DO HEAT TREATMENTS INFLUENCE THE WEAR OF LARGE DIAMETER METAL-ON-METAL HIP JOINTS?
AN IN VITRO STUDY UNDER NORMAL AND ADVERSE GAIT CONDITIONS

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Introduction
The clinical advantages of implanting large diameter (>40mm) metal-on-metal hip implants are gaining increasing credence. Large diameter bearings are more stable in vivo and have a greater range of motion than conventional 22 or 28mm bearings. Elastohydrodynamic theory predicts that large diameter resurfacing joints should also create an exceptionally low wear condition due to improved hydrodynamic action [1], and this has been demonstrated in laboratory studies [2], albeit in small numbers.

As large diameter bearings are often cast, they may be heat treated to improve mechanical properties. A hot isostatic press (HIPing) and solution heat treatment process is often carried out to remove micro-porosity and improve the ductility and homogeneity of the material. However, it has been suggested that these heat treatments may adversely affect wear [3], though there have been no clinically relevant hip joint simulator studies in this area to confirm this hypothesis. As there remain many concerns about possible systemic problems due to the release of exceptionally large numbers of metal wear particles, an improved understanding of the influence of heat treatments on debris generation is essential.

The aim of this study was to therefore investigate and quantify the wear from as cast and HIPed/solution heat treated components using an established multi-station hip joint simulator and a biological lubricant, under both standard and severe testing conditions. This was achieved by wear testing under normal walking, simulated fast jogging activities and using intermittent motion.

Materials and Methods
For this investigation, 40 mm diameter metal bearings (high carbon CoCrMo alloy to BS7252-4) were tested. For all components, the radial clearances were controlled at 0.008 μm, and the maximum deviation of sphericity was 4 to 8 μm. Both heads and cups were machined to the same tolerances as commercially available devices (Cormet®, Corin Medical UK). The prostheses were tested blind in 2 groups. Group one consisted of four hot isostatic pressed (HIPed) and solution heat treated bearing couples (generating a fine carbide structure), and group two consisted of four as cast bearing couples (which have a coarse carbide structure). A multi-station hip joint simulator (MTS Systems, USA) was used to undertake all wear tests, which applies a ±23° biaxial rocking motion to represent flexion/extension and adduction/abduction movements of the femur. This motion combined with the single joint force generates a multiple cross-loop loci pattern, similar to that of the natural hip joint [4,5]. All components were positioned physiologically within the simulator, i.e. cup above a moving head, and all cups were inclined at 35° to the horizontal. All wear tests were performed using 25% newborn calf serum (500 ml) with an approximate protein content of 17 mg/ml, which has been recognised as being clinically relevant.

All components were initially subjected to 3 million cycles of standard physiological walking (2450 N max, 1 Hz) [6] to generate steady-state wear conditions. One million cycles of fast jogging tests were then performed (4500 N max, 1.75 Hz). The results indicated that under simulated fast jogging activities, the wear rates of all test components were still one order of magnitude lower than those reported for moderately crosslinked UHMWPE articulating against CoCrMo heads under identical conditions [8].

The steady state wear rate for both test groups under normal walking was 0.48 mm/10⁶ cycles, which is similar in magnitude to that reported for some high carbon for 28 mm joints [9]. However, varying simulator conditions and lubricants are known to influence the wear rates of metal-metal bearings [9]. Currently, 28mm diameter joints are being tested under identical conditions to those described above, in order to evaluate whether the theoretical improvements in lubrication of large bearings can be reproduced under these test conditions. Full quantitative analysis of all wear particles produced for both groups is also currently underway.

Acknowledgements
This research was funded by the Wishbone Trust, UK, with support from Corin Medical UK.

References