Microscopy analysis of total knee prosthesis failure caused by polyethylene wear

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INTRODUCTION: For the longevity of total knee arthroplasty it is very important to predict the polyethylene wear and optimize the prosthetic design [1]. Polyethylene wear is affected by contact stress, sliding motion and kinematics of the knee prosthesis. The most important factors which cause long-term failure of a prosthetic joint are: macroscopic fracture of the metallic components, wear of implant, corrosion process and osteolysis. Retrieval studies of components of knee prosthesis should help to answer some of these questions.

METHODS: The aim of this study was to study the wear characteristics of retrieved total knee implants. We examined 36 tibial components of knee prosthesis retrieved at revision between 3 and 5 years after implantation.

Fig.1: Example of some retrieved polyethylene components from knee prosthesis

The damage of the polyethylene was analysed by scanning electron microscopy. Also, the macroscopical aspects of retrieval polyethylene components were revealed using 10x light stereomicroscopy; Hood's scoring system was used.

RESULTS: Different modes of surface degradation were identified: burnishing; pitting: depressions in the articulating surface; surface deformation (caused by cold flow and/or creep); abrasion caused by direct contact with bone-cement debris; scratching; delamination. In our retrieved specimens, both longitudinal and transverse wear patterns "ripples' were observed consistent with the "natural" sliding and rolling movement of the knee. Another observation is related to the surface delamination of the surface observed by SEM, with a low uniformity of it, possibly related to a shelf aging phenomenon. This may also explain the relative agglomeration of revision cases in one year time interval.

Fig.2: Macroscopic aspects of polyethylene components (left); stereomicroscopic image from failure zone (right)

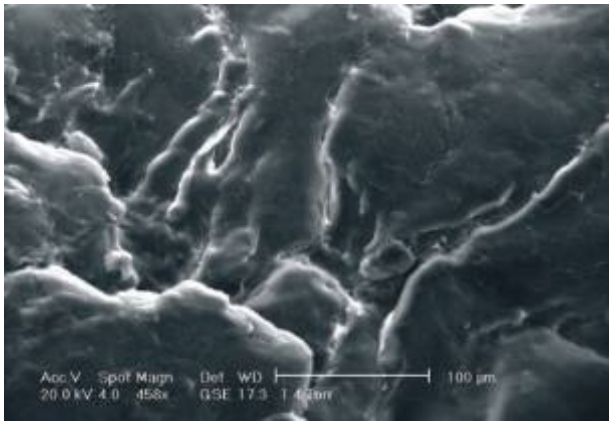

Fig.3: Scanning electron micrographs of retrieved polyethylene components (successive delamination was observed)

DISCUSSION & CONCLUSIONS: Some knee implants are more "forgiving" versus the surgical technique; generally, small rotational errors (± 5º) are consistent with surface damage of the tibial insert. Burnishing, scratching and abrasion are the mechanisms mainly involved in these failures; most damage was seen at the posteromedial area. Delamination and surface deformation are connected to shelf or service life wear. The damage mechanisms of polyethylene components are dependent on the component geometry, the sliding conditions, and the shelf to service lifetime of the implant.

REFERENCES: [1]Hood RW, Wright TW Burstein AH., *"Retrieval analysis of total knee prostheses - a method and its application to 48 total condylar prostheses"*, J.Biomed.Mater.Res., 1983.