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Medial Unicompartmental Knee Arthroplasty: Correlation Between Components' Malalignment and Long-term Outcome in Obese Patients

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Abstract

Background: Unicompartmental knee arthroplasty (UKA) is performed as an alternative to total knee arthroplasty (TKA) and high tibial osteotomy for unicompartmental osteoarthritis.
Objectives: We examined whether the tolerable range of component malalignment is narrower in obese (BMI > 30) or in nonobese patients.
Methods: We performed 163 consecutive all-poly medial UKA from 01/01/1995 to 31/10/2003. We examined 83 patients (88 knees) with a minimal follow-up period of 10 years. We examined the correlation between limb- and component malalignment and clinical outcome separately in the obese (67 knees) and nonobese (21 knees) groups.
Results: The 10-year prothesis survival was 92.8%, and 9 UKA were converted to total knee arthroplasty. The average time for revision was 84.44 (48 to 144) months. The 8 obese and 1 nonobese patients had slightly higher BMI (33.47) than the 83 long-term followed patients (31.72). In each of these 9 patients, knee score and functional score were poor. At every revision, we used stems and augments. In the obese group, the prosthetic joint space depression correlated with fair and poor knee and functional scores, the prosthetic joint space elevation correlated with degenerative changes in the lateral tibiofemoral joint.
Conclusions: In the obese group, we noted at least 2 mm of prosthetic joint space depression in all of the 8 failed knees, and 4 mm or more than 4 mm in 6 cases. We hypothesize that the reason fot the subsidence of the tibial component is the increased loading because of prosthetic joint space depression. The result of this study suggests that tibial component positioning which provides an optimal level of prosthetic joint space reduces the risk of failure in medial UKA, prevents degenerative changes in lateral tibiofemoral joint, and provides better long-term clinical outcome.

Keywords: Unicondylar Knee Arthroplasty, Obesity, Body Mass Index, Unicompartmental Knee Arthroplasty, Revision of UKA

1. Background

The (UKA) is performed as an alternative to total knee arthroplasty (TKA) and high tibial osteotomy for unicompartmental osteoarthritis (1).

Optimally, after medial UKA, the tibial component is positioned just medial to the apex of the medial spine. It should extend to the medial margin of the tibia or overhang by up to 2 mm (2, 3). There is no height difference between the line of tibial component joint surface and the lateral tibiofemoral joint space (LTF), the tibial component joint surface is parallel with the LTF joint space (4, 5) and there is no change in tibial slope (TS) compared with the preoperative position in the sagittal plane (4, 5). In frontal plane, the femoral component is perpendicular to the tibial component joint surface (4, 5), the component is positioned centrally on the medial femoral condyle (6), in sagittal plane the anterior edge of femoral component is in the same level with the line of the remaining cartilage (7).

Several articles have been published about the range of acceptable components' malalignment (3-6, 8-11).

2. Objectives

We hypothesized that obese patients tolerate a narrower range of components' malalignment than nonobese patients, our purpose was to determine the long-term tolerable range of components' malalignment in obese patients.

3. Methods

3.1. Patients

A total of 163 consecutive medial UKA were performed from 01/ 04/ 1995 to 01 /10 /2003 at the department of orthopedic surgery, borsod county teaching hospital, Miskolc, Hungary. A total of 12 patients did not have adequate follow-up radiographs, in 9 patients UKA was converted to TKA, and 2 patients were excluded because of postoperative infection. A total of 36 patients (38 knees) died within 10 years after the surgery with the implant in place and functioning, and 12 patients (14 knees) were lost to the final follow-up.

At a minimum follow-up period of 10 years, 83 patients (88 knees) were examined retrospectively, including 15 men (15 knees) and 68 women (73 knees). Mean age at the time of the surgery was 62.27 (47-71) years. A total of 19 nonobese (21 knees) and 64 obese (BMI > 30) patients (67 knees) were examined. The mean follow-up period was 155.41 (120 - 222) months.

