Total knee replacement in morbidly obese patients

RESULTS OF A PROSPECTIVE, MATCHED STUDY

A. K. Amin,
R. A. E. Clayton,
J. T. Patton,
M. Gaston,
R. E. Cook,
I. J. Brenkel

*From the Department
of Orthopaedics,
Queen Margaret
Hospital, Fife,
Scotland*

The results of 41 consecutive total knee replacements performed on morbidly obese patients with a body mass index $> 40 \text{ kg/m}^2$, were compared with a matched group of 41 similar procedures carried out in non-obese patients (body mass index $< 30 \text{ kg/m}^2$). The groups were matched for age, gender, diagnosis, type of prosthesis, laterality and pre-operative Knee Society Score. We prospectively followed up the patients for a mean of 38.5 months (6 to 66). No patients were lost to follow-up. At less than four years after operation, the results were worse in the morbidly obese group compared with the non-obese, as demonstrated by inferior Knee Society Scores (mean knee score 85.7 and 90.5 respectively, $p = 0.08$; mean function score 75.6 and 83.4, $p = 0.01$), a higher incidence of radiolucent lines on post-operative radiographs (29% and 7%, respectively, $p = 0.02$), a higher rate of complications (32% and 0%, respectively, $p = 0.001$) and inferior survivorship using revision and pain as end-points (72.3% and 97.6%, respectively, $p = 0.02$).

Patients with a body mass index $> 40 \text{ kg/m}^2$ should be advised to lose weight prior to total knee replacement and to maintain weight reduction. They should also be counselled regarding the inferior results which may occur if they do not lose weight before surgery.

The body mass index (BMI) for an individual is their weight in kilograms (kg) divided by their height in metres squared (m^2), and this correlates with their total body fat.¹ Obesity is defined as a BMI $> 30 \text{ kg/m}^2$ and morbid obesity as a BMI $> 40 \text{ kg/m}^2$.¹ While there are several studies in the literature evaluating the results of total knee replacement (TKR) in the obese patient,²⁻¹⁰ few have described the results in the morbidly obese. In a single surgeon series, results of 50 primary TKRs performed in morbidly obese patients were compared with 1768 similar procedures carried out on patients who were not morbidly obese.¹¹ At five years, the clinical outcome scores were significantly inferior in the morbidly obese group: there was a high rate of revision and of peri-operative complications; 22% had wound complications and 10% deep infection.¹¹ These poor results in the morbidly obese patient, together with an increasing prevalence of obesity throughout Europe and North America,¹² highlight the need for further evaluation of the results of TKR in this group of high-risk patients.

To assess the influence of morbid obesity on the outcome after TKR, we designed a prospective, matched study to minimise the influence of confounding variables, with the aim of

comparing the outcome following TKR in a consecutive series of morbidly obese patients (BMI $> 40 \text{ kg/m}^2$), with a matched group of non-obese patients (BMI $< 30 \text{ kg/m}^2$).

Patients and Methods

Between 1995 and 2004, over 1700 TKRs were performed in our unit by many surgeons. Independent, prospective follow-up for all patients was undertaken by a dedicated audit team, led by an arthroplasty nurse practitioner and a physiotherapist who were not directly involved in the study and were not aware of the aims at the time of data collection. All patients were followed up at 6, 18, 36 and 60 months following knee replacement.

During this time 41 primary TKRs were performed in 38 morbidly obese patients. These were individually matched with a control group of 41 primary TKRs performed in 38 non-obese patients. The two groups were matched for age, gender, diagnosis (rheumatoid or osteoarthritis), type of prosthesis (Press fit condylar (PFC) or PFC Sigma; both Depuy International, Leeds, United Kingdom), laterality (unilateral or bilateral) and the pre-operative knee and function score components of the Knee Society Score (KSS).^{13,14} It was not always possible to identify a non-obese patient

■ A. K. Amin, MRCS(Ed),
Specialist Registrar
■ R. A. E. Clayton, MRCS(Ed),
Specialist Registrar
■ M. Gaston, MRCS(Ed),
Specialist Registrar
■ R. E. Cook, FRCS(Ed),
Consultant Orthopaedic
Surgeon
■ I. J. Brenkel, FRCS,
Consultant Orthopaedic
Surgeon
Department of Orthopaedics
Queen Margaret Hospital,
Whitefield Road, Dunfermline
KY12 0SU, UK.

