CLINICAL ARTICLE

Comparison of Functional Performance after Total Knee Arthroplasty Using Rotating Platform and Fixed-bearing Prostheses with or without Patellar Resurfacing

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Objective: To retrospectively compare the functional performances of rotating platform and fixed-bearing total knee arthroplasties with or without patellar resurfacing.

Methods: One hundred and ninety-seven patients (205 knees) of mean age 66.4 years were randomly assigned to receive different prostheses. One hundred ninety-five patients, including 97 fixed-bearing prostheses with 37 patellae resurfaced and 106 rotating platform prostheses with 76 patellae resurfaced, were followed up for a mean duration of 32 months.

Results: Outcomes in the rotating platform with patellar resurfacing and fixed-bearing with patellar resurfacing groups did not differ significantly according to Hospital for Special Surgery (HSS) scores and flexion and extension angles. For total knee arthroplasties without patellar resurfacing, there were no significant differences in HSS score and flexion angle between the rotating platform and fixed-bearing subgroups. Although the extension angle of rotating platform prostheses was slightly better than that of the fixed-bearing in the patellar non-resurfacing group, this difference was not clinically significant.

Conclusions: Rotating platform and fixed-bearing prostheses have similar overall postoperative outcomes with regard to postoperative HSS scores and extension and flexion angles. Rotating platform prostheses are not superior to fixed bearing prostheses.

Key words: Fixed-bearing; Patellar resurfacing; Rotating platform; Total knee arthroplasty

Introduction

Rotating-platform (RP) total knee arthroplasty (TKA) has been endorsed because of its theoretical advantages over a fixed-bearing (FB) design. These advantages include improved stress distribution between the femoral and tibial components, reduction of loosening forces at the bone implant interface, minimization of polyethylene wear and improvement in kinematics by increasing range of motion (ROM) and facilitating axial rotation. These theoretical design advantages are mostly based on findings of *in vitro*

simulation studies¹⁻⁴; the presumed clinical advantages of RP implants have not been consistently supported by available published studies, which have inconclusive and conflicting results⁵⁻⁸. Furthermore, apart from knee scores, the reported improvements are in ROM, but not in flexion and extension angles. Banks *et al.* found that tibiofemoral movements influence the mechanics of weight-bearing in deep flexion of well-functioning knee arthroplasties⁹. Improved active flexion and extension angles are the most important goals for RP prostheses to attain.

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Fig. 1 A 73-year-old woman with osteoarthritis received primary total knee arthroplasty using fixed-bearing prosthesis (P.F.C. Sigma). (a) Preoperative anteroposterior and lateral radiographs. (b) Postoperative anteroposterior and lateral radiographs.

To our knowledge, few studies have yet been published comparing the relative effectiveness of RP and FB TKAs in respect to flexion and extension angles. Therefore, the goals of this study were to evaluate differences in postoperative flexion and extension angles and Hospital for Special Surgery (HSS) scores¹⁰ after using the Press Fit Condylar (P.F.C.) Sigma RP (DePuySynthes, Warsaw, IN, USA), P.F.C. Sigma prosthesis (DePuy) and Genesis II Knee Systems (Smith & Nephew, Memphis, TN, USA) and to assess whether resurfacing the patella influences the outcome.

Materials and Methods

Patients

One hundred and ninety-seven patients (205 knees) who received primary TKAs in our hospital between July 2007 and December 2010 were enrolled in this retrospective study. There were originally 95 patients (99 knees, Fig. 1) in the FB group and 102 (106 knees, Fig. 2) in the RP group. However, two patients in the FB group were lost to follow-up, leaving 93 patients (97 knees) available in this group. At the end of September 2011, the average follow-up time was 32 months (range, 8–52 months). In our original study, there were two types of prostheses in the FB group, namely the P.F.C. Sigma (DePuy, Johnson & Johnson) and the Genesis II Knee System (Smith & Nephew). Only one type of prosthesis was used in the mobile-bearing group, namely the P.F.C. Sigma RP (DePuy, Johnson & Johnson). All patients in this study received cemented posterior-stabilized prostheses: 97 FB and 106 RP prostheses. Relevant clinical data such as age and sex had been recorded at admission by a specialist arthroplasty surgeon in our hospital. The patients and/or their families were given a

full explanation of the study, informed that data from their case would be submitted for publication, and gave their consent. The study protocol was approved by the Institutional Review Board at our hospital and all information was kept confidential. Relevant patient characteristics are shown in Table 1.

