range is 15–25 kg/m², 25–30 kg/m² is overweight, >30 kg/m² is obese and >40 kg/m² morbidly obese.2–4 It has long been recognised that BMI is a predictor of morbidity and mortality for several chronic diseases, including diabetes mellitus, coronary artery disease and stroke, with this health risk increases linearly.

Recently, three primary care trusts in the United Kingdom have ruled that patients with a BMI of over 30 kg/m² will not be entitled to hip and knee replacement surgery. This has sparked a debate by health professionals and politicians. This article reviews the published literature to see if this decision is justified in obese patients undergoing knee and hip replacements.

The currently accepted definition of obesity1 is the BMI. Because earlier studies in the 1980s and early 1990s used relative body weight based on Metropolitan Life Insurance Tables5 to define obesity as 120% ‘ideal body weight’, they have been excluded to allow comparison of published results.

Prevalence of obesity in the United Kingdom
The prevalence of obesity in males has increased from 6% in 1980 to 22% in 2002. Females have shown a similar increase (8–23%).6 Not only does the UK have some of the worst figures in Europe but it also has some of the worst trends. In the majority of European countries the prevalence of obesity has increased between 10% and 40% in the last 10 years, whereas in England it has more than doubled.6 In 1995, according to the World Health Organisation (WHO), there were an estimated 200 million obese adults worldwide and another 18 million children aged under five classified as overweight. However, by 2000, the number of obese adults had increased to over 300 million.7

Risk of obesity in the development of osteoarthritis of the hip and knee
A positive association between obesity and BMI, and OA of the knee has been observed in cohort studies8–12 a case–control study13 and cross-sectional studies.14–21 Weight loss has been shown to reduce the incidence of knee OA in...
women in a cohort study. In the case–control studies, selection bias cannot be completely ruled out because they depend on symptoms for their case definition and patients with OA are more likely to have symptoms if they are obese. The relation with obesity and hip osteoarthritis is less clear. For example, several studies have suggested that obesity increases the risk of symptomatic but not radiographic hip osteoarthritis. Furthermore, because most studies have been cross-sectional, it is not known if obesity preceded or followed hip pathology. Lievens et al. in a systematic review of the literature found associations between obesity and hip OA were stronger in studies in which the diagnosis of hip OA was based not only on radiological criteria but also on clinical symptoms. Overall, moderate evidence was found for a positive association between obesity and the occurrence of hip OA, with an odds ratio of approximately 2. Prospective cohort studies determine obesity status before the development of hip osteoarthritis. Karlson et al. in a prospective cohort study of more than 120,000 women, found that only higher BMI and older age were associated with an increased risk of osteoarthritis requiring hip replacement surgery. In particular, women in the highest category of BMI had a twofold greater risk of hip arthroplasty, compared with those in the lowest category. A particularly intriguing finding by Karlson et al. was the relation of BMI at age 18 years to the risk of hip osteoarthritis. Risk estimates at age 18 years were significantly greater than those for “recent” BMI, which were reported closer to the date of surgery. For those who were obese at 18 there was a five fold increased risk of having a THR. Another study has estimated that if obesity were eliminated, the prevalence of hip osteoarthritis would decrease by 25%.

Total knee replacement in the obese patient

**Results of total knee replacement in the obese patient (BMI > 30 kg/m²)**

Several studies have compared the results of total knee replacement in obese patients, (BMI > 30 kg/m²) with non-obese patients, defined as BMI < 30 kg/m², with follow-up ranging from 1 to 15 years. Three main parameters must be considered when evaluating results of total knee replacement in obese and non-obese patients:

- Short term the peri-operative complications.
- Medium term, the clinical outcome scores.
- Long-term survivorship of the prosthesis.

