IN-VITRO STUDY OF BACKSIDE WEAR AND STIPPLING MARKS ON MODULAR KNEE COMPONENTS

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Introduction Wear on the backside, or non-articulating, surface of artificial knee bearings is receiving increased scrutiny. Several studies have shown the existence of backside wear on both modular fixed bearing and mobile bearing tibial inserts (1,3,4). In metal-backed modular tibial components backside wear has been attributed to micro-motion between the tibial insert and tibial tray (6). Backside wear may generate a significant volume of polyethylene debris particles and be a major factor in occurrence of osteolysis (1).

A common finding on retrievals with backside wear are stippling marks - small, directional scratches that create a radial pattern of arcs on both the tibial insert and tibial tray. Third body debris has been the assumed cause of stippling marks (5). This study seeks to confirm the hypothesis that stippling marks occur during micro-motion when third body debris is present between the tibial insert and tray.

Methods A test apparatus was designed and built to reproduce the axial load and the femoro-tibial rotation to which knee arthroplasty components are subjected. (Figure 1). A controlled axial load of up to 5 kN is applied to the femoral component by an Instron Model 8501 Servo Hydraulic load frame. For this series of tests, the femoral component was locked at 15° of flexion. The tibial components rotate atop a thrust bearing and, per ISO guidelines (2), up to 6 Nm of force-controlled torque was applied to the tibial tray cyclically via linear springs of known spring constant. Micro-motion of the tibial insert relative to the tray was measured with a rotary motion sensor. No lubrication medium was used.

All tests were run on modular, Press Fit Condylar (Johnson & Johnson) components. A never implanted non-porous coated Co-Cr-Mo cruciate retaining femoral component and a never implanted non-porous coated Ti-6Al-4V modular tibial tray were used. A retrieved tibial insert with a moderately worn locking mechanism was used such that moderate insert motion could occur. The retrieval was a size 5, PFC modular curved tibial insert from the retrieval database at the author’s institution. It was retrieved with an intact locking mechanism after 62 months. It was used; crosslinked PMMA (bone cement), 1018 steel, bovine and other materials (Figure 3). This crescent pattern did not appear on any of the retrieved inserts in the study, but appeared on all retrieved tibial trays. Stippling marks from PMMA debris were more commonly found on the tibial insert than on the tray during testing. These marks were typically longer and thinner than those from the steel.

Results The in-vitro tests accurately reproduced the stippling mark pattern seen on retrievals. PMMA, bone chips, and steel particles were capable of creating stippling marks. UHMWPE particles did not create any stippling marks, and no stippling occurred in the absence of third body particles.

Particles of different materials yielded stippling marks of differing patterns. Steel particles created roughly 10 times more stippling marks on the tibial tray than on the tibial insert. Stippling marks from steel were also more likely to appear in a crescent shape than were those from other materials (Figure 3). This crescent pattern did not appear on any of the retrieved inserts in the study, but appeared on all retrieved tibial trays. Stippling marks from PMMA debris were more commonly found on the tibial insert than on the tray during testing. These marks were typically longer and thinner than those from the steel.

Discussion This research gives strong support to the hypothesis that stippling marks result when third body debris is present between the tibial insert and tray, creating local wear scars during micro-motion. Metal and PMMA particles were shown to most readily produce marks seen in retrievals, but with different morphology. This suggests that both types of debris may be present clinically, and they may have different mechanisms of embedding in the UHMWPE insert and creating marks on the tray. Further research is needed to explore the mechanisms by which these particles propagate and to determine if stippling marks are a source of debris from backside micro-motion.


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