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Ten Year Follow-Up of Gap Balanced, Rotating Platform Total Knee Arthroplasty in Patients Under 60 Years of Age

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ABSTRACT

68 patients (91 primary total knee arthroplasties) were evaluated at a mean 10-year, minimum 5 year follow up in patients younger than sixty years of age utilizing the gap balanced, rotating platform design. Follow up assessment included implant survivorship, adverse events, x-rays, Knee Society rating system and clinical evaluation. Three revisions were performed with only one for aseptic loosening at 45 months. Two manipulations were performed in the early postoperative period. Survivorship of the rotating platform, gap balanced knee was 96.7% using surgical revision for any reason and 98.9% using aseptic loosening as endpoints. The rotating platform design using the gap balancing technique in young patients had excellent survivorship at 10-year mean follow up.

The number of total knee arthroplasty procedures (TKA) continues to rise with more than 700,000 performed annually in the United States alone in 2010 [1]. The frequency of TKA in the younger population has also risen, with recent studies identifying that 35%–45% of patients undergoing TKA were below the age of 65 [2–7]. Unfortunately, young patients have been historically considered at a greater risk for revision likely due to their higher levels of activity [5,8,9]. Instability has also been a common cause for TKA failure in this age group, often within the first 5 years of the index procedure [10,11]. Implant design and surgical technique may play a role in prolonging survivorship and improving satisfaction in this difficult patient cohort.

Mobile bearing (MB), rotating platform (RP) total knee prostheses have been designed for the purpose of combining conformity between the femoral component and polyethylene insert while imparting lower torsional stress to the fixation interface [12,13]. Several randomized clinical trials and meta-analyses have reported conflicting results regarding survivability and clinical outcomes between mobile and fixed bearing implant designs [14,15]. The unidirectional motion described in RP designs theoretically decreases the potential for backside wear as seen in fixed bearing designs and allows for increased articular surface contact area and conformity [16,17]. These design attributes offer a potential survivorship benefit in a young, active patient population.

RP TKA using a gap balancing technique offers several theoretical benefits. Gap balancing allows for symmetric flexion and extension gaps resulting in better coronal stability which potentially can increase survivorship and improve functional performance [18]. There is limited information in the literature evaluating the outcome of RP TKAs specifically in the younger patient population using gap balancing. The objective of this study is to evaluate the mid to long term clinical outcome in patients younger than sixty years of age who underwent RP TKA using the gap balancing surgical technique.

Materials and Methods

Institutional review board approval was obtained. All enrolled patients were prospectively followed as part of our joint arthroplasty registry with informed consent.

From December 2000 to July 2004, 108 consecutive gap balanced RP TKAs were performed by 2 senior authors (RSG and SLB) in 85 patients under the age of 60 utilizing the same RP posterior stabilized tibial implant with the (PFC) SIGMA RP femoral component (*DePuy* Synthes *Companies of Johnson & Johnson*, Warsaw, Indiana) in 47 cases (44%) and the LCS COMPLETE femoral component (*DePuy* Synthes *Companies of Johnson & Johnson*, Warsaw, Indiana) in 61 cases (56%). Ninety-three knees were cemented (86%), while 15 cases were fully uncemented (14%).

All procedures were performed through a standard medial parapatellar arthrotomy. The tibial component was aimed to be perpendicular to the longitudinal axis in the coronal plane. Tibial slope was

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Table 1
Demographic Data for Final Cohort.

Duration of follow-up[a] (yr)	10
Age [b] (yr)	54.4 ± 5.3 (37–59)
Male:female ratio (no. of patients)	1.06 (35:33)
Diagnosis (no. of patients)	68
Osteoarthritis	73
Osteonecrosis	15
Rheumatoid arthritis	3
Body mass index [b] (kg/m^2)	31 ± 5.8

[a] The data are based on 68 patients (91 knees).
[b] The values are given as the mean and the standard deviation, with the range in parentheses.

resected to be within 0°–5° posteriorly in the sagittal plane. The gap balancing technique consisted of balancing the extension gap first with the appropriate soft tissue releases. The posterior condylar resection was performed in flexion and determined by creating a rectangular flexion space using the tibial cut and collateral ligament tension, equalizing the medial and lateral tension values with a tensioner. The size of the flexion space was then determined by the size of the previously created extension space with translation of the cutting block to match the flexion space to the extension space. The femoral component rotation was established from this symmetric tensioning prior to making condylar and chamfer cuts. The posterior cruciate ligament was sacrificed in all cases prior to flexion space balancing. Posterior referencing was used to maintain the appropriate flexion space. The patella was resurfaced in 85 knees (93.4%). Wound closure was performed with the knee in flexion. Early passive range of motion was performed with the assistance of a physiotherapist and without a continuous passive motion device.

The clinical results were assessed with Knee Society functional scores and total scores [19] as well as patient submitted questionnaires detailing severity and location of pain and crepitation, activity level (modified Tegner score) and satisfaction scores. Peak knee flexion and extension were measured by an experienced allied health professional using a 12-in goniometer both preoperatively and at each postoperative clinic visit. All adverse events pertaining to the surgical procedure were analyzed, including return to the operating room, infection, and crepitation. When patients could not complete a follow-up evaluation in person, further information was acquired via phone interview or mailed survey to obtain subjective outcome measures and assessments to verify if any operations were performed on the extremity at any other facility. Remote radiographs were also obtained when possible.

