Hip wear and friction simulator test of a novel acetabular cup
Hussain, A., Li, C. X., Kamali, A.
Implant Development Centre (IDC), Smith & Nephew Orthopaedics Ltd., Leamington Spa, CV31 3HL, UK

Introduction

It has been shown that reduced clearance in metal-on-metal hip joints have the potential to reduce wear during the running-in phase\(^1\). Cementless cups in MoM devices are designed to be press fitted into the acetabulum to provide fixation. However, press fitting the cup into the acetabulum can generate non-uniform compressive stresses on the cup and consequently cause non-uniform cup deformation\(^2\,3\). Clinical studies have shown radiolucent lines around the cup of low clearance bearings possibly as a result of increased frictional torque\(^4\). In order to benefit from the low wear generated by low clearance components and at the same time to avoid head seizure and high frictional torque, a deflection compensation acetabular cup, (DefCom) has been developed. The device is designed to compensate for in vivo deformations, without compromising the tribological performance of the device. The articulating sphere provides for a low clearance bearing area, whilst maintaining the standard Birmingham Hip Resurfacing (BHR) clearance in the non-articulating sphere. The low clearance at the point of articulation will also help to reduce wear and potential metal ion release.

Aim

This study was conducted to evaluate the tribological performance of the novel acetabular cup (DefCom)

Materials and Methods

Five pairs of 50 mm ID metal-on-metal DefCom devices (Smith & Nephew) were tested in a ProSim hip wear Simulator. The lubricant was new born calf serum with added carboxymethyl cellulose (CMC) to generate viscosities of 0.001 to 0.01 Pa·s. The loading cycle was conducted in new born calf serum with added carboxymethyl cellulose (CMC) followed by a low steady state wear after 1 MC.

One DefCom device was friction tested in a ProSim hip friction simulator at 0, 3 and 4 million cycles (Mc) of wear testing. The test was conducted in new born calf serum with added carboxymethyl cellulose (CMC) to generate viscosities of 0.001 to 0.01 Pa·s. The loading cycle was set at maximum load of 2 kN and a minimum of 0.1 kN. The force was Paul-type stance phase loading with a maximum load of 3 kN and a standard ISO swing phase load of 0.3 kN. The frequency was 1 Hz.

Results

Friction: The coefficient of friction (CoF) of the DefCom joint tested varied from 0.07 to 0.21 depending on the viscosity of the serum and the number of cycles completed following the simulation test. Under physiologically relevant lubricant conditions (0.001 to 0.01 Pa·s), the COF for the DefCom device tested was comparable to that of the standard BHR device, Figure 1.

Wear: Figure 3 shows the cumulative volume loss against number of wear simulation cycles for the DefCom joints tested compared with BHR joints. The DefCom devices generated typical characteristics of wear, with a higher wear rate during the initial running in period (0 – 1 Mc) followed by a low steady state wear rate after 1 Mc.

Conclusion

The DefCom joints produced a wear rate of 0.23 mm\(^3\)/MC, whilst the BHR joints produced a wear rate of 0.72 mm\(^3\)/MC for the running-in phase. The DefCom joints reduced the wear by three fold, as compared to the BHR device. Steady state wear was achieved for all DefCom joints after 1.0 MC. The average steady state wear (1.0-4.0 MC) rate for the DefCom joints was 0.12 mm\(^3\)/MC at a confidence level of 95%, with 0.19 mm\(^3\)/MC (1.0-4.0 MC) for the BHR joint.

Further studies need to be conducted in order to determine the effect of physiologically relevant deformation on the wear performance of DefCom cups.