**Peri-operative complications**

While there are several reports regarding the influence of obesity on peri-operative complications in general, gynaecological and cardiac surgery, those following total knee replacement has been less well studied. Such studies as have been published have generally focused on wound complications, thromboembolic complications, medical events and peri-operative mortality. They can be criticised for selection bias, as high-risk patients are often discouraged from undergoing total knee replacement. In one prospective study comparing 210 total knee replacements in non-obese patients with 160 total knee replacements in obese patients, there were no differences between the two groups for superficial wound infection, deep joint infection, deep vein thrombosis/pulmonary embolism or peri-operative mortality. In a retrospective matched study, the overall peri-operative complication rate was reported as 3% in 78 total knee replacements performed in the obese group (a deep vein thrombosis and wound dehiscence in one patient and a foot drop in the other) and 0% in the non-obese group, but the difference was not statistically significant. In a crude analysis of ‘medical’ and ‘orthopaedic’ complications following total knee replacement, no difference was reported between patients sub-divided into various BMI categories. While these studies divided patients into obese and non-obese groups based on a BMI greater or less than 30 kg/m² respectively, in one large prospective study of 1813 patients who underwent total knee replacement, the authors studied the peri-operative morbidity using a higher BMI value of 35 kg/m² to divide the study sample into two groups. Patients with a BMI > 35 kg/m² had a significantly higher deep joint infection rate compared to those with a BMI < 35 kg/m² (1.1% vs. 0.3%, respectively) although the rates of medical complications (cardiac, gastrointestinal, genitourinary and pulmonary events) and deep vein thrombosis was similar for both groups. In summary, although selection bias may be a significant confounding factor, reported results suggest the peri-operative complications in obese and non-obese patients following total knee replacement are similar, but infective complications may increase with BMI.

**Clinical outcome scores**

Reported clinical outcome following total knee replacement is usually based on a composite score derived from joint specific and/or patient based formal outcome scoring systems. Studies comparing the 1-year clinical outcome using patient based outcome scoring systems have found no difference in the results between obese and non-obese groups. Studies with longer follow-up (Table 1) have used the Knee Society Score (KSS) to compare the clinical outcome following total knee replacement in obese and non-obese patients. The KSS is a joint-specific outcome scoring system and comprises a ‘knee score’ and ‘function score’. The knee score component of the KSS is derived by evaluating pain, range of movement and stability with deductions for flexion contracture, extensor lag and malalignment. The function score component is derived by evaluating walking distance and stair climbing ability with deductions for walking aids used. The knee and function scores are reported separately and both are scored out of a maximum of 100 points.

Table 1 summarises the knee and function scores from studies comparing the results of total knee replacement in obese and non-obese patients with follow-up ranging from 5 to 15 years, but there are few large study samples beyond 7 years. It is clear that the clinical outcome based on the KSS does not show significant differences between obese and non-obese patients, except for one retrospective study in
which the knee score component was found to be significantly inferior (P = 0.04) in the obese group but not the function score component (P = 0.05). In summary, the weight of the published evidence suggests that there is no difference in the clinical outcome in the mid-term between obese and non-obese patients assessed using patient based or joint specific outcome scoring systems. Larger, prospective studies are required to establish the long-term clinical outcome in obese patients following total knee replacement.

### Prosthesis survivorship

Survivorship of the implant is an important measure of longer term success of total knee replacement. In a survivorship analysis, it is assumed that all patients underwent the total knee replacement simultaneously, which allows analysis of data from patients with different lengths of follow-up with cases being 'entered' or 'censored' from the analysis at any stage and 'failures' identified. The survivorship for a particular length of time can be calculated either by constructing a life table (survivorship calculations based on failures per year of follow-up) or using Kaplan–Meier methodology (survivorship recalculated each time a failure occurs).50

The literature comparing the survivorship of total knee replacement in obese and non-obese patients is difficult to analyse for two reasons. Firstly, a formal survivorship analysis has not been undertaken in the majority of the studies and most authors have reported revision rates with or without radiographic analysis (Table 2). Secondly, the two studies that have reported survivorship of the implant have been retrospective and involved relatively small numbers.42,43

Based on revision of the implant (for any reason) as the endpoint, none of the studies has demonstrated significant differences between obese and non-obese patients following total knee replacement (Table 2). Using revision, clinical failure and radiographic failure as endpoints however, one retrospective study found an inferior survivorship in obese patients (compared to non-obese patients) that became apparent after 60 months.42 At eighty months, survivorship of 78 total knee replacements in the obese group was 88%, compared to 99% in the same number of total knee replacements performed in a matched non-obese group.42

