POLYETHYLENE CONTACT AREA AND ARTICULAR WEAR PATTERNS IN CRUCIATE-RETAINING VERSUS CRUCIATE-STABILIZING TOTAL KNEE ARTHROPLASTY: IMPLANT RETRIEVAL STUDY USING THE SAME PROSTHESIS

INTRODUCTION: Polyethylene failure and the factors contributing to this failure have been a focus of industry wide research for many years. It has been suggested that abnormal knee kinematics may play a role in polyethylene wear. This study examines knee implants retrieved at revision surgery. All implants are Johnson and Johnson Pressed-Fit Condylar (PFC) models and are either posterior-stabilized or cruciate-retaining. The purpose of this study is to determine if wear patterns and points of articular contact differ between posterior-stabilized and cruciate-retaining knee implants of the same model retrieved at revision surgery.

METHODS: From 1990-1999, 27 patients underwent revision knee arthroplasty after having prior knee replacement with a PFC Knee system (Johnson and Johnson). Fourteen of these patients had posterior-stabilized PFC systems prior to revision while 13 patients had cruciate-retaining PFC knees. The reason for revision was similar in both groups with infection (41%) and osteolysis (30%) most common overall.

All revision arthroplasties were performed by one of three total joint surgeons at this institution with patient records available for review. At the time of revision surgery, all retrieved PFC implants were submitted to the Dartmouth Biomedical Engineering Center to undergo implant analysis. These patients were all revised using a PFC posterior-stabilized knee system, regardless if their primary arthroplasty was posterior-stabilized or cruciate-retaining. Patients’ records were reviewed at an average of one year post-revision with documentation of increased range of motion in almost all cases and radiographic evidence of intact bone-implant interface and good alignment.

Implant analyses were then performed at the DBEC on all 27 implants received. Measurements of half the implants were initially made using a digital camera and NIH Image computer software (NIH, Bethesda, MD). Medial and lateral compartments were measured and recorded separately. The anterior-posterior limit of each polyethylene articular surface was then compared to the actual articular track in an anterior-posterior direction. Next, a comparable analysis was made in a medial-lateral direction. Also, the distance between the posterior portion of the articular track to the posterior limit of the polyethylene of the tibia insert was calculated. The polyethylene not available for measurements were either sectioned for oxidation analysis, embedded, etc. during prior studies. Student T-tests were used to compare differences in the two groups.

RESULTS: Of 27 patients, fourteen of these patients had posterior-stabilized PFC systems prior to revision while 13 patients had cruciate-retaining PFC knees. Group characteristics such as age, gender, duration, primary disease, and reason for revision were similar. All patient records were reviewed for comparison of clinical exam and radiographic findings. Upon examination, prior to revision, passive flexion was documented in 10 of 14 posterior-stabilized patients to be a mean of 105 degrees (range, 60-140) while in 10 of 13 cruciate-retaining patients, mean flexion was 96.5 degrees (range, 60-135).

Wear patterns did appear different between posterior-stabilized and cruciate-retaining groups. Ten posterior stabilized polyethylene trays (71%) showed existence of rotational motion while only 4 cruciate-retaining inserts (31%) displayed the same. Furthermore, 5 cruciate-retaining implants (38%) showed no evidence of femoral rollback. All posterior-stabilized implants, as expected, showed evidence of femoral rollback.

Nineteen of the 27 polyethylene tibial inserts were available for contact area mapping. Ratios/percentages for articular track/articular limit were calculated in an anterior/posterior and medial/lateral direction. Marked differences in contact area and position of the contact surface were found.

Of the nine implants in the posterior-stabilized group, 8 medial and 8 lateral compartments were analyzed. Of these 16 compartments, 11 (70%) demonstrated full use of the articular surface. The 10 cruciate-retaining implants had 10 medial and 7 lateral compartments analyzed. Of those 17 compartments, only 2 (12%) demonstrated full use of the articular surface.

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DISCUSSION: The implications of this study should be cautiously drawn. Most apparent is the pattern of articular contact as it differs between those implants preserving the posterior cruciate, and those substituting for it. If the expectation of preservation of the posterior cruciate ligament is to maintain its effect on the knee’s kinematics, this study suggests that that particular goal is not being achieved. The pattern of articular contact in cruciate-retaining knees demonstrates little or no migration of the femoral contact surface across the tibial polyethylene plateau. In particular, most of the changes visible in the tibial plateau suggest that the femoral contact surface moves about on the tibial plateau very little, and only rarely achieves any degree of roll-back.

This observation may suggest that posterior cruciate retaining total condylar knee designs are not achieving roll-back, and this observation may offer at least partial explanation for the observation of the difference between preserving and substituting designs in the degree to which they each achieve flexion motion post-operatively.

Whether these observations also imply differences in the consequences to in-vivo stresses for the polyethylene will require further analysis, and is beyond the scope of this study. The polyethylene of the tibia does appear to be subjected to more of a pure sliding array of stresses in the posterior cruciate retaining designs, whereas it appears that the cruciate substituting designs subject the tibia to a greater combination of sliding and rolling. As more data provides additional insight into the wear mechanisms of the two designs, this observation about contact patterns may have more light to shed.

In posterior-stabilized knee implants, a mean of 93% of the articular surface was used by the articular track in an anterior-posterior direction. In comparison, only a mean 59% of articular surface was used by cruciate-retaining implants in an anterior-posterior direction (p<.001). Average distance from the posterior aspect of the articular track to the posterior limit of the polyethylene also differed. This mean distance was .08 cm for posterior-stabilized implants and .97 cm for cruciate-retaining implants (p<.001). In summary, the contact area for cruciate-retaining knees was not only much smaller than posterior-stabilized implants, but they were also situated more anterior. This is further evidence of lack of femoral rollback in cruciate-retaining knees.

In contrast, posterior-stabilized knees demonstrated full use of the articular surface, which may be due to the design of the implant allowing for more natural motion and load distribution. A deeper understanding of these differences could lead to improved designs that better mimic natural knee kinematics.

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Poster Session - Implant Wear - Hall E