3.2. Selection Criteria

Selection criteria were as follows: medial unicompartmental OA, radiographic evidence of preservation of the LTF and lateral patellofemoral joint, intact anterior cruciate and collateral ligaments, preoperative flexion contracture < 10°, preoperative anatomical femorotibial angle (FTA) < 185°, the osseal deformity < 5°, (the difference between FTA and femoral condylar-tibial plateau angle (FC-TP) is less than 180 degrees), range of motion of at least 110°. FC-TP: the lateral angle between the tangent to the subchondral plate of the femoral condyles and the tangent to the subchondral plate of the tibial plateau (12).

3.3. Exclusion Criteria

The exclusion criteria were inflammatory arthritis and tibiofemoral subluxation. No patient was excluded based on age and excessive BMI.

3.4. Material

The Metrimed unicompartmental cemented knee system (Metrimed, Hodmezovasarhely, Hungary) was used in each procedure. The femoral components were resurfacing type chromium-cobalt-molibdene alloy, the tibial components were all poly type. The femoral components were available in 7 sizes and the tibial components were available in 5 thicknesses (6 - 8 - 10 - 12 - 14 mm).

3.5. Method

The operative goal was the optimal positioning of the components as detailed in the introduction. To avoid overcorrection, we left about 2 mm laxity medially. All procedures were performed through a standard medial parapatellar approach.

In the preoperative weight bearing anteroposterior radiograph, we mesaured the FTA (FTA $\leq$ 174° means valgus, a FTA $\geq$ 176° means varus (13)), and in the lateral radiograph, we measured the TS (the angle between the tangent to the medial tibial plateau and the perpendicular line of the axis of the tibia) (14).

At the final follow-up, on weight bearing anteroposterior radiograph - besides FTA - , we measured the height difference between the tangent to the tibial component joint surface and the LTF joint space (4). Prosthetic joint space depression (PJSD) happens if the prosthetic joint surface is in a lower position than the lateral LTF joint space (negative value), and prosthetic joint space elevation (PJSE) happens if it is in a higher position (positive value).

We measured the obliquity of the tibial component (the angle between the tangent to the tibial component and the tangent to the LTF joint space) (4). If the 2 tangents are parallel with each other, the obliquity is 0 degree, and positive value indicated varus.

We measured the intraprosthetic divergence (the angle between the longitudinal axis of the femoral component and the line perpendicular to the tangent to the tibial component) (4). Medial inclination of the proximal part of the femoral profile indicated varus.

We measured the mediolateral position of the femoral component in the medial femoral condyle; negative value indicated that the component was in a medialised position.

We evaluated the arthritic progression in the LTF joint according to Berger (9). Grade 1: evidence of arthritic changes without loss of joint space, Grade 2: $\leq$ 25%, Grade 3: $\leq$ 50%, Grade 4: > 50% loss of joint space.

At the final follow-up, clinical outcome was evaluated with use of the modified knee society (15) knee and functional score (KS, FS).

We examined the radiological reasons for early failure of UKA, we compared the clinical outcome in the following subgroups: 1, obese (BMI > 30), nonobese; 2, older or younger than 60; 3, male and female patients. We examined what range of components' malalignment affected long-term clinical outcome in obese and nonobese patients.

Statistical analysis was carried out using SigmaStat 3.5 (Systat software Inc., San Jose, California, USA). Differences between two groups were assessed using student's t-test, or Mann-Whitney ranksum test when a variable was not normally distributed. To determine if there was a statistically detectable correlation between parameters, Pearson's linear regression analysis was performed for continuous variable, and Fisher's exact test for dichotomous variables. In addition, age and BMI were also classified as high or low (with limits of 60 years and 30, respectively) and used as binary variables for binary logistic regression. A further binary variable, "outcome", was also generated allocating the value "good" to all patients with both KS and FS above 70, and "fair and poor" to the rest. Survival versus failure of prostheses was also treated as a binary variable. These variables were used in stepwise backward multiple logistic regression to identify the main predictors of outcome. Here, F = 4 was the condition for entering and F = 3.9 for removing co-variates, and BMI was assessed but as an optional and a forced variable. To determine a meaningful cut-off level for using BMI as a dichotomous predictor, logit P = ln (P / (1 - P)) was calculated from logistic regression data, and the parameter value where the logit P was zero was determined. Prosthesis survival was also evaluated with the log-rank test, censoring patients with working prosthesis at their last follow-up event. $P < 0.05$ was considered significant throughout the research. Power analysis was automatically carried out for each statistical test and was determined as acceptable by SigmaStat.

