**In Vivo Wear Particles of Annealed Highly Cross-Linked Polyethylene in Total Hip Arthroplasty**

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**INTRODUCTION:**

Polyethylene wear particles induce cytokine release by macrophage, which leads to osteolysis and aseptic loosening in total joint arthroplasties. Generation of polyethylene wear particles is one of the most important factors that affecting mid-term and long-term results of total hip arthroplasty (THA). Therefore, to reduce wear generation and to achieve better long-term results of THA, highly cross-linked polyethylene (HXLPE) was recently introduced and coming into wide use. Wear reduction in hip simulator and excellent mid-term clinical results were reported. However, there have been only a few reports on the in vivo analysis of HXLPE wear particles.

Number, size, and shape were the features of polyethylene wear particles which had very important effects on macrophage response and the prevalence of osteolysis. Increased number, submicron size, and elongated shape of polyethylene wear particles induced stronger macrophage responses and increased the likelihood of osteolysis.

In vitro study showed that HXLPE generated less, smaller, and rounder particles1. If HXLPE generates smaller particles in vivo, reduction of volumetric wear does not result in reduction of the number and the biological activity of wear particles. Therefore, in vivo HXLPE wear particle analysis is very important. However, there has been only one case report on in vivo wear particle analysis of annealed HXLPE2.

In the current study, annealed HXLPE wear particles from four revision THAs were analyzed and compared to our previous reports on conventional PE3, 100 Mrad cross-linked PE4, and annealed HXLPE5.

**METHODS:**

Peri-prosthetic tissue of four failed THAs with an annealed HXLPE (Crossfire, Stryker Howmedica Osteonics, Rutherford, NJ) (gamma-irradiated with 7.5 Mrad, annealed below the melting point, and then gamma-sterilized with 3 Mrad in nitrogen) was retrieved on the revision surgery. Mean postoperative period was 4.2 years. Mean age at revision was 61 years old (range: 45 to 77 years old).

Polyethylene particles were isolated from the tissue sample using Campbell’s method. Periprosthetic tissue in each case was digested with sodium hydroxide, ultracentrifuged in sucrose density gradient and isopropanol-water density gradient. Polyethylene particles were collected and filtered through 0.1 µm polycarbonate filters. The filter was dried and coated with platinum for scanning electron microscopic (SEM) (Figure 1). The images were analyzed with a computerized image analyzer. The total number and concentration (particles / g of wet tissue sample) of polyethylene wear particles in the synovial fluid were calculated. Particle size was expressed using equivalent circle diameter (ECD). Particle shape was determined by the aspect ratio and roundness.

**RESULTS:**

The mean number of the particles was 1.12 x 10⁸ counts / g, which was much less than the critical dose of osteolysis (1x10⁹ counts / g). Particle size (equivalent circle diameter) was 0.93 µm. Particle shape (roundness and aspect ratio) was 1.41 and 1.40 (Table 1).

**DISCUSSION:**

There has been only one case report on in vivo HXLPE wear particle analysis6. However, that report analyzed only one case and the case was under the extreme condition with 3rd body wear due to hydroxipapatite granules. Therefore, the current study is the first report on the case sires using in vivo HXLPE wear particle analysis.

Previous in vitro study showed that total volume of wear was much less in HXLPE, but the size of HXLPE wear particle was much less than conventional polyethylene7. Therefore, there has been a concern that, if HXLPE generates smaller particles, less weight loss in simulator and less migration in radiographic measurement do not result in reduction of the number and the biological activity of wear particles.

Particle number of an annealed HXLPE in vivo was much less than that of conventional polyethylene in vivo7, and slightly less than that of 100 Mrad polyethylene in vivo. Particle size of an annealed HXLPE in vivo was much larger than that in vitro, and was equivalent to that of conventional polyethylene in vivo1, and 100 Mrad polyethylene in vivo. Particle shape of an annealed HXLPE in vivo was rounder than that of conventional polyethylene in vivo1, and equivalent to that of 100 Mrad polyethylene in vivo. The current in vivo study supported the wear reduction and less biological activity of an annealed HXLPE.

**SIGNIFICANCE:**

An annealed HXLPE generated less and rounder particles than the conventional PE reported. Particle size of an annealed HXLPE in vivo was much larger than that in vitro, and was equivalent to that of conventional polyethylene in vivo. The current in vivo study supported the wear reduction and less biological activity of an annealed HXLPE.

**Table 1:** Comparison of the Number, Size, and Shape of In Vivo PE Wear Particles

<table>
<thead>
<tr>
<th>Materials</th>
<th>Number (1/g)</th>
<th>ECD (µm)</th>
<th>Roundness</th>
<th>Aspect Ratio</th>
</tr>
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<tbody>
<tr>
<td>Conventional PE¹</td>
<td>40.8 x10⁷</td>
<td>0.78</td>
<td>2.61</td>
<td>2.00</td>
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<tr>
<td>(AV: 18 yrs)</td>
<td></td>
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</tr>
<tr>
<td>100Mrad PE⁵</td>
<td>5.9x10⁸</td>
<td>0.65</td>
<td>1.53</td>
<td>1.50</td>
</tr>
<tr>
<td>(AV: 26 yrs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossfire ¹</td>
<td>0.53x10⁸</td>
<td>0.66</td>
<td>1.44</td>
<td>1.37</td>
</tr>
<tr>
<td>(4 yrs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossfire</td>
<td>1.12x10⁹</td>
<td>0.93</td>
<td>1.41</td>
<td>1.40</td>
</tr>
<tr>
<td>(AV:4.2yrs)</td>
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**REFERENCES:**