**Introduction:** Ultra High Molecular Weight Polyethylene (PE) remains the primary bearing surface of choice in total knee replacements (TKR). Traditionally Archard’s Law is used to predict wear rates in hip and knee prostheses. This assumes that the volume of wear between two articulating surfaces is proportional to the applied load and sliding distance. However it has been shown that this is a simplification and that wear is controlled by levels of cross shear motion and contact stress [1,2]. Computational models and in vitro studies have shown that cross shear is important in predicting wear [3,4]. A reduction in cross shear in a mobile bearing (MB) knee in comparison to a fixed bearing (FB) knee results in a 4 fold reduction in wear [3]. However there is conflicting evidence as to the effect of contact stress on the wear of PE in FB knees. With historical PE, which was prone to oxidative degradation, reduced conformity and high stress levels were associated with delamination and structural fatigue. In contrast, by extrapolating pin on plate wear results, low conformity, small contact areas and higher wear would be indicative of lower wear [2]. The aim of this study was to compare the wear of FB knee replacements with curved and flat inserts and to test the hypothesis that the flat inserts which give higher contact stresses and smaller contact areas would lead to lower levels of surface wear.

**Materials and Methods:** The wear of FB design TKRs was investigated using the PFC Sigma TKR (DePuy). These comprised of cobalt chrome femoral components which articulated against 10 mm thick curved or 6 mm thick flat UHMWPE inserts which were assembled by snap fit into cobalt chrome tibial trays. The tibial inserts were GUR 1020 UHMWPE which had been sterilized in foil pouches by gamma irradiation in a vacuum (GVF). The testing was performed on a six station knee simulator (Simulation Solutions, Manchester, UK) using femoral axial loading (max. 2600N) and flexion/extension (0 - 58°) profiles taken from ISO 14243 (2002). The motion profiles consisted of internal-external (IE) rotation 45°, and anterior-posterior (AP) displacement, 0-10 mm for standard kinematics (Std) and 0-5mm for intermediate kinematics (Int). Tests were run under standard and intermediate kinematic conditions for a minimum of 3 million cycles.

The simulator was run at 1 Hz and the lubricant used was 25% (v/v) newborn calf serum with 0.1% (w/v) sodium azide solution in deionised water. Wear of the tibial inserts was determined gravimetrically, using unloaded soak controls to compensate for moisture uptake. Volumetric wear was calculated from the weight loss of the inserts using a density of 0.934 mg/mm³. Statistical analysis was performed using One Way ANOVA.

**Results:** The mean wear rates with 95% confidence limits for the curved and flat PE inserts are shown in Figure 1. The curved PE inserts had a mean wear rate of 15.93 ± 2.93 mm³ per million cycles (mm³/MC) under standard kinematics and 8.64 ± 3.35 mm³/MC with intermediate kinematics. In contrast the mean wear rate of the flat PE inserts under standard kinematics was 3.35 ± 0.68 mm³/MC and under intermediate kinematics was 3.07 ± 1.26 mm³/MC. The flat PE inserts had significantly (p<0.05) lower wear rates than the curved PE inserts under both kinematic conditions. The curved PE inserts under intermediate kinematics had a significantly (p<0.05) lower wear rate than the curved PE inserts under standard kinematics.

The mean wear scars (percentage of total articulating area) for the curved PE inserts under standard kinematics was 34% ± 6% and for the flat PE inserts was 9% ± 1%. The flat PE inserts gave rise to a smaller contact area and therefore higher contact stress (77.94MPa for flat insert, 31.41MPa for curved insert).

**Discussion:** The wear rates for the flat PE inserts were significantly lower than for the curved PE inserts under both kinematics. The smaller wear scars seen on the flat PE inserts gave rise to higher contact stresses and lower wear. Previous studies of surface wear in hip simulators [5] have seen a decrease in wear rate with increasing contact stress. Additional studies carried out on multidirectional pin on plate wear simulators have also shown that an increase in contact stress gives a decrease in wear factor.

**Figure 1. Mean Wear Rates ± 95% Confidence Limits**

**Figure 2. Effect of Contact Stress on the Wear of UHMWPE.**

The wear rates found with the flat PE inserts were comparable to those found with MB knees [4]. These results suggest that two distinct low wear solutions are available in TKRs. A MB knee which allows more unidirectional motions at two articulating surfaces and therefore has decreased cross shear, results in low wear. A FB knee with a flat insert which has increased cross shear in comparison to MB knees, and in this design a higher contact stress and smaller contact area also results in lower wear. Longer duration testing is required to establish if high cycle fatigue and delamination occurs at higher stresses with current generation PEs.

A new low wearing solution in FB knee prostheses has been found. A low conforming, high contact stress knee with a low-medium level of cross shear resulted in significantly lower wear rates in comparison to a standard FB knee. Current designs of FB knees do not offer this low wear solution due to their medium cross shear and medium contact stress.

**References:**