Posterior Cruciate–retaining, Rotating-platform Total Knee Arthroplasty: Minimum 4-year Follow-up Study

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abstract

Rotating-platform, mobile-bearing total knee arthroplasty was initially developed using a posterior cruciate–sacrificing technique and design. Posterior cruciate–substituting and –retaining, rotating-platform total knee arthroplasty designs were developed later. The purpose of this study was to evaluate a minimum 4-year follow-up of total knee arthroplasty performed with a posterior cruciate–retaining, rotating-platform design.

The 4- to 6-year results of 123 patients undergoing 152 consecutive total knee arthroplasties using a posterior cruciate–retaining, rotating-platform design were evaluated. Patients were evaluated clinically for need for revision, and clinical outcome measures included the pain and functional components of the Knee Society Score, the Western Ontario and McMaster Universities Osteoarthritis Index, the Short Form 36 Health Survey, and the University of California Los Angeles activity-level scores. Radiographs were evaluated for loosening, component positioning changes, femoral–tibial alignment, and osteolysis. One knee was lost to follow-up at an average of 5.2 years. No tibial or femoral components required revision. Three polyethylene liners were revised: 2 for infection and 1 for bearing spinout. Average range of motion was 120° (range, 70°-135°). Minor areas of osteolysis were noted around 4.5% of knees, and minimal incomplete radiolucencies were noted around 50% of components. The posterior cruciate–retaining, rotating-platform knee prosthesis demonstrated excellent survivorship at 4- to 6-year follow-up.
Rotating-platform, mobile-bearing total knee arthroplasty (TKA) was developed in the 1970s to lower contact stresses between the femoral component and the polyethylene inserts. The original LCS Rotating Platform Knee (DePuy, Warsaw, Indiana) was designed for use as a posterior cruciate-sacrificing device. In the late 1990s and early 2000s, a rotating-platform device where a posterior cruciate–sparing or –substituting design could be used (PFC Sigma RP; DePuy) was developed.

To the authors’ knowledge, few midterm follow-up studies on posterior cruciate–retaining, rotating-platform TKAs exist. The purpose of the current study was to evaluate the 4- to 6-year follow-up of a consecutive series of patients who underwent a primary posterior cruciate–retaining, rotating-platform TKA fixed with cement. The authors hypothesized that the results of posterior cruciate–retaining, rotating-platform TKA would be comparable to posterior cruciate–substituting TKAs of the same design.

Materials and Methods

Between September 2003 and August 2005, one of the authors (D.D.G.) performed 152 primary cemented TKAs in 123 patients with a posterior cruciate–retaining, rotating-platform total knee prosthesis and enrolled these patients into a prospective study. This represented 61% (152/251) of the TKAs performed by the surgeon during this time interval. Low-demand patients and patients with large angular deformity received fixed-bearing TKAs. All components were cemented. The tibial tray and femoral components were manufactured with a cobalt–chromium alloy (PFC Sigma RP). A 3-peg patellar component was used in 118 of the procedures, and a central peg design was used in the remaining 34 procedures. The thickness of the polyethylene insert was 10.0 mm in 139 (91.4%) knees and 12.5 mm in 13 (8.6%) knees.

The cohort comprised 152 knees in 123 patients. Eighty-seven women (110 knees) and 36 men (42 knees) had an average age at surgery of 61.7 years (range, 46.0–82.2 years). Seventy-seven (50.7%) right and 75 (49.3%) left knees underwent TKA. Twenty-nine (19.1%) patients required bilateral TKAs. Diagnoses included primary osteoarthritis in 146 (96.1%) knees, osteoarthritis secondary to rheumatoid arthritis in 3 (2.0%), osteonecrosis in 2 (1.3%), and posttraumatic osteoarthritis in 1 (0.7%). Mean body mass index at surgery was 34.3 kg/m² (range, 19.8–50.0 kg/m²).

At a minimum of 4 years after primary TKA, 118 patients (146 knees) were living, 4 patients (5 knees) had died, and 1 patient (1 knee) was lost to follow-up. One patient (1 knee) declined to participate in the study. This study was performed with prior approval through the institutional review board.

