The University Of Sheffield.

The Leonardo Tribology Centre

Retrieval analysis of zirconia hip replacement implants

Understanding the wear and degradation of prostheses

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Understanding the mechanisms of *in vivo* wear and degradation is vital to design better prostheses that last longer and allow patients to maintain active lifestyles.
Additionally, our findings help scientists to develop tribological testing techniques that more closely resemble what happens inside the body, providing a reliable prediction of the material's performance *in vivo.*
This knowledge is transferable to the design and development of materials for other biomedical applications such as dental implants.

Characterization techniques:
Optical interferometry (Contour GT, Bruker)
Atomic force microscopy (Nanoscope II,Bruker)
Raman microspectroscopy (LabRam HR, Joriba Jobin Yvon)

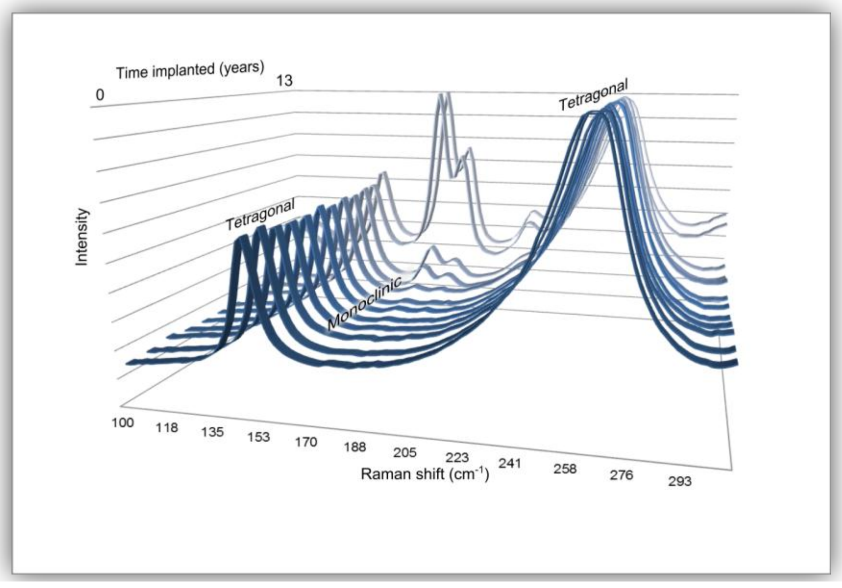

Fig. 1. Increase in monoclinic phase content with implantation time.

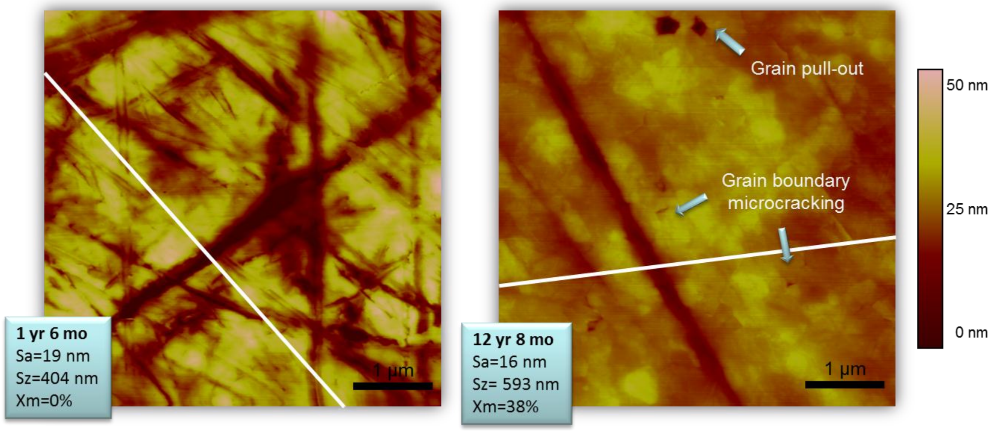

Fig. 2. Smoothening effect on the surface after 12 years implantation.

