Rotaglide Total Knee Arthroplasty: A Long-Term Follow-up Study


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Mobile-bearing knee designs represent an alternative to conventional fixed-bearing implants in total knee arthroplasty. The purpose of this study was to determine the clinical results of a mobile-bearing knee implant.

Methods: From 1990 to 1998, 326 primary consecutive mobile-bearing total knee prostheses were implanted in 260 patients who had a mean age and standard deviation of 66.7 ± 6.9 years. Femoral and tibial components were cemented in all knees, and the patella was resurfaced in 199 knees (61%). Patients were evaluated with the use of the Knee Society clinical rating system and radiographic examinations. Complications were noted, and survivorship of the prostheses was determined.

Results: The mean follow-up period was 156 ± 27.3 months, with maximum follow-up at eighteen years. The mean Knee Society knee score improved from 32.4 ± 21.2 preoperatively to 92.6 ± 10.0 at the time of the last follow-up (p = 0.00), and the mean Knee Society functional score improved from 39.3 ± 18.7 preoperatively to 66.7 ± 18.6 at the time of the last follow-up (p = 0.00). Mean knee flexion improved from 92.3° ± 14.5° preoperatively to 112.1° ± 13.4° at the time of the last follow-up (p = 0.00). There were twenty-four (7.4%) knees that required revision. In eighteen (5.5%) knees, worn out or broken polyethylene was found and a polyethylene-only exchange was done. Six knees (1.8%) were fully revised. The survival rate was 0.96 (95% confidence interval, 0.93 to 0.98) at ten years and 0.87 (95% confidence interval, 0.79 to 0.93) at eighteen years.

Conclusions: A fully congruent, mobile-bearing total knee prosthesis had excellent survivorship during the ten to eighteen-year follow-up interval.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Mobile-bearing knee designs, compared with fixed-bearing knees, have conforming geometry and minimum anteroposterior translation of both the medial and lateral femoral condyles over the polyethylene during gait. This leads to diminished surface stresses and minimizes stresses at the cement-bone interface distal to the tibial tray. Joint-simulator evaluations support the long-term efficacy of this design concept and are consistent with clinical reports. Mobile-bearing total knee prostheses can accommodate a wider range of axial rotation without creating excessive polyethylene stresses. Tibial rotational malalignment can be self-corrected, and both intraoperative adjustment of the joint space and postoperative replacement of the bearings can be done without disturbing prosthetic fixation.

However, subluxation or dislocation of the meniscal component and underface wear are the main concerns of these prostheses and could lead to failure of the implant.

Rotaglide (Corin Group, Cirencester, United Kingdom) is a fully congruent mobile-bearing knee prosthesis with spherical articulating surfaces. Maximum stresses generated between 0° and 90° vary from 4 to 8 megapascals (MPa) (the tensile yield stress of medical-grade ultra-high molecular-weight polyethylene is 19.3 to 23 MPa).

The purpose of this study was to determine the long-term results of patients in whom the Rotaglide knee prosthesis was implanted.

Materials and Methods

From 1990 to 1998, 326 consecutive primary total knee prostheses (188 right-limb prostheses and 138 left-limb prostheses) were implanted into 260 patients (thirty-eight men and 222 women). The mean age (and standard deviation) of patients at the time of the index procedure was 66.7 ± 6.9 years (Fig. 1 and Table I). A three-part mobile-bearing Rotaglide prosthesis (model RTM) (see Appendix) was used in all patients. Sixty-six patients had a bilateral procedure. Forty-nine procedures (15%) were performed in thirty-eight
patients who were sixty years of age or younger. All knee replacements were primary replacements, although nineteen procedures (5.8%) were in patients who had undergone a previous osteotomy. The diagnosis was primary osteoarthritis in 297 knees (91.1%), rheumatoid arthritis in twenty-five knees (7.7%), osteonecrosis of the femoral condyle in three knees (0.9%), and posttraumatic osteoarthritis in one knee (0.3%). Patients were evaluated with use of the Knee Society clinical rating system.

A total of twenty patients (twenty-four knees, 7.4%) did not attend the final follow-up clinic in 2008: eight patients (eleven knees, 3.4%) had died, and twelve patients (thirteen knees, 4%) were lost to follow-up. These twenty-four knees were reported on until their last follow-up examination; therefore, the last follow-up clinical and radiographic assessment of all (326) total knee arthroplasties were included.