An investigator (J.J.E.) not involved in the surgical procedures contacted all living patients and family members of deceased patients. Clinical outcome measures included the pain and functional components of the Knee Society scoring system, the Western Ontario and McMaster Universities Osteoarthritis Index, the Short Form 36 Health Survey, and the University of California Los Angeles activity level scores. All patients were then encouraged to return to the clinic for full clinical and radiographic evaluation. Physical examination in patients returning to the clinic included the physical examination components of the Knee Society scoring system. Final follow-up radiographs, including standing anterolateral, lateral, and Merchant views, were compared with early postoperative radiographs. If the patient was unable or unwilling to return for a full clinical evaluation, local radiographs were subsequently sent to the authors for evaluation. All radiographs were evaluated using the Knee Society protocol for radiolucency at the bone–cement interfaces around the 3 components, any change in the position of the components, femoral–tibial alignment in the coronal plane, and osteolysis. Findings were agreed on through consensus by 2 of the authors (J.J.C., J.J.E.) not directly involved in the surgery or subsequent clinical care of the patients.

For the 118 patients (146 knees) living at the time of follow-up, the survivorship or need for revision of the prosthesis was confirmed for all patients except for the patient who declined to participate in the study. Altogether, 115 patients (143 knees) completed the full telephone evaluation, and 1 patient (1 knee) completed all components of the telephone evaluation except for the Short Form 36 Health Survey. Radiographic follow-up was obtained for 108 patients (135 knees; 92.5% of knees in living patients). Of these, 88 patients (107 knees) returned to the clinic for full evaluation. Local radiographs were obtained for 20 patients (28 knees).

Contact was made with a surviving relative for all deceased patients. In all patients, the survival of the prosthesis at the time of death was confirmed. In addition, no pending revisions or revision indications were identified at the time of death.

Kaplan–Meier survivorship analysis with 95% confidence intervals was performed with SPSS version 13.0 software (SPSS, Inc, Chicago, Illinois) with any revision, including component-specific revision, as the endpoint.

Results

Mean duration of follow-up among living patients was 5.2 years (range, 3.8–6.6 years). Four (2.6%) knees required reoperation during the study period. The first patient required patellar implant excision 8.4 months after the primary procedure. The indication for this procedure was a fractured patella with a loose patellar implant that had caused increased pain and joint effusion. A Staphylococcus aureus infection occurred after this excision, requiring open irrigation and debridement of the knee 18 days postoperatively. Arthroscopic debridement was performed 2 days after the initial irrigation and de-
bridement to further remove damaged tissue. Subsequently, 2 days later, a final irrigation and debridement was conducted with exchange of the polyethylene insert. Both the original and subsequent inserts had a thickness of 10 mm.

The second patient required open reduction and internal fixation with plate fixation for a distal femoral periprosthetic fracture with the index components retained at 4.5 years after primary TKA.

The third patient required irrigation and debridement with liner exchange for infection from *S. aureus* 4.7 years after the primary procedure. Intraoperative assessment of the rest of the index TKA components revealed that they were well fixed. The original insert had a thickness of 10 mm, and it was replaced with a 15-mm-thick insert.

The fourth case occurred 5.5 years after primary TKA for polyethylene liner spinout. The patient had been having symptoms of instability over the years but had an acute traumatic twist of the knee (Figure 1). Only a liner exchange was performed because the other components were well aligned and determined to be well fixed intraoperatively. In addition, approximately 50% of the posterior cruciate ligament was released because it was too tight, and a lateral retinacular release was performed to improve patellar tracking. The original insert was size 2 and had a thickness of 12.5 mm, whereas the replacement insert was size 2.5 and had a thickness of 17.5 mm.

Survivorship curves for overall reoperation and component-specific revision are shown in Figure 2. At 5 years, survivorship was 97.7% ± 2.6% for the endpoint of reoperation for any reason, 99.3% ± 1.3% for the endpoint of patellar component revision, and 98.5% ± 2.1% for the endpoint of polyethylene liner revision. No femoral or tibial components were revised.

Other complications occurred in this study. Seventeen patients (22 [14.5%] knees) required manipulation under anesthesia for poor postoperative range of motion. Two patients (3 [2.0%] knees) developed postoperative deep vein thrombosis, which was treated with anticoagulation. Two patients (2 [1.3%] knees) developed postoperative cellulitis, which was treated with intravenous antibiotics.