The study was approved by the independent research ethic committee.

4. Results

In the long-term followed 83 patients (88 knees), the mean FTA decreased from 180.91 (172 - 185) degrees to 176.2 (169 - 182) degrees, and the TS decreased from 7.2 (2 - 14) to 6.193 (3 - 10). The mean change in TS was 1.011 (-5 - +4) degrees.

The mean modified postoperative knee score was 82.14 (61 - 100) and the functional score was 76.81 (25 - 100).

Overall, women tended to have better KS (85.4 ± 9.2 vs. 81.5 ± 9.6) and FS (81.2 ± 14.2 vs. 75.9 ± 15.7) scores than men, but differences were not statistically significant for either KSS (P = 0.149, t-test) or KSF (P = 0.183, Mann-Whitney test).

There was no correlation between age and KS or FS (linear regression, P = 0.699, $R^2 = 0.002$ and P = 0.665, $R^2 = 0.002$. Splitting patients in above- and below-60 age groups also revealed no differences in KS and FS (P = 0.390 and P = 0.391 in binary logistic regression, and P = 0.433 and P = 0.473 in t-test /Mann-Whitney ranksum test).

There was no correlation between BMI and KS or FS using linear regression (P = 0.437, $R^2 = 0.007$ and P = 0.174, $R^2 = 0.021$). When splitting the population along BMI values of 30, neither KS nor FS differed between the low and high BMI groups (P = 0.324, test, and P = 0.133, Mann-Whitney test).

To enable the inclusion of failures in statistical evaluation, results were considered good on a binary scale if both KS and FS were ≥ 70. If either value was below 70 for a surviving prosthesis, or if the prosthesis failed, results were considered fair and poor.

Using these criteria, PJSD (P = 0.008 and BMI (P = 0.022) were the main determinants of a good replacement as indicated by backward stepwise logistic regression.

The 10-year prothesis survival rate was 92.8%, and the 12-year prothesis survival rate was 91.8%.

9 UKA (9 patients) were converted to TKA. The average time of revision was 84.44 (48 - 144) months. The 8 obese and 1 nonobese patients had slightly higher BMI (33.47) than the 83 long-term followed patients (31.72). In each of these 9 patients, knee score and functional score were poor. In failured knees, prosthetic joint space was in a significantly lower position (-3.88), than in patients with a long-term follow-up (-0.806); ($P < 0.05$). At every revsion, we used stems and augments.

Survival can be predicted from PJSD $P < 0.001$ and TS-diff, P = 0.002 as revealed by stepwise logistic regression, both when BMI is an optional or a forced variable. However, BMI is the third important factor in predicting prosthesis failure or success, it is the last variable to be removed in backward stepwise regression at P = 0.139.

In the long-term followed group (88 knees), the examined radiological parameters did not correlate with each other. In the obese group, PJSD correlated with fair and poor knee (linear regression: r = 0.62) and functional score (linear regression: r = 0.412), arthritic progression in the LTF joint correlated with PJSE (linear regression: r = 0.292, $P < 0.001$). Other examined radiologic parameters neither in the obese, nor in the nonobese group correlated with fair-poor clinical outcome.

