Surface Damage Mechanisms, I*n Vivo* Oxidation, and Reasons For Revision for Highly Crosslinked Tibial Inserts for TKA

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Remelted Highly Crosslinked Polyethylene

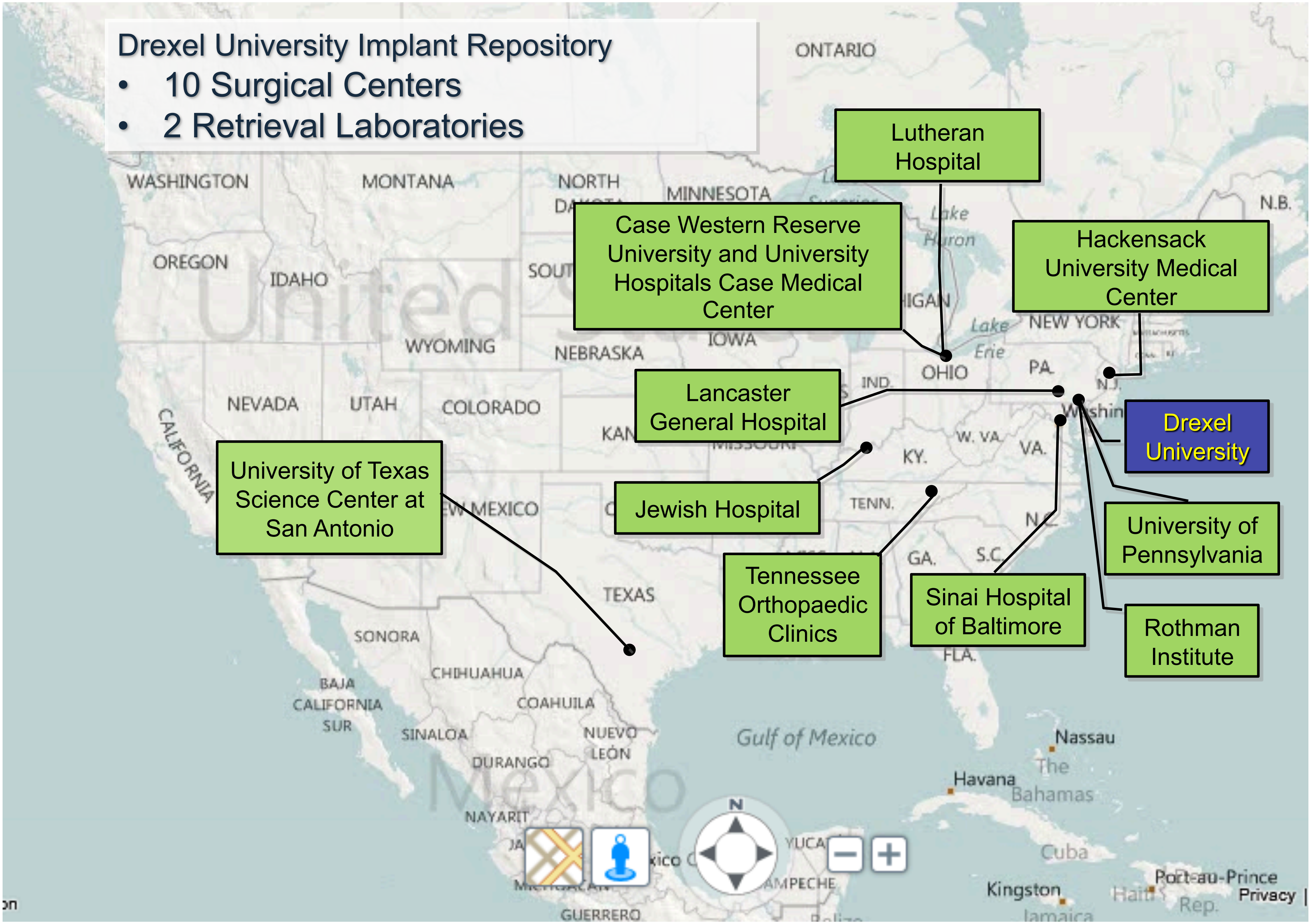
- Introduced in the late 1990's
  - Reduces wear rates in total hip arthroplasty
- Elevated radiation and remelting reduces fracture toughness
- Increasingly used in TKA
- Little known on the *in vivo* damage mechanisms and oxidative stability of HXLPE in TKA.

Study Objective

The purpose of this study was to investigate the damage mechanisms and oxidative stability of remelted polyethylenes in a series of retrieved tibial components.

