Midterm Results of Mobile-Bearing Total Knee Arthroplasty in Patients Younger Than 65 Years

R. Barry Sorrells, MD*; James B. Stiehl, MD**; and Paul E. Voorhorst, MS†

This study evaluated 117 patients younger than 65 years (average, 56 years) in whom mobile-bearing total knee arthroplasties were inserted. All patellae were resurfaced with a mobile-bearing patella implant. Followup averaged 102 months (range, 60–171 months). The average knee score was 91 points, with a pain score of 27 points (possible 30 points). There were eight (7%) revision surgeries in this series, with four malpositioned implants, one infection, and one case of osteolysis. Two patients had bearing revisions for bearing dislocation and polyethylene wear. Survivorship at 14 years was 88%.

Mobile bearings are used in total knee arthroplasty to reduce elevated contact stresses known to be a factor causing tibial polyethylene wear. Surfaces were made to be highly conforming, creating a high area of contact. The unconstrained mobility of these implants was desirable to reduce stresses and strains across fixation interfaces. Long-term results of fixed-bearing designs have shown high durability and clinical success in older patients with disabling arthritis of the knee. A few reports have shown satisfactory results of fixed-bearing total knee arthroplasties in younger patients at midterm to long-term followup of 10 to 15 years.

The current study determined if a mobile-bearing total knee arthroplasty offered a better outcome in patients younger than 65 years than did other methods. Specifically, problems such as periprosthetic osteolysis and exaggerated implant polyethylene wear were studied. In addition, the current study determined whether bearing-related complications were more prevalent using the mobile-bearing implant. The study included long-term followup of 117 patients in whom a mobile-bearing total knee arthroplasty had been done by one of the authors.

MATERIALS AND METHODS

From a consecutive series of 449 knee arthroplasties done from February 1984 until January 1993, one surgeon (RBS) performed 117 mobile-bearing total knee arthroplasties in 99 patients younger than

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65 years at the time of primary surgery. The implant used in all possible cases was the LCS rotating platform total knee prosthesis (DePuy/Johnson & Johnson, Warsaw, IN), which sacrifices and substitutes for the posterior cruciate ligament. Of the original cohort, 15 patients (18 knees) had died, and eight patients had revision surgery, leaving 74 patients (91 knees) with a minimum 5-year followup. Average followup was 102 months (8.5 years), with a range of 60 to 171 months. Eleven (12%) patients were lost to followup.

In all 117 knees (99 patients), the LCS prosthesis had been inserted without cement. All patellae had been resurfaced using a metal-backed mobile-bearing patella prosthesis that has a highly conforming polyethylene bearing that articulates with the prosthetic femoral condylar groove. Of the 99 patients, 46 were men and 53 were women. The diagnosis was osteoarthritis (69%), inflammatory arthritis (21%), and posttraumatic arthritis (10%). The average age was 66 years, with a range of 28 to 64 years.

All operations were done using a technique of initial resection of the proximal tibia followed with ligament and soft tissue balancing in extension. The tibial cut used an extramedullary guide and was determined to be perpendicular to the longitudinal axis of the lower extremity with posterior slope parallel to the original anatomy. A femoral anterior cortical reference and a positioner and spacer that referenced the cut tibial surface determined the femoral rotation and balanced the ligaments in flexion. The 15° posterior sloped distal femoral cut and the femoral valgus angle were set by an intramedullary alignment guide. The sloped distal femoral cut is necessary to accommodate the unique shape of the LCS femoral component. The technique requires careful attention to matching the flexion to the extension gap using block spacers.

Each patient was followed up at 3 months and 6 months after surgery and yearly thereafter. Evaluation was done using the 100-patient New Jersey Orthopaedic Hospital scale. Variables assessed included pain (0–30 points), function (0–25 points), range of motion (ROM) (0–15 points), deformity (0–12 points), stability (0–10 points), and strength (0–8 points). A score of 85 to 100 is rated excellent; 70 to 84 is good; 60 to 69 is fair; and scores below 59 are poor.

