The Outcome of Total Knee Arthroplasty in Obese Patients

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Background: Evidence linking increased body weight to osteoarthritis of the knee and the high prevalence of obesity underscore the importance of defining the outcome of total knee arthroplasty in obese patients. The purpose of this study was to compare the clinical and radiographic results of total knee arthroplasties performed in obese patients with those of total knee arthroplasties performed in nonobese patients.

Methods: Clinical and radiographic data on seventy-eight total knee arthroplasties in sixty-eight obese patients were compared with data on a matched group of nonobese patients. The analysis was also performed after stratification of the obese group for the degree of obesity. All patients had the same prosthesis. The clinical data that were analyzed included the Knee Society objective and functional scores, patellofemoral symptoms, activity level, and complications.

Results: The percentage of knees with a Knee Society score of ≥80 points at an average of eighty months was 88% in the obese group, which was significantly lower than the 99% rate in the nonobese group at the same time. The morbidly obese subgroup had a significantly higher revision rate than did the nonobese group (p = 0.02).

Conclusions: The results of the present study suggest that any degree of obesity, defined as a body mass index of ≥30, has a negative effect on the outcome of total knee replacement.

Level of Evidence: Prognostic study, Level II-1 (retrospective study). See Instructions to Authors for a complete description of levels of evidence.

There is strong evidence linking excessive body weight to degenerative joint disease of the knee. Consequently, a large proportion of patients who undergo total knee arthroplasty are obese or morbidly obese. Many authors believe that a high body weight will lead to a less-than-optimal outcome of total knee arthroplasty as a result of increased stress across the components and increased load on the surrounding bone.

Several studies have implicated excessive weight as a negative predictor of success of total knee arthroplasty, whereas others have indicated that obesity is not a negative predictor of knee arthroplasty outcomes. Winiarsky et al. compared the outcomes of fifty total knee arthroplasties with cement in forty morbidly obese patients (mean body mass index, 44) with the outcomes of 1768 similar procedures in nonmorbidly obese patients (mean body mass index, 28). At approximately five years after the operation, the morbidly obese patients had lower objective and functional Knee Society scores as well as higher rates of wound-healing problems and other perioperative complications. In contrast, Spicer et al. found similar ten-year prosthetic survival rates after 385 arthroplasties in 326 obese patients (body mass index, 30) and 425 arthroplasties in 371 nonobese patients.

The purpose of the present study was to compare the clinical and radiographic results of total knee arthroplasties performed in obese patients with those of arthroplasties performed with the same prosthesis in nonobese patients.

Materials and Methods

Between September 1, 1991, and December 31, 1996, 772 total knee arthroplasties were performed with the Duracon total knee prosthesis (Stryker-Howmedica-Osteonics, Allendale, New Jersey). After institutional review board approval was obtained for the study, seventy-eight knees in sixty-eight patients who were obese (defined as a body mass index of ≥30) at the time of the surgery and who had been followed for a minimum of five years were identified from a database of all patients. An additional eight knees in eight obese patients were identified, but four of those patients had died and four had been lost to follow-up and hence were excluded from the study. All of those eight knees were functioning well at the time of the latest follow-up (mean duration, four years; range, two to five years).

The body mass index equals a person’s weight in kilo-
grams divided by his or her height in meters squared and correlates well with total body fat\textsuperscript{2}. Obesity is defined as a body mass index of $\geq 30$ kg/m\textsuperscript{2}, and morbid obesity is defined as a body mass index $\geq 40$ kg/m\textsuperscript{2} (overweight is defined as a body mass index $25 \leq \text{BMI} < 30$ kg/m\textsuperscript{2}).

With use of a list of the obese patients ordered by duration of follow-up (with the patient with the longest duration listed first), each patient was directly matched with the first nonobese, control patient (with a body mass index of $<30$), hand-selected from a computerized database, who was appropriately matched with respect to the preoperative diagnosis, age at surgery (within ten years), duration of follow-up (within two years), and whether he or she had had a unilateral or bilateral arthroplasty. An attempt was made to match the patients by gender, but this was unsuccessful because there were too many obese women. A separate statistical analysis comparing the results of men and women in the entire group of patients (obese and nonobese) as well as in the individual groups revealed no significant difference in outcome between the two sexes. The authors were blinded to the outcomes at the time of the match. All patients had been followed for a minimum of five years. Seventy-eight knees in sixty-eight nonobese patients were included in the study. Demographic data for each group are summarized in Table I. Follow-up data were obtained by means of a blinded, prospective review of the computerized database, charts, and radiographs as well as with telephone conversations. The mean duration of follow-up was eighty months (range, sixty to 123 months) for the nonobese group and eighty-three months (range, sixty to 123 months) for the obese group.

