EFFECT OF CROSSLINKING ON BIOLOGICAL ACTIVITY OF UHMWPE WEAR DEBRIS

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Introduction: Ultra high molecular weight polyethylene (UHMWPE) wear debris induced osteolysis is a major cause of long term failure of total hip replacements. Particles in the 0.1-1µm size range are believed to have greater osteolytic potential than larger wear debris. Crosslinked polyethylenes have been shown to have improved wear resistance compared to non-crosslinked materials on smooth counterfaces [1]. More recently however the wear debris from crosslinked UHMWPE has been shown to be smaller than that produced from non-crosslinked materials. The aim of this study was to compare the wear, debris and biological activity of non-crosslinked and crosslinked polyethylenes when worn against smooth and scratched counterfaces.

Materials and Methods: Test pins were machined from non-crosslinked GUR1050 and GUR1050 crosslinked with either 5 or 10Mrad of gamma irradiation. Sterile endotoxin free clinically relevant wear debris was generated using a bi-directional pin-on-plate test rig. Prior to each test, UHMWPE pins, stainless steel counterfaces and the test rig were sterilised and all procedures carried out in a class 1 laminar flow cabinet using aseptic technique throughout. Tests were performed on scratched (Rp=1.0µm) or smooth (Ra=0.02µm) counterfaces. RPMI 1640 culture medium supplemented with 25% (v/v) foetal calf serum was used as the lubricant. Following each test the lubricant was collected and the volume adjusted to give the appropriate concentration of debris. Half of the lubricant was subjected to serum digestion and sequential filtration [2] and half was stored for co-culture studies with macrophages. The pin weight loss was determined to allow calculation of wear factors. Filter samples were mounted on aluminium stubs and gold coated for analysis by SEM and image analysis to allow determination of particle size and mass distributions. Particles were co-cultured with C3H murine peritoneal macrophages at particle volume (µm³): cell number ratios of 50:1 10:1 1:1 and 0.1:1. The lubricant from the tests was used directly and half was stored for co-culture studies with macrophages. The pin lubricant was subjected to serum digestion and sequential filtration to adjust the appropriate concentration of debris. Half of the control.

Results: On both scratched and smooth counterfaces crosslinked polyethylene had lower wear than non-crosslinked polyethylene and this decreased with greater crosslinking. (Fig.1) Determination of the volume distribution of the wear debris demonstrated a greater percentage of wear debris in the submicrometre size range from crosslinked materials when worn on scratched counterfaces. Analysis of debris when worn on smooth counterfaces showed a further reduction in size of debris with more particles below 100nm in size (Table 1).

In order to determine the relative biological activities of the particles from the non-crosslinked and crosslinked materials articulating against scratched and smooth counterfaces the production of TNF-α by macrophages was assessed by MTT conversion. The conditioned supernatants were then assayed for TNF-α by ELISA. Results were expressed as the mean specific activities (ng TNF-α/MTT optical density at 570nm) ±95% confidence limits. Data was analysed by two way analysis of variance.

Discussion: When worn against both scratched and smooth counterfaces wear resistance was increased by crosslinking and this increased with the degree of crosslinking. When worn against a scratched counterface crosslinked polyethylene generated a greater percentage of debris in the submicrometre size range compared to the non-crosslinked polyethylene and this led to an increase in biological activity. When worn against smooth counterfaces the size of the wear particles for all 3 materials was further reduced with particles observed in the nanometre size range and this reduced the percentage in the submicrometre size range. This led to a decrease in biological activity compared with that for the non-crosslinked material. We have previously shown reduced biological activity compared with low molecular weight 1120 compared to higher molecular weight 413HP [4]. This study indicated that crosslinking of 1050 increased the biological activity of the debris when articulating on slightly scratched surfaces. Invert in specific biological activity of the crosslinked debris needs to be considered alongside the reduction in wear volume in predicting the long term osteolytic potential.


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