Drexel University Implant Repository

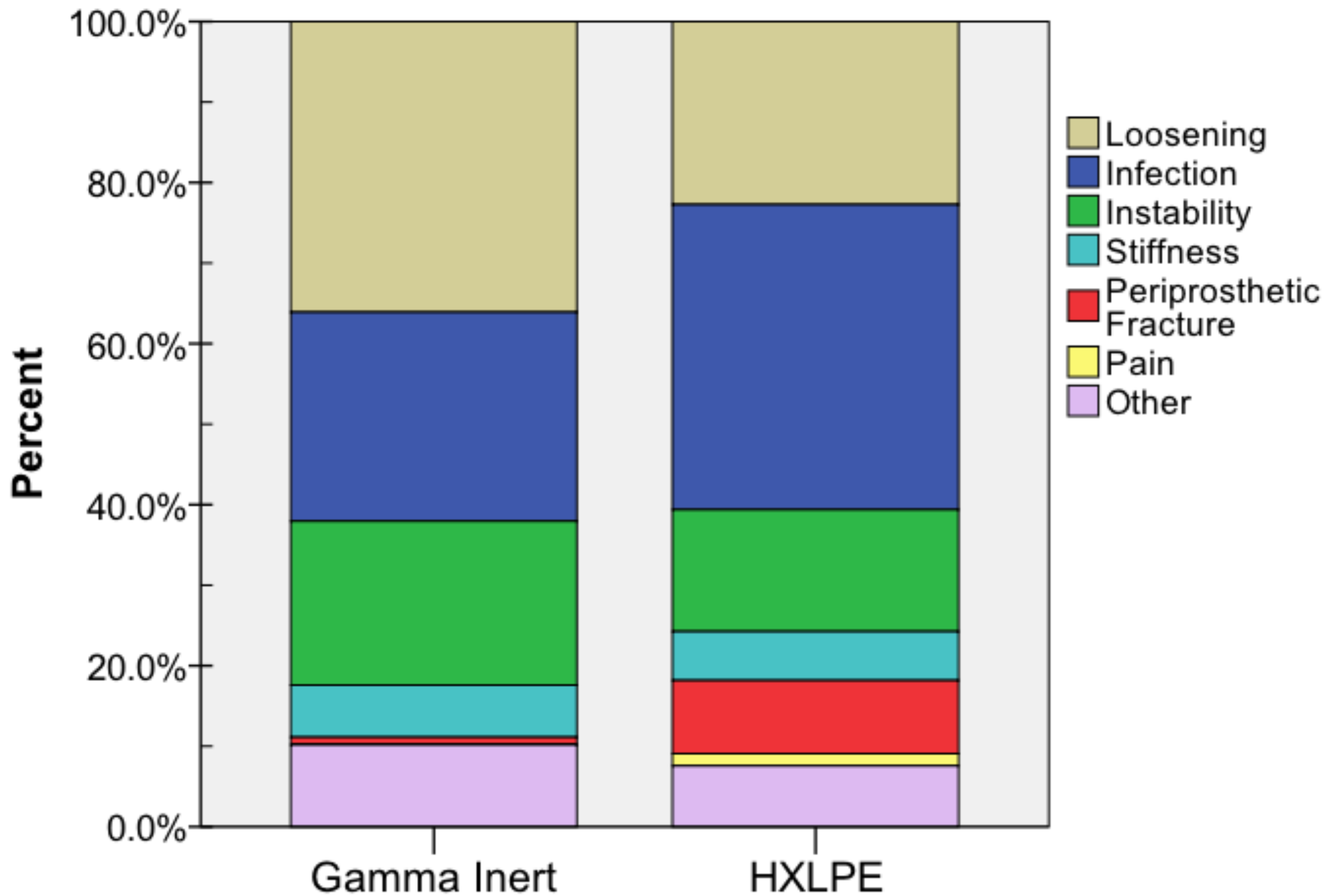
- 10 Surgical Centers
- 2 Retrieval Laboratories



Patient Demographics

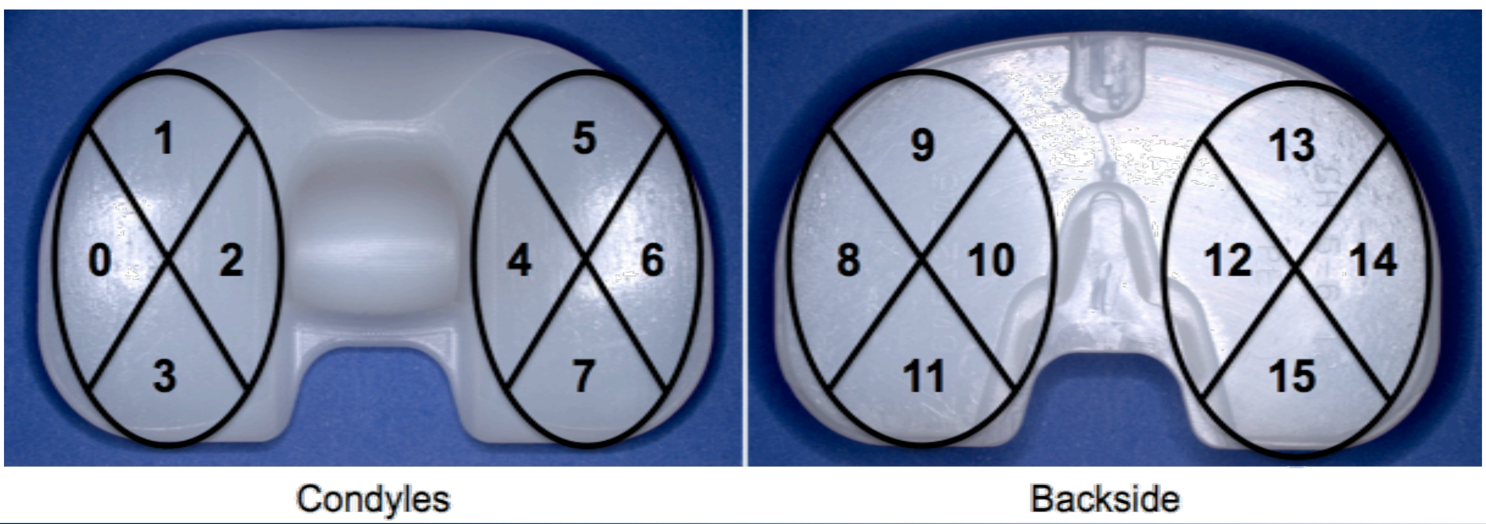
Cohort	n	Age (years)	Gender (%F)	BMI (kg/m^2)	Implantation Time (y)	Max UCLA Score (Range)
Gamma Inert	41	66 ± 10	55%	30.3 ± 3.7	2.7 ± 2.1	5 (2 – 9)
Remelted Highly Crosslinked PE	69	65 ± 10	53%	31.6 ± 5.4	1.4 ± 1.2	6 (1 – 10)

