ANALYSIS OF EARLY RETRIEVED ACETABULAR CUPS OF HIGHLY CROSSTLINKED POLYETHYLENE

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Introduction
One of the major problems in total hip arthroplasty is osteolysis due to particle debris which leads to component loosening. The most important source of this particle debris is the wear of acetabular liners made out of conventional ultra-high molecular weight polyethylene (UHMWPE). Irradiation crosslinking has demonstrated a significant improvement of wear resistance of UHMWPE during in-vitro studies [1].

The highly crosslinked polyethylene Durasul® (Centerpulse Orthopedics Ltd.) was introduced into the market with several market surveillance studies: RSA-method, Poly Ware Edge Detection-method and a retrieval study. Investigations on components retrieved early provide the opportunity to evaluate the highly crosslinked components for early wear damage or other effects on the material.

Materials and Methods
12 Durasul® alpha cups from various sources were surgically retrieved and analyzed. The range of in-vivo duration of the cups was between 3 months and 15 months. The reasons for revision were: 3 for infection, 1 for ossification, 2 for luxation, 1 for pain, 1 for bone fracture, 1 for trochanterfixation and 3 for unstable primary fixation of the metal shell.

The investigations were made by different types of microscopy: optical-, polarization-, scanning-electron- (SEM) and transmission-electron-microscopy (TEM). The articulation geometry of the cups was documented using coordinate-measuring-machine (CMM).

Results
Machining marks in the loaded area look partly flattened, this condition is similar to polished worn surfaces of conventional UHMWPE. Some of the articulation surfaces show a highly scratched surface in the loaded area. This dull scratched morphology suggests third body wear.

When the material is subjected to thermal treatment above the crystalline melting point of UHMWPE, the flattened machining marks on the articulation surfaces become visible again. Also scratches remove, but are still visible as shadows. This memory-effect is due to the relaxation of orientations and internal stresses, which leads to the reconfiguration of the surface morphology [2].

With the memory-effect it is possible to show, that most of these findings are due to plastic deformation and not due to abrasive wear. Plastic deformation does not result in weight loss.

Fig. 1 Surface morphology of a retrieval after 7 months in-vivo before and after the memory experiment (50x)

Fig. 2 Surface of a retrieval after 15 months in-vivo with slight and after 7 month in vivo with heavy scratching (50x)

With a high magnification over 200x the articulation surface shows some microscopic changes in the surface morphology like tears, ripples and folds. These surface phenomena are shear-induced ripple formations and material overlappings [3]. The depth of these minute deformations is a few microns.

In some cases the retrieved cups show a yellow discoloration around the loaded surface. It is associated with the liquid-uptake of conventional UHMWPE. The yellow discoloration indicates the presence of in-vivo absorption of synovial liquid proteins with esterified fatty acids and cholesterol [4], what is also investigated in-vitro with highly crosliked UHMWPE.

Discussion
Although there is extensive experimental wear data on the crosslinked polyethylene, there is little data on the wear performance of these materials in-vivo [5]. The findings from the retrievals showed that there is no adverse wear at 3-15 months and there were no material failures due to wear, delamination or cracks. The dull appearance and the scratches are due to the fact that the wear of this polyethylene is very small. All these observations are accumulating on the articulating surface and lead to the dull scratched morphology. Mechanisms like material overlapping and yellowing due to absorbed body fluids are reported also from conventional UHMWPE and do not show adverse effects on the long-term behaviour of the material.

References