INTRODUCTION: Porous-coated, hemispherical acetabular components with modular polyethylene liners are now in the second decade of use in total hip arthroplasty with excellent clinical results and very low rates of loosening compared to conventional, all-polyethylene cups inserted with cement. Some concerns about the long-term survival of cementless components have been identified from extensive radiographic studies and from material that has become available at revision operations of failed devices. These concerns have centered primarily on osteolysis associated with the increased wear of 32 millimeter femoral heads, inadequate thickness of the polyethylene liners, "back-side" wear between the liner and the metal backing of the cup, and the presence of screw holes and screws used for initial stabilization. However, the actual nature of the interface tissues in the great majority of patients hosting well-functioning arthroplasties remains, for the most part, unknown. The purpose of this study was to quantify the extent of various tissues, including wear particle-induced granulomas, at the bone-implant interface of 28 cementless, porous-coated acetabular components retrieved post mortem from patients whose arthroplasties has functioned well for 2 to 13 years and to relate these findings to measures of polyethylene bearing surface wear and damage to the convex side of the liner.

MATERIALS AND METHODS: Twenty-eight primary porous-coated acetabular components implanted with screws (17 HG, 11 HG2, Zimmer) and adjacent tissues were obtained post mortem from 10 males and 14 females after a mean duration in situ of 74 months (range 22 to 157 months). All of the patients had been treated at our institution for OA [N=14], ON [N=5], femoral fracture [N=3], RA [N=1] or CDH [N=1]. The mean age at insertion was 65 years (range 39 to 90 years) and the mean Harris hip score at last follow-up was 85 (range 47 to 100).

The acetabular components were composed of a commercially-pure titanium shell and fiber mesh polyethylene coating and a modular UHMWPE liner. The components ranged in size from 46 to 62 mm in diameter and had from 9 to 15 screw holes although only 2 to 5 TiteA4V screws had been inserted. Femoral reconstruction consisted of 15 cemented CoCrMo alloy stems (Precrcoat, Zimmer) and 13 cementless Ti6Al4V alloy stems (1 BIAS, 12 HG). All of the components had modular, 28 mm CoCrMo alloy heads.

Histological analysis was conducted on whole cross-sections of each component with the adjoining pelvic bone and joint capsule. These were undecalcified, plastic-embedded sections stained with basic fuchsin and toluidine blue. The extent of both bony and soft tissues surrounding and within the porous coating was quantified by using an eyepiece grid in the light microscope to categorize 1 mm fields as either bone or bone and marrow, marrow alone, fibrous tissue, cartilage, necrosis, particle-induced granuloma or screw hole. In this manner, the extent measures were extended to the number of fields positive for each of these categories divided by the total number of fields. This was done at 3 levels: the shell-porous coating interface, the porous coating, and the interface between the porous coating and the surrounding pelvic bone. The presence of particle-laden histiocytes in the joint capsule was graded (0 to 3) and their ingress into the tissues at the rim of the component was measured at the 3 levels described. Similar measurements were made adjacent to holes with and without screws. Particulate debris from these sites was identified from 4 µm sections using polarized light microscopy and electron microprobe analysis. Clinical radiographs were reviewed for evidence of periprosthetic osteolysis. Surface damage on the convex side of the UHMWPE liners was assessed based on alteration of the manufacturing machine marks using a stereo microscope at 7 to 75 X. Damage was graded 0 to 3 for severity and for area of damage in the superior, medial and inferior sectors. A score for each sector was calculated as the product of the severity and areas graded, and the 3 sector scores were summed. The maximum possible damage score was 27.

Wear of the UHMWPE bearing surface was determined using a computer-assisted vector wear technique on digital images of the 2 year and final radiographs of 22 of the 28 components (1). All of the data were analyzed using the Friedman test and Spearman correlations.

RESULTS: The extent measurements indicated that overall the interface between the porous coating and the surrounding bone was composed of 37.2% (range 7.4-62.4%) bone, 12.1% (0-32.5%) marrow, 4.3% (0-18.7%) cartilage, 31.5% (0-81.4%) fibrous tissue, 0.5% (0-9.2%) necrotic tissue, 2.8% (0-32.2%) granuloma and the balance screws and screw holes. The extent of bone within the porous coating was 34.5% (range 7.4-62.4%). The least extent of bone was at the interface between the porous coating and the metal shell of the cup (12.9%, range 0-4.3%) where a fibrous membrane was often present.

Particles of polyethylene, titanium and to a lesser extent Ti6Al4V alloy were present within holes with or without screws in all of the components. In addition, several cases demonstrated particles of CoCrMo alloy, barium sulfate or stainless steel from the femoral side of the arthroplasties. The particles were found within fibrin membranes or microscopic 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 8 of 17 after 5 years. The deepest penetration of granuloma into the periprosthetic bone was along screw tracts (3 to 15mm).

At the rim of the components, particle-laden granulomas infiltrated the porous coating and bone-implant interface tissues to a limited extent. The depth of granuloma penetration at the superior rim (mean 1mm, range 0 to 5 mm) increased with time (r=0.502, p=0.009).

Damage to the convex side of the UHMWPE liners was moderate but varied widely with a mean damage score of 7.5 (range 0 to 21) without difference by sector. The damage scores increased with duration of implantation (r=0.579, p=0.002). Pitting, scratching, abrasion, screw hole impressions and embedded titanium particles were common. Burnishing and scratching of the polyethylene surface were the dominate modes of damage in the 5 components with scores of 12 of greater. The damage scores were correlated with the extent of polyethylene particle-induced granuloma at the bone-implant interface (r=0.519, p=0.007) Liner thickness was not correlated with either "back-side" damage scores, granuloma penetration at the component rim or granuloma at the bone-implant interface overall.

The mean polyethylene bearing surface volumetric wear was 81.2 mm³/year (range, 1-444) and was not correlated with the extent of granuloma in the interface tissues.

DISCUSSION: The findings of this study suggest potential failure mechanisms for these cementless acetabular components in the very long term. Although not apparent on clinical radiographs, particle-induced granulomas infiltrated the interface tissues, increasing with time, in a limited, highly patterned manner at the rim and screw holes of acetabular components with extensive bone ingrowth. Osteolytic lesions were not found in these specimens, but particulate metal and polyethylene induced microscopic granulomas were observed in the majority of the cases at the rim of the component and at the screw holes. Although screws may increase bone ingrowth in their vicinity, the most frequently observed granulomas and those with the deepest penetration into the periprosthetic bone were along the screw-bone interface of otherwise osseo-integrated fixation screws. Ingress of granulomas into the surrounding bone at holes without screws was also observed. Scores for damage to the convex surface of the polyethylene liner but not bearing surface wear were correlated with granulomas at the holes and screws. Back-side damage scores were not correlated with granulomas at the rim of the component where penetration into the interface tissues was least despite its proximity to the debris-laden joint capsule. For these reasons, screws and screw holes should be avoided, if at all possible, in younger patients.


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