**Technical Considerations of the Rotaglide Prosthesis**

The polyethylene meniscal bearing was made of extruded-rod, conventional ultra-high molecular-weight polyethylene (UHMWPE [GUR 1050, calcium-stearate-free]), was packed and stored in an air-permeable pouch, and was sterilized by gamma irradiation (2.5 Mrad).

**Clinical and Radiographic Evaluation**

Clinical evaluation (preoperative and postoperative) was performed with use of the Knee Society Clinical Rating System, which includes a knee score (pain, range of motion, and stability) as well as a functional score (for activities such as walking and stair-climbing). Two observers (S.R.M. and A.L.P.) measured knee motion with a long-arm goniometer (from the greater trochanter, to the center of rotation of the knee, to the lateral malleolus). Preoperative radiographs included weight-bearing anteroposterior (Fig. 2-A) views, non-weight-bearing lateral views, skyline views of both knees, and long-leg standing radiographs (in knees with more than 15° to 20° of deformity). Postoperative radiographic evaluation (Fig. 2-B) included analysis of tibial, femoral, and patellar components. Each radiograph was assessed for evidence of loosening, implant malposition, radiolucencies, and osteolysis with use of the Knee Society roentgenographic evaluation and scoring system. Osteolysis was defined, according to O’Rourke et al., as a radiolucency with a minimum diameter of 10 mm in at least one dimension and of 5 mm in the second dimension, loss of trabeculation, and the presence of a sclerotic osseous rim.

**Surgical Technique**

Surgical procedures were performed by the senior author (A.C.T.) and his coworkers. Prophylactic antibiotics were administered before initiation of surgery. A tourniquet was routinely used with a standard medial parapatellar exposure. The posterior cruciate ligament was retained in most knees. Femoral and tibial components were implanted with use of extramedullary alignment guides and were cemented in all knees, while the patella was resurfaced in 199 knees (61%). The decision to resurface the patella was based on the severity of patellar arthritis. All patients with rheumatoid arthritis had the patella resurfaced. A patellar lateral retinacular release was used in seventy-nine knees (24.2%) on the basis of soft-tissue balancing requirements. One or two drains were placed intraoperatively and removed on the second postoperative day. Low molecular-weight heparin and elastic stockings were used as prophylaxis against deep venous thrombosis. Physical therapy commenced...
Preoperative anteroposterior weight-bearing radiograph showing the knees of a patient who had bilateral osteoarthritis of the knee.

Anteroposterior weight-bearing radiograph of the same knees, made three years postoperatively, showing the Rotaglide prostheses in place.
the first postoperative day. Partial weight-bearing (with crutches or a walker) commenced from the second postoperative day and gradually progressed to full-weight walking without external support within a month, according to the ability of the patient.

**Statistical Methods**

Descriptive statistics were used to report the clinical and radiographic outcomes and the paired samples t test to compare significant differences between preoperative and postoperative variables. Kaplan-Meier survivorship was calculated using complete revision (replacement of all components) or polyethylene-only revision (mechanical failure and replacement of polyethylene only) as the end point to determine the longevity of this prosthesis. Cox regression (proportional hazards model) was applied to examine the effects of age, preoperative Knee Society knee score, preoperative Knee Society functional score, range of motion, sex, bilateral arthroplasty, and polyethylene on time to revision. The variables with a p value of <0.20 were used in the model and were tested with backward limited-regression elimination (p < 0.05). The log-log transformation and Greenwood’s formula was used to calculate the Kaplan-Meier curve with 95% confidence interval. Data were analyzed with use of the SPSS software package, version 15.0 (SPSS, Chicago, Illinois). P values of <0.05 were considered significant.

**Source of Funding**

There was no external funding for this study.

**Results**

**Follow-up Status**

The mean follow-up was 156 months (range, twenty-two to 216 months). The mean follow-up for the twenty-four knees that were revised was 119.2 months (range, twenty-two to 188 months), and the mean follow-up for the remaining 302 knees was 159 months (range, 120 to 216 months).

