Comparison of Total Knee Arthroplasties with Oxidized Zirconium and Cobalt-Chromium Femoral Components in the Same Patients

- In Vivo Comparison of Wear Particles-

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Introduction: Despite total knee arthroplasty (TKA) provides durable functional outcome, polyethylene wear (PE) is one of the most common causes for failure of TKA. One potential method of reducing PE wear in TKA is to use ceramic bearing surface. We examined two hypotheses in a large randomized prospective series of 331 patients, followed for 7.5 years after surgery: (1) Knee Society (KS) knee and function scores, radiographic results, and complication rates would be similar between knees with OxZr and Co-Cr femoral components; and (2) the weight, size, and shape of polyethylene wear particles would differ between knees with OxZr and Co-Cr femoral components.

Materials and Methods: We performed a bilateral simultaneous TKA in 331 patients (662 knees) who received an OxZr femoral component in one knee and a Co-Cr femoral component in the other. Randomization to an OxZr or Co-Cr femoral component was accomplished with use of a sealed study number envelope, which was opened in the operating room before the skin incision has been made. Mean age was 65.5 (44-85) years. There were 91 men and 240 women. Mean follow-up was 7.5 (7-8) years.

All operations were performed by one surgeon using the same design total knee prosthesis: Genesis II total knee prosthesis (Smith & Nephew, Memphis, Tennessee). Only the material of the femoral component differed between two groups. The preoperative diagnosis was osteoarthritis in all patients. Preoperative and postoperative KS knee and function scores, WOMAC score and UCLA activity scores were evaluated.

Synovial fluid was aspirated from both knees of 120 patients (240 knees) at the latest follow-up. The amount of PE wear particles in the aspirated synovial fluid sample was analyzed by thermogravimetric analysis (TGA) using a TGA instrument (TGA/SDTA 841e model, Mettler Toledo Co., Greifensee, Switzerland). The weight of the sample solution was measured before and after removing the organic content by heating the sample solution. The sample solution was casted onto petri dishes. The petri dish was covered and kept in a dry oven at 60°C for 2 days. While the sample solution was kept in a dry oven for 2 days, a small hole was made on the cover of the petri dish to allow water to evaporate slowly for 2 days. After this procedure, the cover of petri dish was removed and TGA sample was dried at 60°C for another 2 days. After the sample was completely dried out, the dried sample was measured using analytical balance.

TGA was used to determine the weight change profiles of PE subject to heating under a nitrogen atmosphere. The nitrogen flow rate was kept constant at 50 mL per minute. TGA data were taken at heating rate of 5°C per minute in the temperature range of 20°C to 1000°C. The weight loss data were recorded as a function of time and temperature using special software in computer. When the temperature reached to the point of decomposition of the sample, the sample started to lose weight. By calculating the weight of the sample around the temperature which led to start to decomposition, real amount of PE in the sample was measured. The size and shape of PE particles were examined using scanning electron microscopy (HSH-6360A model, Jeol CO., Tokyo, Japan). The samples were coated using a platinum sputtering machine for 20 sec.

Results: At the latest follow-up, the mean KS score (95 points versus 94 points; Student’s t-test, p=0.278), WOMAC score (14.3 vs 14.3 points; Student’s t-test, p=1.000) and range of motion (126° versus 127°; Student’s t-test, p=0.265) were similar in patients with an OxZr and Co-Cr femoral component. All but 50 patients (15%) had an UCLA activity score of 5 or 6 points after the TKA, indicating participation in strenuous farm work (< a score of 5 points) or playing tennis (a score of 6 points). At the time of the latest follow, patient satisfaction was similar in both groups. The satisfaction score was 8.3±1.7 points for the OxZr group and 8.2±1.8 points for the Co-Cr group. Two hundred eighty-five patients (86%) had no preference, 24 patients (7%) preferred the OxZr prosthesis, and 22 patients (7%) preferred the Co-Cr prosthesis. We found no radiographic difference between the two groups in the following parameters: alignment of the knee, position of the component, joint line, posterior condylar offset, and prevalence of radiolucent lines.

Mean weight of the PE particles was 0.0231 g (SD, 0.0052 g) in the OxZr group and 0.0229 g (SD, 0.0058 g) in the Co-Cr group. This difference was not significant (p=0.6234, paired t-test) (Table 1). The size of t particles was not different between the two groups (Table 2).

Also, shape of particles was not different between the two groups (Fig. 1).

Discussion and conclusions: Under the conditions and the duration of this study in this specific group of patients, TKA with an OxZr or a Co-Cr femoral knee component had excellent clinical and radiographic outcomes with no osteolysis. While the wear simulator test in vitro demonstrated significant decrease in PE particles in the knees with an OxZr femoral component and in those with a Co-Cr femoral component. Furthermore, clinical, subjective and radiographic results were similar between the two groups. Therefore, we conclude that more expensive OxZr femoral component are not beneficial.

Table 1. The weight of polyethylene in 1 gram of synovial fluid

<table>
<thead>
<tr>
<th>Sample</th>
<th>Aver (g)</th>
<th>SD (g)</th>
</tr>
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<tbody>
<tr>
<td>Co-Cr</td>
<td>0.0229</td>
<td>0.0058</td>
</tr>
<tr>
<td>OxZr</td>
<td>0.0231</td>
<td>0.0052</td>
</tr>
</tbody>
</table>

Paired t-test P=0.6234

Table 2. Comparison of Particle Characteristics (Mean±SD, Med)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group</th>
<th>ECD (µm)</th>
<th>Aspect Ratio</th>
<th>Roundness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxinium</td>
<td>(0.41)</td>
<td>1.18±0.21</td>
<td>(1.21)</td>
<td>1.69±0.78</td>
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<tr>
<td>Chromium</td>
<td>(0.48)</td>
<td>1.21±0.32</td>
<td>(1.19)</td>
<td>1.64±0.65</td>
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<tr>
<td>Cobalt</td>
<td>(0.59)</td>
<td>1.21±0.32</td>
<td>(1.19)</td>
<td>1.64±0.65</td>
</tr>
</tbody>
</table>

Values are expressed as mean ± standard deviation, with range in parentheses. ECD: equivalent circle diameter=4 x area/π

Aspect ratio: length/breadth

Roundness: perimeter/2π x area

References


Clinical relevance: More expensive OxZr femoral component does not contribute to less wear of polyethylene than Co-Cr femoral component.