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Correlation Between the Detailed Visual Inspection of Retrieved Metal-on-Metal Hips and Their Volumetric Wear

Harry Hothi, Suzie Cro, Paul Bills, Liam Blunt, Radu Racasan, Gordon W Blunn, John A. Skinner, Alister Hart

Abstract

Introduction Metal-on-metal (MOM) total hip arthroplasty using large diameter femoral heads offer clinical advantages however the failure rates of these hips is unacceptably high. Retrieved hips have a wide range of wear rates of their bearing and taper surfaces and there is no agreement regarding the cause of failure.

Detailed visual inspection is the first step in the forensic examination of failed hip components and may help explain the mechanisms of failure. The aim of this study was to determine if there was a correlation between the results of detailed inspections and the volumetric wear of the bearing and taper surfaces of retrieved hips.

Method Detailed, non-destructive macroscopic and stereomicroscopic examinations of 89 retrieved MOM hip components were performed by a single experienced examiner using quantitative assessment to document the severity of 10 established damage features:

Light scratches, Moderate scratches, Heavy scratches, Embedded particles, Discolouration, Haziness, Pitting, Visible wear zone, Corrosion, Fretting

Each surface was considered in terms of zones comprising

of quadrants (cup, head, and taper) and subquadrants (cup and head), Figure 1. Each zone was scored on a scale of 0 to 3 by determining the percentage of the surface area of the zone that exhibited the feature in question: a score of 0=0%, 1<25%, 25%<2<75%, 3>75%. The sum of the scores of each zone was used for the assessment of each damage feature.

The volume of wear at the surfaces of each hip was measured with a Zeiss Prismo coordinate measuring machine (cup and head) and a Talysrond 365 roundness measurement instrument (taper), using previously reported methods^{1, 2}.

Simple linear regression models were used to assess the univariable associations between the inspection scores and wear volumes. Multiple linear regression models were subsequently used to assess the simultaneous contribution of the inspection scores, found significant in univariable analyses, on the wear outcome variables.

All statistical analysis was performed using Stata/IC version 12.1 (StataCorp, USA) and throughout a p value < 0.05 was considered statistically significant.

Results Visible wear zone, moderate scratches, discolouration and haziness scores were all significantly positively correlated with cup ($R^2 = 70\%$, 23% , 72% and 33% respectively) and head ($R^2 = 73\%$, 34% , 67% and 47% respectively) wear volumes.

Visible wear zone and discoloration scores were significant predictors in multivariable analysis ($p < 0.01$) for both surfaces, together explaining 77% and 79% of the variance in the cup and head wear volumes respectively.

Corrosion and discoloration scores were significantly positively correlated with taper wear volume ($R^2 = 57\%$ and 53% respectively) and there was a significant interaction between the two damage features ($p = 0.01$).

Discussion This study demonstrates the importance of detailed visual inspections in retrieval analysis, suggesting that they may help in predicting the severity of bearing and taper surface wear. Future studies will involve assessments of the inter-observer errors of inspections and their relationship with many other variables such as implant design and patient factors.