ANALYSIS OF RETRIEVED UHMWPE TIBIAL COMPONENTS FROM ROTATING PLATFORM TOTAL KNEE REPLACEMENTS

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INTRODUCTION:
The success of a total knee replacement (TKR) depends in part on the mechanical performance of the prosthetic components. Wear damage of ultra high molecular weight polyethylene (UHMWPE) components, producing particulate debris, has been shown to be inversely related to the longevity of the implant (1). The rotating platform, or mobile bearing TKR was designed to increase the contact surface area between the femoral and tibial components, thus decreasing contact stress (2-4). Decreasing contact stress should decrease UHMWPE damage and wear (2). However, there has been some concern that increasing surface area in these designs might lead to increased fine wear debris, with an associated increase in osteolysis.

The objective of this study was to evaluate the performance of mobile bearing TKRs retrieved at our institution, particularly with respect to wear damage of the UHMWPE tibial components and osteolysis.

METHODS:
Between 1997 and 2006, 40 rotating platform TKRs (32 Low Contact Stress, 8 Press Fit Condylar) were revised at our institution from 38 patients (24 female, 14 male). 30/40 of tibial trays were cemented. The mean patient age was 62.2 ± 11.3 years (range 31-84) and the mean weight was 97.2 ± 20.4 kilograms (range 58-138). Implant retrieval was conducted under an IRB-approved protocol. For 9 of the retrieved TKRs, only the year of the primary operation was known, therefore, for those retrievals, an estimate of 6 months was used for the first year of implantation. Using this assumption, the mean implantation time for the 40 retrievals was 27.5 ± 35.3 months (range 0.3 to 191.3 months). Indications for revision surgery included infection (16/40), aseptic loosening (15/40), soft tissue imbalance and instability (5/40), restricted range of motion (4/40), and patellofemoral pain (1/40).

Wear damage analysis was performed on the UHMWPE tibial articulating surfaces following Hood et al. (5). The superior and inferior articulating surfaces were examined visually and at 10x magnification using a stereomicroscope. Seven surface damage modes were evaluated on the superior surface: pitting; scratching; burnishing; embedded particulate debris; abrasion; permanent deformation; and, delamination. The surface was divided into 10 sections and a grading scale of 0-3 was allotted to each section for each damage mode. The inferior articulating surface was analyzed for the presence of pitting and scratching and an overall score of 0-3 was assigned for each of the two damage modes. Two independent observers assessed the components and total damage scores of the superior surface and of the inferior surface were obtained. Mean total damage scores of the superior and inferior surfaces were determined for the 40 retrieved UHMWPE tibial components.

AP radiographs taken prior to revision surgery were available for 30/40 TKRs and were analyzed for varus/valgus alignment. An osteolysis score was determined for 28/40 TKRs using both AP and lateral radiographs of the tibia and femur according to the Knee Society evaluation system (6). The total damage scores were correlated to implantation time, patient weight, and osteolysis score.

RESULTS:
Wear damage analysis of the superior articulating surface showed pitting in 40/40, scratching in 40/40, burnishing in 24/40, embedded particulate debris in 21/40, abrasion in 20/40, permanent deformation in 16/40, and surface delamination in 1/40 retrieved components. The mean total damage score was 47.1 ± 15.7 (range 18-86). On the inferior articulating surface, 40/40 implants displayed pitting and 40/40 displayed curvilinear scratching (Fig. 1). The mean total damage score was 3.4 ± 1.2 (range 2-6) for these two modes. Summation of the damage scores for the superior and inferior articular surfaces revealed a mean damage score of 50.5 ± 16.4 (range 21-91). There was a significant positive correlation when the summated total damage score was compared to implantation time (r²=0.31, p<0.001). There was a significant negative correlation when comparing patient weight and summed total damage score (r²=0.25, p=0.001).

Mean varus/valgus alignment was 3.3 ± 6.2° of valgus (range 24° valgus - 9° varus). 12 TKRs had a varus/valgus alignment outside of the standard acceptable range of 1° to 6° of valgus alignment. The mean total damage score of the summated superior and inferior articulating surfaces was not significantly higher within this subset (53.4 ± 14.2). The mean osteolysis score was 17.6 ± 13.2 (range 2-63). There was no significant correlation between the summated total damage score and the osteolysis score.

Figure 1. Curvilinear damage on the inferior surface of the UHMWPE component and tibial tray.

DISCUSSION:
The physiologic reaction to particulate debris has influenced the design of TKRs to minimize the amount of UHMWPE wear damage. The rotating platform/ mobile bearing TKR designs attempt to achieve this by reducing UHMWPE contact stress through highly congruent articulating surfaces. Kinematics is also thought to be improved through the use of dual articulating surfaces (2, 3). In this study, there was a positive, though weak, correlation to implantation time and overall damage score. All 40 components had damage on both articulating surfaces. The curvilinear scratching observed on the inferior surface has also been observed by others for both cemented and cementless components (7) and is believed to be associated with third body wear. The negative correlation between damage score and patient weight may reflect a lower patient activity level with increase in weight. Osteolysis was cited as the reason for revision in 37.5% of the revision surgeries and some amount of radiolucency and/or osteolysis was observed radiographically in 100% of the cases prior to revision. Although mobile bearing TKR designs decrease contact stress, the findings of this retrieval study demonstrate that the UHMWPE tibial components are still susceptible to wear damage with subsequent osteolysis and that aseptic loosening is a significant reason for revision.

REFERENCES:

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