**Clinical Outcome**

The mean Knee Society knee score was 32.4 points (range, 0 to 85 points) preoperatively and improved to 92.6 points (range, 29 to 100 points) at the last follow-up (p = 0.00) (Tables I and II). The mean Knee Society functional score increased from 39.3 (range, 0 to 90) preoperatively to 66.7 (range, 20 to 99) postoperatively (p = 0.00). Knee alignment (from 5° to 10° of valgus) was achieved in 274 knees (84%). Knee stability (<5-mm gap in anteroposterior translation and <5° of varus or valgus translation when the knee is tested under application of stress) was achieved in 294 knees (90.2%). Knee flexion improved from a preoperative mean of 92.3° (range, 30° to 120°) to 112.1° (range, 45° to 135°) at the time of the last follow-up (p = 0.00).

**Radiographic Outcome**

In twenty-two knees with questionable wear radiographically, fluoroscopic examination was used with tangential screening of the cement bone interface to assess and measure radiolucent lines.

Radiolucent lines were found adjacent to thirteen tibial implants (4%). Six of the thirteen knees had radiolucencies under the tibial tray that were <1 mm in thickness, with no worsening seen on the follow-up radiographs. The other seven knees had radiolucenties that were 1 to 2 mm in thickness, mainly in zones 1 and 2 of the tibial tray.”. Four of these seven knees met the criteria of osteolysis, according to the classification system of O’Rourke et al., and had arthroplasty revisions at six, seven, nine, and fourteen years, respectively.

**Complications**

Six knees (1.8%) had intraoperative patellar tendon detachment and repair; two of these knees had previously undergone a high tibial osteotomy. In two knees (0.6%), a medial collateral ligament detachment was repaired with a screw and washer, while osteosynthesis of the tibial condyle was used to repair one knee (0.3%) that had a medial tibial condylar fracture. These complications occurred within the first fifty total knee arthroplasties. Early postoperative complications occurred in eighteen patients (eighteen knees, 5.5%). These complications included superficial infection in ten patients, deep infection leading to late stiffness in three patients, quadriceps rupture during physical therapy in one patient, subcutaneous hematoma in two patients, deep venous thrombosis in one patient, and pulmonary edema in one patient.

Twenty-four knees (7.4%) had late postoperative complications. These included wear and breakage of polyethylene in eighteen implants (5.5%). A replacement of the polyethylene only was carried out at a mean of nine years (range, 4.3 to fourteen years) following total knee arthroplasty. One had a previous dislocation of the polyethylene platform nine months after the primary implantation, likely due to excessive ligament laxity. The polyethylene was replaced with a thicker polyethylene, and the prosthesis was eventually totally revised at thirteen years. Tibial implant loosening was evident in four prostheses (1.2%), while loosening and metal breakage of the tibial tray was noted in two prostheses (0.6%). These six knees were revised at a mean of 11.1 years (range, seven to fifteen years) following primary total knee arthroplasty.

In the forty-nine patients who were sixty years of age or younger, four had revision with a polyethylene exchange only.

<table>
<thead>
<tr>
<th>TABLE II Clinical and Radiographic Measurement Variables of the 260 Patients (326 Knees) at the Time of Last Follow-up</th>
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<tbody>
<tr>
<td>Knee Society knee score*</td>
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<td>Knee Society functional score*</td>
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<tr>
<td>Range of motion* (deg)</td>
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<tr>
<td>Knees with good alignment† (no. of knees)</td>
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<td>Knees with good stability† (no. of knees)</td>
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<td>Knees with radiolucencies of &lt;1 mm (no. of knees)</td>
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<tr>
<td>Knees with radiolucencies of 1 mm or more (no. of knees)</td>
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*Values are given as the mean and standard deviation. † From 5° to 10° of valgus. ‡ <5-mm gap in anteroposterior translation and <5° of varus or valgus translation when tested under application of stress.
Survival of the Prosthesis
From the data gathered at the eighteen-year follow-up, revision of all components due to metal implant loosening or failure and polyethylene-only revision due to polyethylene failure were calculated as 1.8% and 5.5%, respectively. The survivor function index of the log-log transformation and Greenwood’s formula analysis (Kaplan-Meier curve, Fig. 3) was 0.96 (95% confidence interval, 0.93 to 0.98) at ten years and 0.87 (95% confidence interval, 0.79 to 0.93) at eighteen years. This index includes the thirteen (4%) knees of twelve patients who were lost to follow-up and eleven knees (3.4%) of eight patients who died.

