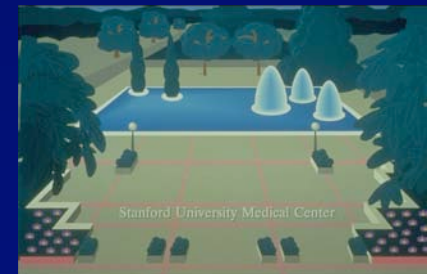


Polyethylene

The Hip: Long-term Results

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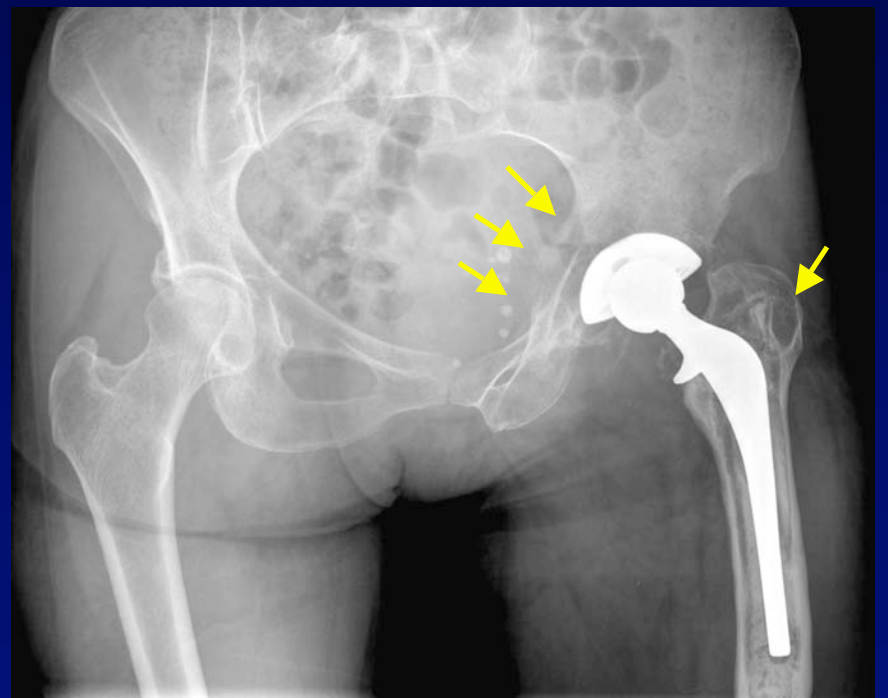
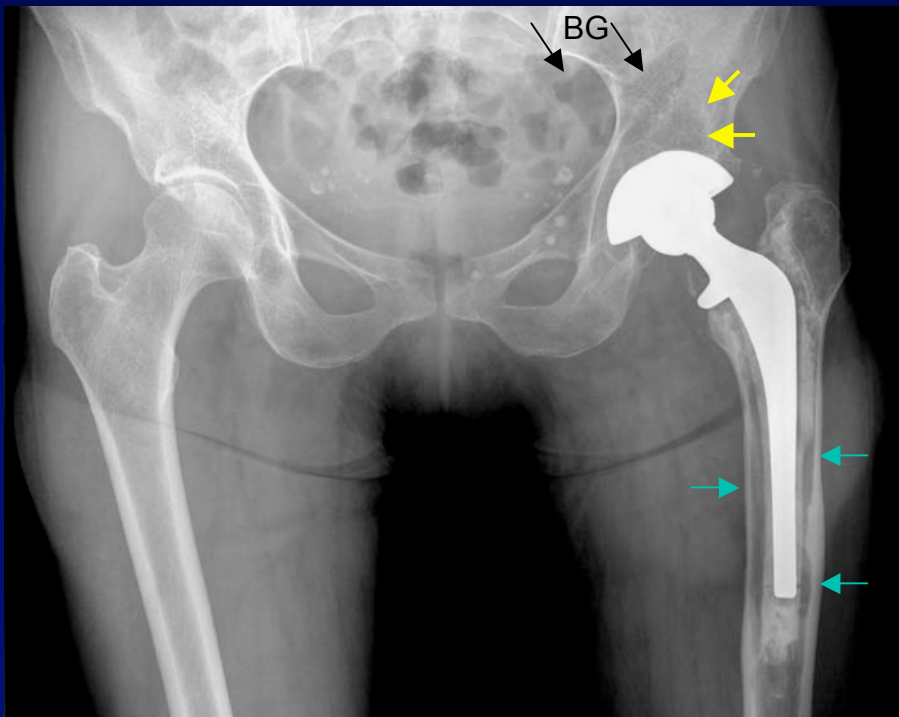


The Problem:

Wear, Particles and Osteolysis



Particle Disease



Rationale for Alternative Bearings

Decreased Volumetric Wear Rates

- “Conventional” UHMWPE: 30 - 120 mm³/yr
- **X-linked UHMWPE: 17 mm³/yr**
- Metal-on-metal bearings: 6 mm³/yr
- Ceramic-on-ceramic bearings: 0.04 mm³/yr

Slide adapted, courtesy of Dr. J Jacobs

Highly Cross-Linked Polyethylene

Highly Cross-linked Polyethylene in Total Hip Arthroplasty

Table 4

Summary of Highly Cross-linked Polyethylene Clinical Studies

Author	Cross-linked Polyethylene (Fixation)	Conventional Polyethylene	Follow-up (years)	Wear Reduction of Cross-linked Polyethylene
Digas et al ³⁹	Durasul	Gamma/Nitrogen	2	50% linear wear
Digas et al ⁴⁰	Durasul (cemented)	Gamma/Nitrogen	3	50% linear wear
	Longevity (hybrid)	Gamma/Nitrogen	2	62% linear wear
Martell et al ⁴¹	Crossfire	Gamma/Nitrogen	2	40% to 50% linear wear
Heisel et al ⁴²	Marathon	Gamma/Air	2	81% volumetric wear
Dorr et al ⁴³	Durasul	Gamma/Nitrogen	5	50% linear wear; 60% to 75% less head penetration
Rohrl et al ⁴⁴	Crossfire	Gamma/Air	2	85% linear wear

Gordon AC, D'Lima DD, Colwell CW Jr.
 Highly cross-linked polyethylene in total hip arthroplasty.
 J Am Acad Orthop Surg. 2006 Sep;14(9):511-23.

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.
J Arthroplasty 2005 Jun;20(4):409-13.

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 cupslooks promising.

Rohrl S, Nivbrant B, Mingguo L, Hewitt B:
In vivo wear and migration of highly cross-linked
polyethylene cups - a radiostereometry analysis study.
J Arthroplasty 2005 Jun;20(4):409-13.

THE OTTO AUFRANC AWARD

Highly Cross-linked Polyethylene in Total Hip Arthroplasty

*Randomized Evaluation of Penetration Rate in Cemented and Uncemented Sockets Using
Radiostereometric Analysis*

*Georgios Digas, MD, PhD; Johan Kärrholm, MD, PhD; Jonas Thanner, MD, PhD;
Henrik Malchau, MD, PhD; and Peter Herberts, MD, PhD*

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.

