Method for Creating Abrasive Components for Wear Testing

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Introduction:

Various forms of abrasive wear testing have been developed to try and recreate the phenomenon of third body wear which occurs in vivo. Previous methods used include the introduction of bone cement particles into the lubricant and deliberate scratching of the femoral components [1-3]. Other forms of testing include tumbling of the femoral components prior to testing, which was described by Good et al [4]. However, the method they followed was created for knee femoral components. The purpose of this study was to establish an aggressive method for testing hip femoral components under abrasive conditions using a tumbling methodology.

Materials and Methods:

A tumbling polisher (Model # 1600; A.E. Aubin Company, Marlborough, CT) was used for abrasion of the femoral components. The tumbling drum was filled with 90mL of 500 grit alumina oxide powder, 200mL of plastic cones, and 500mL of deionized water. Each femoral component was tumbled for 30 minutes at 40 rpm.

Two different materials were tumbled to establish the effects of the method on various surfaces. Cobalt chrome (CoCr) femoral heads (Trident®, Stryker Orthopaedics, Mahwah, NJ) were compared to alumina matrix composite ceramic heads (Biolox® delta, Ceramtec, Memphis, TN). All femoral components were 40 mm in diameter.

Femoral heads were CMM scanned for precise measurement of diameter and sphericity before and after tumbling (Mitutoyo, Aurora, IL). Roughness measurements of femoral heads were also taken before and after tumbling using white light interferometry (Zygo, Middlefield, CT). Statistical analysis was performed using the Student’s t-test (p<0.05).

Wear testing was conducted using the tumbling femoral components to assess the effectiveness as an abrasive testing method. A multi-station hip joint simulator (MTS, Eden Prairie, MN) was used. Femoral heads articulated against GUR 1020 UHMWPE that was sequentially annealed and irradiated three times and then gas plasma sterilized (X³®, Stryker Orthopaedics, Mahwah, NJ). Inserts had a thickness of 5.9 mm. Testing was run at 1Hz with cyclic Paul curve physiologic loading applied axially, at a maximum of 2450 N [5]. Component assemblies were lubricated using Alpha Calf Fraction serum (Hyclone Labs, Logan, UT) diluted to 50% with a pH-balanced 20-mMole solution of deionized water and EDTA (protein level = 20g/l) [6]. Testing ran for 2.0 million cycles. Inserts were cleaned and weighed according to standard protocols every 0.5 million cycles and serum was also changed at that interval [7].

Results:
The changes in surface roughness are shown in Figures 1 and 2. There was a significant increase in surface roughness for both delta and CoCr (p < 0.05). Delta had a 116% increase while CoCr increased over 3900%.

Discussion:
The methodology and results discussed create a foundation for a new method of wear testing for both current and future bearing materials. The model is clearly aggressive enough that it can scratch delta ceramic. Despite the severity of the tumbling methodology, delta ceramic still outperformed cobalt chrome components.

References: