Patients Prefer A Bicruciate-Retaining or the Medial Pivot Total Knee Prosthesis

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Abstract: Four-hundred forty patients underwent staged bilateral total knee arthroplasty using a different prosthesis on each side. Prostheses used were anterior-posterior cruciate-retaining (ACL-PCL), posterior cruciate-retaining (PCL), Medial Pivot (MP), posterior cruciate-substituting (PS), and mobile bearing (MB). At the 2-year evaluation, we asked “Which is your better knee overall?” Responses were as follows: 89.1% preferred the ACL-PCL to the PS and 76.2% preferred the MP to the PS. The ACL-PCL and the MP were preferred equally. The MP was preferred over the PCL by 76.0%, and 61.4% preferred the MP over the MB. The PS and PCL were preferred equally. Range of motion, pain relief, alignment, and stability did not vary significantly by prosthesis used. Patients with bilateral total knee arthroplasties preferred retention of both cruciates with use of the ACL-PCL prosthesis or substituting with an MP prosthesis. Keywords: total knee arthroplasty, bilateral

Total knee arthroplasty has revolutionized the treatment of patients with osteoarthritis. The long-term results using any of the currently available prostheses are good. Surgeons have strong expert opinions on which device they believe is the best, and published literature supports the various designs from a variety of sources.

There are a number of variables in knee prostheses, including the size and shape of the prosthetic parts. However, most differences in knee prostheses currently revolve around issues of integrity and balance of the cruciate ligaments [1]. Prostheses that allow preservation of the anterior (ACL) and posterior cruciate ligaments (PCL) are the designs that necessitate precise soft tissue balance [2] (Fig. 1). The most popular total knee prostheses have been the posterior cruciate-substituting (PS), which require the excision of both cruciate ligaments, and the PCL-retaining prosthesis (PCL). A central post or a symmetric deep-dished tibial polyethylene insert is substituted for the PCL with these designs [3-6] (Fig. 2).

One newer design concept, the medial pivot (MP) prosthesis (Fig. 3), has an asymmetric tibial polyethylene insert [7,8]. Anterior and posterior translation is limited in the medial compartment and translation in the lateral compartment is unrestricted, making this implant ultra congruent in the medial compartment [7]. For all of the prostheses described, the tibial tray polyethylene and femur are fixed.

The concept of the mobile bearing knee (MB) is equally novel (Fig. 4) [9]. Because knee motion is multidirectional, increased tibial polyethylene wear can result. Mobile bearing knees uncouple the motion between the femur and tibial insert and the insert and the tibial tray. This, in theory, converts the multidirectional motion to unidirectional motion and reduces wear. Also, there may be less proximal tibial metaphyseal bone strain in a MB knee with less possibility of tibial prosthetic loosening [9].

In 2004, we reported the preferences according to knee of a group of patients who underwent staged, bilateral knee arthroplasties [10]. In the present study, some patients also received the newer MB implant, which became available in 2003 (Fig. 4). This study sought to determine whether patients with well-functioning prostheses in both knees can notice differences between knee prostheses, and if so, do they also have a preference? We also asked the patients the reason for their opinion.

Patients and Methods

From June 1987 until September 2005, all patients who underwent bilateral, staged primary total knee
arthroplasties were offered enrollment in this random-
ized, prospective study. Randomization of the prosthesis
was determined from a sequential pool on the basis of a
table of random numbers. The study protocol was
approved by the institutional review board, and each
patient provided written informed consent. The patients
served as their own internal controls, which eliminated
variability that could be introduced by differences in age,
weight, sex, comorbidities, bone quality, and activity level.

