Characterization of wear particles from periprosthetic tissues from total hip patients

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Statement of Purpose: Wear particle mediated osteolysis has been widely attributed as the main cause of long term failure of total joint replacements. Although, investigators have previously used acid, base and enzyme digestion techniques to identify and characterize wear particles [1], from simulated wear fluids [2,3], data from actual tissue explants is limited [4]. This may be attributed to the lack of a standardized tissue digestion technique/protocol. In this project we have further modified the base digestion technique, and according to our knowledge this is the first study that has identified simultaneously multiple wear-particulate species from retrieved periprosthetic tissue.

Methods: Periprosthetic tissue was obtained from synovium regions of a patient undergoing revision surgery of total hip. The implant was of a metal-on-poly type. The tissue (2g) was cut into 1×1cm pieces and treated with 15ml of 10M NaOH at 70°C for 72h with constant stirring at 300rpm. The viscous fluid was further treated with 15ml of chloroform:methanol (2:1) for 24h with stirring at 300rpm. To 2ml of this extract 8ml of ddH_2O added and filtered through a 20µm pore filter (Osmonics) to discard larger agglomerates. Suspension was continuously stirred at 300rpm during the whole process to prevent formation of sediments and/or supernatants. One milliliter of the filtrate was collected on a 0.2µm pore filter and washed with 5ml water to dissolve any salt crystals and also to disperse the particles and facilitate disaggregation of particulates. Thereafter, the filter was dried using a hot-air gun. The filter membrane thus obtained was coated with 25nm carbon and imaged using a JOEL JXA-8530F field- emission scanning electron microscope (FE-SEM) with an energy-dispersive spectrometry (EDS) component for metal detection.

Results: Ultra-high molecular weight polyethylene (UHPE) was found to be the most widely prevalent particulate species present in the digest. Almost 80% of all particles isolated were identified as UHPE followed by Ti (8-9%), Co (5-6%), Cr (3-4%) and other trace elements including Fe, Pb (~1-2%). Figure 1 shows the SEM micrograph along with the EDS spectra for Ti and UHPE. The UHPE particles appeared as either fibers 1-15µm or as flat flakes (mean dia. 650nm). Titanium appeared as oval granules (mean dia. 150nm). Some of the other metals (Co and Cr) (Figure 2) appear as diffused amorphous structures. Almost all particles appear as aggregates of numerous individual particles clumped together.

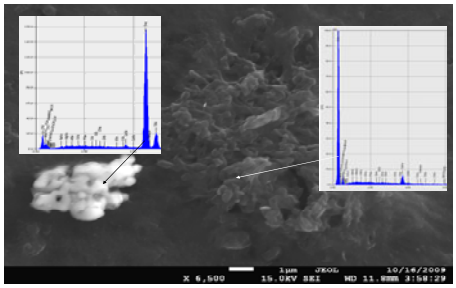

Figure 1. SEM micrograph of the tissue digest on a 0.2µm pore filter along with the corresponding EDS spectra for Ti (left) and UHMWPE.

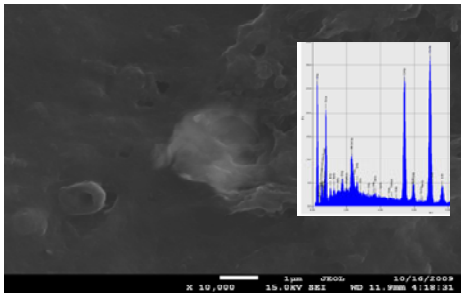

Figure 2. SEM micrograph of the tissue digest on a 0.2µm pore filter along with the corresponding EDS spectra showing peaks for Co and Cr.

Conclusions: 1. UHMWPE accounts for the majority (~80%) of the particulate matter present in the periprosthetic tissue for a metal-on-poly implant, followed by Ti, Co, Cr and other metals in trace amounts.
2. The modified base digestion method used for this study was able to completely digest the periprosthetic tissue.

Limitations and future work: 1. Further studies are being conducted to disaggregate the larger agglomerates to facilitate isolation of individual particles.
2. Efforts are being initiated to isolate and quantify individual particulate species and fractionate them into well defined, reproducible and clinically relevant size ranges for further cell-response studies.

References: 1. Baxter RM. J Biomed Mater Res B Appl Biomater 2009;91:409-418. 2. Fisher J. Proc Inst Mech Eng [H] 2001;215:127-132. 3. Fisher J. Clin Orthop Relat Res 2004;(428):114-119. 4. Catelas I. J Biomed Mater Res B Appl Biomater 2004;70:167-178.