Uncemented versus Cemented Socket and Highly Cross-Linked Polyethylene

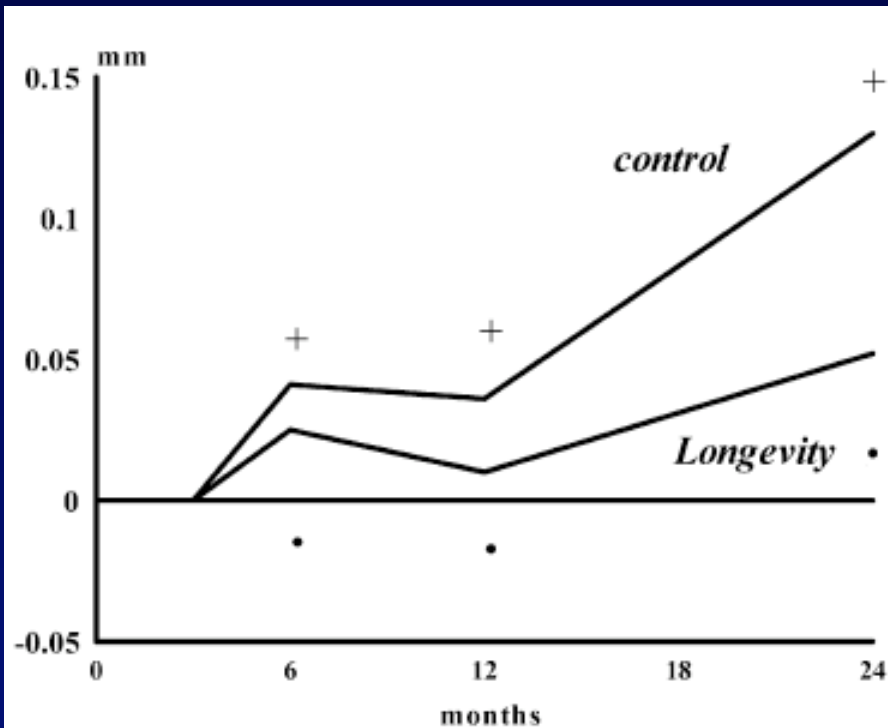


Fig 3. This graph shows the proximal femoral head penetration into the uncemented acetabular component in 20 patients with bilateral total hip arthroplasty. The examination was done with the patient in the standing position. Mean \pm SE

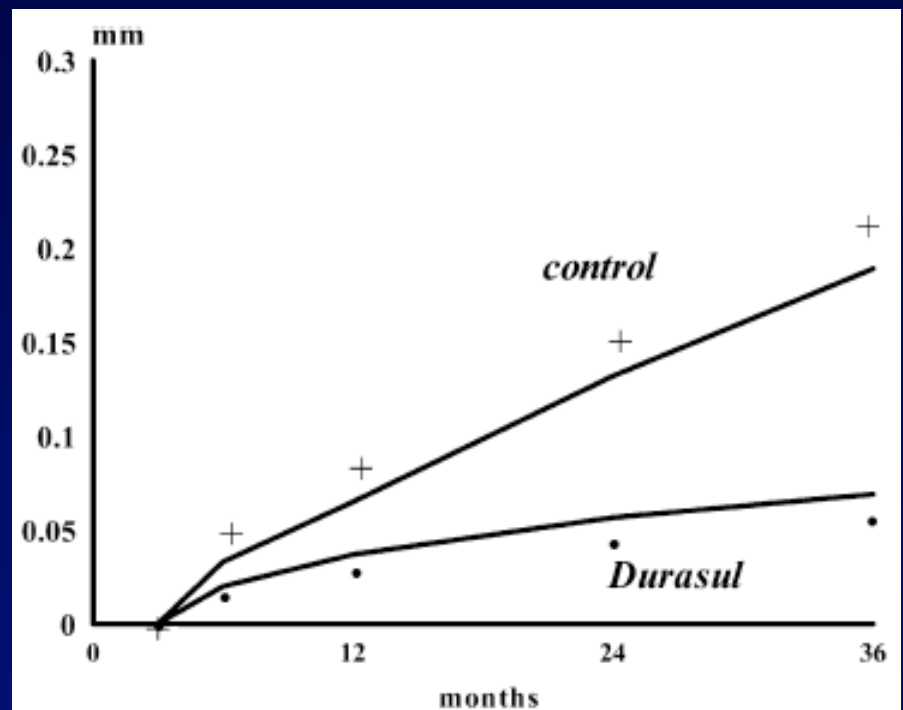


Fig 5. This graph shows the proximal femoral head penetration into the cemented acetabular component in 18 patients with highly crosslinked (Durasul) and 25 patients with conventional (control) polyethylene. The examination was done with the patient in the standing position. Mean \pm SE

Highly Cross-Linked Polyethylene Crossfire (Stryker)

- 56 hips (47 patients) highly cross-linked (Crossfire) polyethylene *versus* 53 conventional (N2Vac™) polyethylene total hip bearings.
- 28-mm Co-Cr head with a low friction ion treatment (LFIT) surface treatment, cementless femoral stem (Omnifit HA)

D'Antonio JA, Manley MT, Capello WN, Bierbaum BE, Ramakrishnan R, Naughton M, Sutton K; Five-year experience with Crossfire highly cross-linked polyethylene. Clin Orthop Relat Res. 2005 Dec;441:143-50.