Inclusion criteria for the study were as follows: age 45
to 89 years, English speaking or access to an interpreter,
and a primary diagnosis of osteoarthritis. Exclusion
criteria were as follows: follow-up less than 2 years; a
history of patellectomy, high tibial osteotomy, unicomp-
artmental prosthesis, bicompartmental prosthesis,
fixed or rotating hinge prosthesis, previous septic
arthritis, and rheumatoid arthritis; flexion of less than
90°, flexion contracture of 20° or more, valgus deformity
more than 15°, and varus deformity more than 20°
(Table 1). In addition, to accurately assess patients’
subjective opinions about which well-functioning knee
they preferred, it was necessary to also exclude those
patients with fair and poor results in one or both knees.
This avoided comparing a fair or poor result to a good or
excellent result. All patients in this report, therefore, had
a good or excellent result in both knees.
There were 5 knee prostheses used in this study: (1) the anterior-posterior cruciate-retaining (ACL-PCL) prosthesis (Biopro Inc, Port Huron, Mich, and Wright Medical Technology, Arlington, Tenn), (2) the Medial Pivot (MP) prosthesis (Wright Medical Technology), (3) the posterior cruciate-retaining (PCL) prosthesis (Biomet, Warsaw, Ind; Biopro, DePuy, Warsaw, Ind; Stryker, Mahwah, NJ; Wright Medical Technology; and Zimmer, Warsaw, Ind), (4) the posterior-substituting (PS) prosthesis (Biomet, DePuy, Stryker, Wright Medical Technology, and Zimmer), and (5) the MB prosthesis (DePuy [PFC Sigma]). Two prostheses were not available when the study began in 1987; the MP prosthesis was not used until 1999, and the MB prosthesis was not used until 2003. Also, if there was no functional ACL, another randomized prosthesis was used. The author performed all the operations.

The surgical procedure for all cases consisted of cementing all components, resurfacing the patella with an all-polyethylene button, and the same technique for ligament balancing, guide use, exposure, and tissue handling. Each prosthesis, however, required variation in technique as necessary to accommodate the design features. For the MP prosthesis, the entire PCL was excised. Each patient received the same postoperative care. All patients began walking with crutches or a walker and started active and passive motion exercises on the day after the operation. All patients were permitted immediate full weight bearing using crutches or a walker only for balance. Starting in 1990, the knee was placed in a continuous passive motion machine starting on the day of surgery and this was continued for 2 weeks.

Postoperative clinical and radiographic assessments were recorded at 6 weeks, 3 months, and 1 year after the operations and yearly, thereafter, by physicians not involved in the care of the patient and who had no knowledge of the type of prosthesis used. In addition, patients did not know which implants they received. Preoperative and follow-up ratings according to the Knee Society score were obtained for all patients [11]. At the 2-year follow-up, patients were asked, “Which is your better knee overall?” to determine the patients’ preferences. We also asked patients for the reason(s) for their preferences.

The Kruskal-Wallis nonparametric test was used, and the statistical power estimation gives values from 0.86 to 0.99. All the intergroup comparisons have significant power to detect a large size effect. A 4-point difference can be detected by the analysis used and may be clinically important.

### Results

There were 492 patients who underwent bilateral knee arthroplasty in this study; the diagnosis was osteoarthritis in each case. Fifty-two patients were excluded because of a fair or poor result or because they were lost to follow-up, leaving 440 patients for analysis. The mean follow-up was 6.8 years (range, 2-14 years), and the mean time interval between knee arthroplasties was 2 years (range, 0.5-6 years). The mean age of the patients was 68 years (range, 45-89 years); 70% of the patients (308) were women. Additional preoperative and postoperative data are shown in Table 2. The mean total postoperative Knee Society clinical score was 92 [10]. The mean range of motion for all patients was 121° and varied slightly according to the type of knee prosthesis used. There were no important differences in the mean pain score, range of motion, knee score, or function score between the types of knee prostheses (Table 2). Radiographic assessment showed that all knees appeared fixed solidly. There were no progressive radiolucent lines at the bone-

### Table 1. Excluded Patients

<table>
<thead>
<tr>
<th>Prosthesis</th>
<th>Poor Result</th>
<th>Fair Result</th>
<th>Lost to Follow-Up</th>
<th>Total Excluded</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACL-PCL</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>MP</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>PCL</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>PS</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>MB</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>11</td>
<td>26</td>
<td>52</td>
</tr>
</tbody>
</table>

