LONG-TERM WEAR DAMAGE ANALYSIS OF 38 POSTMORTEM RETRIEVED CANINE TOTAL HIP REPLACEMENTS

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Introduction: Retrieved human acetabular components made of ultra high molecular weight polyethylene (UHMWPE) usually exhibit a characteristic wear pattern [1-3]. A smooth, highly polished region is usually distinct from a low wear region. A wear ridge commonly separates the two regions. The types of UHMWPE damage commonly seen on human retrievals are creep, pitting, embedded polymethyl methacrylate (PMMA) debris, embedded metal debris, scratching, burnishing, abrasion, delamination, presence of white specks, and yellowing. Dogs are used as an animal model for total hip replacement (THR) research. In addition, THR surgery has been performed clinically in dogs for over 20 years; however, there is very little literature available on the long-term performance of cemented canine THR. Thus, a postmortem canine THR retrieval program was established at Colorado State University (CSU) with the goal of providing orthopedic researchers with benchmark data on the long-term performance of cemented THRs that were clinically implanted in dogs. No previous postmortem retrieval studies had been performed in the dog to examine wear damage in cemented, UHMWPE acetabular components. The present study examines and grades damage to the canine acetabular component using a method adapted from human THR postmortem and revision retrieval studies [1-3]. The hypothesis was that wear patterns would be less extensive in canine postmortem retrievals than those seen in human studies due to lower peak joint forces (i.e. 1.50-1.65 * body weight) [4,5] in the dog hip compared to the human (2.40-5.00 * body weight) [6].

Materials and Methods: Demographic data (e.g., breed, weight, surgery date) were retrieved from the clinical chart. A cursory examination of the articulating surfaces of the canine retrievals for the most commonly seen damage modes was made using a stereoscopic microscope. The most common damage categories found were creep, pitting, embedded PMMA debris, embedded metal debris, scratching, abrasion of machine marks, abrasion, non-scratch macroscopic removal of UHMWPE, and yellowing. Human wear grading studies break the components into specific regions [1,2]. Due to the 45-degree dorsal cutout in the canine acetabular component the areas chosen for individual grading scores were (See Figure 1) four quadrants of the articulating surface (I-IV), two corners (V-VI), cutout rim (VI), cranial rim (VII), and caudal rim (IX). Commonly used scoring criteria (1-2) involved a semi-quantitative, non-parametric score based on the percentage of the surface affected by each type of damage within each specific area on the implant. The scores were 0 (no damage), 1 (< 10% of area damaged), 2 (10-50% of area damaged), and 3 (> 50% of area damaged). Each component was graded twice by the same observer on different days. Scores were then averaged. Statistical analysis was performed using SAS software (Cary, NC).

**Figure 1** - Schematic drawing of canine acetabular component with quadrants and areas marked for individual wear grading scores.

Results: Thirty-eight implants with hemipelves and femora were retrieved from 29 dogs (9 bilateral s) at necroscopy and stored at –20°C until testing began. Two designs of acetabular components were retrieved, both made of UHMWPE. The earlier design was manufactured by Smith & Nephew Richards (Memphis, TN), and the second design was manufactured by BioMedtrix (Allendale, NJ). The dogs ranged in weight from 18 to 66 kg. The implant duration ranged from 8 months to 11 years and 8 months. Canine acetabular cup wear patterns were considerably different than those seen in human THR (See Figure 2). There was considerably more third body wear, and there are no readily apparent distinct high wear/low wear regions. Evidence of cement mantle breakdown was seen on several retrievals. There was a significant positive correlation between the total UHMWPE wear damage score and implant duration (See Figure 3) (R² = 0.25, p=0.002).

**Figure 2** - Acetabular component retrieved 9 years and 5 months after THR. (A) = Implant-on-implant impingement by the femoral component on one corner of the cutout. (B) = Aggressive third body wear on the entire articulating surface. (C) = Upper rim of the implant is no longer supported by PMMA.

**Figure 3** – Implant duration vs. total UHMWPE damage score.

Discussion: This is first report of UHMWPE wear damage in long-term, clinical canine THR. The hypothesis was not supported because the damage to the canine acetabular components was more extensive than that seen in human acetabular components. There is considerably more third body wear and implant-on-implant damage. There is no distinct high wear/low wear region. Evidence of cement mantle breakdown was seen in several retrievals. Extensive third body wear may be caused by loose bone cement fragments. Impingement on the corners and along the edge of the cutout was extensive and most likely caused by the neck of the femoral component. The level of damage indicates that the 45-degree cutout is not adequate impingement protection. Perhaps the impingement of the femoral neck on the acetabular component caused high forces on the bone cement, causing it to break. Loosening of the acetabular component [7] was positively correlated with the total UHMWPE damage score (R² = 0.11, p = 0.042) and was not correlated with measures of UHMWPE volumetric wear [7]. This indicates that the primary failure mechanism in canine acetabular components may be mechanical in nature in contrast to biological mechanisms found in human postmortem retrieval studies [8].

References

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