Highly Cross-Linked Polyethylene Crossfire (Stryker)

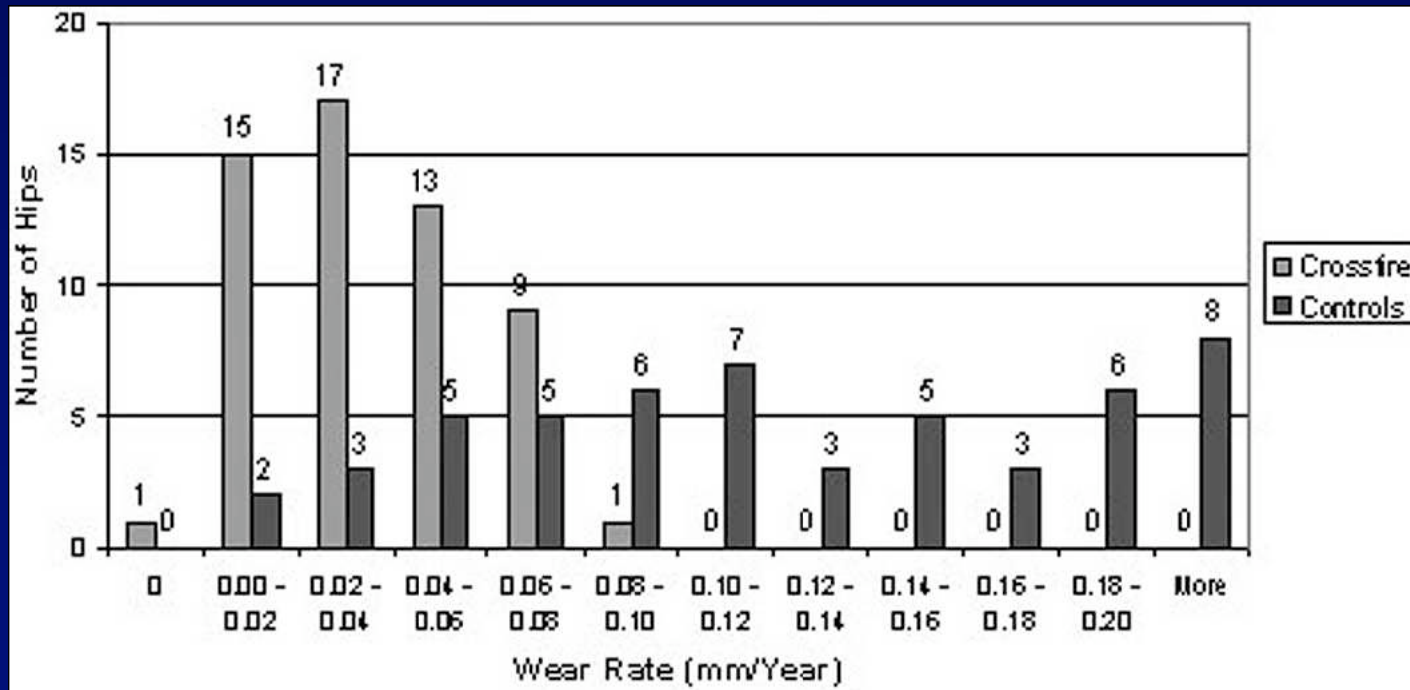
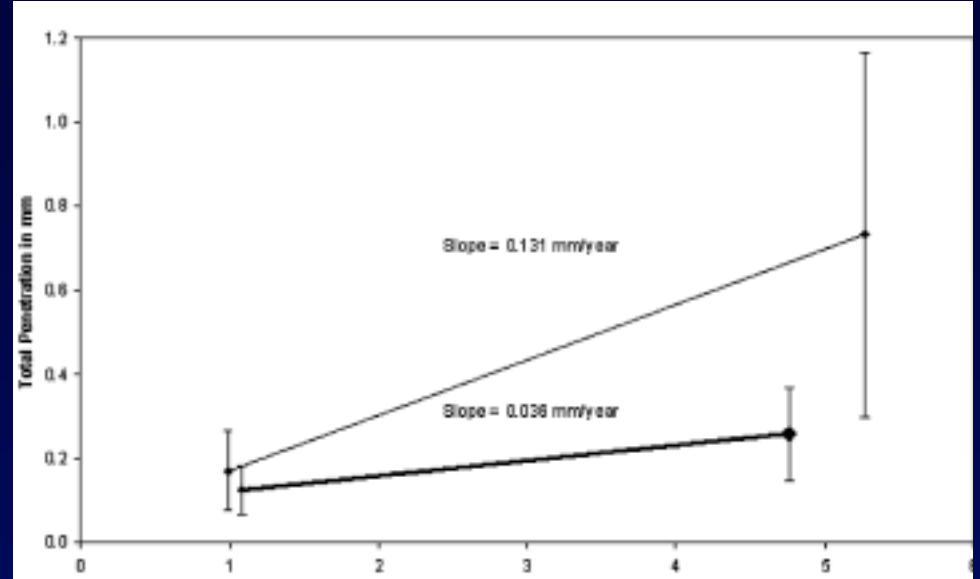
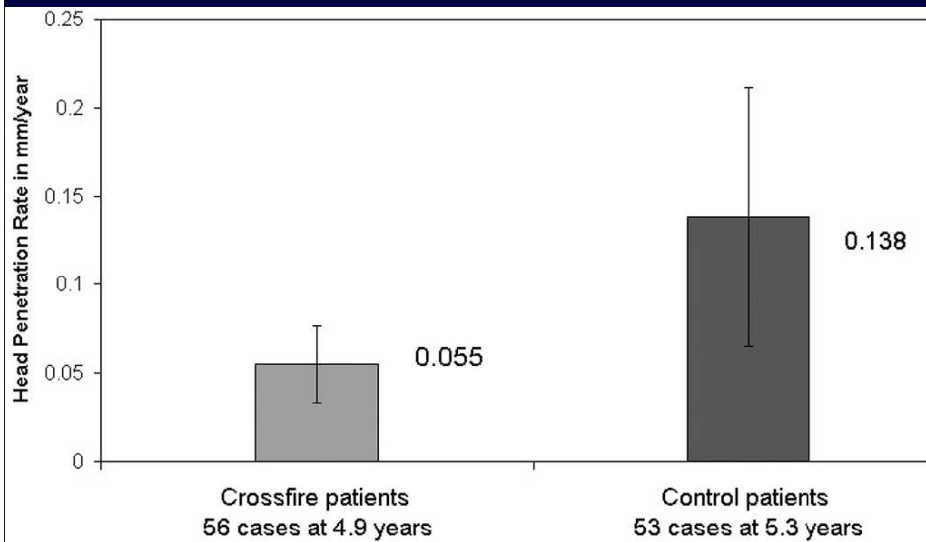
- 56 hips highly cross-linked (Crossfire) polyethylene *versus* 53 conventional polyethylene bearings
- control group - ram extruded GUR 1050 UHMWPE inserts gamma sterilized to 3 Mrad in nitrogen and vacuum packaged (N2Vac™; Stryker).
- experimental group (Crossfire) - cup manufactured from ram extruded 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.