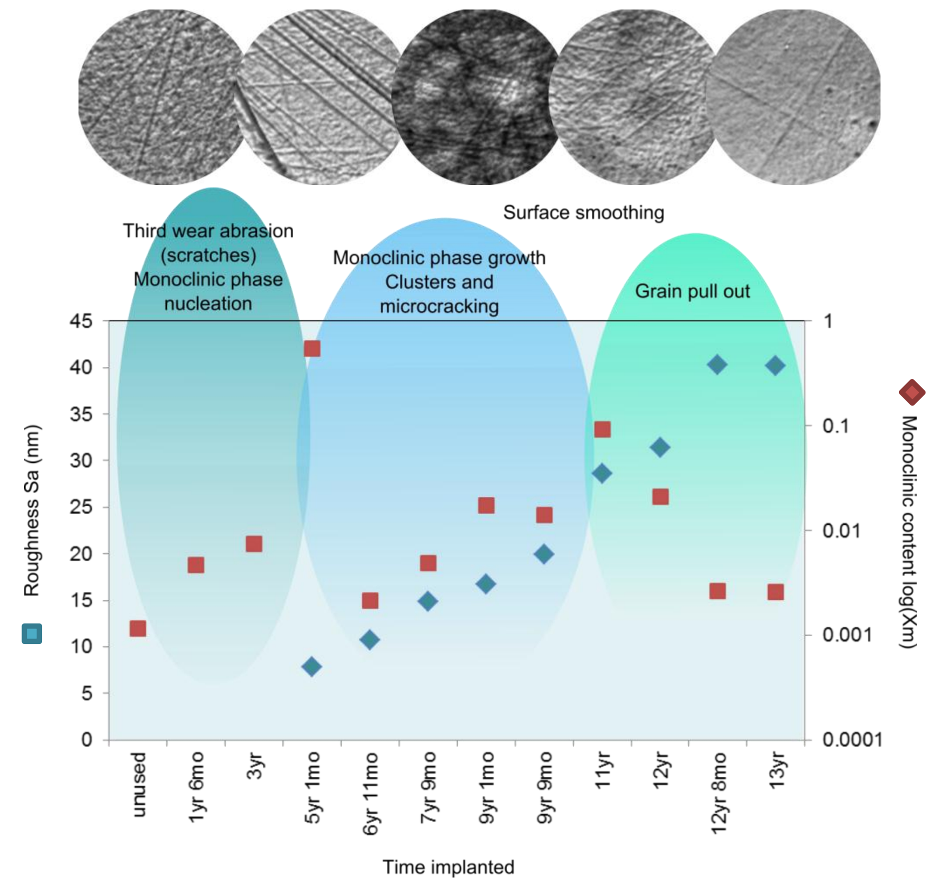

Fig. 3. Development of surface features during implantation time: the monoclinic content increases constantly (sign of material degradation) while the surface roughness shows two maxima.

The durability of zirconia ceramics in orthopaedic applications is seriously affected by the tetragonal to monoclinic (t→m) phase transformation that initiates on surfaces exposed to aqueous environments under stress conditions. This transformation involves a volume expansion that causes microcracks and fractures, and potentially leads to the failure of the implant. In this work, zirconia femoral heads retrieved from patients after different periods of time (up to 13 years) were analysed using a variety of characterization techniques. The t→m transformation was identified by the formation of the characteristic clusters of monoclinic grains that protrude from the surface due to the volumetric expansion and the monoclinic phase was quantified by Raman microspectroscopy. The concentration of monoclinic phase increases with implantation time and accumulates mostly in the top and the equator of the implant. The surface roughness also increases with time due to the formation of scratches but as the first monoclinic clusters appear the roughness value decreases. When more monoclinic clusters are formed (i.e. elevated features) the roughness increases again. After long implantation times and significant surface transformation, the surfaces become considerably smoother with some porosity produced by grain pull-out. This indicates that the detrimental surface changes and the t→m transformation occurring *in vivo* are not only time dependent but the result from a variety of interrelated reasons.

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