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Introduction
The use of large cobalt chrome femoral heads reduces dislocation and increases the range of motion. However, failure of large head metal on metal hip replacements (LHMMHR) has recently been identified and is believed to be associated with the high torque at the interface of standard modular taper junction leading to fretting and corrosion. Compared with standard 28 mm heads the relative forces at the interface transmitted for larger femoral heads are increased. This is because the offset of the larger femoral head increases the torque transmitted through a standard 12/14 taper. Increasing the femoral head size leads to a reduction in the ratio of the head size to the contact area of the spigot (HS:CA). In this study we investigated the hypothesis that the reduced ratio of the head size with the contact area of the spigot (HS:CA) will increase wear and corrosion on modular tapers.

Methods
Wear and corrosion of spigots were compared in-vitro when loaded with a force representative of the resultant force passing through the hip. The heads (female tapers) were made of 28 mm cobalt-chrome-molybdenum (CoCrMo) and the stems (male tapers) of titanium alloy (Ti). Commercially available modular heads and tapers were used. The surface parameters & profiles of the tapers were measured before testing. The spigots were immersed in saline solution and loaded with a sinusoidal offset load of 300N-2.3 kN for 10 million cycles at 1Hz. After testing, the femoral heads and the tapers were sectioned using a slitting wheel, which avoided damaging the surfaces and the surface profiles were again assessed. The HS:CA was adjusted by reducing the taper contact using commercially available mini spigots. Two tests were carried out. In the first test the effect of changing the HA:SC was investigated by comparing a standard taper (n=3) with a reduced taper (n=3). In this test the surface finishes of the tapers were the same. In the second test the effect of the 2 different (n=3) commercially available modular tapers male tapers with different surface finishes were investigated both with a reduced HS:CA. In all samples from both test 1 and 2 the femoral head taper was of the same surface finish. During testing electrochemical static and dynamic corrosion, (pitting) tests were performed on spigots under loaded and non-loaded conditions using a potentiostat.

Results
In test 1, the surface parameters Ra, Ry & Rz on the head tapers became significantly greater after 10 million cycles compared with start of the test. After testing this increase was significantly greater (p=0.04) in the group with reduced HS:CA with higher Ra values (1.65-1.83 µm), compared to the standard spigot group (0.96-0.98 µm) (figure 1). In all instances, the profile of the titanium male tapers was unchanged. SEM and profilimetry of the female cobalt chrome tapers with reduced HS:CA showed the surface profile of corroded region of the head had significantly changed and was similar to the profile on the Ti male taper. The machine marks associated with the unloaded part of the taper were evident and were less deep and more frequent than those associated with corroded part of the taper (figure 2). This imprinting effect was associated with pitting in the cobalt chrome. This effect was more evident on the cranial and caudal surfaces and less prominent on the medial and lateral surfaces.

In test 2, the rough surface finishes were affected more severely than those with a smoother surface. Potentiostatic static corrosion tests showed evidence that the passive film was being destroyed and repassivated during each loading cycle for the rough but not the smooth spigots (figure 3). In the taper with the smooth finishes there was no evidence of imprinting which again was restricted to the rough surface finishes. The pitting scans showed a greater hysteresis with the male tapers with the rough surface finishes compared with the male tapers with the smoother surface finishes, indicating greater corrosion.

Conclusion
This study shows that the relative contact area of the taper in comparison to the head size combined with the surface finish is crucial for corrosion at this interface. As the HS:CA reduced, corrosion of the cobalt chrome head increased and is further enhanced if the surface finish on the tapers is rough. The finishes on the male tapers are those that are used commercially. The imprinting seen in these in vitro tests has recently been identified in retrieved LHMMHR.

Significance
This study has important implications for LHMMHR as the head size to spigot contact area is reduced. Corrosion is increased where the surface finish on the male tapers are coarse. Corrosion of the spigot for LHMMHR will be reduced if smoother taper surfaces are used.