Reasons for Revision



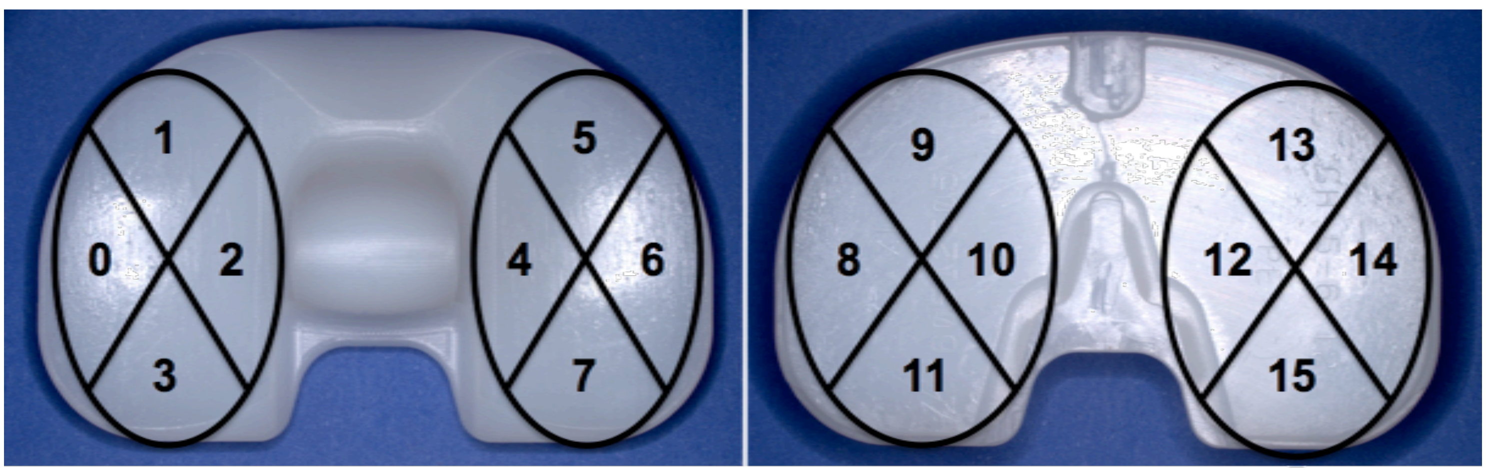
Methods
Damage Scoring

- Semi-quantitative Scoring Method
- 7 Damage Modes
  - Burnishing, Pitting, Delamination, Abrasion, Embedded Debris, Scratching, and Surface deformation



