Reduced Backside Wear, Particle Migration, and Osteolysis in Third Generation Cementless Acetabular Components Retrieved Postmortem

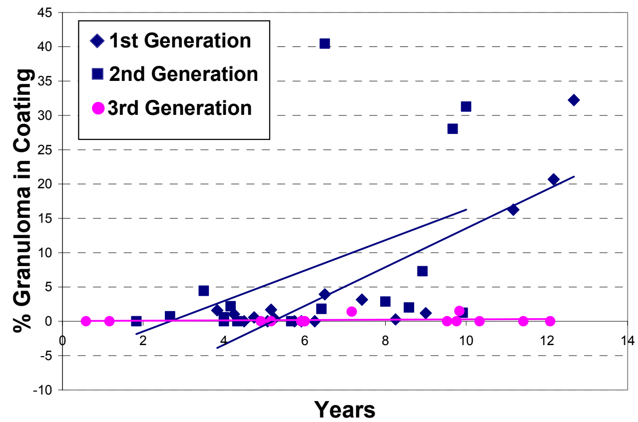
Urban RM, Hall DJ, Dahlmeier EL, Wright JL, Jorge O. Galante, Jacobs JJ
Dept. of Orthopedic Surgery, Rush University Medical Center, Chicago, IL

Purpose: 1st and 2nd generation porous-coated acetabular cups (Harris-Galante, Zimmer) with conventional polyethylene (PE) liners have shown excellent clinical results and very low rates of aseptic loosening. In younger patients, the liner, its locking mechanism, and screw holes have been associated with peri-acetabular osteolysis. Third-generation components (Trilogy, Zimmer) have improved locking mechanisms, fewer or no screw holes or screws and are implanted using under-reaming and impaction. The purpose of this study was to quantify the extent of wear particle-induced granulomas in 3rd generation components retrieved post mortem and to relate these findings to measures of backside liner damage. We hypothesized that the design improvements would result in reduced backside wear and less osteolysis in the peri-acetabular tissues compared to earlier designs.

Methods: Fourteen 3rd-generation acetabular implants were harvested postmortem from 12 subjects, 1 to 12 yrs after insertion for OA. Three components had no screw holes, 5 had 3 clustered holes, and 6 had 9 to 15 holes. One to 4 fixation screws were used with 9 components. Histomorphologic and tribological data on these components were compared to duration-matched data for 1st (n=17) and 2nd (n=16) generation cups previously reported (1).

Stained sections of each cup with adjoining pelvic bone and joint capsule were analyzed using a point-counting grid to quantify the extent of particle-induced granuloma at the bone-implant interface and within the porous coating. Wear particles were identified using polarized light or energy dispersive x-ray analysis. Backside damage to the conventional PE liners was defined as alteration of the original machined surface at 10-50X. The area and severity of backside damage were graded 1 to 3 separately for the superior, medial, and inferior regions. A damage score for each region was calculated as the product of the area and severity scores (max=9), and scores for the 3 regions were summed for a total score (max=27). Data were analyzed using the Mann-Whitney test and Spearman correlations.

Results: Particle-induced granuloma in the porous coating was markedly reduced ($p \leq 0.003$) in 3rd generation components compared to 1st or 2nd generation devices (Figure). The mean extent of particle-induced granuloma within the porous coating was 4.9±9.2% for the 1st generation, 7.7±13.0% for the 2nd, and 0.2±0.5% for 3rd generation components. In several 1st and 2nd generation components, and in none of the 3rd generation cups, particle-induced granuloma occupied 15 to 40% of the porous coating after 6 or more years. Particle-induced granuloma in the porous coating increased with time in the 1st generation (r=0.516, p=0.034) and 2nd generation (r=0.583 p=0.018) devices, but not in the 3rd generation cups. Infiltration of particle-induced granuloma was



limited to the rim of the 3rd generation components. This was in sharp contrast to the 2 earlier designs in which particle-induced granulomas were observed not only at the rim but along the tracks of fixation screws and extending from holes without screws into the porous coating and in some cases into ballooning lesions deep in the pelvic bone. The wear debris in granulomas included abundant intracellular PE. Some particles in these lesions were identified as CoCrMo or barium sulfate and clearly had originated at the femoral side of the arthroplasty and migrated behind the liner and into the screw holes. PE particles in the screw holes had a wider range in size compared to PE particles in the joint capsule. In all of the 3rd generation cups, only scant particles could be detected at screw holes and within the porous coating.

Liner backside damage was minimal in 3rd generation components with a mean score of 4, range 2 to 7, out of a possible 27. Damage scores were relatively greater for 1st generation (mean score = 9, range 3 to 19, p=0.003) and 2nd generation (mean score = 8, range 3 to 21, p=0.061) components. Backside damage was correlated with the extent of granuloma at the implant-bone interface for the 1st (r=0.572, p=0.021) and 2nd generation (r=0.717, p=0.002) cups, but not for the 3rd generation devices.

Conclusions: Damage to the backside of the PE liner and particle-induced granuloma in the periprosthetic bone and porous coating were remarkably reduced relative to previously reported data for 1st and 2nd generation components of the Harris-Galante design. Periprosthetic particle-induced granulomas were not observed with 3rd generation devices up to 12 years following implantation regardless of the number of screw holes or screws employed. This suggests that the improved locking mechanism and stability between the liner and metal shell of the Trilogy components were effective in limiting the backside generation of PE debris and migration of particles from the joint, both of which contribute to pelvic osteolysis. Improved bearing surfaces promise to increase the durability of these devices even further.

References: (Urban RM. Trans ORS 2007, 1716)