■ J. T. Patton, FRCS(Ed),
Consultant Orthopaedic
Surgeon
Department of Orthopaedics
New Royal Infirmary of
Edinburgh, Old Dalkeith Road,
Edinburgh EH16 4SU, UK.

Correspondence should be sent
to Mr A. K. Amin; e-mail:
Anish_Amin@yahoo.com

©2006 British Editorial Society
of Bone and Joint Surgery
doi:10.1302/0301-620X.88B10.
17697 \$2.00

J Bone Joint Surg [Br]
2006;88-B:1321-6.

Received 30 January 2006;
Accepted after revision 18 May
2006

with exactly the same pre-operative knee and function score as a morbidly obese patient. In this instance, the control with the next 'worse' score was identified. If no other control with a 'worse' score could be identified, the control with the next 'better' score was used. This protocol was maintained for matching all the patients so that the control group would have either a similar, or worse, pre-operative knee and functional status compared with the morbidly obese patients. The matching of patients was undertaken using pre-operative data in isolation and without knowing the individual outcomes.

The KSS is a joint-specific outcome scoring system comprising a separate knee score, which rates the joint itself, and a function score, which rates the ability of the patient to walk and climb stairs.¹³ Both components are scored out of a maximum of 100 points. The specific parameters assessed by the knee score component are pain (50 points), range of movement (25 points) and stability (25 points), with deductions for flexion contracture, extensor lag and malalignment. The function score component addresses the walking distance (50 points) and the ability to climb stairs (50 points), with deductions for any walking aids used.

A standard surgical approach with a medial parapatellar incision and arthrotomy was used. Between 1995 and 1999 the PFC TKR was used for all patients. In 1999, this was superseded by the PFC Sigma, produced by the same manufacturer. The manufacturer's instructions regarding the use of implants and instruments were followed, with cementing of components in all cases. All patients had antibiotic prophylaxis at induction of anaesthesia. The patella was not resurfaced in any patient and the posterior cruciate ligament was preserved whenever possible. Low molecular weight heparin and full-length elastic stockings were used for prophylaxis against deep-vein thrombosis in all patients. The post-operative rehabilitation programme, based on an 'integrated care pathway', was the same in both groups. Seven different consultant orthopaedic surgeons (including IJB and REC) either carried out or supervised all the TKRs. In the morbidly obese group, consultant surgeons performed all procedures, whereas in the non-obese group, trainees under the supervision of a consultant performed two operations, with the remainder undertaken by consultants.

No patients were lost to follow-up. We used several outcome measures to compare the results following TKR for the two groups.

Clinically, we analysed the post-operative KSS, while radiologically we assessed the presence of radiolucent lines and compared the alignment of the components.

We also noted any complications including superficial wound infection, deep infection, deep-vein thrombosis and peri-operative mortality.

The five-year survivorship, with revision (defined as revision or the intention to revise) as an end-point, or with revision and pain (defined as a pain score < 20 on the KSS) as end-points, was calculated.

All the radiographs were evaluated by a single observer (AKA) using the Knee Society radiological evaluation guidelines¹⁵ to determine the post-operative alignment of the components and to identify linear radiolucent lines around implants. Previous radiographs were examined to determine whether radiolucent lines were progressive or non-progressive. A wound infection was initially diagnosed on the basis of clinical signs. A swab was obtained for microscopy and culture of organisms in all suspected cases. A wound infection was considered to be superficial if it resolved with oral antibiotics alone and deep if a re-operation or revision procedure was required. All cases of deep-vein thrombosis were confirmed by venography or duplex ultrasonography. Peri-operative mortality was defined as a death during the immediate peri-operative period or within three months of the knee replacement.

All statistical analysis was undertaken using SPSS v 13.0 (SPSS Inc., Chicago, Illinois). Survivorship analysis was based on the Kaplan-Meier method.¹⁶ The two groups were compared using Student's *t*-test or the Mann-Whitney *U* test for continuous data, the chi-squared test with Yates correction¹⁷ for continuity for proportions and the log-rank test for survivorship analysis. The level of significance was set at $p < 0.05$.

Results

There were no significant differences between the morbidly obese and non-obese groups for the pre-operative matched variables (Table I). The mean follow-up in the morbidly obese group was for 38.5 months (6 to 66) and in the non-obese group for 44 months (6 to 67). The difference was not statistically significant ($p = 0.3$).