The New Jersey Orthopaedic Hospital scale was developed for the original Food and Drug Administration investigational device exemption study done with the LCS in 1984, of which many early patients in this study were entered. This system is most comparable to the Hospital for Special Surgery assessment scale, which has similar criteria for pain, stability, and outcome groups, such as good or excellent. Minor differences are seen with ROM (0–18 points), function (0–22 points), and strength (0–10 points). However, the specific questions and measurements for each scale are significantly unique and do not allow conversion of one system to the next.

Radiographic data included weightbearing anteroposterior (AP), lateral, and tangential patellar images. Measurements were made to determine the postoperative anatomic axis and alignment of the femoral, tibial, and patellar components in the coronal and sagittal planes. Postoperative radiolucent lines were recorded by zone (Fig 1). Fluoroscopic imaging was not used to determine implant positioning for interface assessment.

Significant changes between the preoperative and postoperative results were examined by means of a one-sample t test. Fisher’s exact test was used to analyze complications. Differences in survival rates were examined by life table methods.

RESULTS

Of the 91 total knee arthroplasties in 74 patients evaluated at a minimum of 5 years after surgery, the mean New Jersey Orthopaedic Hospital score improved from 61 to 91 (p < 0.001). Before surgery, 0% were excellent, 12% were good, 48% were fair, and 40% were poor. At final followup, 74% were excellent, 11% were good, 14% were fair, and 14% were poor. Preoperative pain was rated moderate to severe in 99% of patients, whereas after surgery, occasional or no pain was reported in 91% of patients (p < 0.001). The mean function score improved from 11 to 20 (p < 0.001). The average passive ROM improved from 104° ± 17° to 115° ± 14° (p < 0.001).

There was no gender difference with preoperative grouping or with postoperative analysis. The noninflammatory group, which included patients with osteoarthritis and posttraumatic arthritis, had a greater preoperative total score (p < 0.001) and function score (p < 0.001) than did the group of patients with...
rheumatoid arthritis, but there was no significant difference between groups for total score, function, or ROM. With age, younger patients had a lower preoperative total score (p = 0.001), function score (p = 0.029), and ROM (p = 0.007) than did older patients. However, there was no difference with age and postoperative total score, function score, and ROM. Patients with rheumatoid arthritis were younger than patients with noninflammatory arthritis at the time of surgery (average age, 48 years versus 58 years; p < 0.001).

Radiolucent lines occurred infrequently and were small, and nonprogressive (Table 1). No radiolucencies greater than 2 mm were observed, and no continuous lines were apparent around any component. There was one knee implant that accounted for all radioluencies of 1 to 2 mm in width (Zones 5, 6, 10, 11, 12), and this implant was revised.

Survivorship analysis, defined as revision for any reason, estimated at 14-years followup was 88.1% (95% confidence interval, 79.5% – 96.7%) (Table 2). There were eight (6.8%) patients with failed surgery, six patients requiring revision surgery, and two patients treated with bearing exchange. When the definition of failure was limited to unpreventable mechanical failure (excluding malposition and infection), there were three (2.6%) reoperations. The corresponding survival estimate at 14 years is 94.6% (95% confidence interval, 88%–100%).

Eight patients required revision surgery for implant-related problems. In two patients there was tibial component malpositioning with placement in exaggerated varus. Both components were revised because the patients experienced chronic pain at 100 and 104 months after surgery, respectively. Patellar malpositioning occurred in two patients, where the metal backing was placed such that rotation of the patellar polyethylene uncovered the metal-on-metal

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**Fig 1.** Diagram of radiographic zones used with the New Jersey Orthopaedic Hospital Knee Scale is shown.
### TABLE 1. Periprosthetic Radiolucencies Using New Jersey Orthopaedic Hospital Knee Scale

