Retrieval Analysis of Femoral Zirconium Components in Total Knee Arthroplasty

Preliminary Results

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Abstract: Safety of oxidized zirconium (OxZr) in total knee arthroplasty (TKA) has been supported by biomechanical, clinical, and radiologic data. Retrieved OxZr femoral components and corresponding polyethylene (PE) inserts were examined to rule out patterns leading to early failure. Sixteen retrieved TKA with an OxZr femoral component were included. The PE inlays were analyzed applying an established scoring system for wear and surface damage. Femoral components were screened for scratching, pitting, delamination, and striations. The prostheses were in situ for 16.4 ± 11.9 months. The average wear and damage score for the tibial PE inserts was 36.0 ± 12.7. The average score in the visual analysis of the OxZr femoral components was 1.3 ± 1.3. The data presented in this study did not show major wear of the PE in TKA using OxZr components. In this cohort, there were no failures directly related to this implant.
Keywords: total knee arthroplasty, oxidized zirconium, Oxinium, polyethylene, wear analysis, femoral component.

Wear of polyethylene (PE) in total knee arthroplasty (TKA) is a major long-term failure mode. Its sequelae include osteolysis, implant loosening, and instability. Because average patient age when receiving TKA is decreasing, and as expectations and demands for TKA are growing, minimization of wear is an essential goal. Attempts to minimize PE wear include the use of more conforming articular surfaces and various modifications of PE mechanical and chemical properties.

Another recent approach to decrease PE wear has been the introduction of an oxidized zirconium (OxZr) counter surface on the femoral component of the prosthesis. The component is fabricated from an alloy of zirconium and niobium (Zr-2.5 Nb) that is oxidized in an attempt to provide the wear resistance of a ceramic with the ductility of the underlying metallic alloy. Thermal diffusion creates a zirconium oxide layer with a thickness of about 5 μm [1]. The advantages of ceramic surfaces in decreasing wear have long been established through biomechanical testing [2], and clinical improvments in wear of zirconia-on-polyethylene compared to a conventional metal-on-polyethylene bearing combination were shown in prospective, randomized studies [3,4].

Oxidized zirconium implants have been in clinical use since 1997 in TKA. Improved wear performance over that of cobalt alloy, the most frequently used metallic bearing surface, was demonstrated in knee simulator tests [5]. The clinical safety and efficacy of oxidized zirconia in TKA were shown in a randomized controlled trial [1], with no adverse effects observed within the first 2 years after implantation. But except for these short-term results, little is known of the in vivo wear performance of oxidized zirconia TKA components. The aim of this study, therefore, was to examine retrieved components as a means of quantitatively describing wear patterns on both the PE and oxidized zirconia bearing surfaces. The primary goal of this descriptive study was to rule out early major wear or other damage patterns that might lead to early failure attributable to the use of oxidized zirconia in TKA.

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Material and Methods

Sixteen partially or completely explanted TKAs were included in the study. All had an oxidized zirconia femoral component (Oxinium, Genesis II, Smith and Nephew, Memphis, TN). The corresponding tibial components were all modular with a PE insert in a titanium alloy (Ti-6Al-4V) base plate. The PE tibial insert was retrieved for all 16 cases, the femoral component was available for 15 of the cases, and the patellar component was explanted in 6 cases (all 6 were of the all PE inset design). Eleven metallic tibial base plates were explanted and analyzed.

All components were removed during revision at the Hospital for Special Surgery between October 2003 and November 2007 and maintained in the institution's ongoing institutional review board-approved retrieval analysis program. Implants were ultrasonically cleaned in a mild detergent bath. No other cleaning or sterilization method was applied before examination of the retrievals. Care was taken to minimize extraneous damage during cleaning, processing, storage, and handling during examination.

Components were cataloged with an identification number to provide patient anonymity. Patient medical records were screened, and revision diagnoses as well as age, sex, side, body mass index (BMI), and the primary diagnosis that led to TKA were documented. The main revision diagnosis was determined from the operative report.

