CLINICAL WEAR AND SIMULATOR STUDY OF CERAMIC-CERAMIC THR TO 20YEARS AND BEYOND

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INTRODUCTION: Alumina all-ceramic implants were first used in 1970 by Pierre Boutin in France [1] and around 1972/3 in the rest of Europe. Thus the European ceramic experience is approximately 30 years. In the early 1980’s, the so called Mittelmeier THR was introduced into the USA but the clinical results were generally far from satisfactory [2]. However, the survivors now provide a useful benchmark of about 15-18 years in the USA [3]. Perhaps as a result, the FDA has still not permitted use of all-ceramic THR in the USA. However, there are a number of new materials recently approved for use, including the highly crosslinked polyethylenes (HCLPE) and CoCr on CoCr.

In anticipation of all-alumina THR being approved in the near future, we have examined the types of wear seen long term ceramic on ceramic THR. Implants were retrieved after 15-25 years of successful use and compared to simulator studies with 10-20 Mc duration.

MATERIALS AND METHODS: Two Mittelmeier THR 16year and 17year were retrieved from the USA and a more conventional all-ceramic THR retrieved from Vienna after 24 years. The implants were revised for aseptic loosening. In retrieval operation, the balls and cups were marked for orientation. Maps were drawn of wear patterns using stereomicroscopy and surveyed by SEM. In the simulator experiment 28mm diameter alumina heads and liners were used. The cups were mounted inverted in a hip simulator and run with 50% α-calf serum as the lubricant. The hip-loads were 2kN maximum and a 1 Hz frequency for 20 million cycles.

RESULTS: In retrieved implants, gray surface contamination was evident on load-bearing areas. Gray stripe areas were also observed on the periphery of the heads. SEM analysis showed that the main bearing areas were classed as wear stage 4. The peripheral gray stripe areas had severe wear stage 5. The wear on the periphery of the heads was more severe than on main bearing areas (Fig.2). EDAX showed the gray contamination was due to transferred CoCr particles. In the simulator study the wear progress was more severe in main the central load-bearing area. At 20 million cycles, the main load-bearing area had high wear. The relation between wear stage and cycles are indicated (table 1). The femoral stems showed burnished areas, indicative of micromotion against bone.

Figure 1

Figure 2

Table 1 Grades of ceramic wear progressing in clinical and simulator wear

<table>
<thead>
<tr>
<th>Stage</th>
<th>Wear</th>
<th>Cycles</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>No wear</td>
<td>0</td>
<td>Lose scratch and polishing marks, round pits</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Light wear</td>
<td>0-5</td>
<td>Low polishing marks</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Mild wear</td>
<td>5-10</td>
<td>Ultra smooth</td>
</tr>
<tr>
<td>Stage 4</td>
<td>High wear</td>
<td>10-20</td>
<td>Loosening grain and polygonal pits</td>
</tr>
<tr>
<td>Stage 5</td>
<td>Severe wear</td>
<td>20+</td>
<td>Rough surface</td>
</tr>
</tbody>
</table>

DISCUSSION: All-ceramic implants revealed minimal wear even after 24 years. It was noted that the wear of retrieved implants was different from the simulator. The contact zones showed even distributed mild wear. In the periphery of the contact zones, the stripe scars corresponded to neck-socket impingement with more severe wear. Such stripe wear was not created in the simulator experiments. However in the load-bearing area, there was good correspondence between clinical wear and simulator wear. The gray wear areas represented metal contamination from micromotion of the femoral stem against bone. This study is the first report to grade the micro wear progress in clinical and simulator wear of ceramic on ceramic bearings to equivalent of 20years use. In conclusion the ceramic bearings proved excellent up to 25years in simulator studies and clinical studies.


ACKNOWLEDGEMENT: This study was supported in part by Western Center for Orthopaedics Research Foundation (Riverside, CA), and Department of Orthopaedic, LLUMC.

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