Operative Procedure

All operative procedures were performed by the same senior knee surgeons, who were experienced in the instrumentation and use of both FB and RP prostheses. These are both posterior-stabilized prostheses. The surgical procedure and postoperative protocol were the same for both groups. The procedure was performed via a midline skin incision and a medial parapatellar approach to the knee. The cruciate ligaments were excised. For both prostheses, intramedullary alignment was used for the femur and extramedullary alignment for the tibia. Appropriate soft-tissue procedures to realign the knee were performed in both groups. The patellae were resurfaced in patients with severe articular cartilage degeneration and advanced patellofemoral arthritis, the final decision regarding resurfacing being made by the surgeon at the time of operation. Thirty-seven (of 97) knees in the FB group and 76 (of 106) knees in the RP group underwent patellar resurfacing (Table 1).

Outcome Indicators and Follow-up Evaluation

The primary outcome indicators, namely postoperative flexion and extension angles, were assessed by an independent senior knee surgeon. To assess the extension and flexion angles, the patients were asked to stand upright and flex their knee as much as possible using their own muscle force.

Fig. 2 A 58-year-old woman with osteoarthritis received primary total knee arthroplasty using rotating-platform prosthesis (P.F.C. Sigma RP). (a) Preoperative anteroposterior and lateral radiographs. (b) Postoperative anteroposterior and lateral radiographs.

The secondary outcome indicator was the HSS score, a functional evaluation of TKAs which assesses pain, stability, motion, quadriceps strength, and subtractions such as extension lag, flexion contracture and varus/valgus deformity¹⁰. Scores range from 0 (worst score) to 100 (best score), a rating of 90–100 being classified as excellent, 80–89 as good, 70–79 as fair and <70 as poor.

Two patients (2 knees) in the FB group were lost to follow-up, leaving 162 patients (170 knees) available with an average follow-up of 32 months (range, 8–52 months).

Statistical Analysis

Student's *t*-test and independent *t*-test statistical analysis were performed to compare differences in outcomes. Two-tailed values of $P < 0.05$ were considered statistically significant. All

values are presented as mean and standard deviations (SD). Analysis of the data was performed using the SPSS 17.0 statistical package.

Results

Evaluation of Overall Outcomes

No patients in either group had intraoperative or postoperative complications. Of the assessed postoperative outcome indicators, the HSS score and mean extension angle were significantly better than the corresponding preoperative measures (Table 2). The HSS score increased from 51.3 points preoperatively to 87.1 points postoperatively ($P < 0.01$). The mean extension angle was 12.6° preoperatively; this improved to 1.9° postoperatively ($P < 0.01$). However, the flexion angle did not change significantly after TKA (from 106.4° to 108.9°).

TABLE 1 Relevant patient variables for 195 TKA patients (203 knees)

Index	Fixed-bearing group	Rotating platform group
Cases (knees)	93 (97)	102 (106)
Age (mean $\pm$ SD, years)	64.4 $\pm$ 15.9	67.6 $\pm$ 7.0
Sex (Male/Female)	23/70	20/82
Patellar resurfacing (Yes/No)	37/60	76/30
<i>Diagnosis (knees)</i>		
Osteoarthritis	84	97
Rheumatoid arthritis	10	8
Post-traumatic arthritis	2	1
Pigmented villonodular synovitis	1	0

TABLE 2 Preoperative and postoperative outcomes after TKA of 203 knees (mean $\pm$ SD)

Variable	Preoperative	Postoperative
HSS score	51.3 $\pm$ 14.1	87.1 $\pm$ 10.4*
Extension angle (°)	12.6 $\pm$ 14.6	1.9 $\pm$ 3.3*
Flexion angle (°)	106.4 $\pm$ 18.5	108.9 $\pm$ 11.1

Note: *Compared with preoperative group, no significant difference was found ($P < 0.05$).

TABLE 3 Postoperative outcomes in fixed-bearing and rotating platform groups, with and without patellar resurfacing (mean $\pm$ SD)

Variable	Fixed-bearing group (97 cases)	Rotating platform group (106 cases)
HSS score	86.8 $\pm$ 11.2	87.2 $\pm$ 9.9
Extension angle (°)	2.2 $\pm$ 3.3	1.7 $\pm$ 3.3
Flexion angle (°)	105.6 $\pm$ 13.8	110.9 $\pm$ 8.7*

Note: *Compared with fixed-bearing group, no significant difference was found ($P < 0.05$).

Comparison of Postoperative Functional Outcomes between Fixed-bearing and Rotating-platform Groups

There were no significant differences in HSS score and extension angle between the two groups. The flexion angle in the RP group ($110.9^\circ \pm 8.7^\circ$) was better than that in the FB group ($105.6^\circ \pm 13.8^\circ$) after TKA ($P < 0.01$, Table 3).