<table>
<thead>
<tr>
<th>Zone Number</th>
<th>No Radiolucency (%)</th>
<th>Less than 1 mm Radiolucency (%)</th>
<th>1–2 mm Radiolucency (%)</th>
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<tbody>
<tr>
<td>Femur lateral view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior 1</td>
<td>99</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Posterior 4</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Tibia AP view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral 5</td>
<td>91</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Cone 6</td>
<td>99</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Medial 7</td>
<td>93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tibia lateral view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior 10</td>
<td>90</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Cone 11</td>
<td>99</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Anterior 12</td>
<td>84</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Patella skyline view</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral 14</td>
<td>99</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Central 15</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Medial 16</td>
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<td>Patella lateral view</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Superior 17</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central 18</td>
<td>99</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Inferior 19</td>
<td>97</td>
<td></td>
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</table>

### TABLE 2. Survivorship Analysis of 117 Total Knee Arthroplasties With Mobile-Bearing Total Knee Prostheses

<table>
<thead>
<tr>
<th>Interval (Lower, Upper)</th>
<th>Number Failed</th>
<th>Number Censored</th>
<th>Effective Sample Size</th>
<th>Survival Failure</th>
<th>Standard Error</th>
<th>Lower 95% Confidence Interval</th>
<th>Upper 95% Confidence Interval</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>114.0</td>
<td>1.000</td>
<td>0.000</td>
<td>1.000</td>
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<tr>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>107.5</td>
<td>0.983</td>
<td>0.018</td>
<td>0.958</td>
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<tr>
<td>2</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>103.5</td>
<td>0.973</td>
<td>0.027</td>
<td>0.944</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>101.0</td>
<td>0.973</td>
<td>0.027</td>
<td>0.944</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>98.5</td>
<td>0.973</td>
<td>0.027</td>
<td>0.944</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>94.0</td>
<td>0.973</td>
<td>0.027</td>
<td>0.944</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>0</td>
<td>14</td>
<td>83.0</td>
<td>0.963</td>
<td>0.037</td>
<td>0.927</td>
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<tr>
<td>7</td>
<td>8</td>
<td>1</td>
<td>18</td>
<td>67.0</td>
<td>0.963</td>
<td>0.037</td>
<td>0.927</td>
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<tr>
<td>8</td>
<td>9</td>
<td>2</td>
<td>19</td>
<td>47.5</td>
<td>0.949</td>
<td>0.051</td>
<td>0.904</td>
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<tr>
<td>9</td>
<td>10</td>
<td>1</td>
<td>7</td>
<td>32.5</td>
<td>0.909</td>
<td>0.091</td>
<td>0.839</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>0</td>
<td>15</td>
<td>20.5</td>
<td>0.881</td>
<td>0.119</td>
<td>0.795</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>0</td>
<td>6</td>
<td>10.0</td>
<td>0.881</td>
<td>0.119</td>
<td>0.795</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
<td>0</td>
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<td>4.5</td>
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<td>0.119</td>
<td>0.795</td>
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<tr>
<td>13</td>
<td>14</td>
<td>0</td>
<td>1</td>
<td>1.5</td>
<td>0.881</td>
<td>0.119</td>
<td>0.795</td>
</tr>
</tbody>
</table>

Summary of results: Total = 117; Failed = 8; Censored = 109; % censored = 93.1624.
contact with the lateral femoral condyle and exaggerated wear. These revisions occurred at 22 and 67 months after surgery. Only one revision surgery was done in a patient younger than 50 years; there were 16 knees in this subset of patients with greater than 5-years followup.

One patient had radiographic evidence of severe medial polyethylene wear at 85 months and definite periprosthetic osteolysis but had no symptoms at the time of revision surgery. Subsequent analysis of the retrieved polyethylene bearing revealed significant fusion abnormalities in the polyethylene. An additional patient without osteolysis had revision surgery at 104 months for tibial and patellar polyethylene wear. There was one case of bearing dislocation or spinout that occurred 3 weeks after surgery. This was resolved with a bearing exchange to a large, more constrained deep-dish bearing. One patient had an acute postoperative infection treated successfully with two-stage revision.

