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A Prospective Randomized Study of Bicompartmental vs. Total Knee Arthroplasty with Functional Testing and Short Term Outcome

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ABSTRACT

The purpose of this study was to compare 50 bicompartmental knee arthroplasty (BKA) and total knee arthroplasty (TKA) cases, particularly in restoring knee function. Patients were between 30 and 65 years old, with a BMI under 35, and had osteoarthritis in the medial and patellofemoral compartments. Knee Society scores, Oxford questionnaires, radiographs, and functional tests were performed preoperatively, and at 1, 4, 12, and 24 months postoperatively. Functional testing included gait analysis, stair climbing, lunging, and sit-to-stand analysis. Both groups achieved equivalent Knee Society scores (2 year mean 93.6 vs. 92.6, $P = 0.43$) and Oxford scores (2-year mean 43 vs. 41, $P = 0.35$). Functional testing showed significant improvement. Two years postoperatively the BKA and TKA groups achieved equivalent results in clinical scores and functional testing.

Total knee arthroplasty (TKA) is an effective and reliable treatment for osteoarthritis of the knee. In 2007 a bicompartmental prosthesis for the medial and patellofemoral compartments was released to treat patients with mild or absent lateral compartment arthritis [1,2]. The geometry of the prosthesis allowed retention of both the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL). Some small cohort studies have reported kinematics of the bicompartmental knee arthroplasty (BKA) in the gait and biomechanics journals, but there is a lack of prospective randomized studies about the function of knees with these prostheses in the arthroplasty literature [3,4].

Since the ACL is sacrificed without substitution in TKA, joint motion of a total knee patient possesses some features in common with that of an ACL-deficient patient. Gait studies of ACL-deficient knees and TKA patients have shown knee motion that is different than that of an intact knee [5–7]. A small study of 8 BKA patients by Wang et al. showed that those patients had gait patterns and knee mechanics comparable to healthy control subjects [4]. We sought to measure improvements in function as well as clinical and satisfaction scores in a larger group of patients that retained their ACL following a BKA compared to TKA patients with a similar preoperative level of arthritis in the medial and patellofemoral compartments. Based on previous kinematic studies, we hypothesized an improvement in function of BKA patients beyond that of TKA patients [3,7,8].

Activities of daily living impacted by having an ACL and normal knee motion include stair climbing and descent, rising from a chair, and pivoting. The purpose of this study was to assess any difference in clinical outcome or knee function in patients with the Journey Deuce Bicompartmental Knee System (Smith & Nephew, Andover, MA) at 1 month, 4 months, 1 year, and 2 years postoperatively when compared to TKA using the Genesis II Total Knee System (Smith & Nephew, Andover, MA).

Methods

A prospective, randomized study was undertaken to compare the functional and clinical outcome of 50 patients with bicompartmental arthritis treated with either a BKA or TKA. Enrollment in the study required patient consent, age between 30 and 65 years, BMI under 35, no prior knee surgery, and no hip arthritis or arthroplasty. All patients had non-inflammatory degenerative joint disease of the medial and patellofemoral compartments and intact cruciate ligaments preoperatively. The lateral knee compartment was disease-free. Seventy primary unilateral knee arthroplasty patients were screened for the study. Preoperative examination included a clinical evaluation, medical history, radiographs, Knee Society score, Oxford score, and functional testing [9–15].

Patient function was measured with several validated tests. The first test we used was the timed Functional Assessment Test [16], which reflects the speed of walking and stairclimbing [12]. While being timed, the patient rises from a chair, walks 30 feet, climbs 4 stairs, turns around, descends the stairs and walks 30 feet back to the chair. The test ends when the patient is seated again. In addition, function was tested on a BalanceMaster long force plate (Neurocom, a division of Natus, Clackamus, OR) with the step-over protocol, the sit-to-stand protocol, and the forward lunge protocol [14] (Fig. 2). For the step-over protocol the patient steps up onto an 8-inch step with one foot, lifts the *other* foot over the step, and steps down onto it

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on the floor on the far side of the step. After 3 trials, this is repeated, leading with the contralateral leg. Time to complete the test as well as the lift-up force and impact force were recorded. The sit-to-stand protocol, while performed on the force plate records the projection of the patient's center of gravity and the time it takes to rise from a seated position. For the forward lunge protocol, the patient lunges forward three times with each foot, which reflects strength and symmetry of motor control. Forces are measured as they step and as they return to upright posture. The length of their step is measured as a percentage of body height, and the difference between left and right legs is also recorded. This test challenges the quadriceps mechanism and the stability of the knees. Patient gait patterns such as step length, width, and speed were recorded with a portable gait lab device which uses accelerometers at five positions on the feet, thighs, and chest (IDEEA, Minisun, CA) [13]. This device was worn during the FA test and the Neurocom BalanceMaster protocols.