Evaluation of Outcomes after Total Knee Arthroplasty with and without Patellar Resurfacing

In the patella resurfaced group, FB prostheses were used in 37 knees and RP prostheses in 76 knees (Table 4). There were no significant differences in postoperative HSS score or flexion and extension angles between the FB and RP groups according to patellar resurfacing.

In the patella non-resurfaced group, an FB prosthesis was used in 60 knees and an RP prosthesis in 30 knees (Table 5). There were no significant differences in postoperative HSS score or flexion angle between the FB and RP groups according to patellar non-resurfacing. However, the two groups differed regarding postoperative extension angle; although the difference was statistically significant ($1.7^\circ \pm 3.3^\circ$, $0.4^\circ \pm 1.2^\circ$; $P < 0.05$), it was not clinically significant.

Among the FB TKAs, 37 knees underwent patella resurfacing and 60 did not (Table 6). There were no significant differences in postoperative HSS score or flexion and extension angles between the patellar resurfacing and patellar non-resurfacing groups.

Among the RP TKAs, 76 knees underwent patella resurfacing and 30 did not (Table 7). There were no significant

TABLE 4 Postoperative outcomes in fixed-bearing and rotating platform groups with patellar resurfacing (mean $\pm$ SD)

Variable	Fixed-bearing group (37 cases)	Rotating platform group (76 cases)
HSS score	85.4 $\pm$ 14.8	85.8 $\pm$ 10.7
Extension angle (°)	2.9 $\pm$ 3.2	2.2 $\pm$ 3.7
Flexion angle (°)	104.7 $\pm$ 18.4	111.5 $\pm$ 10.0

TABLE 5 Postoperative outcomes in fixed-bearing and rotating platform groups without patellar resurfacing (mean $\pm$ SD)

Variable	Fixed-bearing group (60 cases)	Rotating platform group (30 cases)
HSS score	87.8 $\pm$ 7.9	90.8 $\pm$ 6.2
Extension angle (°)	1.7 $\pm$ 3.3	0.4 $\pm$ 1.2*
Flexion angle (°)	106.3 $\pm$ 9.8	109.3 $\pm$ 3.6

Note: *Compared with fixed-bearing group, no significant difference was found ($P < 0.05$).

differences in postoperative HSS score or flexion and extension angles between the patellar resurfacing and patellar non-resurfacing groups.

Discussion

Total knee arthroplasty has become a standard operative procedure for relieving pain and restoring function in patients with osteoarthritis or rheumatoid arthritis. Current total knee prostheses can be subdivided into two groups with different fundamental design principles: namely *fixed-bearing* knees, in which the polyethylene tibial insert is locked to the tibial tray, and *mobile-bearing* (MB) designs, which facilitate movement of the insert in relation to the tibial tray³. FB prostheses have been used extensively worldwide and have satisfactory results on long-term follow-up. Several studies have shown their survival rates are 95%–97% at 10 to 15 years of follow-up¹¹. However, problems with polyethylene wear and aseptic loosening remain a concern, especially with young and active patients¹². The design of the MB is intended to provide more natural features than the FB prosthesis; it approximates more closely to a natural knee^{13–15}. The MB implant offers

TABLE 6 Postoperative outcomes in fixed-bearing group with or without patellar resurfacing (mean $\pm$ SD)

Variable	Resurfaced (37 cases)	Not resurfaced (60 cases)
HSS score	85.4 $\pm$ 14.8	87.8 $\pm$ 7.9
Extension angle (°)	2.9 $\pm$ 3.2	1.7 $\pm$ 3.3
Flexion angle (°)	104.7 $\pm$ 18.4	106.3 $\pm$ 9.8

TABLE 7 Postoperative outcomes in rotating platform group with or without patellar resurfacing (mean $\pm$ SD)

Variable	Resurfaced (76 cases)	No resurfaced (30 cases)
HSS score	85.8 $\pm$ 10.7	90.8 $\pm$ 6.2
Extension angle (°)	2.2 $\pm$ 3.7	0.4 $\pm$ 1.2
Flexion angle (°)	111.5 $\pm$ 10.0	109.3 $\pm$ 3.6

greater conformity and decreased contact stresses through a polyethylene liner that is mobile in relation to the tibial tray³. MB prostheses are designed to provide more conforming surface shapes with reduced polyethylene contact stresses, reduce wear, minimize tibial loosening, and improve the ROM, especially in young and active patients¹⁶. Several *in vitro* studies have shown that MB prostheses do reduce polyethylene contact stresses and polyethylene wear^{1-3,17}.