<table>
<thead>
<tr>
<th>Study, follow-up</th>
<th>Groups</th>
<th>N</th>
<th>Mean KS*</th>
<th>Mean FS*</th>
<th>Summary</th>
<th>Level of evidence†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amin et al. 2006</td>
<td>Obese</td>
<td>147</td>
<td>84</td>
<td>85</td>
<td>No difference in scores</td>
<td>Level I, prospective study</td>
</tr>
<tr>
<td>5 years</td>
<td>Non-obese</td>
<td>181</td>
<td>86</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spicer et al. 2001</td>
<td>Obese</td>
<td>326</td>
<td>76</td>
<td>63</td>
<td>No difference in scores</td>
<td>Level II, prospective study</td>
</tr>
<tr>
<td>6 years</td>
<td>Non-obese</td>
<td>425</td>
<td>79</td>
<td>68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foran et al. 2004</td>
<td>Obese</td>
<td>78</td>
<td>90</td>
<td>71</td>
<td>Inferior KS in obese, FS similar</td>
<td>Level II, retrospective study</td>
</tr>
<tr>
<td>6.6 years</td>
<td>Non-obese</td>
<td>78</td>
<td>94</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Griffin et al. 1998</td>
<td>Obese</td>
<td>32</td>
<td>93</td>
<td>67</td>
<td>No difference in scores</td>
<td>Level II, retrospective study</td>
</tr>
<tr>
<td>10 years</td>
<td>Non-obese</td>
<td>41</td>
<td>93</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foran et al. 2004</td>
<td>Obese</td>
<td>30</td>
<td>81</td>
<td>NR</td>
<td>No difference in KS, FS not reported</td>
<td>Level II, retrospective study</td>
</tr>
<tr>
<td>15 years</td>
<td>Non-obese</td>
<td>30</td>
<td>89</td>
<td>NR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N—number of total knee replacements in each group, KS—knee score component of KSS, FS—function score component of KSS, NR—not reported.

*Rounded to nearest decimal point.

†Levels of evidence based on material published by the Centre for Evidence Based Medicine, Oxford, UK (www.cebm.net).

<table>
<thead>
<tr>
<th>Study, follow-up</th>
<th>N obese vs. non-obese</th>
<th>Revision rate obese vs. non-obese</th>
<th>Radiographic analysis</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amin et al. 2006 5 years</td>
<td>210 vs. 160</td>
<td>2.5% vs. 1.4%</td>
<td>No</td>
<td>No statistical difference</td>
</tr>
<tr>
<td>Spicer et al. 2001 6 years</td>
<td>326 vs. 425</td>
<td>4.9% vs. 3.1%</td>
<td>Yes</td>
<td>No statistical difference</td>
</tr>
<tr>
<td>Foran et al. 2004 6.6 years</td>
<td>78 vs. 78</td>
<td>5% vs. 0%</td>
<td>Yes</td>
<td>No statistical difference</td>
</tr>
<tr>
<td>Mont et al. 1996 7 years</td>
<td>50 vs. 50</td>
<td>8% vs. 4%</td>
<td>Yes</td>
<td>No statistical difference</td>
</tr>
<tr>
<td>Griffin et al. 1998 10 years</td>
<td>32 vs. 41</td>
<td>0% vs. 7.3%</td>
<td>Yes</td>
<td>No statistical difference</td>
</tr>
</tbody>
</table>

N—number of total knee replacements.

*Calculated from numbers provided in study.
demonstrated a trend towards inferior survivorship in obese patients only after 14 years, but the differences were not statistically significant due to small numbers. In summary, present evidence suggests that mid-term survivorship is probably similar for obese and non-obese patients, but in the long-term, the survivorship may deteriorate in obese patients and requires further investigation.

Results of total knee replacement in morbidly obese patients (BMI > 40 kg/m²)

Patients with a BMI > 40 kg/m² are 'morbidly obese'. If obesity were to have a negative influence on the results of total knee replacement, one would expect the inferior results to be most obvious in these patients with severe obesity.

All published comparative studies using the BMI to divide patients into 'obese' (BMI > 30 kg/m²) and 'non-obese' (BMI < 30 kg/m²) groups have included morbidly obese patients, within the 'obese' category. A separate analysis of results in the subgroup of obese patients who are morbidly obese was reported in one large study with an average follow up of about 6 years. A total of 326 knee replacements performed in the obese group were compared with 425 similar procedures performed in a matched group of non-obese patients. Of the total knee replacements performed in obese patients, 59 procedures were performed in the morbidly obese. The survivorship and clinical outcome scores were similar for obese and non-obese patients, but in the subgroup of obese patients who were morbidly obese, seven (12%) implants were revised or in need of revision by 6 years with a focal osteolysis rate five times higher than the non-obese control group.

