Polyethylene Wear in Total Ankle Replacement is Significantly Reduced with Use of Highly Crosslinked Polyethylene

Jeffrey E. Bischoff, J. Craig Fryman, Diego A. Orozco-Villaseñor
Research, Zimmer, Inc., Warsaw IN
Disclosure

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Jeffrey E. Bischoff

My disclosure is in the Final AOFAS Program Book.

I have a potential conflict with this presentation due to:
I am a Zimmer employee.
Introduction

Wear debris of polyethylene within total ankle replacement (TAR) can result in osteolysis and component loosening [1-4].

- **Highly-crosslinked polyethylene** (HXPE) was introduced into other total joint replacement systems to improve these outcomes.

- Bearing couples within TAR systems have historically used **conventional polyethylene** (CPE) articulating on metal; but improved wear performance could be obtained through use of HXPE.

**Hypothesis:** Use of HXPE within TAR will result in significantly lower wear rates than with CPE.
Methods: Components

- **Components**: Zimmer® Trabecular Metal™ Ankle semiconstrained TAR implant system
  - HXPE samples (n=6)
  - CPE samples (n=6)
  - Note: CPE samples were manufactured solely for this study, and are not cleared for clinical use
  - Load-soak controls for each polyethylene (n=2)
Methods: Material Processing

CPE

Bar Stock

Machine

Package & Sterilize

HXPE

Bar Stock

E-Beam Irradiation

Remelt

Machine

Package & Sterilize

Chain scission

Crosslink formation
Methods: Wear Testing

• All testing was performed on a multi-axis, displacement controlled knee wear simulator (AMTI Inc., Watertown, MA)
• Specimens were tested in a physiological environment (20 mg/mL protein concentration bovine calf serum; 37 ± 3° C) for 5.0 million cycles at 1Hz
• Mass loss was measured at fixed intervals; particle debris was isolated for morphological analysis
Methods: Kinematics and Kinetics

• Load and motion waveforms representative of human level walking gait [5] were utilized
  - 3188N peak load
  - 16.0° plantarflexion (-) to 15.2° dorsiflexion (+)
  - 2.0° internal (-) to 8.0° external (+) rotation
  - 1.5 mm anterior (+) to 1.5 mm posterior (-) displacement
Results: Gravimetric Wear

- Average gravimetric wear rates for CPE and HXPE samples were $7.4 \pm 1.2 \text{ mg/Mc}$ and $1.9 \pm 0.3 \text{ mg/Mc}$ respectively.
- HXPE samples exhibited a significant ($p<.01$) wear rate reduction of 74% when compared with CPE.

![Graph showing weight loss vs cycles for CPE and HXPE samples.](image-url)
Results: Wear Scars

- **Wear scars** (contact patterns) at 5.0Mc reflect the conformity of the bicondylar design of the bearing couple, and are qualitatively insensitive to the type of polyethylene.

![HXPE](image1.png) ![CPE](image2.png)
Results: Debris Analysis

HXPE had larger aspect ratio ($p=.008$) and smaller equivalent circular diameter ($p=.002$) than CPE.

<table>
<thead>
<tr>
<th></th>
<th>HXPE</th>
<th>CPE</th>
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<tbody>
<tr>
<td>Aspect Ratio</td>
<td>2.05 ± 0.13</td>
<td>1.79 ± 0.06</td>
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<tr>
<td>Equivalent Circular Diameter (µm)</td>
<td>0.17 ± 0.02</td>
<td>0.24 ± 0.02</td>
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Discussion

• The observed signification reduction in wear due to use of HXPE in TAR is consistent with reductions seen in other total joint replacement systems [6,7]

• Wear rates of the bicondylar design with HXPE are decreased relative to those previously reported on other TAR systems using CPE [5]

• Clinical relevance: Highly-crosslinked polyethylene may reduce clinical complications of total ankle replacement that are linked to polyethylene wear.
References


