INTRODUCTION:
Mobile bearing knee designs are intended to resolve the conflict between conforming bearing surfaces to reduce wear and non-conforming surfaces to reduce load transfer to fixation interfaces. The mobile bearing between the tibial insert and tray allows rotation about a longitudinal axis. Mobile bearing designs should be resistant to wear and surface damage, but little data on wear at the bearing and insert-tray surfaces have been reported. We assessed the severity and symmetry of polyethylene (PE) wear on retrieved tibial insert surfaces. Evidence for 3rd body debris was analyzed under scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDAX). Finally, relationships between subjective wear grades and clinical and radiographic data were examined to determine what, if any, factors contribute to wear in these designs.

MATERIALS AND METHODS:
We examined 48 retrieved mobile bearing implants (LCS and PFC Sigma, DePuy, Warsaw, IN), 35 of which included the metallic femoral components and tibial trays along with the PE tibial inserts. To assess PE wear modes and their severity, each implant was divided into 18 regions (Fig. 1) and graded on a 0-3 scale for 7 wear modes—scratching, pitting, burnishing, embedded debris, creep, abrasion, and delamination. Implants were then digitally photographed on both surfaces and worn areas outlined (Fig. 2). The total bearing surface areas were also outlined. Using ImageJ (NIH), area measurements of each mode were determined as a percentage of the total available bearing surface area.

RESULTS:
The damage score (39±10, range: 20-65) for the tibiofemoral articular surface was comparable to that of the insert-tray bearing surface (47±13, range: 20-65). Wear occurred over a large portion of the available surfaces (mean of 95±15% for the tibiofemoral and 73±23% for the insert-tray bearing surfaces). Dominant modes on both surfaces were scratching, burnishing, and pitting. Scratching was often extensive, forming concentric rings over much of the mobile bearing interface on both the PE insert (Fig. 2b) and metallic tray surfaces, though PE scratching and pitting were more severe in regions 2 and 4 than 8 and 9 (p<0.05). Heavier wear on the superior bearing surface correlated with heavier wear on the inferior mobile bearing surface. The tibial insert peg (part of the mobile bearing mechanism) often showed burnishing at the anteroposterior region, consistent with contact with the tray.

3rd body wear was associated with much of the wear damage to the mobile bearing surface. SEM and EDAX revealed PMMA debris (Fig. 3) and, for porous coated implants, metallic debris (Fig. 4).

Clinical data were available for 42 patients. Length of implantation was 3±2 yrs; range from 10 months to 12 yrs. Mean BMI was 30 (range: 16 to 45). No significant correlation existed between wear scores on either surface and BMI or length of implantation. Stiffness (13; 31%) was the leading reason for revision, followed by osteolysis (9; 21%) and instability (9; 21%), infection (6; 14%), and malposition (1; 3%). Wear grades associated with implants removed for osteolysis or instability were higher than those removed for stiffness or infection.

Radiographs (for 28 patients) showed a tibiofemoral angle of 4±4º valgus and femoral and tibial angles of 1±4º and 3±4º flexion, respectively.

DISCUSSION:
The most striking finding in this retrieval analysis is the marked amount of wear damage that occurred to the mobile bearing surfaces, even in those implants not removed for reasons associated with wear. That 21% (9 of 42) of the implants were removed for osteolysis after short implantation times lends credence to the increased wear debris burden resulting from this second bearing surface.

Another important finding was the large contribution of 3rd body debris to mobile bearing wear. Most scratching observed on the insert-tray PE surfaces exhibited a comet-like appearance, with 3rd body PMMA debris embedded at the head of the comet. The debris appeared to have tumbled across the surface, plowing long concentric rings (Fig. 3), similar to that described by Atwood et al. The role of 3rd body debris was underscored by the appearance of moderate to severe scratching of polished bearing surfaces of the metallic tibial trays.

A common observation on the polyethylene mobile bearing surface was pitting; small pits lay next to one another in a curvilinear line, paralleling similarly curved scratches. This suggests that 3rd body debris particles rolled between the surfaces, repeatedly sinking into and being torn from the softer polyethylene. Given the uneven shapes of the pits, this debris was probably PMMA, but circular pits matching the shape of metallic beads were found in nearly all of the 10 implants with porous-coated metallic components (Fig. 4).

All implant retrieval studies have the limitation of examining failed devices, which introduces selection bias favoring the worse performing implants. Nonetheless, the severity of the damage on both the bearing and insert-tray surfaces, even on implants that did not fail for mechanical reasons, and the high prevalence of osteolysis failures suggest that the mobile bearing does not reduce wear, but rather adds another source of wear debris. The prevalence of 3rd body debris suggests that the proximity of mobile bearing to the fixation interfaces of the tibial component makes it susceptible to ingress of debris.

Prospective clinical studies of mobile bearing designs found no benefits over fixed bearing knee replacements. The retrieval results from this study serve to further question the suitability of this approach, since it appears to neither reduce wear nor improve performance.


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