Emphasis was placed on the amount and severity of surface damage, gross deformation, and cracks occurring on the bearing surfaces of the femoral component and the PE insert. The femoral components were inspected visually and at 8 to 32× magnifications in a light stereomicroscope. Four modes of wear on the oxidized zirconia

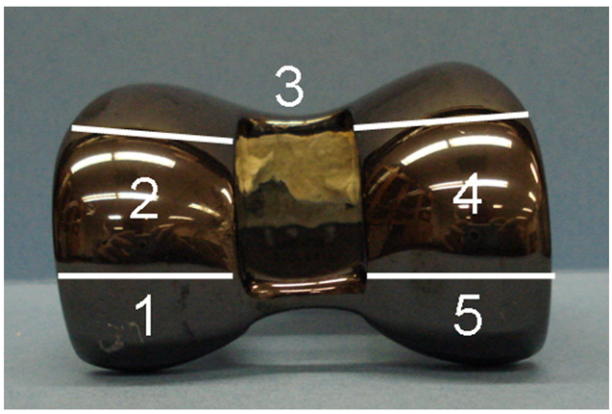

Fig. 1. For description of wear, the femoral component was divided into 5 areas: zone 1 was the medial flexion contact area, zone 2 was the medial extension contact area, zone 3 comprised the patellofemoral contact area, zone 4 covered the lateral extension, and lastly, zone 5 was the lateral flexion contact area. Four qualities of wear (scratches, delamination, pitting, and striation) were graded as present or absent.

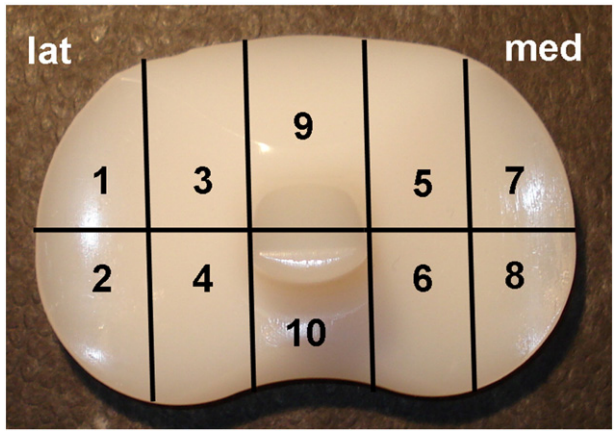

Fig. 2. The partition system for retrieved inlays according to the grading by Hood, Wright et al is shown. This system includes a 0 to 3 scale to evaluate both, severity and amount of each of the seven damage modes of the PE (surface deformation, third body debris, scratching, burnishing, delamination, pitting, and abrasion).

patellofemoral and the femorotibial bearing surfaces were assessed as being present or absent: scratches, delamination, pitting, and striations. The femoral component was divided into 5 areas: zone 1 was the medial flexion contact area; zone 2, the medial extension area; zone 3, the patellofemoral area; zone 4, the lateral extension area; and lastly, zone 5 was the lateral flexion area (Fig. 1).

The retrieved PE inserts (and, if available, the patellar component) were analyzed for wear damage by applying an established subjective grading system [6], which uses a 0 to 3 scale to evaluate both severity and amount of each of 7 PE wear modes: scratching, burnishing, pitting, delamination, third body debris, surface deformation, and abrasion (Fig. 2). The bearing surfaces of the components (each tibial plateau and the patellar surface) were divided into quadrants. Grade 0 was assigned if the wear mode was absent in a particular quadrant. Grade 1 was applied if less than 10% of a quadrant's surface was affected. Grade 2 was applied if 10%to 50% of the surface was affected, and grade 3 if more than 50% of the surface was affected. Wear scores for each section were added to obtain a total wear score. The theoretical maximum wear score for a single section was 21 (the sum of grade 3 for all 7 wear modes), 210 for an entire insert, and 84 for the entire patellar component. All components were graded randomly on 3 separate occasions by an independent observer blinded to the demographic and clinical data.

Prerevision radiographs were evaluated, including anteroposterior, lateral, merchant, and long-leg standing views. Radiographs were analyzed for alignment, component positioning, and signs of loosening [7].

Results

This series included retrieved TKA components from 16 patients (7 female, 9 male; 11 right and 5 left TKA).