The operative technique was the same in all patients. All tibial and patellar components were cemented, and all patellae were resurfaced. A cementless femoral component (a so-called hybrid total knee replacement) was used when there was qualitatively good bone stock and excellent bone cuts had been made. All of the components were cemented in thirty-six knees (46%) in the obese group and forty knees (51%) in the nonobese group, and a hybrid replacement was performed in forty-two knees (54%) in the obese group and thirty-eight knees (49%) in the nonobese group (p = 0.71).

The postoperative activity level of all patients was assessed at the time of the latest follow-up but was utilized to describe the entire activity level throughout the postoperative period. A description of the scoring system can be found in Table II. All patients were evaluated preoperatively and postoperatively with the Knee Society objective rating scale\textsuperscript{31} at the time of the latest follow-up. Ratings of excellent (90 to 100 points) and good (80 to 89 points) were considered to indicate success, whereas ratings of fair (70 to 79 points) and poor (less than 70 points) were considered to indicate failure. Additionally, knees revised or in need of revision because of aseptic loosening, infection, or polyethylene wear or that showed signs of radiographic loosening were considered failures.

Patients were also evaluated for the presence of comorbidities, perioperative complications, wound-healing complications, and patellofemoral symptoms. The status of the patellofemoral joint at the time of the latest follow-up was graded as described by Stern and Insall\textsuperscript{32,33}, with grade 0 indicating no symptoms referable to the knee; grade I, mild pain when climbing stairs; and grade II, moderate-to-severe pain when rising from a chair or limiting stair-climbing.

Initial and subsequent postoperative radiographs were examined for changes or progression of abnormalities. Measured parameters included zonal interface lucencies and preoperative and postoperative alignment\textsuperscript{34}.

The obese group was divided into nonmorbidly obese and morbidly obese subgroups to determine the effects of increasing obesity on outcome. The mean body mass index (and standard deviation) for the obese patients was $35.3 \pm 4.2$ (range, 30.0 to 47.0). Eleven patients (with twelve knees) in the obese group were morbidly obese, with a mean body mass index of $43.2 \pm 2.3$ (range, 40.0 to 47.0). The mean body mass index for the nonobese group was $26.2 \pm 2.5$ (range, 17.6 to 29.8) (Table I).

### Table I: Comparison of the Demographic Data of the Obese, Nonobese, Nonmorbidly Obese, and Morbidly Obese Groups

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Nonobese Group</th>
<th>Obese Group</th>
<th>P Value for Difference Between Nonobese and Obese Groups</th>
<th>Nonmorbidly Obese Subgroup</th>
<th>Morbidly Obese Subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up period* (mo)</td>
<td>83 ± 19.2 (60 to 123)</td>
<td>80 ± 19.4 (60 to 123)</td>
<td>0.356</td>
<td>81 ± 19.9 (60 to 123)</td>
<td>0.634</td>
</tr>
<tr>
<td>Age* (yr)</td>
<td>70 ± 7.9 (42 to 84)</td>
<td>66 ± 8.6 (32 to 84)</td>
<td>0.002†</td>
<td>66 ± 9.0 (45 to 82)</td>
<td>0.006†</td>
</tr>
<tr>
<td>Gender (no. of knees)</td>
<td>Men 28</td>
<td>16</td>
<td></td>
<td>13</td>
<td>0.095†</td>
</tr>
<tr>
<td></td>
<td>Women 50</td>
<td>62</td>
<td>—</td>
<td>53</td>
<td>9</td>
</tr>
<tr>
<td>Body mass index*</td>
<td>26.2 ± 2.5 (17.6 to 29.8)</td>
<td>35.3 ± 4.2 (30.0 to 47.0)</td>
<td>&lt;0.001</td>
<td>33.8 ± 2.6 (30.0 to 39.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*The data (except for the p values) are given as the mean and standard deviation, with the range in parentheses. †Patients were matched for age within ten years. ‡Patients were not matched for gender in order to increase the size of the comparison groups.
Data Analysis

The clinical and radiographic outcomes in the obese group were compared with those in the nonobese group. In addition, the outcomes in the nonmorbidly obese and morbidly obese subgroups were stratified and independently compared with those in the nonobese group.