Serial radiographic analysis taken at 6 weeks, 3 months, and annual radiographs included weight-bearing antero-posterior, non-weight bearing lateral, and merchant views. Radiographs were evaluated by two board eligible joint arthroplasty fellows. Each radiograph was assessed for radiolucent lines adjacent to the implants, osteolysis, malalignment, and migration according to criteria defined by the Knee Society scoring system for radiographic standardization [20].

Statistical Methods

Descriptive analyses (mean, median, minimum, maximum, range, missing values, and standard deviation) were performed on all data sets. A paired t-test analysis was used to compare objective clinical improvement with preoperative and postoperative pain, function and total knee scores. Survival analysis was utilized to compare different adverse event types. Kaplan–Meier survival analysis was utilized to estimate device survivorship and the absence of adverse events. Statistical tests were performed with SAS (v9.3).

Results

At the time of most recent follow-up, eighty-five patients (108 knees) met our inclusion criteria with minimum 5 year follow-up. Seventeen patients (17 knees; 15%) were lost to follow-up. 68 patients (91 knees; 84%) were evaluated postoperatively at a mean of 10 years post index procedure (Table 1). The average age for the cohort at the time of surgery was 54.4 years (range 37 to 59 years). Thirty-three patients (48.5%) were women and thirty-five patients (51.5%) were men. The preoperative diagnosis was osteoarthritis for 73 knees (80.2%), post-traumatic arthritis in 15 knees (16.4%) and rheumatoid arthritis in 3 knees (3.3%). The mean body mass index (BMI) was 31 ± 5.8 kg/m^2 (Range 22.3 to 49.6 kg/m^2). Preoperative anatomic tibiofemoral alignment averaged 3.3° of varus (range, 15° varus to 16° valgus). Mean range of motion averaged a range from 10°(range, 0°–30°) to 109°(range, 80°–140°) of flexion. 54.9% (50 of 91) of knees had a 10° or greater flexion contracture and 31.9% (29 of 91) of knees had less than 105° total of flexion.

Compared with the preoperative baselines, there was a significant ($P < 0.001$) improvement in mean Knee Society total score [18], function score, and mean flexion (Table 2). The function score improved from 46.4 (±19.2) to 87.4 (±15.7). The mean total Knee Society score improved from 27.6 (±13.7) preoperatively to 92.8 (±11.4) postoperatively. The patient administered satisfaction questionnaire demonstrated that 95.6% of patients (87 of 91) were extremely or very satisfied with the procedure at their last follow-up visit. Modified Tegner scores (1–4 based on increased level of activity) increased from 2.16 ± 0.9 to 3.18 ± 0.74 [21]. Mean knee extension improved from 10° ± 6° (range, 0° to 30°) preoperatively to 1° ± 3° (range, 0° to 15°) at the latest follow-up ($P < 0.001$). Likewise, mean knee flexion improved from 109° ± 14° (range, 80° to 140°) preoperatively to 119° ± 14° (range of 80° to 140°) at the latest follow-up ($P < 0.001$). The mean gain in range of motion from baseline was 11°. There were no cases of symptomatic flexion instability identified in this study group.

Radiographic evaluation was available for 67 knees (74 %) and demonstrated one case of early uncemented aseptic femoral component loosening. Non-progressive radiolucent lines less than or equal to 1 mm were identified on the radiographs of five knees during annual radiographs and were not present in more than 2 zones around the femoral or tibial components. No components were deemed radiographically malaligned and osteolysis was not identified in any instance. There were no obvious signs of asymmetrical wear of the mobile-bearing tibial polyethylene insert or patellar component and no cases showed bearing malrotation or malposition (Fig. 1). Postoperatively, mean anatomic alignment was 4.4° ± 2.19° of valgus, with the mean femoral component measuring 4.96° ± 1.96° of valgus. The tibia measured a mean of 0.55° ± 1.84° of varus relative to the mechanical axis with a posterior tibial slope of 3.44° ± 1.89°.

Table 2
Clinical Results for Final Cohort (N = 91).

Measurement	Preoperative[a]		Postoperative[a]		*P* Value
Knee Society function score (points)	46.4 ± 19.2	(range, 0 to 80)	87.4 ± 15.7	(range, 35 to 100)	<0.001
Knee Society total score (points)	27.6 ± 13.7	(range, 0 to 60)	92.8 ± 11.4	(range, 57 to 100)	<0.001
Knee extension (deg)	10 ± 6	(range, 0 to 30)	1 ± 3	(range, 0 to 15)	<0.001
Knee flexion (deg)	109 ± 14	(range, 80 to 140)	119 ± 14	(range, 80 to 140)	<0.001
Modified Tegner score (0–4)	2.16 ± 0.9	(range, 1 to 4)	3.18 ± 0.74	(range, 1 to 4)	<0.001

[a] The values are given as the mean and the standard deviation.