LINEAR AND VOLUMETRIC WEAR OF THE OXFORD TOTAL MENISCAL KNEE

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Introduction

One of the potential advantages of mobile bearing knees, such as the Oxford Total Meniscal Knee (TMK), is reduced wear compared to standard fixed-bearing condylar designs. The TMK has a conforming area contact throughout the range of motion, but allows ±2 mm of A-P translation and unrestricted internal-external rotation. The purpose of this test is to establish the expected wear rate of the TMK design.

Materials and Methods

A Stanmore 4-station knee simulator was used for this correlation. The standard left-knee walking profile with a maximum axial load of 2 kN was utilized. Four components, femoral and tibial, were mounted to the machine with bone cement. The femoral component has a single-axis of rotation which was positioned to be the same as the femoral rotation axis of the simulator.

Standard 7.24 N/mm springs (simulated ligament constraints) were utilized with a precompression of 6 mm to limit A-P displacement and rotation. The test was conducted at 1 Hz. The lubricant was standard bovine serum diluted to 25 g/l protein concentration. No antibiotic was added, nor was EDTA. The temperature was maintained at 30°C.

All PE components were manufactured by direct compression molding of 1900H resin (Montell Polyolefins, Inc.). All components were packaged in Argon and sterilized with a nominal 3.3 Mrad gamma irradiation dose.

Linear wear was measured by an electronic gauge (Mitutoyo ID-F150E) with a resolution of 0.001 mm. Mass loss was measured with a Denver Instruments A 200 DS balance with a resolution of 0.02 mg.

Results

The mass loss data is shown in figure 1. One component experienced a short-term unexplained increase in wear between 0.8 and 1 million cycles. All of the components appeared to have a change in the wear-rate at approximately 0.8 million cycles. The initial mass loss rate was 10.8 mg/10⁶ cycles whereas the steady state mass loss rate was 4.0 mg/10⁶ cycles. Mass loss rates were converted to volumetric wear rates using the density of UHMWPE (0.933 g/cc).

The linear penetration data is shown in figure 2 along with the calculated penetration rates. The measured penetration rate showed a significant bi-phasic response. The initial penetration rate was 0.11 mm/10⁶ cycles occurring through 0.8 million cycles. The steady state penetration rate was 0.0039 mm/10⁶ cycles. A maximum and minimum calculated linear penetration was estimated by dividing the volumetric wear rate by the projected contact surface area for either the bearing/femoral condyle interface (~740 mm²) or the bearing/tibial baseplate interface (~1940 mm²).

Discussion

The higher wear of one of the components would be explained by the higher amount of rotation experienced by this component. However, the reason that the other components experienced only 2-3 degrees of rotation is not understood as there are no design features to resist axial rotation. One possible explanation may be that the static friction between the top of the baseplate and the bottom of the tibial bearing may be enough to resist the rotational torque in a simulator where there is always some amount of compressive load. Clinical verification of this phenomenon, or lack of it, is an area of future investigation.

It appears that the initial penetration rates include a creep phenomenon. This is supported by the correlation of the calculated steady state penetration wear rate to the measured steady state penetration wear rate. The initial linear penetration rate is higher than would be predicted by the volumetric wear rates. As the measured penetration rate matches closely to the maximum calculated penetration rate (steady state), it appears that the majority of the wear is occurring at the bearing/femoral condyle interface. This is further supported by the fact that the axial rotation was only 2-3 degrees for three of the components tested.

The wear rates of the TMK are very similar to or lower than other mobile bearing knees. The wear of the one component in this study that showed the higher rotation was almost identical to that reported on “double movement” of the MBK by Bell et al (1) and the wear for the standard motion in that study was similar to the lower rotation components in this study. Further, the penetration rate of the TMK during this test is less than that reported for clinical use of the Oxford Unicompartmental knee (2).

Reference

(2) Argenson, J. et al., JBJS 1992; 74-B: 228-32.