In both groups, the mean post-operative knee and function score components of the KSS were significantly better compared with the pre-operative scores (paired sample *t*-test, $p < 0.001$). The mean post-operative knee and function scores were, however, lower in the morbidly obese group, although the difference in the knee score component only approached statistical significance (Table II). There was a significantly higher rate of radiolucent lines around the implants in the morbidly obese patients compared with the non-obese group (29% and 7%, respectively, $p = 0.02$), with approximately half being progressive. All radiolucent lines were present around the tibial component. In one patient, a progressive radiolucent line was noted around both the femoral and tibial components. There was no difference in the overall alignment of the components.

The overall rate of complications following TKR was significantly higher in the morbidly obese group compared with the non-obese group (32% and 0%, respectively, $p = 0.001$; Table III). Of the seven superficial wound infections in the morbidly obese group, organisms were cultured from five, and no growth was obtained in the remaining two. Organisms were cultured from both the knees with deep infection in the morbidly obese group. No peri-operative deaths occurred in either group but there were two deaths

Table I. Pre-operative characteristics of the two groups

	Morbidly obese patients	Non-obese patients	p-value
Mean body mass index in kg/m ² (range)	43.2 (40.1 to 61.3)	27.0 (22.8 to 29.7)	< 0.001
Mean height in cm (range)	160 (147 to 182)	162 (139 to 190)	-
Mean weight in kg (range)	111 (89 to 163)	72 (47 to 103)	-
Mean age in yrs (range)	62.2 (40 to 80)	62.8 (42 to 80)	0.7
Females (%)	30 (73)	30 (73)	-
Diagnosis			
Osteoarthritis (%)	37 (90)	37 (90)	-
Rheumatoid arthritis (%)	4 (10)	4 (10)	-
Prosthesis			
Press-fit condylar (%)	12 (29)	12 (29)	-
Sigma (%)	29 (71)	29 (71)	-
Laterality			
Unilateral (%)	38 (93)	38 (93)	-
Bilateral (%)	3 (7)	3 (7)	-
Knee Society score			
Mean knee score (range)	28.2 (0 to 57)	30.0 (0 to 56)	0.5
Mean function score (range)	50.6 (0 to 75)	52.4 (10 to 80)	0.5

Table II. Clinical and radiological results at last follow-up

	Morbidly obese patients	Non-obese patients	p-value
Knee Society score			
Mean knee score (range)	85.7 (32 to 97)	90.5 (45 to 100)	0.08
Mean function score (range)	75.6 (30 to 100)	83.4 (35 to 100)	0.01
Radiolucent lines (%)	12 (29)	3 (7)	0.02
Progressive radiolucent lines	5	1	-
Radiologically loose	2	0	-
Anteroposterior radiographs			
Mean femoral angle – α (range)	96.4 (92 to 101)	95.6 (85 to 104)	-
Mean tibial angle – β (range)	88.3 (82 to 91)	88.6 (80 to 97)	-
Mean total valgus angle (range)	4.8 (-3 to +10)	4.2 (-4 to +12)	0.5
Lateral radiographs			
Mean femoral flexion – γ (range)	0.2 (-5 to +5)	0.3 (-8 to +6)	0.8
Mean tibial angle – σ (range)	85.0 (79 to 98)	84.7 (78 to 90)	0.7

Table III. Post-operative complications

	Morbidly obese patients	Non-obese patients	p-value
Complications			
Superficial wound infection	7	0	-
Deep joint infection	2	0	-
Deep-vein thrombosis	4	0	-
Peri-operative mortality	0	0	-
Overall complication rate (%)	32	0	0.001

from unrelated causes – one patient in the morbidly obese group died three years after revision for deep infection, and one patient in the non-obese group died four years after a primary TKR which was not causing any problems when last reviewed at 37 months. The last available data after the primary procedure for both patients is included in the analysis. There were no intra-operative avulsions of the medial collateral ligament in the morbidly obese group, a complication that has been previously reported during TKR in such patients.¹¹

Using revision as an end-point, the five-year survivorship was 74.2% (95% confidence interval (CI) 53.8 to 94.6) in the morbidly obese group, compared with 100% (95% CI 100 to 100) in the non-obese group (log-rank test, $p =$

0.01). Using revision and pain as the end-point, the five-year survivorship was 72.3% (95% CI 52.1 to 92.5) in the morbidly obese group and 97.6% (95% CI 92.9 to 100) in the non-obese group (log-rank test, $p = 0.02$, Fig. 1). As there were no patients lost to follow-up, the 'worst-case' survivorship would be the same as the five-year survivorship based on revision and pain as an end-point. Table IV summarises the details of the TKRs considered as failures for the survivorship analysis. Two had unexplained pain; one in each group. Both patients complained of severe pain in the knee immediately after the surgery, and required referral to the pain management service. They both remained symptomatic at the latest review despite the lack of any obvious clinical or radiological abnormality.