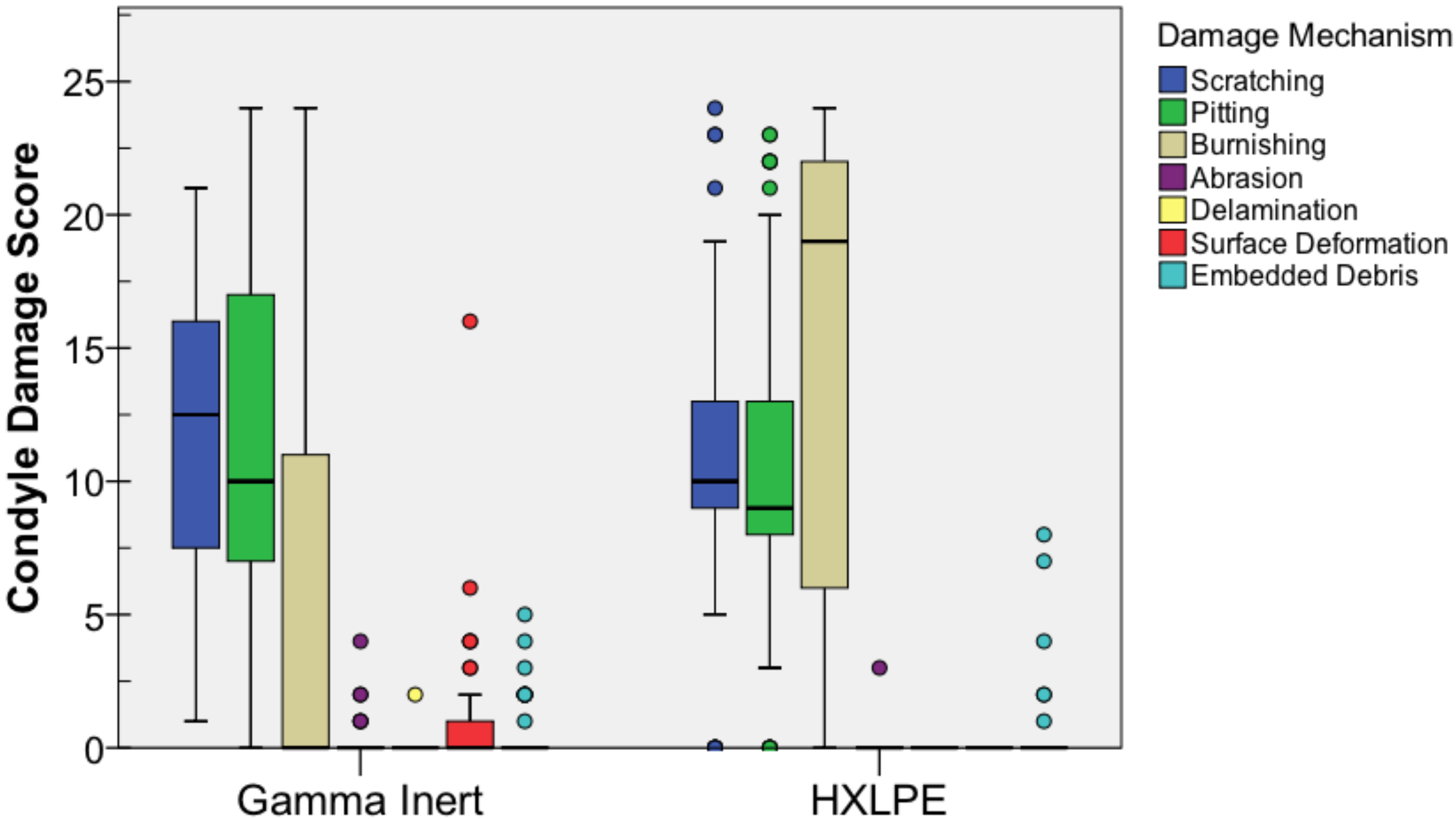
Methods
Damage Scoring

Score	Area Damage Present
0	Not Present
1	< 10%
2	10 – 25%
3	> 50%

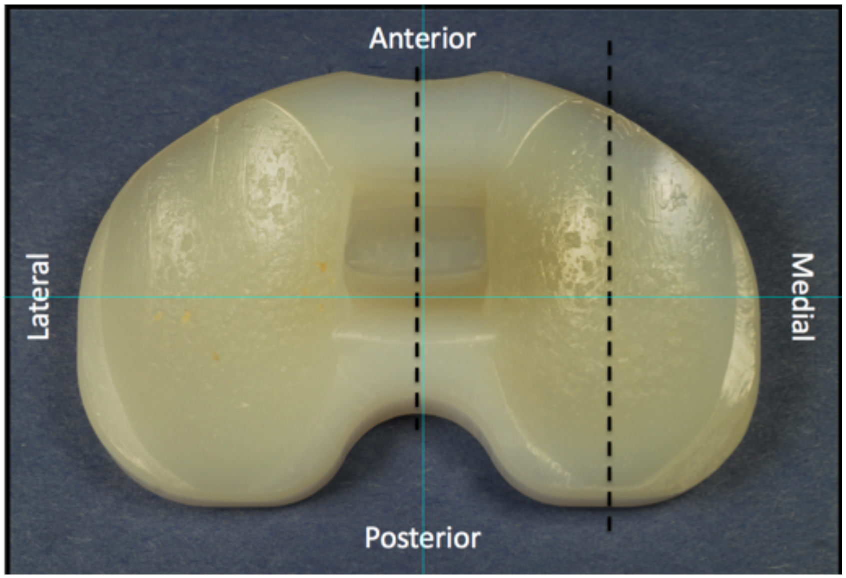


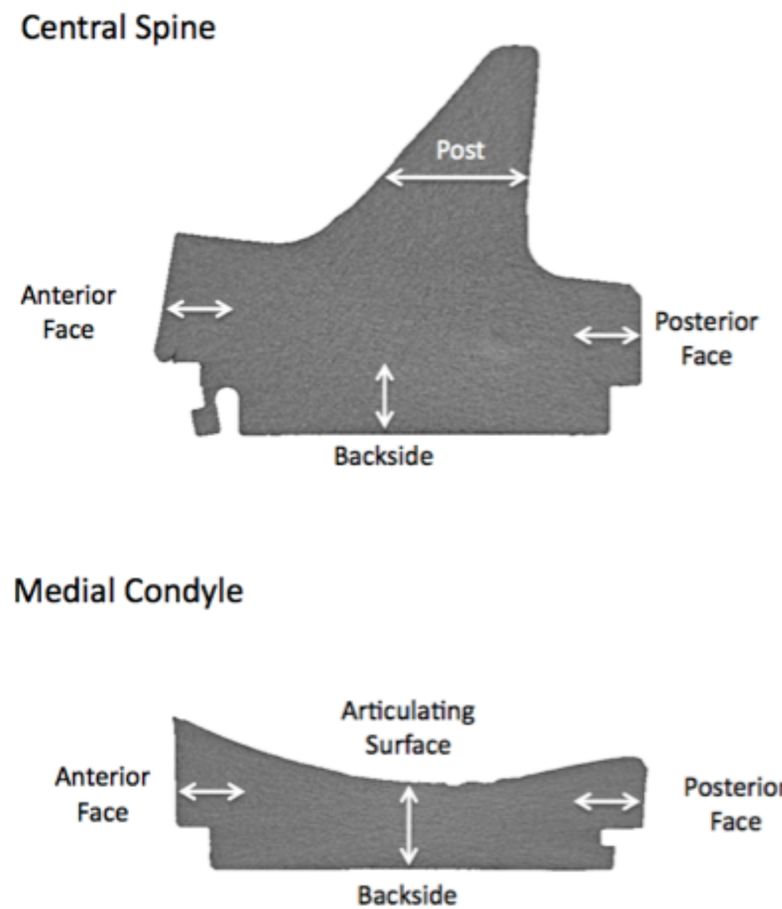
Condyles Backside

Results
Damage Scoring



Methods
Oxidation Analysis

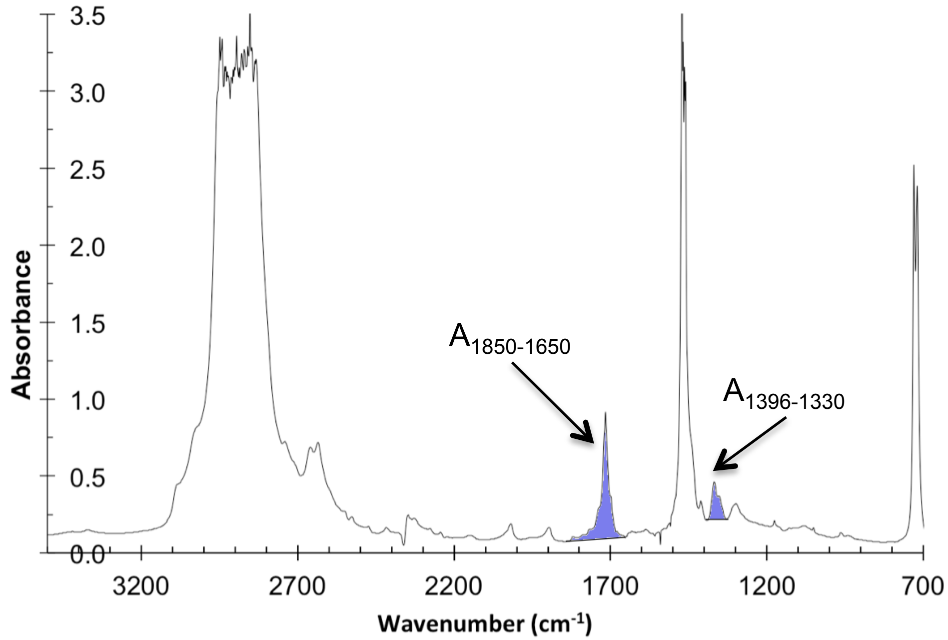




- 200 μm sections taken:
  - Medial Condyle
  - Central Spine

Methods
Oxidation Analysis

- Boiled for 6h in heptane to avoid interference of absorbed lipids
- Scanned at 0.1 mm increments
  - 32 repeat scans per location
- Maximum Oxidation Index in accordance with ASTM F2102-01

