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## Surface analysis of early retrieved polyethylene tibial inserts for both knees in total knee replacement

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### ENGINEERING FAILURE ANALYSIS

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### Abstract

This study involves the failure analysis of a pair of ultra-high-molecular-weight-polyethylene (UHMWPE) knee tibial inserts from Scorpio (R) fixed-bearing total knee system by Stryker, which were retrieved from Total Knee Replacements (TKR) that was performed on 64 years old male patient with periprosthetic joint infection detected on both knees. Although the implants were removed due to infection, surface analysis was essential to be studied in order to analyse the surface damage mode of short-term implants. This study reports relevant damage mechanisms seen in early-retrieved UHMWPE tibial inserts (implanted for 6 and 8 months) and further analysis of chemical, physical and mechanical properties that possibly accompanied with failure. The surface characterization was done using a 3D laser microscope and Scanning Electron Microscope (SEM) to evaluate surface damage and dimensional change of both UHMWPE tibial inserts. Nano-indentation is used to measure the hardness and elasticity modulus of the tibial inserts. Attenuated Total Reflection-Fourier Transform Infra-Red (ATR-FTIR), Differential Scanning Calorimetry (DSC) and Gel Permeation Chromatography (GPC) were used to characterize the chemical and physical properties of the inserts. In present study, retrieved polyethylene inserts with short implantation duration was considered to have high-grade wear modes. The high incidence of micro pits (with the average depth of 27.5  $\mu\text{m}$  for 6 months insert and 18  $\mu\text{m}$  for 8 months insert) and scratches as the observed surface defects strengthen the role played by the particles upon defects generation for both tibial inserts. The average surface roughness of 6 and 8 months inserts were 1.6798  $\mu\text{m}$  and 1.2376  $\mu\text{m}$ , respectively. The rough surface (4.207  $\mu\text{m}$ ) of region 4 at the lateral compartment proves that the 6 months tibial insert suffered more damage due to loosening defect where the radiolucencies (the gap between bone and cement) were seen below medial and lateral aspects of the tibial tray. Our data demonstrated a strong association between the change of molecular weight and degradation of mechanical properties with wear for both inserts. The oxidation induced wear mechanism was observed on 6 months old insert due to the presence of delamination features with the evidence of in vivo oxidation from IR analysis.

### Keywords

**Author Keywords:** Polyethylene tibial insert; Wear; Early-retrieved implant; Total knee replacement; Surface analysis

**KeyWords Plus:** MOLECULAR-WEIGHT POLYETHYLENE; WEAR; PROSTHESIS; COMPONENTS; FATIGUE; LIFE; HIP

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