Table IV. Details of failures

Age (yrs)	Gender	Diagnosis	Body mass index	Reason for failure
Morbidly obese group				
65	M	Osteoarthritis	42.0	Deep infection: revised at 27 mths
46	M	Osteoarthritis	45.7	Deep infection: revised at 16 mths
59	F	Osteoarthritis	41.3	Aseptic loosening: awaiting revision due to severe pain with radiologically loose tibial component
72	F	Osteoarthritis	42.0	Aseptic loosening: awaiting revision due to severe pain with progressive tibial radiolucency
47	F	Rheumatoid arthritis	49.1	Bilateral aseptic loosening: after staged bilateral total knee replacements – severe pain with non-progressive tibial radiolucency on the left; radiologically loose tibial component on the right. Patient unfit for revision surgery
57	F	Osteoarthritis	43.2	Unexplained pain
Non-obese group				
61	F	Osteoarthritis	26.7	Unexplained pain

* in the survivorship analysis, each knee is considered to be a separate 'failure'

Fig. 1

Kaplan-Meier five-year survivorship curve using revision and pain as an end-point. Various time points at which cases 'censored' are also indicated on each curve.¹⁶

Discussion

This study shows that in a subgroup of patients who are morbidly obese, TKR is associated with inferior clinical outcome scores, a higher rate of complications and inferior five-year survivorship, when compared with a matched, control group of non-obese patients.

The BMI is a predictor of morbidity and mortality from several chronic diseases, including diabetes mellitus, coronary artery disease and stroke. Health risks increase as the BMI rises from normal (BMI 15 kg/m² to 25 kg/m²) to overweight (BMI 25 kg/m² to 30 kg/m²), to obese (BMI 30 kg/m² to 40 kg/m²) and to morbidly obese (BMI > 40 kg/m²).¹⁶⁻¹⁸ It also correlates with the development of degenerative disease of the knee.^{19,20}

The influence of BMI on the eventual outcome following TKR remains uncertain. Several studies have compared the results in obese and non-obese patients, with follow-up ranging from 1 to 15 years.^{2,4-10} The rate of peri-operative complications, where reported, has been found to be similar for obese and non-obese patients,^{6,8-10} although infection may be significantly higher for patients with a BMI > 35 kg/m².²¹ With the exception of one retrospective study,⁸ none could demonstrate a significant difference between obese and non-obese patients when the results were compared using patient-based or disease-specific formal outcome scoring measures.^{2,4-7,9,10} Survivorship of the implant is more difficult to compare because varying end-points have been used. Using revision as the end-point, none showed significant differences between obese and non-obese patients following TKR.^{2,4,5,8-10} Using revision, clinical failure and radiological failure as end-points however, inferior survivorship has been noted in obese patients in retrospective studies.^{8,9} We have reported observations suggesting that the results of TKR in obese and non-obese patients are comparable, at least in the mid-term.¹⁰ However, until results from larger, prospective, long-term studies become available, opinions regarding the results of TKR in patients with a BMI > 30 kg/m² are likely to remain divided.

All published comparative studies using the BMI to divide patients into obese and non-obese groups^{2,4-10} have included morbidly obese patients within the obese category. An analysis of results in the subgroup of obese patients who are morbidly obese^{2,8,11} has consistently demonstrated worse results in the morbidly obese patients when compared with non-morbidly obese and non-obese patients.

In our study, while the post-operative function score component of the KSS was significantly inferior in the morbidly obese group, the difference in the post-operative knee score component was not. This suggests that while morbidly obese patients may achieve similar pain relief, range of movement and stability, they are likely to remain more functionally impaired following TKR, with limitation of walking distance, ability to climb stairs and greater dependence on walking aids.

