The Effect of In Vivo Damage of Oxinium Femoral heads on the Wear of Highly Cross-linked Polyethylene

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Statement of Purpose: Oxidized zirconium (Oxinium™) is a bearing surface introduced for use in THA to minimize wear in vivo. It has been postulated that damage of Oxinium femoral heads in vivo may lead to accelerated polyethylene wear[1, 2]. The purpose of this study was to evaluate wear of highly cross-linked polyethylene (XLPE) acetabular liners articulating against retrieved Oxinium heads damaged in vivo following dislocation using a 12 station Boston Hip Simulator.

Methods: Six Oxinium femoral heads retrieved from revision surgery secondary to dislocation and repeated closed reduction were identified. The femoral heads, three 28mm and three 32mm diameter, had various amounts of abrasive damage confined to one quadrant of the surface. These were coupled with the appropriate sized XLPE liner. Three new 32 mm Oxinium heads were coupled with new XLPE liners. An additional three new 32 mm CoCr heads were coupled with conventional, non-irradiated polyethylene liners. All were gas sterilized.

Hip simulator testing was performed on a 12-Station AMTI Boston Hip Simulator using a standard walking gait program with the peak load of 3000 N at a rate of 1 Hz for 5 million cycles. Two additional liners for each group were subjected to load without motion. The damaged area of the retrieved heads was positioned so that it contacted the polyethylene surface during the highest load phase of the gait cycle. Weight change was determined after each 0.25×10^6 cycle interval according to ISO 14242. Due to the inhomogeneous damage on each retrieved femoral head, the individual data from each retrieved component was compared to the average values of the two control groups. All surfaces were examined by optical microscopy and photographed at each weighing interval.

Results: The damage on the retrieved femoral heads was characterized by severe plastic deformation of the substrate leading to cracking of the oxide surface, several areas of oxide breach, extensive Ti transfer indicative of contact with the acetabular shell and presence of Fe, Cr indicative of surgical instrument damage.

The three control, non-cross-linked polyethylene components wore at a near steady average rate, calculated by linear regression, of -47.7 ± 2.9 mg/million cycles with an average total net weight loss of 219.1 ± 12.3 mg. The weight loss of each XLPE liner is shown in Figure 1. The three XLPE liners which articulated against new 32 mm Oxinium femoral heads had an average net weight gain at a near steady average rate, calculated by linear regression, of 2.04 ± 0.5 mg/million cycles with an average total net weight gain of 12.9 ± 2.9 mg. In contrast, the weight change of the XLPE liners which were coupled with the in vivo damaged Oxinium heads varied in relation to the magnitude of the damage present on the femoral heads. One 32 mm XLPE liner had a weight loss throughout the test having a total wear rate of -1.1 mg/million cycles with a total net weight loss of 4.8 mg. A second 32 mm XLPE had a net weight change that varied between negative and positive during the test, having a total wear rate of -0.1 mg/million cycles with a total net weight gain of 1.71 mg. While the other four XLPE liners in this group maintained a net weight increase thoroughout the testing, this net weight change was less than that of the XLPE control liners, indicating that a small amount of wear occurred.

There were no changes in the appearance of any of the femoral heads in this study as judged by optical microscopy. The cross-linked liners coupled with the *in vivo* damaged Oxinium heads showed relatively more damage than the control groups. The highly loaded quadrant (coinciding with the damaged portion of the heads) showed more scratching and polishing. The original machining marks were no longer visible. However, the machining marks were seen in the other quadrants and near the dome.

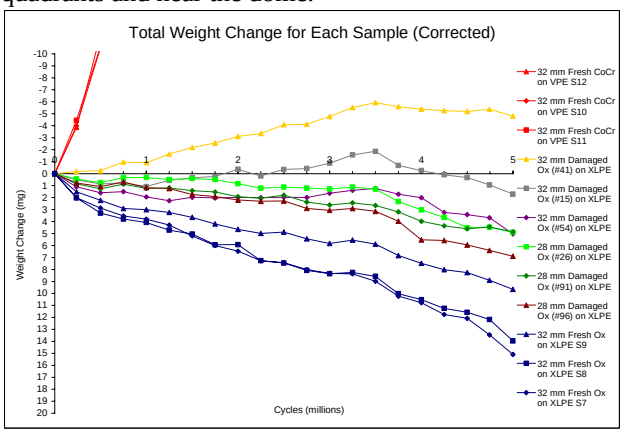

Figure 1 The scale of the Y axis has been changed in order to highlight the weight change of the XPLE liners. The XLPE articulating against in vivo damaged Oxinium had varying amounts of weight change, indicating some wear in this group.

Conclusions: The dislocation damaged Oxinium femoral heads resulted in a measurable increase in the wear of the XLPE liners compared to the XLPE liners coupled with new Oxinium heads. However, this change was relatively small in light of the substantial wear of the non-cross-linked liners and remained below what some have described as a wear threshold for osteolysis[3]. The damage due to dislocation and repeated closed reduction is primarily confined to the inferior aspect of the head which has minimal contact with the interface under high loads for most daily activities. By positioning this damaged area such that it contacts the liner in the high load region of the gait cycle, this study represents the worst case scenario for accelerated wear evaluation. While the amount of in vivo damage can vary widely, this study suggests that it would not lead to catastrophic run away wear of XLPE.

References: 1. Kop AM; J Arthroplasty. 2007; 22(5): 775-9; **2.** Evangelista GT; J Bone Joint Surg Br. 2007; 89(4): 535-7; **3.** Fisher, J., Proceedings of the Inst of Mech Eng 2001. 215(2):