Also, when the results were adjusted under the proportional hazards model for the effect of age (p = 0.09), sex (p = 0.79), preoperative Knee Society knee score (p = 0.40) and Knee Society functional score (p = 0.12), range of motion (p = 0.74), and polyethylene thickness (p = 0.75), no significant independent factor was determined. No significant difference was found when survivorship was compared between patient groups (age sixty years or younger and age older than sixty years [p = 0.92], bilateral versus unilateral total knee arthroplasty [p = 0.51], polyethylene insert thickness ≤9.5 mm versus >9.5 mm [p = 0.49], and preoperative range of motion of <90° and ≥90° [p = 0.57]).

Discussion
The long-term results of conventional fixed-bearing total knee arthroplasty have shown survivorship of 91% to 99% at a minimum of ten years of follow-up. Comparison of fixed-bearing and mobile-bearing knee prostheses has shown comparable clinical and radiographic results, supported also by recent meta-analyses. The short-term and midterm results that have been associated with mobile-bearing total knee arthroplasty have been encouraging. A long-term follow-up study of patients who received a low-contact-stress mobile-bearing knee design, which is a partially congruent mobile-bearing implant, demonstrated durable clinical and radiographic results at a minimum follow-up of fifteen years. In our study, the Rotaglide total knee prosthesis demonstrated very good long-term results, with survivorship reaching 87% at eighteen years. Decoupling and redistribution of knee motion into two articulating interfaces are the major characteristics of mobile-bearing knees. This results from increased conformity and single-direction motion at the flexion-extension articulating interface. Linear motion has been reported to result in the realignment of polyethylene molecules along the sliding direction, leading to a hardening effect and thus increasing the wear resistance of polyethylene parallel to the sliding direction.

Mobile-bearing knees differ from each other with regard to the extent of conformity during motion (which affects the kinematic advantage of the implant). The kinematic advantage depends on the amount of conformity of the articulating surfaces throughout the range of knee motion, and these prostheses should thus be distinguished in three categories, as follows: the gait congruent, the partial congruent, and the fully congruent mobile-bearing knee. Key characteristics of a mobile-bearing design are increased lubrication and a reduction in the amount of torque that is transferred to the tibial baseplate. Previous studies have shown a remarkably low
prevalence of radiolucent lines and enhanced stability in mobile-bearing knees\textsuperscript{3,4,5}. Our study supports this hypothesis, although our revision rate of 1.84% for tibial loosening is higher than the revision rates for the Rotaglide prosthesis that were previously reported in studies with a shorter period of follow-up\textsuperscript{27-29}. The patients in our study who were more recently operated on did not experience the aforementioned complication.

In our study, the polyethylene failure rate of the mobile platform was increased in comparison with that reported in previous studies\textsuperscript{27-29}. We attribute the increased rate to the in vivo oxidative degradation of polyethylene, the extensive use (in 53% of knees) of thin (7-mm) polyethylene inserts, and the consecutive inclusion of knees. Compared with fixed-bearing prostheses, mobile-bearing prostheses need more accurate soft-tissue balancing because of the enhanced conformity of their bearing surfaces. Most of our patients who had polyethylene complications either had ligamentous laxity postoperatively or an increased flexion gap at the time of revision\textsuperscript{20}.

In previous studies, bearing dislocation has been reported as one of the main causes of implant failure in mobile-bearing knees\textsuperscript{13,14,10,41}. In our series, one patient had bearing dislocation, which was attributed to excessive ligamentous laxity that necessitated exchange with a thicker polyethylene insert.

A special characteristic of the patient population of our study was the high female-to-male ratio (222 women and thirty-eight men). In addition, the majority of our female patients were obese, short in stature, and had a wide pelvis. This body habitus is reflective of the general female population of Greece and often leads to the development of genu varum and increased forces on the medial compartment of the knee.

**Appendix**

A photograph of the Rotaglide prosthesis is available with the online version of this article on our web site at jbjs.org.

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**References**