At five years, six TKRs in five patients were revised, awaiting revision for aseptic loosening (loosening/osteolysis without infection) or were radiologically loose in the morbidly obese patients (Table IV), and nearly a third of TKRs demonstrated linear radiolucent lines on the post-operative radiographs. Increased body-weight results in increased loading across a TKR and the surrounding bone.²² This does not appear to produce high rates of failure in obese patients who have total knee replacements, probably because of the lower activity levels in these patients compared with non-obese patients.²³ It is possible however, that in the patients who are morbidly obese, lower activity levels may not compensate for the higher stresses across the tibial component. This may explain the high rate of radiolucent lines and aseptic loosening observed in morbidly obese patients in the study.

There were revisions in two patients for deep infection in the morbidly obese group (Table IV) and another seven developed superficial wound infections. A high rate of infective complications has been reported following total knee replacement in the morbidly obese patient,¹¹ and this increased risk of infection is also seen following gastric bypass surgery to treat morbid obesity.²⁴⁻²⁶ In a study of mainly morbidly obese patients, the intra-operative subcutaneous tissue oxygen tension was found to be significantly lower than in a non-obese control group.²⁷ As the risk of infection is inversely related to tissue oxygen partial pressure,^{28,29} a lower peri-operative tissue oxygenation may explain the high rate of wound complications noted in morbidly obese patients.

This study has certain limitations. A joint-specific outcome scoring system was used in the study, but use of a more patient-based outcome score may have provided more information regarding the clinical outcome. These morbidly obese patients represent only a small proportion of patients selected for TKR since between 1995 and 2004, over 1700 TKRs were performed at our institution, with only 41 (2.4%) in the morbidly obese. Similar numbers have been reported in other series.^{2,11} With the current rapid rise in average body-weight and prevalence of obesity,¹² it is likely that clinicians will encounter an increasing number of patients who are morbidly obese requiring TKR.³⁰ It is therefore imperative that we define the results of TKR in these patients early, and identify any pitfalls in the criteria for selection for an operation which has otherwise proved to be extremely successful in alleviating pain and improving mobility for a large number of patients.³¹⁻³⁶ The two groups were not matched for medical co-morbidity or disease in the adjacent hip or knee and we do not know if these factors may have confounded the overall results.

The present evidence suggests that the results of TKR in patients with a BMI between 30 kg/m² and 40 kg/m² are probably comparable with the results of the procedure in non-obese patients. Morbidly obese patients may expect improvement in pain and function following TKR,

although the overall results are inferior when compared with non-obese patients. Patients with a BMI > 40 kg/m² should therefore be advised to lose weight prior to surgery or be counselled regarding the inferior results before proceeding with surgery.

We would like to thank Lorraine McComiskie, Ann Simpson, Janette McDonald and Wilma Addison for data collection.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