Parametric and nonparametric statistical analysis, with use of the Computer Program for Epidemiological Analysis (PEPI) software package (version 2.03; USD, Stone Mountain, Georgia) and Statistics Calculator (version 5.0; Statpac, Minneapolis, Minnesota), was employed to compare the groups. The significance of differences between groups was determined with the Pearson chi-square test (with use of the Yates correction), Wilcoxon-Mann-Whitney test, Fisher exact test, likelihood ratios, and Student t test. Kaplan-Meier survivorship curves were generated to analyze differences in time to prosthetic failure between the obese and nonobese patients as well as among the morbidly obese, nonmorbidly obese, and nonobese patients. A p value of <0.05 was considered significant.

Results

Sixty-nine (88%) of the seventy-eight knees in the obese group were considered to have a successful outcome at the time of the latest follow-up. Four knees in four obese patients required revision and thus were considered failures, and five knees in five obese patients were considered failures because of a fair or poor Knee Society objective score. In comparison, seventy-seven (99%) of the seventy-eight knee replacements in the nonobese group were successful, and there were no revisions in that group. At the time of the latest follow-up, there

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### TABLE II Comparison of Clinical Results of the Obese and Nonobese Groups

<table>
<thead>
<tr>
<th></th>
<th>Nonobese Group</th>
<th>Obese Group</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of knees</td>
<td>78</td>
<td>78</td>
<td>—</td>
</tr>
<tr>
<td>Overall result (no. of knees)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>67</td>
<td>57</td>
<td>—</td>
</tr>
<tr>
<td>Good</td>
<td>10</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>Fair, poor, or revised</td>
<td>1</td>
<td>9</td>
<td>—</td>
</tr>
<tr>
<td>Successful</td>
<td>77 (99%)</td>
<td>69 (88%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Failure</td>
<td>1 (1%)</td>
<td>9 (12%)</td>
<td>—</td>
</tr>
<tr>
<td>Preop. Knee Society score* (points)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>57 ± 9.0 (30 to 82)</td>
<td>59 ± 11.7 (31 to 80)</td>
<td>0.14</td>
</tr>
<tr>
<td>Functional</td>
<td>53 ± 16.2 (15 to 90)</td>
<td>51 ± 16.9 (5 to 90)</td>
<td>0.24</td>
</tr>
<tr>
<td>Postop. Knee Society score* (points)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>94 ± 6.5 (62 to 100)</td>
<td>90 ± 12.7 (40 to 100)</td>
<td>0.04</td>
</tr>
<tr>
<td>Functional</td>
<td>78 ± 23.4 (0 to 100)</td>
<td>71 ± 23.1 (0 to 100)</td>
<td>0.05</td>
</tr>
<tr>
<td>Change in Knee Society objective score (postop. minus preop.)* (points)</td>
<td>+37 ± 10.2 (+6 to +70)</td>
<td>+31 ± 16.6 (-33 to +65)</td>
<td>0.01</td>
</tr>
<tr>
<td>Patellofemoral symptoms (no. of knees)</td>
<td></td>
<td></td>
<td>0.73</td>
</tr>
<tr>
<td>Grade 0</td>
<td>40 (51%)</td>
<td>45 (58%)</td>
<td>—</td>
</tr>
<tr>
<td>Grade I</td>
<td>28 (36%)</td>
<td>23 (29%)</td>
<td>—</td>
</tr>
<tr>
<td>Grade II</td>
<td>10 (13%)</td>
<td>10 (13%)</td>
<td>—</td>
</tr>
<tr>
<td>Activity level† (no. of knees)</td>
<td></td>
<td></td>
<td>0.72</td>
</tr>
<tr>
<td>1</td>
<td>22 (28%)</td>
<td>24 (31%)</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>23 (29%)</td>
<td>29 (37%)</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>25 (32%)</td>
<td>20 (26%)</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>7 (9%)</td>
<td>4 (5%)</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td>1 (1%)</td>
<td>1 (1%)</td>
<td>—</td>
</tr>
<tr>
<td>Periop. complications (no. of knees)</td>
<td>0 (0%)</td>
<td>2 (3%)</td>
<td>0.50</td>
</tr>
<tr>
<td>Revision (no. of knees)</td>
<td>0 (0%)</td>
<td>4 (5%)</td>
<td>0.12</td>
</tr>
<tr>
<td>Infection (no. of knees)</td>
<td>1 (1%)</td>
<td>1 (1%)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*The data (except for the p values) are given as the mean and standard deviation, with the range in parentheses. †1 = sedentary (wheelchair, bedridden), 2 = semi-sedentary (light duty), 3 = light labor (yard work), 4 = moderate labor (can lift ≤23 kg and walk >5 km), and 5 = heavy manual labor, vigorous sports.
There was a significant difference in the success rates between the knees in the obese group and those in the nonobese group (p = 0.02) (Table II).