D'Antonio JA, Manley MT, Capello WN, Bierbaum BE, Ramakrishnan R, Naughton M, Sutton K: Five-year experience with Crossfire highly cross-linked polyethylene. Clin Orthop Relat Res. 2005 Dec;441:143-50.

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 ± 0.022 mm/year for the Crossfire polyethylene and 0.138 ± 0.073 mm/year for the control, a reduction of **60%** for the Crossfire components.

D'Antonio JA, Manley MT, Capello WN, Bierbaum BE, Ramakrishnan R, Naughton M, Sutton K: Five-year experience with Crossfire highly cross-linked polyethylene. Clin Orthop Relat Res. 2005 Dec;441:143-50.



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%** ($p < 0.001$).

Krushell RJ, Fingerroth RJ, Cushing MC: Early femoral head penetration of a highly cross-linked polyethylene liner vs a conventional polyethylene liner: a case-controlled study. *J Arthroplasty*. 2005 Oct;20(7 Suppl 3):73-6.

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**

Manning DW, Chiang PP, Martell JM, Galante JO, Harris WH:
In vivo comparative wear study of traditional and highly cross-linked polyethylene in total hip arthroplasty. J Arthroplasty 2005 Oct;20(7):880-6.

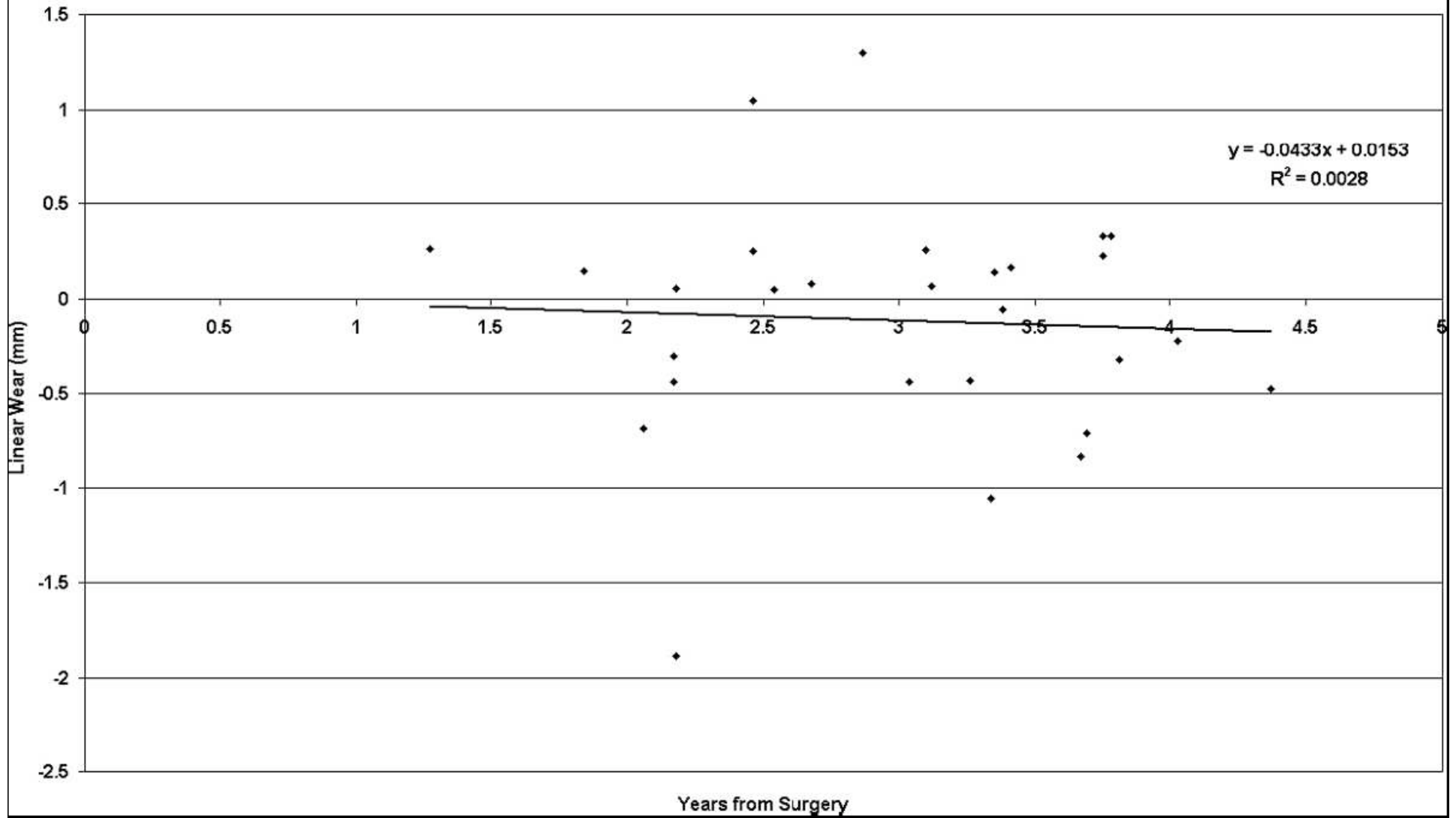
Large Diameter Femoral Heads on Highly Cross-linked Polyethylene

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 ± 0.41 mm/year

Steady State Wear Scatter Plot for Large Head Group



Highly Cross-Linked Polyethylene

- 37 1° THRs with HXLPE (**Durasul, Zimmer**) matched with 37 1° THRs 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** **0.151 mm**
 - Five years **0.011 mm** **0.04 mm**
- data showed a **45%** reduction in wear with HXLPE

Dorr LD, Wan Z, Shahrदार C, Sirianni, L, Boutary M, Yun A: Clinical performance of a Durasul highly cross-linked polyethylene acetabular liner for total hip arthroplasty at five years. J Bone Joint Surg 2005 Aug;87(8):1816-21

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:
 - .001 ± .007 mm/year for HXLPE**
 - .19 ± .12 mm/year for traditional UHMWPE**

Engl CA et al: A randomized prospective evaluation of outcomes after total hip arthroplasty using cross-linked marathon and non-cross-linked Enduron polyethylene liners. J Arthroplasty. 2006 Sep;21(6 Suppl 2):17-25.

Thank you



Stanford University