5. Discussion

Several authors examined the correlation between the BMI and UKA survival (10, 11, 16-21). As far as we know, this study is the first to examine which component's malalignment has an effect on medial UKA survival and long-term clinical outcome in obese patients. Our study has several limitations. We could examine only 83 (88 knees) of the 154 patients (163 knees) operated between 1995 and 2003. Low number of revisions made the statistical evaluation difficult.

Sebilo (22) has reported that 10-year prosthesis survival was significantly better in men than in women, but the IKS knee and functional score was similar. Tabor (16) has noted a lower failure rate in women, but higher knee and functional score in men after a more than 10 year long follow-up period. At a minimally 10-year-long follow-up, we noted higher knee and functional score in men than in women, but the difference was not significant. Considering all 163 knees, we noted higher revision rate in men (10.3%) than in women (4.5%).

Tabor (16) has not found any significant difference in clinical outcome and prothesis survival between groups of patients under and over 60 years of age. Sebilo (22) has reported that functional score was significantly higher in patients under 60 years of age than in patients over this age, but there was no significant difference in knee score between these two groups. We did not note any significant difference in knee and functional score between patients under 60 years of age and in patients over this age. Revision rate was higher in patients under 60 years of age (7.9%) than those who were over it (4.8%).

In Tabor's study (16) the ten-year ptothesis survival rate was higher in obese patients, Thompson (17) reported lower failure rate in nonobese patients. Bonutti (10) noted higher revision rate and lower knee and functional score in obese patients. In our study, there was no significant difference in knee and functional score, but we noted a higher revision rate in obese (6.7%) than in nonobese patients (2.8%).

The reasons for the revision of UKA to TKA are the followings: component loosening (8, 23), progressive arthritis in patellofemoral joint (9, 10) in lateral tibiofemoral joint (17, 24), PE wear (8, 25), tibia plateau fracture, stress fracture (10, 25), infection (2, 26), and persistent pain (17, 26).

Several authors' opinion is that the reason for failures is component malalignment such as varus-valgus component malalignment (3, 10, 11), more than 6 degrees of intraprosthetic divergence, more than 3 degrees of change in tibial component's obliquity and 2 degrees of cange of TS (4). Chatellard (4) reported that more than 2 mm of prosthetic joint space elevation or depression and more than 5 degrees of residual varus deformity both lead to mechanical failure.

Aleto (8) has reported that anterior tibial collapse is associated with decrease in TS, and posterior tibial collapse is associated with increase in it. Medial tibial plateau collapse (MTC) is often the reason of failure in all-poly UKAs. Aleto (8) has performed 59%, O'Donell (27) has performed 58% of revisions from all-poly UKA to TKA because of MTC. In our study, all of the 9 revisions were performed because of MTC. Besides MTC, we noted femoral component loosening in 4 patients, and femoral component fracture in 1 patient. In cases of MTC, bony defects were significantly greater, and implant requirements were more increased than in cases of other modes of failures (8). We noted MTC in all of the cases. At every revision, we used stems and augments.

Bonutti (10) has hypothesized that the tolerable range of component malalignment is narrower in obese than in nonobese patients.

In case of excessive tibial cut, tibial component is placed to the more fragile cancellous zone, the contact point of the femoral pad shifts to the periphery of the tibial plateau that leads to tibial loosening (5, 28, 29). Minimal tibial resection leads to overcorrection, joint line elevation (30), and - according to our study - to degenerative changes in lateral tibiofemoral joint.

In the obese group, PJSD closely correlated with fair and poor knee ($r = 0.62$) and functional score ($r = 0.412$), arthritic progression in the LTF joint correlated with PJSE ($r = 0.292$, $P < 0.001$). In the obese group, we noted at least 2 mm of prosthetic joint space depression in all of the 8 failured knees, and 4 mm or more than 4 mm in 6 cases. We hypothesize that the reason for the subsidence of tibial component is the increased loading because of prosthetic joint space depression. The result of this study suggests that tibial component positioning which provides optimal level of prosthetic joint space reduces the risk of early failure in medial UKA and prevents degenerative changes in lateral tibiofemoral joint.

Footnote

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