OXIDATION AND WEAR RESISTANCE OF DIRECTLY MOULDED UHMWPE

*Bell, C. J., +Blunn, G. W., Walker, P. S., Bosman, H., Bartlett, G., **Scott, R. *+Centre for Biomedical Engineering, University College London, Royal National Orthopaedic Hospital, Stanmore, Middlesex, UK: 44 181 954 9427, Fax. 44 181 420 7392.

INTRODUCTION

Oxidation of ultrahigh molecular weight polyethylene (UHMWPE) is of considerable importance because it leads to higher wear and has recently been correlated with delamination in TKR, due to the development of an oxidised sub-surface band. Current sterilisation processes have been altered to try and eliminate the problem. It has been reported that polyethylene from retrieved knees which has been directly moulded (DM) from Montell 1900H resin, is resistant to oxidation. Our work compares the oxidation and wear resistance of directly moulded polyethylene with extruded and sheet compression moulded material.

METHODS

Seven shelf-aged components (10-13 years) which had been manufactured from Montell 1900H resin by direct moulding and then gamma irradiated in air, were obtained and examined for oxidation. The oxidation of these components was compared with that of components machined from RCH1000 compression moulded sheet (GUR 412 resin) or from extruded bar (GUR 415 resin); these had been irradiated in air and shelf-aged for 10-11 years. In addition, directly moulded components and machined components, recently sterilised in air or argon were artificially aged and compared. Artificial ageing was performed by heating samples at 80°C in a sealed pressure vessel at 70psi in oxygen for eight days. This has previously been shown to reproduce levels of oxidation seen in retrievals after approximately ten years. Specimens were then sectioned and examined for the formation of a sub-surface oxidised band. FTIR was performed to quantify oxidation and crystallinity. Density of polyethylene sections taken at different depths from the plastic surface were measured using a calibrated density column. A four station force input knee simulator was used to compare the wear performance of artificially aged knees manufactured by direct moulding (AGC) and by machining from extruded polyethylene (Kinematic). In addition two AGC components which were shelf aged for between 11-14 years were tested against two Kinematic TKRs where the plastic was shelf aged for between 6-8 years.

RESULTS

Shelf-aged, directly moulded components sterilised in air showed no sub-surface oxidised band (Fig. 1) However, components machined from both extruded and sheet moulded polyethylene, sterilised in air, showed well developed sub-surface bands of oxidation. Artificial ageing of newly manufactured, air-irradiated directly moulded components showed the development of a slight sub-surface band of oxidation, but this was much less than the level of oxidation associated with shelf aged compression moulded components (Fig. 1). This level of oxidation was also lower than the oxidation observed on machined components which had been artificially aged. Argon-irradiated directly moulded components did not develop a sub-surface oxidation band. Morphologically, the directly moulded components showed a band below the surface, which was less oxidised than the bulk of the material. This finding has also been seen in retrieval specimens that had been directly moulded from 1900 resin.

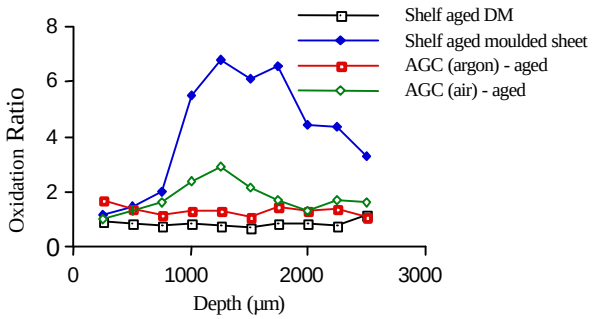

Figure 1 – Oxidation ratio with depth from the articulating surface.

Density measurements of shelf aged components showed significantly higher density for the machined components compared to the directly moulded components to a depth of 2mm from the articulating surface (Fig. 2). Directly moulded components showed no significant change in density with depth.

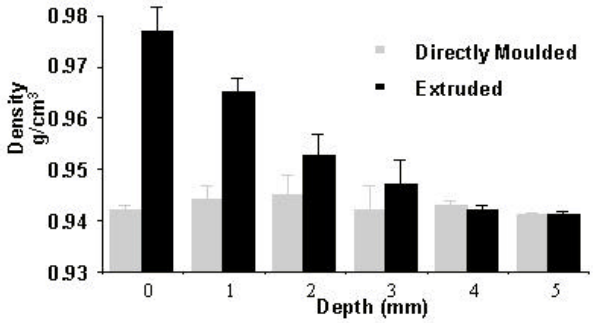

Figure 2 – Density with depth from the articulating surface for directly moulded and extruded polyethylene.

Results from the knee simulator testing of aged tibial components showed high sub-surface oxidation and delamination wear for the extruded components after only 600,000 cycles, whereas the directly moulded components did not show delamination, only surface wear. Weight loss data to four million cycles for aged directly moulded components did not show significantly different wear to non-aged directly moulded components. For components that were shelf-aged and then tested in the knee simulator, delamination developed on the Kinematic components, but did not occur on the directly moulded AGC components.

DISCUSSION

These results show that components directly moulded from Montell 1900H resin and sterilised in argon are resistant to oxidation, and particularly to the development of a sub-surface band of oxidation. The reasons for this are unclear at present but probably are due at least in part to the process associated with directly moulding. Polyethylene manufactured by the direct moulding process resulted in a reduction in wear, notably delamination wear often seen in TKR retrievals. Our data is consistent with the empirical data noted in retrieved knees. Hence the direct moulding process could prolong the useful life of TKR components.

ACKNOWLEDGEMENTS

Supported by the Medical Devices Agency, Department of Health, UK. and Biomet Merck Ltd., UK.

** Biomet Merck Ltd., Swindon, UK.

☒ One or more of the authors have received something of value from a commercial or other party related directly or indirectly to the subject of my presentation.
☐ The authors have not received anything of value from a commercial or other party related directly or indirectly to the subject of my presentation.