INTRODUCTION: Porous-coated, hemispherical acetabular cups with UHMWPE liners are entering their 3rd decade of use with excellent clinical results and very low rates of aseptic loosening. Most long-term studies of these devices rely on clinical radiographs for assessment of the bone-implant interface. For this reason, the exact nature of the interface tissues and the long-term durability of bone ingrowth fixation in the majority of patients hosting well-functioning arthroplasties in the very long-term are largely unknown. The purpose of this study was to quantify the extent of various interface tissues, including bone and wear particle-induced granulomas in Harris-Galante cementless acetabular cups retrieved post mortem after 2-21 years and to relate these findings to measurements of bearing surface wear and an assessment of “back-side” liner damage.

MATERIALS AND METHODS: 36 primary porous-coated cups. Ti acetabular cups (Zimmer, 17 HG, Zimmer) implanted using 2 to 5 Ti6Al4V screws were harvested postmortem after a mean of 8 (2-21) yrs under an IRB protocol. The liners had been machined from GUR4150 UHMWPE (PE) and sterilized in air. Femoral reconstruction consisted of 19 cemented CoCr and 17 cementless TiAlV stems, all with CoCr heads. Mean age at implantation was 65 (33-89) yrs. The Harris hip score at last follow-up was 85 (47-100). The overall area fraction of bone ingrowth was determined from image analysis of backscattered-electron SEM images of plastic embedded, undecalified sections. Stained sections of each cup with adjoining pelvic bone and joint capsule were analyzed using a grid in the microscope eyepiece to estimate the extent of bone, marrow, fibrous tissue, and particle-induced granuloma surrounding and within the porous coating. Wear particles in the periprosthetic tissues were identified using polarized light or energy dispersive x-ray analysis. Serial clinical radiographs were reviewed for evidence of periarthroplasty osteolysis and compared to the histological findings. “Back-side” damage to the PE liners was studied using a stereo light microscope. The area and severity of damage were each graded (1-3) separately for the superior, medial, and inferior regions. An overall damage score for each cup was calculated by summing the product of severity and area grades of the 3 regions (max score=27). Wear of the PE bearing surface was determined in 21 cups >5 yrs using a touch probe coordinate measuring system. Data were analyzed using the Friedman test and Spearman correlations. Means and standard deviations are reported.

RESULTS: Overall, the area fraction of bone ingrowth measured from SEM images was 12.1 ±6.6%. The interface between the porous coating and the surrounding bone was composed of 37.5 ±16.9% bone, 12.4 ±10.2% marrow, 4.4 ±5.3% fibrocartilage, 30.8 ±22.9% fibrous tissue, 0.5 ±0.4% necrotic tissue, 3.1 ±7.1% granuloma, and the balance was screw holes. The extent of bone within the coating was 35.6 ±19.6%. The least extent of bone was at the interface between the porous coating and the metal shell of the cup (12.9 ±12.1%) where a fibrous membrane was often present. Particles of PE, Ti and TiAlV alloy were present within holes with or without screws in all of the components. Several cups demonstrated particles of CoCr alloy, barium sulfate or stainless steel from the femoral reconstruction. The particles were found within granulomas composed primarily of histiocytes. Expansion of the granulomas through the screw holes into the periprosthetic bone was observed in 2 of 11 components after < 5 years and in 14 of 25 cups > 5 years. Pelvic granulomas increased from a few millimeters at 5-10 years to ballooning lesions measuring up to 20 millimeters in several specimens with follow up of 15-21 years (Figure 1).

The full extent of these granulomas was poorly visualized on plain clinical radiographs. In some of the longest-term specimens, the granulomatous tissue invaded the interface between the porous coating and the metal shell, in effect, undermining bone ingrowth fixation of the components. At the rim of the components, particle-laden granulomas also infiltrated the bone-implant interface tissues, but to a lesser extent. The depth of granuloma penetration at the rim increased with time (r=0.502, p=.009). Some peri-acetabular component lesions contained fibrous tissue or necrotic debris without the presence of wear particles.

DISCUSSION: This study documents the durability of bone ingrowth fixation of porous-coated acetabular components over 2 decades. Potential failure mechanisms for the very long term are suggested. Although not fully apparent on plain clinical radiographs, histological evaluation indicated that particle-induced granulomas infiltrated the interface tissues, increasing with time, in a highly patterned manner at the rim and screw holes of components with substantial bone ingrowth. In this study, the extent of particle-induced granuloma in the tissues was correlated with back-side liner damage, but not with bearing surface wear. Importantly, the granulomatous tissue invaded the interface between the porous coating and the metal shell substrate, in effect, undermining bone ingrowth fixation. In this manner, osteolysis advancing from within the porous coating may prove to be an important mechanism of very late failure. Some pelvic lesions did not contain particle-induced granulomas and may represent cysts remaining from the original pathology or cavities related to fluid pressure through screw holes. All of these findings have importance for design of acetabular components. Extensive pelvic osteolysis can present formidable challenges for revision. Therefore, the very large population still hosting these and similar devices for decades, whether or not they have radiographic indications of peri-acetabular osteolysis, require long-term monitoring.

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