Introduction

- Metal transfer, consisting of titanium or cobalt chromium (CoCr), has been observed on retrieved total hip replacements
- Greater surface roughness and increased polyethylene wear has been correlated to the presence of metal transfer
- Little is known about the morphology of metal transfer on the bearing surface or its causes.

Objective

The purpose of this study was to investigate metal transfer on the bearing surface of CoCr and ceramic femoral heads. Additionally, we sought to identify common morphologies.

Materials and Methods

- Over thirteen years, more than 3000 total hip replacements were retrieved under an IRB-approved, multicenter, orthopaedic implant retrieval program.
- 50 CoCr and 50 ceramic femoral heads matched for a previous study were divided by bearing couple into three cohorts: CoCr-on-polyethylene (M-PE); ceramic-on-polyethylene (C-PE); and ceramic-on-ceramic (C-C; Table 1). 

Table 1: Summarized patient demographics per cohort. All values are reported as the mean ± standard deviation with the exception of gender.

<table>
<thead>
<tr>
<th>Cohort</th>
<th>n</th>
<th>Age (years)</th>
<th>Gender (%F)</th>
<th>BMI (kg/m²)</th>
<th>Implantation Time (years)</th>
<th>Max UCLA Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-PE</td>
<td>50</td>
<td>57 ± 14</td>
<td>50%</td>
<td>30 ± 7</td>
<td>3.2 ± 3.8</td>
<td>5 ± 2</td>
</tr>
<tr>
<td>C-PE</td>
<td>35</td>
<td>55 ± 11</td>
<td>37%</td>
<td>30 ± 8</td>
<td>3.8 ± 4.3</td>
<td>6 ± 2</td>
</tr>
<tr>
<td>C-C</td>
<td>15</td>
<td>47 ± 7</td>
<td>27%</td>
<td>31 ± 6</td>
<td>2.2 ± 1.6</td>
<td>5 ± 2</td>
</tr>
</tbody>
</table>

- Extent and severity of metal transfer on a three-point visual scale.
- Femoral heads with evidence of metal transfer were photographed using a diffused lighting technique, capturing metal transfer on the upper hemisphere.
- Metal transfer surface area coverage was analyzed using a custom MATLAB algorithm (Figure 1).
- Patterns on the upper hemisphere were categorized into seven distinct categories (Figure 2).
- Length, width, and height dimensions were measured with a calibrated micrometer, non-contact white light interferometry and TalyMap Platinum surface analysis software.

Results

- 75% of the femoral heads had observable metal transfer (score ≥ 2), with severe metal transfer (score = 3) on 20% of the M-PE cohort, 23% of the C-PE cohort, and 80% of the C-C cohort (Figure 3).
- Metal transfer coverage was similar across the three cohorts (M-PE = 4.5% ± 5.3%, p = 0.90; Figure 4).

![Figure 1](https://via.placeholder.com/150)

**Figure 1** (above): MATLAB algorithm to calculate the curved surface area on the upper hemisphere featuring metal transfer.

**Figure 2** (left): Seven identified metal transfer patterns, exhibited on CoCr, alumina, and zirconia-toughened alumina femoral heads. Top Row: Random Stripe, Patterned Coverage, Solid Patch. Bottom Row: Directional Scratches, Random Patches, Longitudinal Stripe. Middle: Miscellaneous.

![Figure 3](https://via.placeholder.com/150)

**Figure 3**: Visual metal transfer score distribution.

- Observed patterns varied across cohorts (p = 0.02; Figure 5).
- Random patches and random stripes were most common for the M-PE and C-PE cohorts; Longitudinal stripes for the C-C cohort (Figure 6).
- Metal transfer was shorter in length, but greater in height, for the M-PE cohort (p<0.001, p = 0.014).

![Figure 4](https://via.placeholder.com/150)

**Figure 4**: Surface area coverage on the upper hemisphere was similar across all cohorts (p = 0.90).

![Figure 5](https://via.placeholder.com/150)

**Figure 5**: Distribution of metal transfer patterns across the three cohorts (p = 0.02), highlighting the most common. Clockwise: random stripe on CoCr, longitudinal stripe on alumina, random patches on alumina, random stripe on ZTA.

Conclusion

- We found that bearing couples do not predict the presence nor the amount of metal transfer on the bearing surface of femoral heads.
- The morphology of observed metal transfer differs across bearing couples, and may be related to the material properties of the implant bearing surface.
- The effects (if any) that different metal transfer has on polyethylene morphology is still unclear; warranting future in-vitro studies.
- Metal transfer morphology may be useful for predictive studies of HXLPE wear.

References:

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