Introduction

Fatigue damage in the form of pitting and delamination remains a major cause of polyethylene failure in total knees. Osteolysis induced by particulate debris is also a growing concern for the longevity of total knee reconstructions. Crosslinking and melting has been shown to improve the oxidation resistance of polyethylene, which, in turn, increases the delamination resistance of tibial inserts. In addition, crosslinking and melting also improve the adhesive wear behavior of polyethylene, thereby reducing the particulate debris generation. To date, most in vitro knee simulator investigations with highly crosslinked polyethylene have been carried out with smooth femoral components (1,2). Recently, Widding et al (3) have shown in vitro that the knee simulator wear rate of a 100kGy-irradiated and melted polyethylene tibial insert was higher than that of conventional polyethylene when the surface of the femoral component was extensively scratched. In that study, the femoral components were tumbled in a highly abrasive media containing alumina particles to artificially introduce scratches. Fundamental to such studies is the question of whether or not this form of surface scratching of the femoral components accurately represents the type of scratching that occurs in vivo. Therefore, to study the effect of counterface roughness as it is actually generated in vivo on the wear behavior of highly crosslinked polyethylene, we carried out a knee simulator study with surgically explanted, femoral components which had become scratched during in vivo use. These articulated against either fresh, highly crosslinked or fresh conventional polyethylene components on a knee simulator under normal gait.

Materials and Methods

Five femoral components of NKII design (Centerpulse Inc, Austin, TX) were retrieved at revision surgery and were used in the present study (two size-3, two size-2, one size-4). The surfaces of the femoral components were first characterized to determine the surface roughness using a SurfTest 501 Surface Profilometer. Roughness measurements were carried out in the neutral position (0°) and 45° of flexion in both the anterior/posterior and medial/lateral directions. Each roughness measurement was repeated five times and an average of the peak surface roughness (R_p) is reported here. Four femoral components with the highest surface roughness were selected and used in the simulator studies discussed below.

The femoral components were mounted on stainless steel holders and were articulated against fresh tibial inserts on an AMTI knee simulator (Watertown, MA) under physiologic normal gait at a frequency of 1.5Hz. In the first phase of the study, 95kGy irradiated and melted polyethylene tibial inserts (Durasul) of NKII cruciate-retaining design were tested for 2 million cycles. In the second phase, the same femoral components were used to test fresh conventional polyethylene (gamma sterilized in oxygenless packaging) tibial inserts.

The tibial inserts were mounted on a tibial base plate which was held with seven degrees of posterior slope. Undiluted bovine serum with 20mMol EDTA and 0.2% wt. sodium azide was used as the lubricant. Wear was determined gravimetrically at every 0.5 million cycles up to two million cycles of testing. To correct for fluid absorption in the polyethylene, additional liners were loaded at the neutral position in bovine serum without any motion.

Results and Discussion

Figure 1 shows the peak roughness (R_p) measurements of the four explanted femoral components contrasted to identical values of a new femoral component. Although all explanted femoral components showed multiple scratches, they were mainly all localized in certain domains, which were randomly distributed throughout the articular surfaces. An example of a scratched surface on an explanted component is shown in Figure 2.

Figure 3 shows the wear rates of the conventional and highly crosslinked polyethylene inserts articulating against the explanted femoral components at 2.0 million cycles. These data were compared to the wear rates from a previously published study on the highly crosslinked and conventional polyethylenes tested against new smooth


Acknowledgement: This study was funded by Centerpulse, Inc.