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RETRIEVAL ANALYSIS OF SOME CEMENTLESS HA-COATED SMOOTH SURFACE ACETABULAR IMPLANTS

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INTRODUCTION: The most common mechanism in total hip arthroplasties has been shown to be surface wear. Hydroxyapatite (HA) forms biological bonds between host bone and implant, being used as a surface coating for total hip arthroplasties since '80s [1]. Important questions still remain regarding the use of HA-coated acetabular components in total hip arthroplasty. Osteolysis due to bearing surface wear is the greatest unsolved problem that limits the durability of joint replacement. Retrieval studies of clinically well-functioning acetabular components should help to answer some of these questions.

METHOD: We examined four clinically successful HA coated cementless acetabular components retrieved at revision between 6 and 15 years after implantation. All components were of the same design (smooth-surfaced HA coated acetabular shell with two to three screws).

Fig. 1: Macroscopy view of the primary implant components who was analized: acetabular cup, poliethylene liner, screws.

The prostheses and the surrounding bone were prepared for qualitative histological and quantitative histomorphometric analysis [2]. The percentage of bone growth onto the implant, the relative bone area around the implant, the extent of residual HA coating, and the coating thickness were measured. Retrieved metallic shells were initially visually analyzed, then digital pictures were taken, areas of HA demarked and extent of bone ingrowth and HA absorption was analyzed. ESEM analysis was the next step, using two types of electron detectors: LFD and BED - composition images on shell surface and retrieved broken screws.

RESULTS: The primary implants - cementless HA coated smooth surface (Landos, France) had a HA coating of 60 micrometers thick and 5 screw holes on the surface. Tissues samples retrieved at the time of revision surgery for a migrated cementless acetabular implant associated with important osteolysis have demonstrated a consistent histological pattern. All intraoperative bacteriological cultures were negative. The most common finding was extensive chronic inflammation with a predominance of plasma cells and lymphocytes. Other anatomo-pathologic features included granulomas, foreign-body giant cells, necrosis, and fibrin exudation (figure 2). Each acetabular cup was removed with as much care as possible with regard of the bone stock and surrounding tissues. Gross inspection at the retrieved acetabular liners revealed a group of changes.

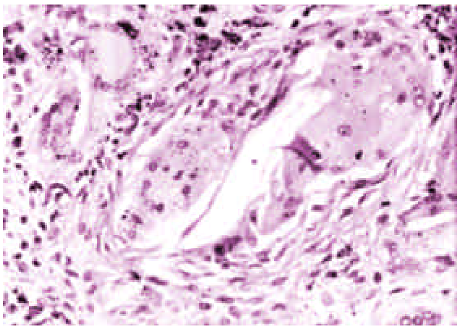

Fig. 2: Histological view of the tissue surrounding the implant under light microscopy. 1-foreign bodies, 2-foreign body inside giant cell, 3-giant cell and fibrin exudation; (hematoxilin Eosin, coloration of sample tissues; x 200)

Backside deformity with loss of machining lines, important backside markings around the screw holes, minimal wear inside the cup, advanced wear along the peripheral rim where impingement occurred. The digital analysis of the implants showed the degree of bone ingrowth at an average of 10 to 15% and the HA resorbtion extent averaged from 60 to 85% of the surface. ESEM analysis showed two patterns. The Ti6Al4V alloy type screws presents unhomogenous material, surface morphology analysis indicates a fatigue screw breakage type of failure, probably because of presence of the poliedric compounds with different composition compared with base metal (fig. 3).

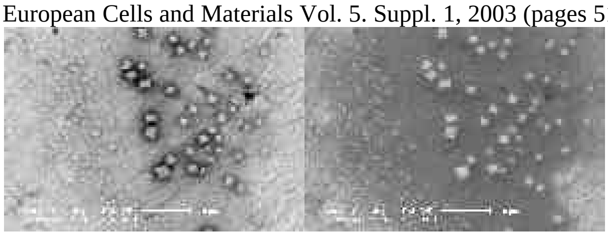

Fig. 3: Scanning Electron Microscopy (SEM) of the screw breakage area: left-BSE, right-LFD (x2931); note the poliedrical compounds with a visible different composition than surrounding metal basis, a possible source for weakness and failure.

The up surface of acetabular cup presents three different zones: base material porous type-titanium, remnant areas covered with hydroxy-apatite and areas polished by fretting (fig. 4).

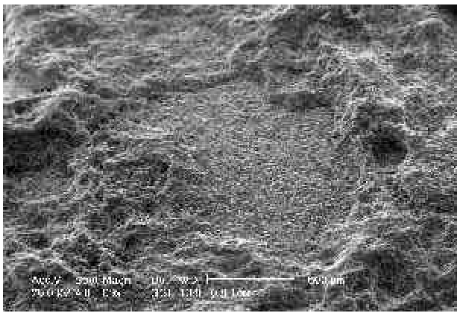

Fig. 4: Scanning Electron Microscopy (SEM) of the external surface of the acetabular shell (x69); note the difference in porosity between HA coated area and TiAlVa smooth metal surface.

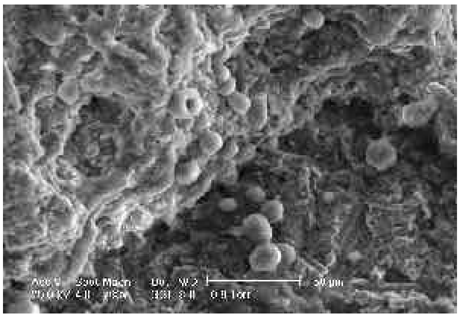

Fig. 5: Scanning Electron Microscopy (SEM) of the same area of the acetabular shell at the interface HA-metal (733X); note the important cell adhesions (bone and erythrocytes) related to the remnant HA in contrast with the smooth surface.

DISCUSSION & CONCLUSIONS: Regarding the fixation failure-poor biological fixation may be related to surgical errors at primary implantation; the best option is to have a porous surface HA-sprayed. Because of biocompatibility and osteoconductivity, HA coated implants, become stabilized by strong bone; whether macro or micro-textured surface of the implant is better for bone-ingrowth and prosthesis longevity is still a subject of debate [4]. The screws in acetabular fixation: usually not needed for press fit primary fixation they prevent rotation and tilt (good for revisions) but provide access for debris and development of “cold flow” mechanism. In our cases we think that the failure of the smooth surface HA coated implant occurred over time. It is not reasonable to expect soft tissue interlocking of such an implant, and with no osteointegration, the cup will be instable and fail. The screws not sufficiently well implanted at primary intervention became mobile and an initial source of debris. The screw holes reduced the potential area for bone ingrowth and became the entry for polyethylene debris in the acetabular bone-testimony being brought by the important screw-hole markings on the backside of the polyethylene liner. The small particles are well known to produce a strong notch effect, in the gap created, oxygen content is consumed with a decrease in the local pH value of the body fluid and an increase of the corrosion rate. The added cell-mediated HA resorbtion seems to be the main reason for loss of HA coating. The area of bone ongrowth was within a certain range (15% to 40%) of the measured surfaces, and it was independent of the amount of HA residue. The excessive wear generated important debris and the inflammatory answers of the organism lead to osteolysis, excessive HA restoration and failure of the acetabular cup. The analyzed failure cases may be caused by the inaccurate insertion of the cup with inefficient screws that led to a combination of metal and polyethylene debris disease. After an initially normal clinical evolution, the local biological and mechanical factors led to failure of the initially good but insufficient lamellar bone and eventually bony bridges.

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