Altogether, 116 patients (144 knees) participated in at least clinical telephone follow-up. In addition, 1 patient (1 knee) did not participate in clinical telephone follow-up but was clinically evaluated by 1 of the authors (D.D.G.). Overall, average time to clinical follow-up for these 145 knees was 5.2 years. Patients reported no pain in 86 (59%) knees, mild pain in 45 (31%) knees, moderate pain in 12 (8%) knees, and severe pain in 2 (1%) knees. Patients were satisfied with 140 knees and not satisfied with 5 knees. Average function and pain components of the Knee Society Score were 55.2/100 (range, 10.0-100) and 5.8/50 (range, 0.0-45.0) preoperatively, respectively, and these values increased to 83.6/100 (range, 18.0-100) and 43.7/50 (range, 0.0-50) at final follow-up, respectively. Average Western Ontario and McMaster Universities Osteoarthritis Index scores (lower score indicates higher outcome) at final follow-up were 9.6/100 (range, 0.0-80.0) for the pain component, 17.6/100 (range, 0.0-75.0) for the stiff-
ness component, and 12.2/100 (range, 0.0-76.6) for the functional component. Average University of California Los Angeles score was 5.0/10 (range, 2-10), which correlates with participation in moderate activities. Average Short Form 36 scores were 41.6 (range, 20.7-56.1) for the physical component and 50.7 (range, 23.0-69.7) for the mental component. Average body mass index was 34 kg/m², and many patients had multiple comorbidities. Average range of motion was 103° (range 40°-130°) preoperatively and 119.8° (range, 70°-135°) at final follow-up for patients personally examined at final follow-up. For these patients, average functional Knee Society Score was 35.5/100 (range, 17-74) preoperatively and 90.8/100 (range, 33-100) at final follow-up.

Radiographic follow-up was obtained for 108 of 123 patients (135 knees; 88.8% of the 152-knee cohort). Four patients (5 knees) had died before 4-year follow-up, 1 patient (1 knee) declined to participate, and 1 patient (1 knee) was lost to follow-up. Average radiographic follow-up was 5 years (range, 4-6 years) after the index procedure. The femorotibial alignment in the coronal plane averaged 6.7° of varus (range, 20° of varus to 30° of valgus) pre-

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**Figure 3:** Distributions of radiolucencies around the various components according to the lateral femur (A), anteroposterior (AP) tibial (B), lateral tibial (C), and patellar (D) projections. Abbreviations: Ant, anterolateral; Lat, lateral; Med, medial; Post, posterolateral.

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**Figure 4:** Distributions of osteolysis around the various components according to the lateral (Lat) femur (A), anteroposterior (AP) tibial (B), and lateral tibial (C) projections. Abbreviations: Ant, anterolateral; Med, medial; Post, posterolateral.
operatively and 4.3° of valgus (5° of varus to 8° of valgus) postoperatively. Sixty-seven knees had radiolucent lines on radiographic evaluation (Figure 3), with 30 involving only the femur, 11 involving only the tibia, and 26 involving the femur and tibia.

Eleven patellar radiolucent lines were identified. Eighteen knees had femoral radiolucencies in 2 zones, with the remaining knees showing femoral radiolucencies in a single zone. No radiolucencies were greater than 1 mm in thickness. Anteroposterior radiographs showed tibial radiolucent lines in 1 zone in 17 knees, 2 zones in 5 knees, and 4 zones in 3 knees. Lateral radiographs showed tibial radiolucent lines in 1 zone in 16 knees and 2 zones in 1 knee. A single radiolucent line greater than 1 mm was identified, and it was estimated to be 1 to 2 mm in size. No circumferential radiolucencies were identified. Thus, no components were radiographically loose. Early changes consistent with osteolysis were evident in 6 patients (6 knees) (Figure 4). In 2 patients (2 knees), the osteolysis totaled less than 1 cm², and all cases were limited to a single tibial or femoral zone.

**DISCUSSION**

Rotating-platform, mobile-bearing knee prostheses were designed to increase the conformity between the femoral component and the polyethylene insert to lower contact stress. Despite the corresponding increased conformity, there were cases of implant loosening with polyethylene dislocation. Although a posterior cruciate–sacrificing design was developed initially, posterior cruciate–substituting and –retaining designs were later developed. To the authors’ knowledge, few studies have evaluated the midterm follow-up of a posterior cruciate–retaining, rotating-platform TKA. The strengths of the current study include the single-surgeon, consecutive-case cohort design.