### Table 2. Results of Knee Arthroplasty

<table>
<thead>
<tr>
<th>Prosthesis</th>
<th>Mean Range of Motion (°)</th>
<th>Mean Follow-Up (y)</th>
<th>Mean Postoperative Knee Score</th>
<th>Mean Knee Function Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACL-PCL</td>
<td>119</td>
<td>8.3</td>
<td>92.6</td>
<td>76.7</td>
</tr>
<tr>
<td>MP</td>
<td>125</td>
<td>6.1</td>
<td>94.2</td>
<td>80.4</td>
</tr>
<tr>
<td>PCL</td>
<td>121</td>
<td>9.2</td>
<td>90.8</td>
<td>71.3</td>
</tr>
<tr>
<td>PS</td>
<td>120</td>
<td>6.6</td>
<td>91.7</td>
<td>74.1</td>
</tr>
<tr>
<td>MB</td>
<td>124</td>
<td>3.6</td>
<td>92.4</td>
<td>81.1</td>
</tr>
</tbody>
</table>

### Table 3. Patient Preferences Regarding Their Knee Arthroplasties (When Asked: Which Is Your Better Knee Overall?)

<table>
<thead>
<tr>
<th>Implant Types</th>
<th>Prefer Procedure 1*, n (%)</th>
<th>Prefer Procedure 2*, n (%)</th>
<th>Cannot Tell, n (%)</th>
<th>P†</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACL-PCL vs PCL</td>
<td>91 (73.6%)</td>
<td>67 (18.7%)</td>
<td>17 (7.7%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ACL-PCL vs PS</td>
<td>46 (89.1%)</td>
<td>41 (8.3%)</td>
<td>2 (3.6%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ACL-PCL vs MP</td>
<td>64 (48.1%)</td>
<td>31 (48.3%)</td>
<td>17 (7.7%)</td>
<td>.000</td>
</tr>
<tr>
<td>MP vs PS</td>
<td>42 (76.2%)</td>
<td>32 (58.8%)</td>
<td>8 (47.3%)</td>
<td>.003</td>
</tr>
<tr>
<td>MP vs PCL</td>
<td>50 (80.0%)</td>
<td>38 (60.0%)</td>
<td>6 (12.0%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>MP vs MB</td>
<td>83 (61.4%)</td>
<td>51 (37.0%)</td>
<td>17 (12.0%)</td>
<td>.001</td>
</tr>
<tr>
<td>PCL vs PS</td>
<td>64 (78.8%)</td>
<td>28 (34.2%)</td>
<td>9 (14.1%)</td>
<td>.893</td>
</tr>
</tbody>
</table>

* Procedure 1 (2) refers to the first (second) procedure under the column Procedures.
† Likelihood ratio test for equal percentage of preferred procedures.
cement or prosthesis-cement interfaces. Postoperative alignment was between 0° and 7° varus. All patients had a tibial polyethylene thickness of between 10 and 14 mm.

The patient preferences for all prosthetic types are shown in Table 3. Patients gave the following reasons for their preference for 1 knee over the other: feels more normal; stronger on stairs; superior single-leg weight bearing; flexion stability; feels more stable overall; fewer clunks, pops, and clicks; and don’t know.

**Discussion**

This study was conducted to determine patients’ preferences about their total knee arthroplasty; no attempt was made to assess other factors, such as implant loosening and/or wear, which determine the procedure’s ultimate success. This study confirms the results of our previous study [10] that patients often have a preference for 1 knee prosthesis over another; however, the reason for the preference remains unclear. Differences in proprioception, subjective sense of stability, sagittal plane kinematics, or differences in the femoral radius of curvature are among the possibilities.