In a study with the primary aim of evaluating results of total knee replacement in the morbidly obese patient, 50 primary total knee replacements performed in morbidly obese patients were compared with 1768 similar procedures performed in a control group of non-morbidly obese (BMI < 40 kg/m²) patients by the same surgeon. The peri-operative complication rate in morbidly obese patients was 26% compared to 2% in the control group. Additionally, at an average follow up of about 5 years, the KSS was inferior in the morbidly obese with a 10% revision rate and a 10% deep joint infection rate (three revised, two re-operated with retention of implant).

Although a high body weight results in increased stress across a total knee replacement and surrounding bone, it does not appear to produce high failure rates in obese patients (BMI > 30 kg/m²) who have total knee replacements. This is probably due to the lower activity levels in these patients compared to non-obese patients. It is possible however, that in the subgroup of obese patients who are morbidly obese (BMI > 40 kg/m²), lower activity levels may not compensate for the much higher stresses across the knee joint. The high rate of infective complications following total knee replacement in the morbidly obese patient appears to substantiate similar problems noted following gastric bypass surgery to treat morbid obesity.

Total hip replacement in the obese patient

There is little evidence describing the influence of BMI on the outcome of total hip replacements (THR).

Postoperative infection

Our prospective study reported 800 consecutive hip replacements in 759 patients. Thirty-three per cent were obese. One of the strengths of our paper is the use of regression analysis to identify independently significant predictors. For example, in our initial univariate analysis, an association between BMI and infection was suspected. It would be erroneous to draw the conclusion that obesity is responsible for increased rates of infection as an increased BMI is associated with an altered incidence of other conditions, such as diabetes mellitus. Regression analysis allows us to separate out diabetes and BMI and test the effect of each on the incidence of infection. Other studies also found no increased infection.

Blood loss

A paper comparing 41 obese and 125 non-obese patients noted increased blood loss in the obese group as did Bowditch and Villar in a series of 80 patients. Multiple regression analysis allows for the correction of other variables in assessing the individual influence of BMI. Even with the large numbers in our study, once other factors such as co-morbidity are taken into account, we did not find that BMI increased measured blood loss or transfusion requirement. It is likely that the comparison of obese and non-obese patients without factoring in confounding data oversimplifies the true state of affairs. In a separate study, in our unit, we performed a multivariate analysis on 1016 THR, looking at transfusion requirements. BMI did not affect the transfusion rate in these patients.

Harris Hip and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Scores

In our study BMI independently predicted a lower Harris Hip Score (HSS) at 6 and 18 months. Although its individual effect was significant statistically, the difference was small. Stickles et al. found no difference in the WOMAC scores between obese and non-obese patients.

Quality of life scores (QOL)

Two studies used the Short Form 36 (SF36) and showed no difference in the outcomes between obese and non-obese patients. Chan and Villar used the Rosser Index Matrix to generate a QOL score on 176 prospective patients undergoing THR. Forty-nine percent were obese but was no difference in the QOL compared to the non-obese patients at 1 and 3 years post-operatively.
Loosening and early failure

In our study we saw no relationship between early failure of the THR and obesity confirmed by other studies. Indeed published data suggests that over a third of all total hip and knee replacements are performed in obese patients. It is important to establish how results of total knee and hip replacement in weight following total hip or knee replacement. Two prospective studies showed that obese patients gained disabling joint disease a cause of their increased weight.

Summary

Total joint replacement is established as a very successful operation in treating degenerative disease of the hip and knee when conservative measures fail to alleviate symptoms. As the prevalence of obesity is increasing in Europe and North America, the percentage of total joint replacements performed in obese patients is likely to increase dramatically. Indeed published data suggests that over a third of all total hip and knee replacements are performed in obese patients. It is important to establish how results of total knee and hip replacement in such patients compare with the results obtained in non-obese patients. Present evidence suggests that the results of total knee replacement in obese (BMI > 30 kg/m²) patients are probably comparable to the results of the procedure in non-obese (BMI < 30 kg/m²) patients, at least in the mid-term, but larger, prospective studies are necessary to ascertain the influence of obesity on the long-term survivorship following total knee replacement. There is some evidence that in morbidly obese (BMI > 40 kg/m²) patients, the results of total knee replacement are consistently poor, but there is too little data on the effect of morbid obesity on the outcomes of THR. Finally, patients undergoing total hip or knee replacement who are obese often consider their disabling joint disease a cause of their increased weight. Two prospective studies showed that obese patients gained weight following total hip or knee replacement. Successful treatment of lower limb osteoarthritis does not lead to weight loss, and obesity is not just a result of inactivity.

References

7. www.who.int/nut