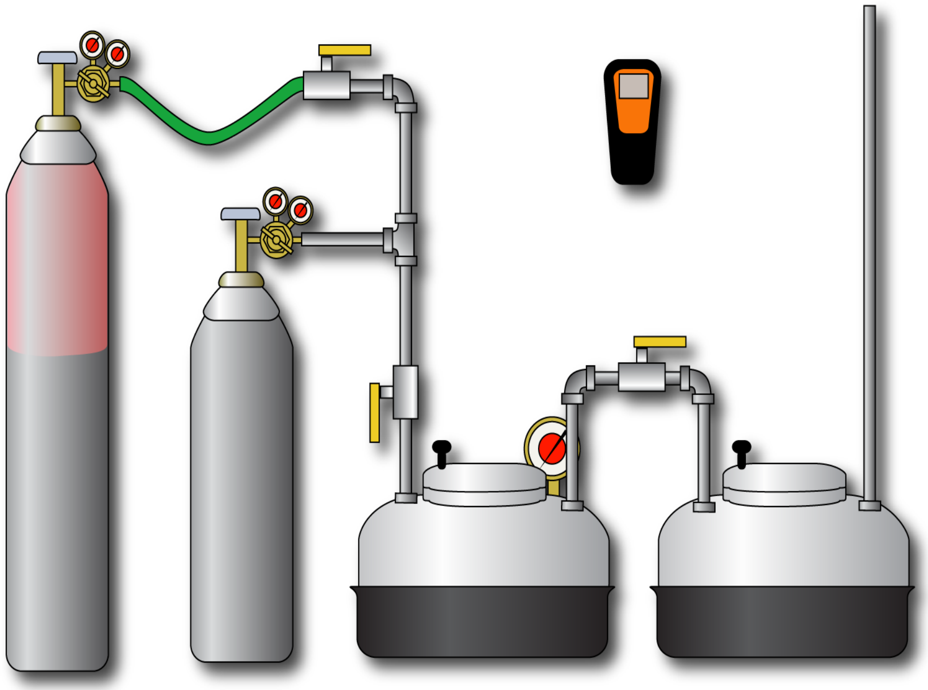


$$OI = \frac{A_{1850-1650}}{A_{1396-1330}}$$

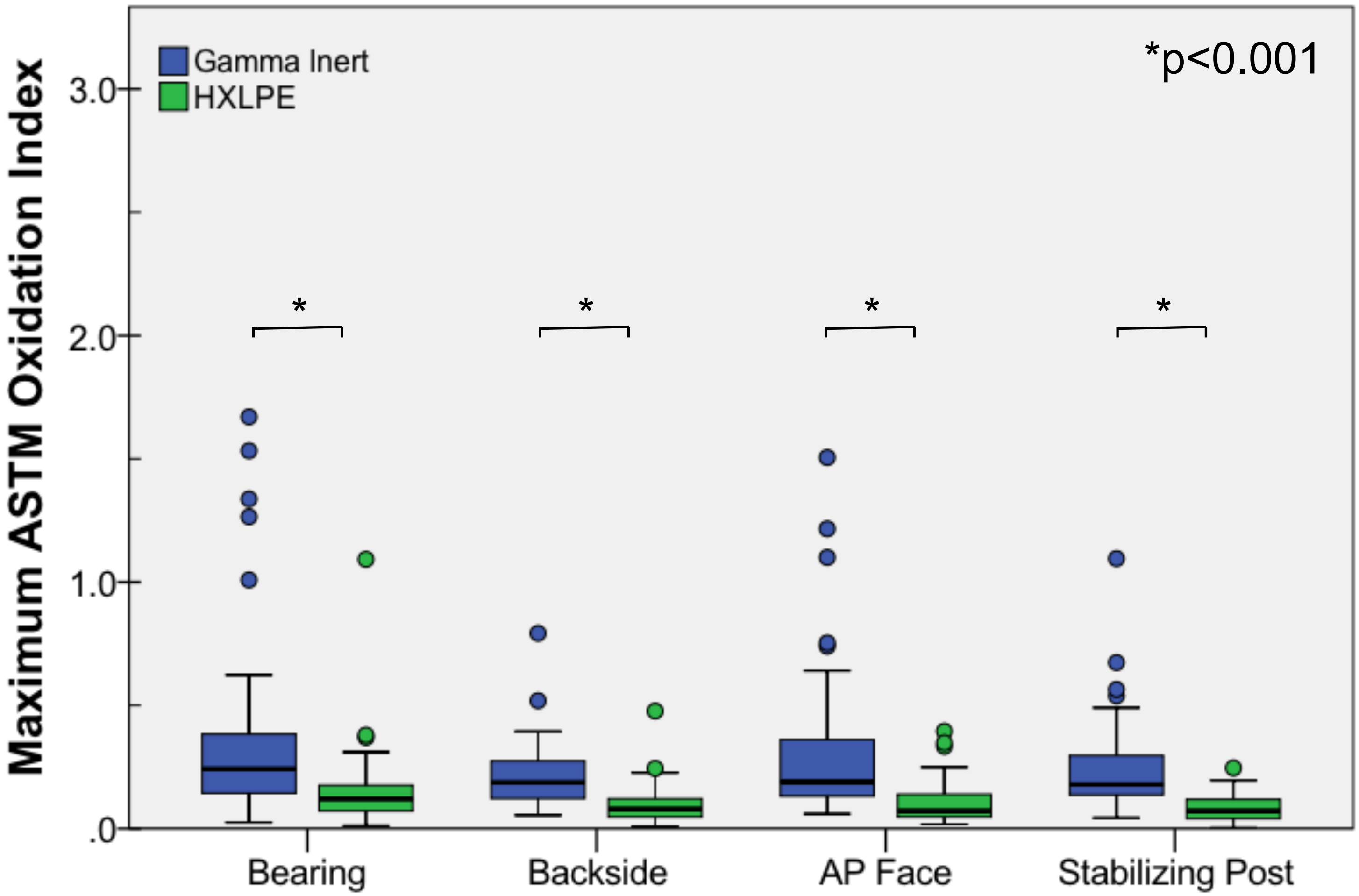
Methods
Hydroperoxide Analysis

- Expose UHMWPE to nitric oxide (NO) gas in the absence of oxygen
