POLISHED FIXED-BEARING TKR TIBIAL TRAY DECREASES BACKSIDE POLYETHYLENE WEAR, INCREASES RATIO OF SUBMICRON PARTICLES

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Introduction
Polyethylene (PE) wear debris has long been recognized as a major cause of osteolysis and failure of total knee replacements. Recently, clinical evidence, such as osteolysis in the tibial metaphysis or around screws in TKRs, has pointed to the backside of PE tibial plateau as a significant source of debris.[1] Furthermore, it has been shown that submicron-size PE particles produce bone resorbing activity at lower volumetric dose than larger particles.

Investigators have hypothesized that particles from backside wear are smaller than those generated at the knee articular surfaces.[2] However, to date, no study has been able to differentiate between the characteristics of polyethylene particles generated from the articular surface and those generated at non-articulating surfaces.

Materials and Methods
A novel fretting wear simulator,[3] was used to reproduce loads and motions typical of the backside of fixed-bearing tibial inserts of TKR implants.[4] The effects of metal surface roughness, metal alloy and micromotion amplitude, on PE particles morphology were measured.

A ±3° rotational motion of the pin was combined with linear displacements of 200 or 50 μm, corresponding to cross-path overall sliding distances of 296 and 211 μm per cycle, respectively. Pins of UHMWPE (10mm dia, gamma sterilization in foil barrier package) were tested against disks of Ti6Al4V and CoCrMo alloy with polished or blasted surfaces. A double-peak Paul curve load profile was applied with a maximum stress of 10 MPa for 3 million cycles.

PE particles were isolated from the serum collected at the end of each test following a protocol already established.[5] The final solutions were filtered on a 0.02 μm polycarbonate filter. The particles were then analyzed using scanning electron microscope analysis (SEM) (Zeiss DSM 960). On average, 200 particles per sample were then characterized using digital image analysis (Metamorph v.4.6, Molecular Devices Corp.).

Results
The percentage of submicron PE particles produced by polished metal surfaces was higher than that of rough surfaces, regardless of metal alloy. (Figure 1) However, taking into account the total wear of all PE pins against the four different metals and surfaces, polished surfaces still resulted in the generation of a smaller total volume of submicron particles. (Figure 2)

Discussion
The results of the current study suggest that there are different fretting wear mechanisms involved for polished versus rough metal surfaces fretting against polyethylene pins under micromotion amplitudes representative of clinically stable implants. Specifically, a polyethylene surface conforms more evenly to the surface of a polished metal disk, therefore; adhesive wear is likely to predominate, as seen by the higher percentage of submicron particles. In contrast, a polyethylene surface does not conform as well to the surface of a rough metal disk as compared to a polished disk, and therefore; abrasive wear is the most dominant mechanism of debris production, resulting in larger particle sizes.

Studies have shown that the majority of UHMWPE debris present around aseptically failed joint replacements are submicron in size, predominantly less than 5 μm.[6] Further, in vitro studies have confirmed that submicron particles can stimulate macrophages to release a variety of pro-inflammatory mediators and stimulate bone resorption, while non-phagocytosable particles larger than 10 μm are minimally stimulatory.[7, 8]

The results obtained show that surface roughness plays an important role in the production of submicron-size particles for motion amplitudes that are typical of well functioning implants (p<0.05; ANOVA). Specifically, polished surfaces produce a higher percentage of submicron particles compared to the blasted ones (more than double).

![Figure 1](image1.png)

![Figure 2](image2.png)

For PE pins against polished surfaces, there was a predominance of round and elongated particles, and the percentage of round particles was even higher with the lower displacement amplitude. In contrast, for rougher surfaces, particles of larger dimension and irregular texture were observed. Furthermore, at the higher displacement amplitude, elongated particles of large dimension were found.

References
[1]. Wasielewski RC et al.; CORR 1997; 345: 53-59
[2]. Hirakawa, K et al; J Arthroplasty. 1999; 14, 2: 165-171
[7]. Shanbhag A.S. et al; J Orthop Res. 1995; 13-5; 792–801

53rd Annual Meeting of the Orthopaedic Research Society
Poster No: 1808