<table>
<thead>
<tr>
<th>Study</th>
<th>Implant Design</th>
<th>Total No. of Patients (Knees)</th>
<th>No. of Patients at Index Surgery (Range), y</th>
<th>Mean Age at FU (Range), y</th>
<th>Diagnoses of Initial Cohort</th>
<th>Mean FU (Range), y</th>
<th>No. of Patients (Knees) Lost to FU</th>
<th>Patients With FU Radiographs, %</th>
<th>Revision Surgeries</th>
<th>Survivorship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>PFC Sigma RP (CR)</td>
<td>123 (152)</td>
<td>117 (145)</td>
<td>61.7 (46.0-82.2)</td>
<td>96% OA; 2% RA; 1% AVN; 1% PA</td>
<td>5.2 (3.8-6.6)</td>
<td>1 (1)</td>
<td>88.8</td>
<td>No tibial or femoral components revised; 3 liner exchanges and 1 patellar component removed</td>
<td>97.7% at 5 y (reop for any reason)</td>
</tr>
<tr>
<td>Goldstein et al7</td>
<td>PFC Sigma RP (CR)</td>
<td>733 (1101)</td>
<td>251 (370)</td>
<td>67 (42-85)</td>
<td>NR</td>
<td>3.5 (2-5)</td>
<td>482 (731)</td>
<td>NR</td>
<td>1 tibial revision and 1 patellar revision</td>
<td>98.5% (revision for any reason)</td>
</tr>
<tr>
<td>Signorelli et al7</td>
<td>PFC Sigma RP (CR)</td>
<td>75 (105)</td>
<td>71 (100)</td>
<td>NR</td>
<td>94% OA; 4% RA; 1% PA; 1% AVN</td>
<td>2.5 (2-3.2)</td>
<td>4 (5)</td>
<td>NR</td>
<td>1 tibial revision</td>
<td>99% at 2 y (revision for any reason)</td>
</tr>
<tr>
<td>Ranawat et al12</td>
<td>PFC Sigma RP (PS)</td>
<td>118 (150)</td>
<td>96 (125)</td>
<td>71 (29-85)</td>
<td>NR</td>
<td>4.8 (3.8-6.2)</td>
<td>9 (10)</td>
<td>79.2</td>
<td>2 revision TKAs for infection and 1 tibial revision for posterior prosthesis dislocation</td>
<td>97% at 6 y (revision for any reason)</td>
</tr>
</tbody>
</table>

Abbreviations: AVN, avascular necrosis; CR, cruciate-retaining; FU, follow-up; NR, not reported; OA, osteoarthritis; PA, psoriatic arthritis; PS, posterior-stabilizing; RA, rheumatoid arthritis; reop, reoperation; TKA, total knee arthroplasty.

*DePuy, Warsaw, Indiana.*
series; the fact that all radiographs were reviewed by 2 observers (J.J.E., J.J.C.) who were not involved in the surgery; and the fact that few patients were lost to follow-up (1 patient [1 knee] was lost, and 1 patient [1 knee] declined to participate). The major limitation is the relatively short follow-up and the fact that not all patients returned for personal follow-up examination, although most (88.8%) obtained final follow-up radiographs.

The authors have demonstrated excellent survivorship of the tibial and femoral components using this design with no revisions at 4- to 6-year follow-up (Figure 5). One patellar component was revised due to a patellar fracture. One bearing spinout occurred related to a traumatic event and asymmetric ligament balancing. It was treated with ligament balancing and liner exchange.

Comparing the current study with other studies of the same design (Table), the current bearing spinout rate of 0.7% was comparable with the 0.56% rate noted in another study, and the finding of no tibial or femoral revisions is comparable with those of Goldstein et al, who had a 40% follow-up, and Signorelli et al, who used cementless fixation.

These results are comparable with 1 report of a posterior cruciate–substituting knee of similar design with 4.8-year follow-up of 150 knees. In that study, 1 knee (1 tibial component) was revised for instability. In a 10-year follow-up of the same group, no knees had been revised for aseptic loosening. Reports of newer fixed-bearing designs also demonstrate minimal reoperations at this duration of follow-up. In addition, at short-term follow-up of prospective, randomized studies comparing fixed- vs mobile-bearing knees, no clinical differences were noted. The current study’s average of 120° flexion is also comparable with other contemporary fixed- and mobile-bearing, posterior cruciate–substituting designs and fixed-bearing, posterior cruciate–retaining designs. However, 14.5% of knees in the current study underwent early postoperative manipulation.

CONCLUSION

The posterior cruciate–retaining, rotating-platform knee prosthesis demonstrated excellent survivorship at 4- to 6-year follow-up. However, long-term follow-up is required to determine whether newer designs will demonstrate superior durability in younger, heavier patients that undergo TKA (average age, 61.7 years; average body mass index, 34.3 kg/m²). These results encouraged the authors to continue using this design.

REFERENCES