  - Hydroperoxides → nitrates
  - Alcohols → nitrites
- Hydroperoxide index measured using FTIR

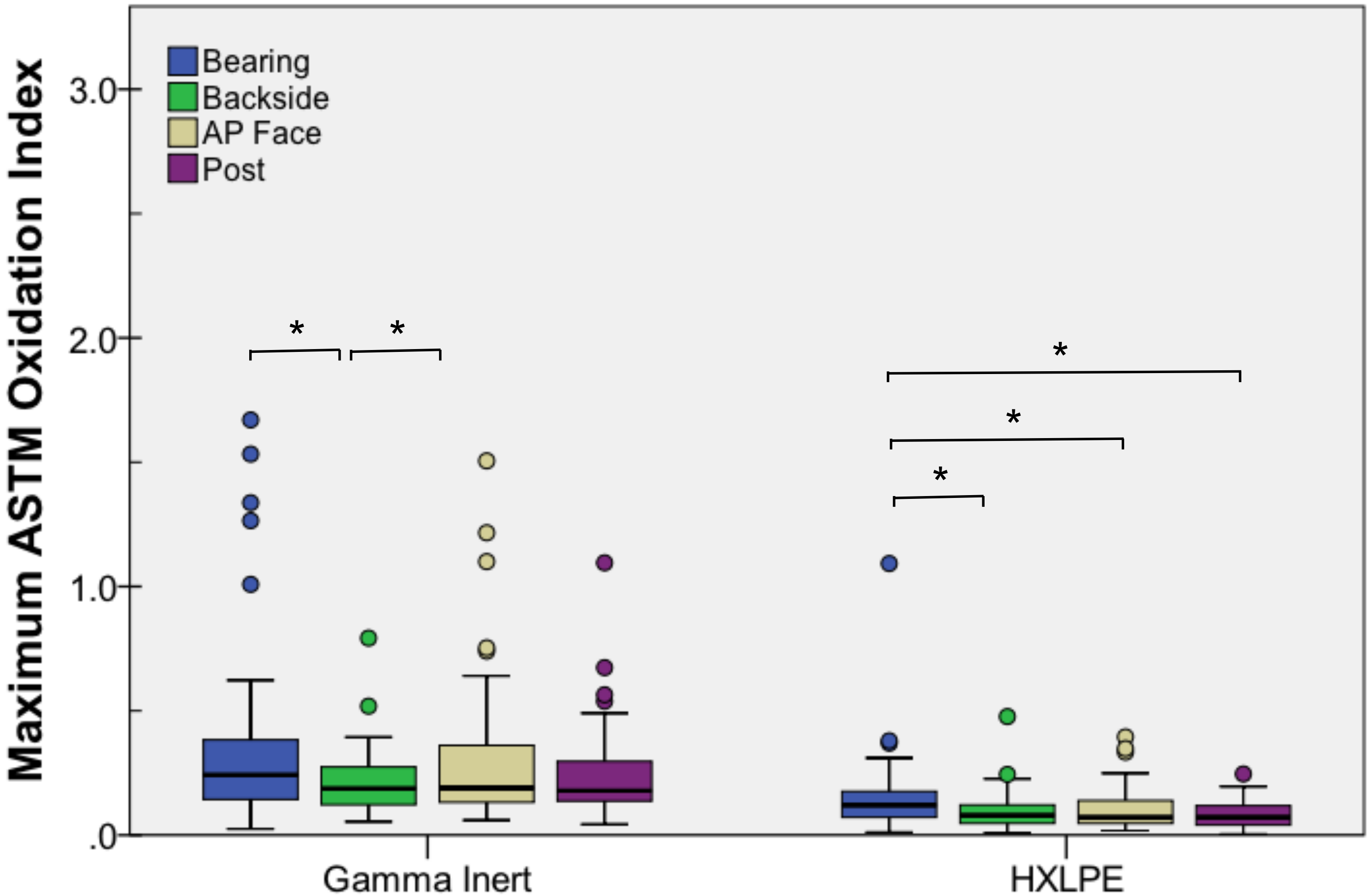
$$HI = \frac{A_{1670-1600}}{A_{1396-1330}}$$



