INTRODUCTION

The most common bearing couple used in total knee arthroplasty (TKA) is ultra-high molecular weight polyethylene (UHMWPE) articulating against a CoCrMo alloy femoral component. Although this couple has demonstrated good clinical results, UHMWPE wear has been identified as one of the principal causes of long-term failure in total knee joint replacements [1] indicating a need for improvements in TKA bearings technology.

The wear resistance of UHMWPE can be improved by radiation crosslinking; however, in order to get the full benefit of this improved wear resistance, an abrasion resistant ceramic counterface is necessary [2]. Since the radiation crosslinking degrades mechanical properties, it is also important to have an optimized radiation dose and subsequent processing. The purpose of this study was to evaluate the long-term wear performance of VERILAST Technology comprising two advanced bearing technologies, abrasion resistant oxidized zirconium (OxZr or OXINIUM™) femoral components [3, 4] and 7.5 Mrad crosslinked polyethylene (7.5-XLPE).

MATERIALS AND METHODS

Three component assemblies of LEGION™ cruciate retaining OxZr femoral components, 7.5-XLPE tibial inserts were tested on an AMTI knee simulator under displacement control at 1 Hz frequency as described previously [2]. The tibial inserts were manufactured from compression-molded GUR 1020 UHMWPE, gamma irradiated with 7.5 Mrad, remelted to extinguish free radicals, and sterilized by EtO. The wear test was conducted for 45 Mcycle, which was considered to be a conservative estimate for the amount of cycles that would occur during 30 years of typical in-vivo use based on the relationship between patient age and the number of loading cycles as reported in the literature [5-7].

Average roughness (Ra) of the OxZr femoral components was measured at various intervals of wear testing using a contact profilometer. Oxide thickness of the OxZr femorals was measured at various intervals of wear testing using a Fourier Transformed Infrared spectrometer with an attached specular reflectance fiber optic probe. Roughness and oxide thickness measurements were made at pre-selected locations in the articulating areas from 0 to 60° of flexion on both condyles of the femoral components. A single factor ANOVA was used to determine the effect of wear testing on roughness and statistical differences between wear rates.

RESULTS

The predominant wear feature on the 7.5-XLPE inserts was burnishing. There were no signs of fatigue wear or delamination. The mean volumetric wear rate (± SD) of the 7.5-XLPE inserts articulating against OxZr femoral components for 45 Mcycle was 0.58±0.17 mm/Mcycle (Figure 1).

In a previous wear test under substantially identical conditions for 5 Mcycle simulating approximately 3 years of use, the mean volumetric wear rate of CoCr and virgin UHMWPE (CPE) couples was 23.4±2.4 mm³/Mcycle [2]. The mean volumetric wear rate of the OxZr/7.5-XLPE couples was approximately 98% lower compared to the CoCr/CPE couples (p<0.01) (Figure 2).

At approximately 5 Mcycle, the mean volumetric wear of OxZr/7.5-XLPE couples (2.67±1.47 mm³) was approximately 98% lower than CoCr/CPE couples (120.42±11.99 mm³) (p<0.01) (Figure 2). Furthermore, at 45 Mcycle, the mean volumetric wear of OxZr/7.5-XLPE couples (22.78±7.23 mm³) was approximately 81% lower than the CoCr/CPE couples at approximately 5 Mcycle (120.42±11.99 mm³) (p<0.01) (Figure 2).

After 45 Mcycle of wear testing, the OxZr femoral components appeared to be in excellent condition. No scratches were observed in the articulating areas of the femoral components. The roughness of the femoral components did not significantly change during wear testing (p>0.05). The femoral components showed no measurable loss of oxide surface within the measurement accuracy of 0.2 µm (Figure 3).

DISCUSSION

This study demonstrates that coupling OxZr femoral components with 7.5-XLPE inserts results in a TKA bearing combination that provides significantly improved, long-term wear performance.

REFERENCES

2. Parikh et al., Trans ORS, 2007; 0021.