A power analysis was performed to determine that a sample size of 25 patients in each group provided at least 80% power to detect a difference of 10% for the KSS score and an alpha value of 0.05. Sample size estimates were based on standard deviation of the outcome measures observed at the 2-year follow-up in prior clinical studies of the Genesis II Knee System. We used a repeated measures statistical test to compare the means at each interval, with a Bonferroni adjustment for repeated comparisons.

At the time of surgery, the articular knee cartilage was visually inspected. Patients with lateral compartment arthritis, requiring TKA, were not entered into the study. Likewise, patients with unicompartmental arthritis received a unicompartmental knee arthroplasty and were not entered into the study. Twenty patients fell into these screen failure categories. The 50 remaining patients had arthritis limited to the medial and patellofemoral compartments. For those 50 cases, a sequentially numbered envelope was opened that specified via a 1:1 randomization schedule whether that patient would receive a Deuce BKA or a Genesis II TKA. Average patient age was 60.3 years in the BKA group (range 53–65 years) and 58.3 years in the TKA group (range 45–65 years); $P = 0.09$. Patients in both groups had similar preoperative BMI, knee scores, Oxford scores, and function (Table 1).

Fig. 1. Model of a left bicruciate-retaining knee implant.

The BKA was the Journey Deuce (Smith & Nephew, Andover, MA), shown in Fig. 1. The tibial component is the same as that of a medial Journey unicompartmental knee arthroplasty. The femoral component covers the medial femoral condyle as well as the patellofemoral groove. The patellar component is the same as a TKA patellar button. The BKA replaces only the medial and patellofemoral compartments and preserves both cruciate ligaments. The Genesis II TKA components (Smith & Nephew, Andover, MA) used for this study replaces the medial, lateral, and patellofemoral compartments and preserves the posterior cruciate ligament, but sacrifices the ACL. All cases were performed by a single surgeon.

The surgical approach and postoperative course were identical for both groups. A medial parapatellar approach was used in all cases, and the length of the incision was measured for each case in millimeters. The patella was completely subluxed and everted to allow resurfacing of the patella. The retraction was more extensive with the total knees to gain full access to the lateral compartment with more tissue dissection in the posterolateral corner to remove the lateral tibial plateau. The tibial side of the BKA was performed in a manner similar to a unicompartmental knee, whereas the femoral and patellar technique was more similar to a total knee. None of the patients required transfusions for blood loss during the course of their treatment. Continuous passive motion (CPM) devices were used throughout the hospital stay. Patients received physical therapy in the hospital on day 1 and 2 and were discharged to home with partial weight bearing on day 2. Patients returned for postoperative follow-up examinations at 1, 4, 12, and 24 month intervals. At each interval they were evaluated clinically, radiographically, and functionally. Each patient received a Knee Society score, filled out an Oxford survey, a satisfaction survey, and repeated the functional testing of their knees. All adverse events and reoperations were recorded.

Results

Clinical Results

Table 1 shows a summary of the outcome variables for each group at each study interval. By clinical scores, both groups improved significantly over the first two years following surgery but did not vary significantly from each other. Average Knee Society scores improved over 40 points in each group. Oxford scores, which rate the ease with which patients perform daily activities, nearly doubled after two years in both groups from 22 to 43 (BKA) and 22 to 41 (TKA), $P = 0.35$.

Radiographically each group had cases with small lucencies. Four of the BKA tibial components showed a radiolucent line under the tibial component. In the TKA group, there were radiolucencies in 2 femurs, 1 patella, and 3 tibias. One of the TKA cases had a complete tibial radiolucency, and that case went on to be revised for tibial loosening. The average length of the surgical incision was shorter but not statistically so in the BKA group (136 mm vs. 145 mm, $P = 0.1$).

Function Results

All patients showed improved function over the course of the study in many of the functional tests from the preoperative