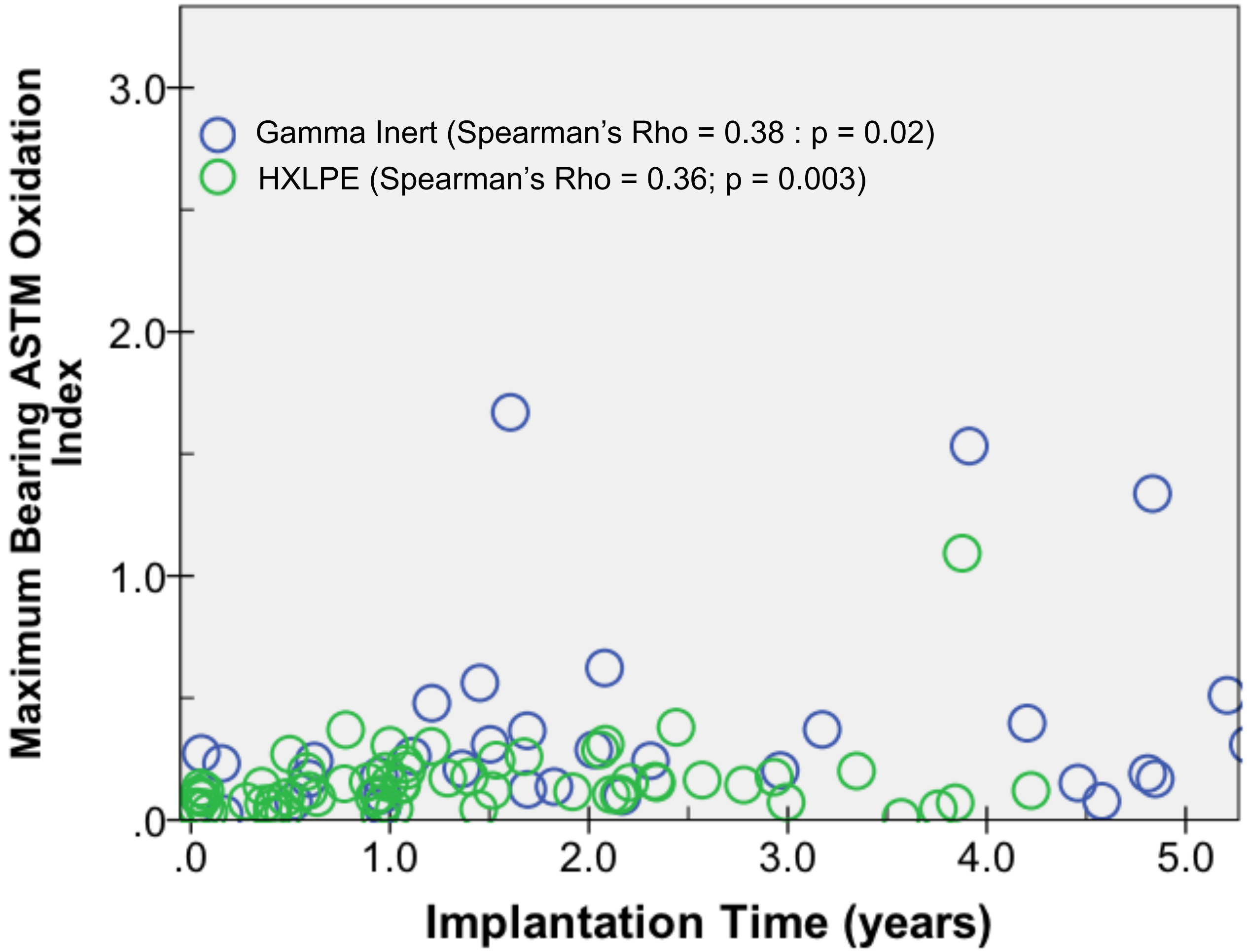
Results
Oxidation



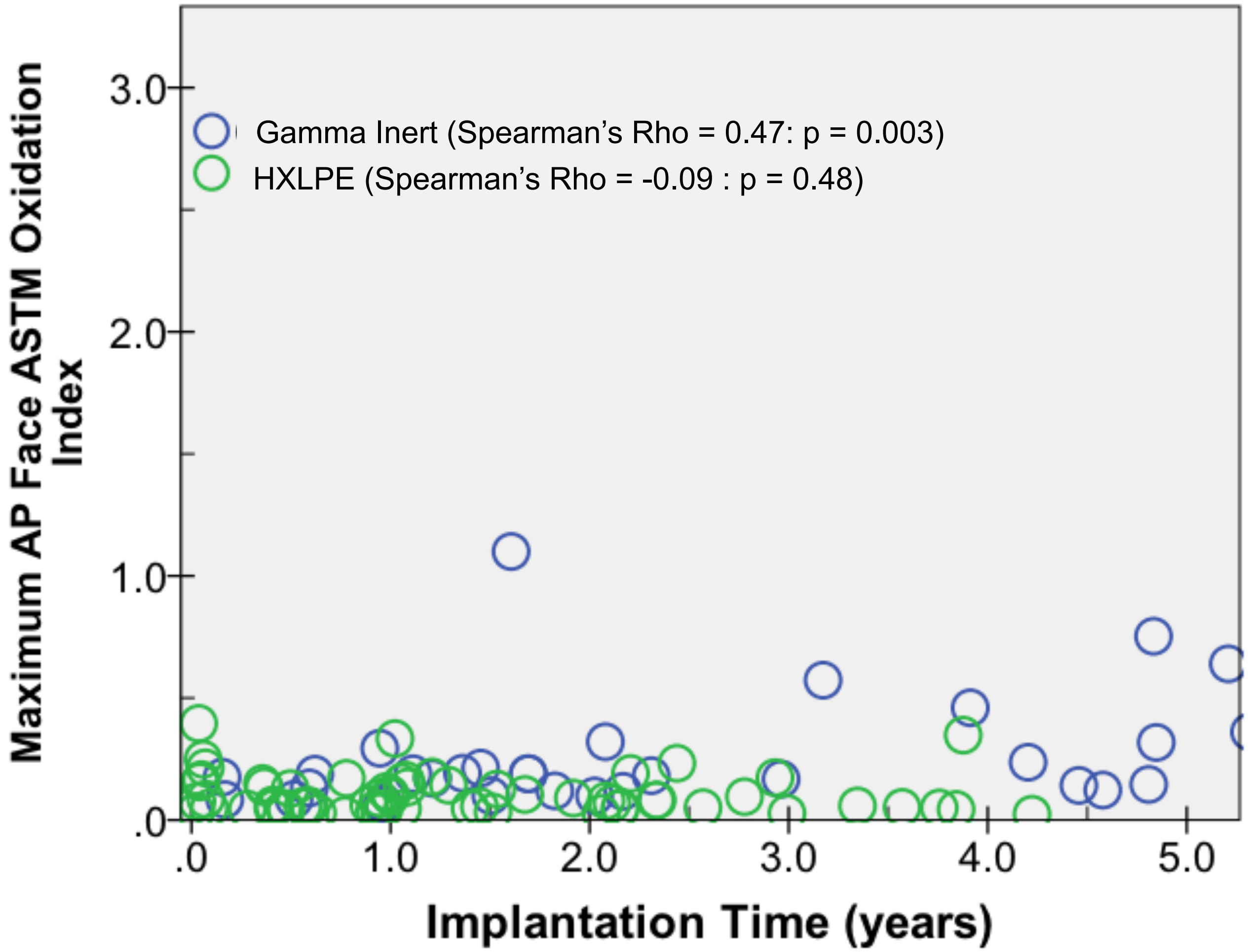
Results
Oxidation



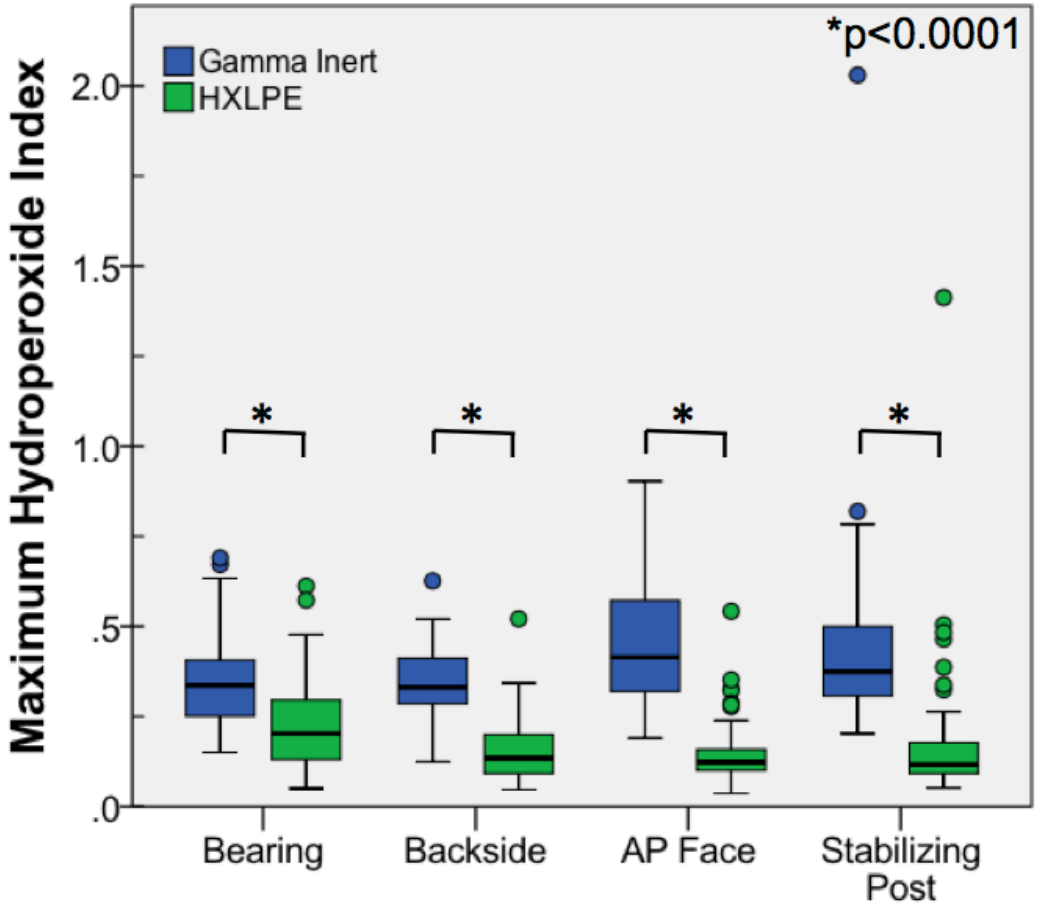
Results
Oxidation



Results
Oxidation



Results
Hydroperoxide Index



School of Biomedical Engineering,
Science, and Heath Systems

Case Study #1

- 62 year old male
  - BMI: 30.3 kg/m^2
- Implanted: 2005
  - Osteoarthritis
- Explanted: 2010
  - Tibial Loosening
  - $UCLA_{Max}$: 5
- Low Oxidation (<0.3)
- Pitting, scratching, and Burnishing

in vivo: 4.2 years

Case Study #2

- 48 year old male
  - BMI: 28.4 kg/m^2
- Implanted: 2005
  - Osteoarthritis
- Explanted: 2009
  - Tibial Loosening
  - $UCLA_{Max}$: 10
- Moderate Oxidation (1.1 at the bearing surface)
- Pitting, scratching, and Burnishing

in vivo: 3.9 years

Discussion

- Remelted HXLPE exhibited lower oxidation levels than gamma inert implants.
- In gamma inert components, AP Face and Bearing Surface had the highest oxidation.
- In HXLPE components, the bearing surface had the highest oxidation.

Discussion

- Pitting, Scratching and burnishing were the main damage modes
  - No delamination in HXLPE Cohort
  - 1 Case of Delamination in the gamma inert cohort
- Longer-term studies necessary to determine stability of remelted HXLPE in total knee replacement

Thank You For Your Attention