Unlike some other mobile-bearing designs, the PFC Sigma Rotating Platform prosthesis has no functional movement on the tibial tray in the anteroposterior and mediolateral directions, but allows rotation of the tibial insert in relation to the tibial tray. Some clinical reports have found no differences between MB/RP and FB prostheses. In 2004, Ranawat *et al.* were the first to report a comparison of the PFC Sigma FB and RP TKA in patients with an average follow-up of 46 months for the FB side and 16 months for the RP side. They found no significant differences in terms of knee performance, knee pain, range of motion, overall satisfaction or Knee Society scores¹. Hasegawa *et al.* conducted a prospective randomized trial to compare the results of RP and FB posterior stabilized TKAs in the same patients using the same femoral component design of a PFC sigma RP prosthesis in one knee and a PFC sigma FB prosthesis in the other knee in 25 patients with osteoarthritis². At an average follow-up of 40 months, they had found no significant differences between the MB and FB knees in terms of clinical and radiographic results. Kim *et al.* also obtained similar results and demonstrated no significant clinical advantage for MB prosthesis over FB ones¹⁸. However, there are some positive clinical reports on MBs. One study showed that fewer patients (4.3%) experienced persistent anterior knee pain with MBs (NexGen Complete Knee Solution Legacy posterior-stabilized mobile bearing knee, which allows rotation of the insert around a pivot axis, Zimmer, Warsaw, IN, USA) than did patients with posterior-stabilized FBs (18.9%). Theoretically, this difference might be because the FBs can self-align and therefore accommodate small errors in component placement; the resultant better patellar tracking might decrease the incidence of anterior knee pain⁶. Moreover, the MB design offers the advantage over the FB design of self-adjustment to accommodate surgical malalignment of tibiofemoral joint. The former also redistributes the motion between the femoral-insert and the tray-insert articular surfaces, thus reducing wear³. In addition, with the MB prosthesis, similar to normal knees, at full extension the femoral component is in a neutral or anterior position, progressive posterior femoral rollback (PFR) being achieved with increasing knee flexion⁴.

Our study does not show any marked advantage in terms of HSS score or extension angle for FB or RP TKAs at a mean follow-up of 32 months. However, the postoperative flexion angle is better in the RP than in the FB group (Table 3). Table 3 shows findings for patella resurfaced TKAs and patella non-resurfaced TKAs within the same group and allows comparison of the groups. Because the need for patellar resurfacing was assessed by the surgeon at the time of

surgery, this part of study was not randomly designed; thus, contrived biases could confound the results. When we compared outcomes between FB and RP prostheses in TKAs with (Table 4) and without (Table 5) patellar resurfacing, RP prostheses did not significantly improve the postoperative flexion angle no matter whether the patellae had been resurfaced or not. Although MB prostheses have the theoretical advantages of self-adjustment and PFR to improve knee flexion⁴, we observed no actual advantages in our study. Our findings that MB prostheses are not superior to MB prostheses are consistent with the foregoing studies^{19,20}, even though most of these clinical comparative studies did not specify the flexion and extension angles, in general using the sums of ROM as outcome measures.

Whether or not to resurface the patella in primary TKA remains controversial. Many studies show that, in general, regardless of patellar resurfacing or not resurfacing, TKAs achieve satisfactory clinical results. It is difficult to conclude there are any qualitative differences between patellar resurfaced and non-resurfaced TKAs²¹. Rather than never or always resurfacing, appropriate indications should be considered when deciding whether to resurface the patella. These include rheumatoid arthritis or other diseases (such as pigmented villonodular synovitis) that severely erode the patellar articular cartilage, severe osteoarthritis with patellar articular surface damage or deformation, and the likelihood that the patellar thickness will be >12 mm after osteotomy. Unlike previous study in which all patellae were resurfaced, our study contained both patellar resurfaced TKAs and patellar non-resurfaced TKAs. We found that the postoperative outcomes of FB and RP prostheses were roughly the same and were not significantly changed by patellar resurfacing. Surgical training and experience, preoperative analysis of patellofemoral tracking, and intraoperative analysis of the patellofemoral articular surface and articulation are critical to the final decision as to whether a patella should be resurfaced. It is generally considered that optimal outcomes can be obtained for TKAs with and without patellar resurfacing with optimal implant design and appropriate surgical techniques²².

As we have shown in the current study, there are no significant differences at 32 months follow-up between rotating platform and fixed-bearing TKAs in postoperative HSS scores and flexion angle both in TKAs with and without patellar resurfacing. The postoperative extension angle of RP prostheses was slightly better than that of FBs in the patellar non-resurfacing group, but this difference was not clinically significant. In the patellar resurfacing group, we found no differences between RP and FB TKAs in extension angle. Patellar resurfacing is not superior to patellar non-resurfacing with regards to improving knee function. Therefore, we conclude that the overall outcomes of RP and FB TKAs are similar with regard to postoperative HSS score and extension and flexion angles. We demonstrated no clear superiority for either type of prosthesis.

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