Polyethylene
The Hip: Long-term Results

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The Problem:
Wear, Particles and Osteolysis
Particle Disease

BG
Rationale for Alternative Bearings
Decreased Volumetric Wear Rates

• “Conventional” UHMWPE: 30 - 120 mm$^3$/yr

• X-linked UHMWPE: 17 mm$^3$/yr

• Metal-on-metal bearings: 6 mm$^3$/yr

• Ceramic-on-ceramic bearings: 0.04 mm$^3$/yr

Slide adapted, courtesy of Dr. J Jacobs
Highly Cross-Linked Polyethylene

Gordon AC, D'Lima DD, Colwell CW Jr.
Highly cross-linked polyethylene in total hip arthroplasty.
Highly Cross-Linked Polyethylene

- 50 cemented hip arthroplasties
- wear and migration of the PE cup measured with RSA
- 20 had a normal gamma-in-air-sterilized PE
- 20 had a PE sterilized with 30000 Gy followed by heat stabilization (Duration, Stryker)
- 10 had highly cross-linked PE cups irradiated with 100000 Gy (Crossfire; Stryker)

Rohrl S, Nivbrant B, Mingguo L, Hewitt B:
In vivo wear and migration of highly cross-linked polyethylene cups - a radiostereometry analysis study.
Highly Cross-Linked Polyethylene

- **initial 2 months**, head penetration (creep) was 63 µm on average for the 3 groups.
- **2 to 24 months**, the mean proximal head penetration (wear) was:
  - **156 µm** for standard PE
  - **138 µm** for stabilized PE (P = .45)
  - **23 µm** for highly cross-linked PE (P < .001)

The low in vivo wear rate for highly cross-linked cemented cups looks promising.
Thirty-two patients (12 men, 20 women; 64 hips), median age = 48 years (range, 29–70) with bilateral arthrosis of the hip had hybrid THA with liners made of highly cross-linked polyethylene (Longevity, Zimmer) on one side and conventional polyethylene on the other.

Another group, comprised of 60 patients (61 hips), median age of 55 years (range, 35–70), was randomized to receive either highly cross-linked polyethylene (Durasal, Zimmer) or conventional cemented all-polyethylene of the same design.

All patients received Spectron stems with 28-mm Co-Cr heads.
Highly Cross-Linked Polyethylene

• penetration rate almost identical in the study and control groups at 6 months after the operation
• At 2 years the highly cross-linked polyethylene liner showed 62% lower proximal penetration and 31% lower total (three-dimensional) penetration when the patients were examined in the supine position.
• The highly cross-linked all-polyethylene cemented cups showed lower proximal penetration in both supine and standing positions.

Digas et al: Highly cross-linked polyethylene in total hip arthroplasty. CORR 2004;429;6-16.
Fig 3. This graph shows the proximal femoral head penetration into the uncemented acetabular component in 20 patients with bilateral total hip arthroplasty. The examination was done with the patient in the standing position. Mean ± SE

Fig 5. This graph shows the proximal femoral head penetration into the cemented acetabular component in 18 patients with highly crosslinked (Durasul) and 25 patients with conventional (control) polyethylene. The examination was done with the patient in the standing position. Mean ± SE
<table>
<thead>
<tr>
<th>Highly Cross-Linked Polyethylene Crossfire (Stryker)</th>
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<tr>
<td>• 56 hips (47 patients) highly cross-linked (Crossfire) polyethylene <em>versus</em> 53 conventional (N2Vac™) polyethylene total hip bearings.</td>
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<td>• 28-mm Co-Cr head with a low friction ion treatment (LFIT) surface treatment, cementless femoral stem (Omnifit HA)</td>
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Highly Cross-Linked Polyethylene
Crossfire (Stryker)

- 56 hips highly cross-linked (Crossfire) polyethylene versus 53 conventional polyethylene bearings

- control group - ram extruded GUR 1050 UHMWPE inserts gamma sterilized to 3 Mrad in nitrogen and vacuum packaged (N2Vac™; Stryker).

- experimental group (Crossfire) - cup manufactured from ram extruded GUR 1050 UHMWPE that had been irradiated to 7.5 Mrad and annealed for 8 hours at 130°C. After machining, the Crossfire inserts were sterilized in the same manner as the conventional UHMWPE inserts.

Highly Cross-Linked Polyethylene Crossfire (Stryker)

- minimum 4-year and average 5-year follow-up
- Livermore method for femoral head penetration from plain radiographs
- linear femoral head penetration rate from radiographs was $0.055 \pm 0.022$ mm/year for the Crossfire polyethylene and $0.138 \pm 0.073$ mm/year for the control, a reduction of 60% for the Crossfire components.

Highly Cross-Linked Polyethylene Crossfire (Stryker)

- 40 1° THRs with HXLPE matched with 40 1° THRs with conventional polyethylene (articulating with a 28 mm head)
- inserts: 10° hood packed in Nitrogen environment
- follow-up = 47.7 months
- 2-D femoral head penetration rate from radiographs was 0.05 (0.01-0.09) mm/year for the HXLPE and 0.12 (0.02-.29) mm/year for the conventional polyethylene, a reduction of 58.33% (p<0.001).

Highly Cross-Linked Polyethylene

- Wear performance of electron beam-irradiated, post irradiation-melted, highly cross-linked (HXLPE) versus traditional UHMWPE compared via the Martell method
- 70 HXLPE cementless cups (MGH) with 31.4 mo. f/u
- 111 conventional cementless cups (Rush U) 48 mo. f/u
- Patients matched for age, sex, body mass index
- Steady state wear rates after 2 years:
  - .007 mm/year for HXLPE
  - .174 mm/year for traditional UHMWPE

Large Diameter Femoral Heads on Highly Cross-linked Polyethylene

Minimum 3-year Results

Jeffrey A. Geller, MD*; Henrik Malchau, MD, PhD†; Charles Bragdon, PhD†; Meridith Greene, BS†; William H. Harris, MD†; and Andrew A. Freiberg, MD†

• prospective series of 42 patients (45 hips) who had total hip replacement using large diameter cobalt-chrome femoral heads (36, 38, 40 mm) articulating with highly cross-linked polyethylene (electron beam ram extruded)
• minimum of 3 years follow-up (mean = 3.3 years)
• average steady state wear rate = $-0.06 \pm 0.41$ mm/year
Steady State Wear Scatter Plot for Large Head Group

\[ y = -0.0433x + 0.0153 \]

\[ R^2 = 0.0028 \]
Highly Cross-Linked Polyethylene

- 37 1° THR with HXLPE (Durasul, Zimmer) matched with 37 1° THR with conventional polyethylene (articulating with a 28 mm head)
- follow-up at least 5 years
- no clinical differences
- Linear penetration rate: Durasul versus conventional
  - One year: 0.074 mm vs. 0.151 mm
  - Five years: 0.011 mm vs. 0.04 mm
- data showed a 45% reduction in wear with HXLPE

Highly Cross-Linked Polyethylene

- prospective randomized study
- wear performance of HXLPE (Marathon, DePuy) versus traditional UHMWPE (Enduron, DePuy)
- mean follow-up = 5.7 years
- clinical outcomes the same
- increased osteolysis in the traditional UHMWPE group
- mean wear rates:
  \[0.001 \pm 0.007 \text{ mm/year for HXLPE}\]
  \[0.19 \pm 0.12 \text{ mm/year for traditional UHMWPE}\]

Thank you