**DISCUSSION**

Long-term results of total knee arthroplasty have shown fixed-bearing total knee prostheses to be durable for older patients with osteoarthritis and rheumatoid arthritis, with a survivorship of 95% to 97% reported at 10 to 15 years and 90% at more than 20 years.\(^{12,18,19,25,27,28,31–35,38,44,46}\) Mobile-bearing total knee arthroplasties have had similar overall long-term results with a few reports of survivorship of 92% to 98% at 7 to 14 years. Jordan et al\(^{22}\) found survivorship of 94.6% at 8 years in 410 total knee arthroplasties with the LCS meniscal-bearing implant that retains the posterior cruciate ligament. In that series, mobile-bearing breakage, dislocation, or subluxation was seen in 3.6% of cases. Stiehl and Voorhorst\(^{39}\) reported the results of the initial LCS Food and Drug Administration clinical trial, which found an overall 7-year survivorship of 98.1%. In that series, the overall bearing-related complication rate was 0.6%, whereas the incidence of patella fracture or subluxation was 1%. Sorrells\(^{36}\) reported long-term results of 525 total knee arthroplasties with the LCS rotating platform implant, finding an overall revision rate of 5% and survivorship of 92% at 13-years followup.

Several previous studies evaluated total knee arthroplasty in patients younger than 55 years, but these patients were evaluated predominantly for nonosteoarthritic diagnoses, including rheumatoid arthritis, hemophilia, and posttraumatic arthritis.\(^{14,29,40}\) Stuart and Rand\(^{40}\) evaluated 26 patients with rheumatoid arthritis younger than 40 years at the time of total knee arthroplasty, finding 86% good or excellent results at 5-years followup. Ranawat et al\(^{20}\) evaluated 90 patients younger than 55 years at the time of total knee arthroplasty, of whom 81% had rheumatoid arthritis, finding 97% good or excellent results at an average of 6-years followup. Duffy et al\(^{14}\) evaluated 74 total knee arthroplasties in patients younger than 55 years, of whom ½ had rheumatoid arthritis, finding implant survival to revision of 95% at 15 years.

Three other studies specifically evaluated younger patients with osteoarthritis.\(^{13,37,42}\) Stern et al\(^{37}\) analyzed 50 patients younger than 55 years with an average followup of 6.2 years using a posterior stabilized total condylar prosthesis. They found good or excellent results in all patients when considering only the femoral and tibial components.\(^{35}\) However, the overall failure rate was 5% if revision of metal-backed patella components was included. In that study, significant radiolucent lines were identified in approximately 20% of tibial and patellar-implant interfaces. Their conclusion was that total knee arthroplasty results in younger patients were comparable with results in other published reports regarding older patient groups.\(^{9,21,35}\) Diduch et al\(^{13}\) evaluated an expanded group of patients included in the subset of Stern et al\(^{37}\) with an average followup of 8 years (range, 3–18 years). Seven of 108 total knee arthroplasties had been revised, with a survivorship of 87% at 18 years. Taylor et al\(^{42}\) evaluated 67 total knee arthroplasties done in patients younger than 50 years with a minimum of 5-years followup, and all were done with a posterior-cruciate retaining de-
vice. With an average followup of 9 years, more than 22% had been revised with 10-year survivorship of 78% and 15-year survivorship of 71%.

In the current study, a rate of survivorship to revision of 88% was seen. The average functional knee score was 20 (possible 25), which compares favorably with scores reported in other studies of the LCS using the New Jersey Orthopaedic Hospital Knee Score, which ranged from 19 to 22.4,6,22,23 The overall revision rate was 7%. However, five of eight cases were attributable to problems that were inherent with the early surgical technique using this system. Initially, there were only two available sizes, and instrumentation was relatively primitive by today’s standards. Only one case of radiographic osteolysis was identified in a woman who was active and overweight. Late radiographic polyethylene wear has not been apparent in any of the long-term clinical followups.