The knee prostheses in this study can be categorized as either anatomical or functional designs. An ACL-PCL and some PCL knee prostheses try to simulate normal anatomy. The PS, MB, MP, and many PCL knee prostheses strive for improved function without retaining or recreating normal anatomy and are, therefore, termed functional designs. A patient may actually prefer a prosthesis that might fail earlier than another implant type. More congruent knee prostheses, such as the MP, could reduce polyethylene contact stresses and increase implant longevity. The MB knee prosthesis may also have reduced polyethylene wear over time. Recent reports on MP and MB prostheses suggest that functional and longevity results are equal to or better than other designs [10,12].

Comparing the benefits of 2 different knee designs in the same patient has the advantage that patient-dependent variables are eliminated. However, it is difficult to separate function of the 2 knees, particularly in overall patient function. Comparison studies within-patient (paired) and between patients may be advantageous because fewer patients are required and confounding variables are controlled. Also, traditional parallel group trials may have a potential for bias. As stated previously, knees with fair and poor results were excluded from analysis to avoid comparing a poor result on 1 side to a good result on the other side; therefore, the postoperative knee scores in this study are higher than those usually reported.

Several reports, including bilateral paired series, have demonstrated no clear clinical advantage for retaining or excising the PCL and substituting with a PS knee prosthesis [1,3-5]. The clinical results of both fixed-bearing and mobile-bearing knees are excellent in paired bilateral comparison studies. The ACL-PCL knee prosthesis has been used and studied much less often, but the results are excellent or good in most cases [13,14].

The advantage of the ACL-PCL prosthesis was in improved performance, as documented by gait analyses during walking and stair climbing [15]. Only patients with retained cruciates have near normal kinematics [16,17]. New, redesigned ACL-PCL prostheses allow greater range of motion than did the older designs. The older designs had less rollback in the lateral compartment. New redesigned ACL-PCL prostheses are capable of more rollback and have more flexion. For the MP prosthesis, if the PCL is retained, most knees will not regain adequate flexion or function. In addition, the rotational alignment of the MP prosthesis is critical for successful function [8].

Several reports have used fluoroscopic analysis to evaluate the kinematics of knee prostheses. For ACL-PCL knees, fluoroscopy showed limited anterior and posterior translation and position posterior to the midsagittal plane in all positions, as with normal knees [16,17]. In extension, the tibial component of the PCL prosthesis was posterior to the femur, showed anterior translation with flexion, and demonstrated exaggerated medial condyle translation with deep-knee flexion. The PS knees were stable in the midsagittal areas through positions when the post was engaged [16,17]. The most abnormal kinematics were seen in the PCL knees [16]. For the MP knees, the medial femoral condyle remained fully constrained, and posterior translation occurred in the lateral compartment, by design [7].

“Paradoxical motion” may be the reason that some patients have problems with some total knee arthroplasties. If the implant allows the femur to move forward on the tibia, the patient may sense this as an instability and may accommodate that perceived instability by altering his/her gait (eg, using a quadriceps avoidance gait). Conversely, if the prosthesis provides anterior/posterior stability, such as with the ACL-PCL and MP prostheses, patients may sense a feeling of stability. This may be the reason patients preferred these 2 types of prostheses in this study. In addition, patients may prefer ACL-PCL prostheses because of superior proprioception. Just as frequently, however, patients prefer the MP prosthesis. The MP prosthesis provides a single radius of femoral curvature. Quadriceps power is enhanced, especially in early flexion, by promoting early roll out of the femur. Greater leverage for the extensor mechanism is maintained by preventing anterior slide and shortening of the quadriceps lever/arm [18], which may also improve patellofemoral mechanics by engaging the patella earlier in flexion. Difficulties with the patellofemoral articulation have been suggested as a drawback of the PS prosthesis [19]. In addition, patients often cite superior single-leg weight-bearing flexion...
performance as an advantage for both the ACL-PCL and MP knee designs.

In conclusion, this study found that patients who underwent bilateral staged total knee arthroplasties were more likely to prefer retention of their ACL and PCL or substituting with the MP prosthesis. Because all current knee prostheses perform well, the paired bilateral study design may be optimal to assess patients’ preferences for 1 knee over another.

References