**Aggressive 3rd-body wear challenge to highly crosslinked polyethylene: -A hip simulator model**

Kubo K1,2, Clarke IC1, Williams PA1, Sorimachi T2, and Yamamoto K3.

1 Peterson Tribology Laboratory, Loma Linda University, Loma Linda, CA.
2 Department of Orthopaedic Surgery, Tokyo Medical University, Tokyo Japan
3: after cleaning condition

**Introduction**

Wear in polyethylene appears to be exacerbated by 3rd-body abrasion with the CoCr balls used for total hip replacements. This has implications for various wear modes encountered in patients. Clinical and laboratory studies have offered weak and sometimes contradictory wear relationships with respect to polyethylene crosslinking, femoral head diameters, 3rd-body wear effects and CoCr roughness. [1] This hip simulator model investigated the effect of severe wear challenge by 3rd-body cement particles to highly crosslinked polyethylene liners (HXPE 75kGy) compared to control liners; CXPE 35kGy) using both large diameter CoCr and alumina balls.

**Methods**

The polyethylene liners were gamma-irradiated to 35 and 75kGy under N2 (CXPE, HXPE). Liner wear with 44mm CoCr balls (44M) was compared to that with 32mm CoCr balls (32M: ENCORE, Austin, TX) with 44mm alumina-ceramic (44C: Biolox-florte, CeramTec AG) serving as 'scratch-resistant' controls. Also compared was the effect of different roughnesses present in 'new' and 'pre-worn' liners. The cups were mounted the 'inverted' in an orbital hip simulator and run with a physiological load profile (0.2-3kN load/1Hz). Diluted bovine serum (Hyclone Inc., Logan, UT) was used as lubricant (20mg/ml protein, 400ml volume). In phase I, all cups were run in standard ('clean') lubricant for 1.5 million cycles (1.5Mc). In phase II, the liners were run in a PMMA slurry of 5mg/ml serum for 1.5Mc [2].

Wear-rates were measured sequentially at each 0.25Mc, ball and liner roughnesses by white light interferometry (Newview 600, Zygo Inc) and at 5Mc all wear surfaces were imaged by SEM (Phillips FEG). Linear regression analysis was performed on Surface Roughness parameters (Sa, Sp, Sz) and wear rates. In addition, the variables of roughness parameters were excluded from the regression analysis if the F< 4.0 at each calculation step, with statistical significance defined as P< 0.05. Statistical analyses were performed using JMP 7.0 software (SAS Institute).

**Results**

Phase-1 ‘clean’ lubricant: wear of ‘new’ liners HXPE[44M] and HXPE[44C] appeared identical at 30mm/3Mc. However ‘pre-worn’ HXPE[44M] liners averaged 38mm/3Mc, 25% higher than ‘new’ HXPE[44M]. Compared to CXPE[32M] wear of 178mm/3Mc, the new HXPE wear represented a 6-fold reduction and was statistically significant (p<0.05).

**Conclusion**

Under clean lubricant conditions, wear of both new and pre-worn HXPE[44M] liners was significantly reduced compared to controls [3]. Under abrasive conditions, all liners showed greatly accelerated wear but wear with HXPE liners was still reduced or similar to controls. Since there was no change in ball roughness, the increased liner wear appeared to be the result of severe abrassion on the cement debris transferred onto CoCr surfaces. Use of alumina balls protected the HXPE liners from such 3rd-body wear effects[2]. It was also clear that the degree of liner roughness increased in a linear fashion with the higher wear regimes.

**References**