The current study showed a low incidence of radiographic lucent zones, with the highest rate of 15% seen about the medial tibial component of the LCS rotating platform knees. The incidence of lucent lines about the femurs was extremely low, being less than 1% in all zones. Radiographic lucencies greater than 1 mm were identified about the tibial component of only one knee. Fluoroscopic positioning was not used in any of the patients, and interpretation of findings about cementless implants may significantly underestimate the true prevalence of lucencies in the current report. In addition, subsidence was not measured by referencing a fixed point such as a tantalum marker. The presence of radiolucent lines about the mobile-bearing implants in the current study seemed to be considerably lower than that reported in the literature.25

The prevalence of complications related to the patella range from 4% to 21% in the literature, with incidence of radiolucent lines adjacent to the patella component from 39% to 72%.25,41 There was a paucity of patellar problems using the LCS mobile-bearing patella, with fracture and subluxation the primary complications seen in 2.6% of cases. The incidence of radiolucent lines was at a maximum of 3% about the inferior patella on the sagittal plane view. This satisfactory performance of patellar resurfacing could be attributed to the anatomic femoral design, which has a deepened patellofemoral groove and requires intercondylar notch bone removal to accommodate the prosthesis. The LCS rotating patella prosthesis has an anatomically shaped surface compared with most other implants, which are dome shaped. One other fixed-bearing anatomically shaped patella has had an unacceptably high failure rate, suggesting the benefit of the mobile-bearing feature.43 One disadvantage of the LCS patella is its relative thickness, requiring a minimum of a 9-mm resection to accommodate the smallest implant.6,7 This feature seems to be well compensated by the deep trochlear groove and the sagittal plane geometry of the femoral implant that anatomically matches the shape of the natural femur and places the patellofemoral articulation in the natural position.

Mobile-bearing failure attributable to implant dislocation or fracture has been a major concern with implants such as the LCS meniscal-bearing, cruciate-retaining prosthesis. Goodfellow and O’Connor20 reported mobile-bearing dislocation or subluxation in 7% of the their initial 114 patients but experienced no problems in the next 135 patients. Technical details, such as restoring physiologic ligament tension and placing the mobile bearings in a kinematically correct unconstrained position, were reported as essential features for success. Murray et al26 reported a 10-year survivorship of 98% using the Oxford unicompartmental knee prosthesis, with only one case of bearing dislocation of 143 knee arthroplasties. They recommended that both cruciate ligaments be present for the Oxford knee prosthesis to be successful.26 Only one case of bearing dislocation was identified in the current series, but with appropriate flexion space ligament balancing, rotating platform bearing spinout has become a rare occurrence.

Polyethylene wear is an important mecha-
nism of failure, causing osteolysis and subsequent implant loosening. This problem was not seen commonly with earlier posterior cruciate-sacrificing and substituting prostheses but increased dramatically with posterior cruciate-retaining implants. Design features, such as flat-on-flat noncongruent articulations and thin polyethylene inserts, along with abnormal kinematic motion patterns have been implicated as factors that increase wear problems. Schai et al recently reported a 10-year followup of a nonconforming flat fixed-bearing tibial insert used with a posterior cruciate-retaining total knee arthroplasty, finding an 8% incidence of wear-related problems. Collier et al evaluated the LCS mobile-bearing prosthesis for wear, finding minimal scratching and burning of the tibial insert compared with most other fixed-bearing implants. In addition, contact stress analysis levels were approximately ⅓ of those seen with fixed-bearing inserts. The authors were encouraged by the rare occurrence of osteolysis in the LCS long-term followup group, with only one documented case in the current study.

The midterm results of younger patients using a rotating platform mobile-bearing total knee arthroplasty seem to be comparable with results from studies involving older patient groups. However, these results do not seem to exceed the results reported with the use of fixed-bearing design knee prostheses in younger patients. It is anticipated that patients with osteoarthritis who comprised most of the patients in the current study would be more active, with a greater chance for late wear-related problems. However, only two patients in the current study had evidence of osteolysis or late implant wear. The primary concern for using mobile-bearing implants relates to potential complications related to the surgical technique. Recent improvements in instrumentation and careful attention to ligamentous balancing would have eliminated several of the early failures seen in the current study. Additional followup is required to determine whether these improvements will produce better long-term results with the use of mobile-bearing prostheses in younger patients than is obtainable with fixed-bearing designs.

References
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