1. Bray GA. Overweight is risking fate: definition, classification, prevalence and risks. *Ann NY Acad Sci* 1987;499:14-28.
2. Spicer DD, Pomeroy DL, Badenhansen WE, et al. Body mass index as a predictor of outcome in total knee replacement. *Int Orthop* 2001;25:246-9.
3. Stern SH, Insall JN. Total knee arthroplasty in obese patients. *J Bone Joint Surg [Am]* 1990;72-A:1400-4.
4. Mont MA, Mathur SK, Krackow KA, Loewy JW, Hungerford DS. Cementless total knee arthroplasty in obese patients: a comparison with a matched control group. *J Arthroplasty* 1996;11:153-6.
5. Griffin FM, Scuderi GR, Insall JN, Wayne Colizza W. Total knee arthroplasty in patients who were obese with 10 years follow-up. *Clin Orthop* 1998;356:28-33.
6. Stickles B, Phillips L, Brox WT, Owens B, Lanzer WL. Defining the relationship between obesity and total joint arthroplasty. *Obes Res* 2001;9:219-23.
7. Deshmukh RG, Hayes JH, Pinder IM. Does body weight influence outcome after total knee arthroplasty: a 1-year analysis. *J Arthroplasty* 2002;17:315-19.
8. Foran JRH, Mont MA, Etienne G, Jones LC, Hungerford DS. The outcome of total knee arthroplasty in obese patients. *J Bone Joint Surg [Am]* 2004;86-A:1609-15.
9. Foran JRH, Mont MA, Rajadhyaksha AD, et al. Total knee arthroplasty in obese patients: a comparison with a matched control group. *J Arthroplasty* 2004;19:817-24.
10. Amin AK, Patton JT, Cook RE, Brenkel IJ. Does obesity influence the clinical outcome at five years following total knee replacement for osteoarthritis? *J Bone Joint Surg [Br]* 2006;88-B:335-40.
11. Winiarsky R, Barth P, Lotke P. Total knee arthroplasty in morbidly obese patients. *J Bone Joint Surg [Am]* 1998;80-A:1770-4.
12. Bjorntorp P. Obesity. *Lancet* 1997;350:423-6.
13. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop* 1989;248:13-14.
14. Kreibich DN, Vaz M, Bourne RB, et al. What is the best way of assessing outcome after total knee replacement? *Clin Orthop* 1996;331:221-5.
15. Ewald FC. The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. *Clin Orthop* 1989;248:9-12.
16. Murray DW, Carr AJ, Bulstrode C. Survival analysis of joint replacements. *J Bone Joint Surg [Br]* 1993;75-B:697-704.
17. Yates F. Contingency tables involving small numbers and the χ^2 test. *J Roy Stat Soc Supp* 1934;1:217-18.
18. World Health Organisation. Obesity: preventing and managing the global epidemic: report of a WHO consultation. *World Health Organ Tech Rep Ser* 2000;894: i-xii:1-253.
19. National Institutes of Health, National Heart, Lung and Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: The evidence report. *Obes Res* 1998;6(Suppl 2):51-209.
20. Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. *N Engl J Med* 1999;341:427-34.
21. Manek NJ, Hart D, Spector TD, MacGregor AJ. The association of body mass index and osteoarthritis of the knee joint: an examination of genetic and environmental influences. *Arthritis Rheum* 2003;48:1024-9.
22. Gelber AC, Hochberg MC, Mead LA, et al. Body mass index in young men and the risk of subsequent knee and hip osteoarthritis. *Am J Med* 1999;107:542-8.
23. Namba RS, Paxton L, Fithian DC, Stone ML. Obesity and perioperative morbidity in total hip and total knee arthroplasty patients. *J Arthroplasty* 2005;20:46-50.
24. Morrison JB. The mechanics of the knee joint in relation to normal walking. *J Biomech* 1970;3:51-61.
25. Blair D, Buskirk ER. Habitual daily energy expenditure and activity levels of lean and adult-onset and child-onset obese women. *Am J Clin Nutr* 1987;45:540-50.
26. Pasulka PS, Bistrian BR, Benotti PN, Blackburn GL. The risks of surgery in obese patients. *Ann Intern Med* 1986;104:540-6.

27. Colquitt J, Clegg A, Sidhu M, Royle P. Surgery for morbid obesity. *Cochrane Database Syst Rev* 2003;2:CD003641.
28. Derzie AJ, Silvestri F, Liriano E, Benotti P. Wound closure technique and acute wound complications in gastric surgery for morbid obesity: a prospective randomised trial. *J Am Coll Surg* 2000;191:238-43.
29. Kabon B, Nagele A, Reddy D, et al. Obesity decreases perioperative tissue oxygenation. *Anesthesiology* 2004;100:274-80.
30. Hopf HW, Hunt TK, West JM, et al. Wound tissue oxygen tension predicts the risk of wound infection in surgical patients. *Arch Surg* 1997;132:997-1004.
31. Van Eshroek G, Gys T, Hubens A. Evaluation of tissue oximetry in perioperative monitoring of colorectal surgery. *Br J Surg* 1992;79:584-7.
32. Bostman OM. Prevalence of obesity among patients admitted for elective orthopaedic surgery. *Int J Obes Relat Metab Disord* 1994;18:709-13.
33. Ritter MA, Campbell E, Faris PM, Keating EM. Long-term survival analysis of the posterior cruciate condylar total knee arthroplasty: a 10-year evaluation. *J Arthroplasty* 1989;4:293-6.
34. Font-Rodriguez DE, Scuderi GR, Insall JN. Survivorship of cemented total knee arthroplasty. *Clin Orthop* 1997;345:79-86.
35. Ranawat CS, Boachie-Adjei O. Survivorship analysis and results of total condylar knee arthroplasty: eight- to eleven-year follow-up period. *Clin Orthop* 1988;226:6-13.
36. Gill GS, Joshi AB. Long term results of Kinematic Condylar knee replacement: an analysis of 404 knees. *J Bone Joint Surg [Br]* 2001;83-B:355-8.