Kaplan-Meier survivorship analysis revealed similar rates of prosthetic survival between the obese and nonobese groups until between sixty and eighty months, when the decreased survival rate in the obese group became apparent. At eighty months, the obese group had an 87.7% ± 5.4% (standard error) chance of prosthetic survival (95% confidence interval, 72.1% to 95.1%), with a reoperation, clinical failure, and radiographic failure as the end points, and the nonobese group had a 98.7% ± 1.9% chance (95% confidence interval, 87.9% to 99.9%) in the nonobese group at eighty months.

Stratification of knees in the obese group into morbidly and nonmorbidly obese subgroups revealed a lower success rate when those subgroups were compared with the nonobese group. Ten of the twelve knee replacements in the morbidly obese subgroup were successful at the time of the latest follow-up, whereas fifty-nine (89%) of the sixty-six knees in the nonmorbidly obese subgroup and seventy-seven (99%) of the seventy-eight knees in the nonobese group were successful. The rate of success in the nonobese patients was significantly higher than the rate in the nonmorbidly obese patients (p = 0.02).

The survivorship curves revealed that, at eighty months, there was a 91.7% ± 11.8% (standard error) chance of prosthetic survival (95% confidence interval, 47.9% to 99.2%) in the morbidly obese subgroup, an 83.6% ± 8.7% chance (95% confidence interval, 58.7% to 94.8%) in the nonmorbidly obese subgroup, and a 98.7% ± 1.9% chance (95% confidence interval, 87.9% to 99.9%) in the nonobese group.
with primary wound-healing, were similar in all of the groups. The rates of perioperative complications, including problems that were done in obese patients, were considered failures because of persistent pain that led to a fair or poor Knee Society objective score. None of those knees showed radiographic signs of impending failure, and no additional surgical treatment was undertaken. In the nonobese group, one knee was considered a failure because of persistent pain, which led to a poor Knee Society objective score of 62 points at sixty months postoperatively.

**Complications**

The rates of perioperative complications, including problems with primary wound-healing, were similar in all of the groups. Nine knees in nine obese patients were classified as failures (Table II). Four were considered to be failures because they required revision, whereas the other five were failures because of a fair or poor Knee Society objective score.

**Perioperative complications:** Two obese patients (two knees) had perioperative complications (a deep vein thrombosis and a wound dehiscence in one patient and a footdrop in the other), whereas none did in the nonobese group. At the time of the latest follow-up, both patients with perioperative complications had a successful Knee Society objective score.

**Postoperative complications:** Of the four obese patients who required revision, one underwent the reoperation at thirty-six months because of unremitting pain; approximately twelve months later, he underwent a neurectomy to treat continued pain. At forty-four months after the revision, the Knee Society objective score for this patient was poor (65 points) because he continued to have pain at rest. The three other revisions that were done in obese patients were performed because of loosening of a tibial component at fifty-five months after the index arthroplasty, to exchange the polyethylene insert and accomplish a lateral patellar release at 103 months, and to treat a chronic infection at eighty months. All three of those patients eventually had a successful outcome, with Knee Society objective scores of ≥90 points. In addition, five knees in five other obese patients were considered failures because of persistent pain that led to a fair or poor Knee Society objective score. None of those knees showed radiographic signs of impending failure, and no additional surgical treatment was undertaken. In the nonobese group, one knee was considered a failure because of persistent pain, which led to a poor Knee Society objective score of 62 points at sixty months postoperatively.

**Discussion**

We undertook this study to evaluate the effects of obesity on one type of total knee implant that has been highly successful in the general population. The results suggest that obesity has a negative effect on the outcome of total knee replacement. At a mean of approximately seven years postoperatively, the obese group had a significantly lower rate of success than did the nonobese group. Stratification of the obese group into nonmorbidly obese and morbidly obese subgroups revealed significant differences in revision rates and postoperative objective and functional scores when those subgroups were compared with the nonobese group. Kaplan-Meier survival analysis revealed similar rates of prosthetic survival between the two cohorts until between sixty and eighty months, at which time the decrease in the survivorship in the obese group became apparent (Fig. 1). The survival analysis of the morbidly and nonmorbidly obese groups showed a similar pattern of failure (Fig. 2).

Several reports have described the adverse effects of obesity on the outcomes of total knee arthroplasty. Stern and Insall evaluated the results of 257 knee arthroplasties in 182 patients at a mean of four years (range, two to seven years) postoperatively and found a higher prevalence of patellofemoral symptoms in obese patients. Thirty percent (thirteen) of
Ahlberg A, Lunden A.
9. Aglietti P, Rinonapoli E.


