

# **In Vivo Performance of Highly Cross-linked UHMWPE**

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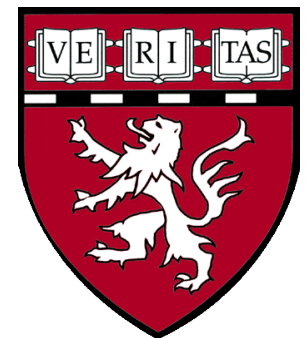
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# Disclosures

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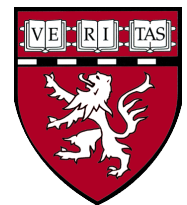
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# Retrievals

Type	Number of Retrievals	In Vivo Durations (months)
Marathon™	12 hips	0.9-84
Longevity™	28 hips	2.5-120
Prolong™	5 knees	4-47
Crossfire™	1 hips	120
X3™	27 (16 hips, 11 knees)	0.5-48
E1™	10 (9 hips, 1 knee)	0.1-19.5

**Patient Ages:** 67 ± 12.5 years

**Patient Gender:** 28 males, 42 females (13 unknown gender)

**Reasons for Revision:** Infection (33), dislocation (14), loosening (13), instability (12), femoral fracture (1), rim fracture (2), poly wear (1), osteolysis (1) unknown (5)

# Cleaning and Storage of Retrievals

Arrive at lab from OR or off-site institution

Ethanol Soak

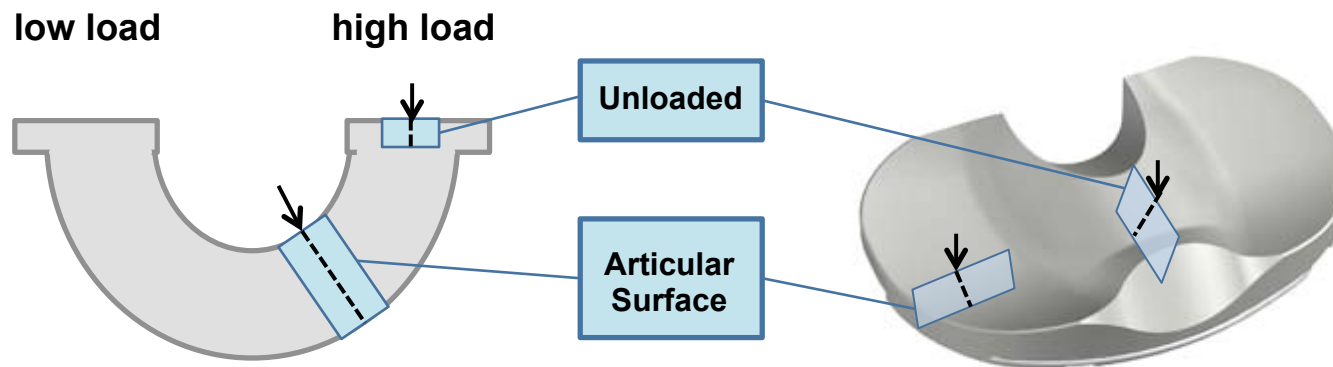
Rinse with H<sub>2</sub>O and soft brush to clean

Air dry in hood

Vacuum package and store at -20°C until analysis  
or -80°C for long-term storage

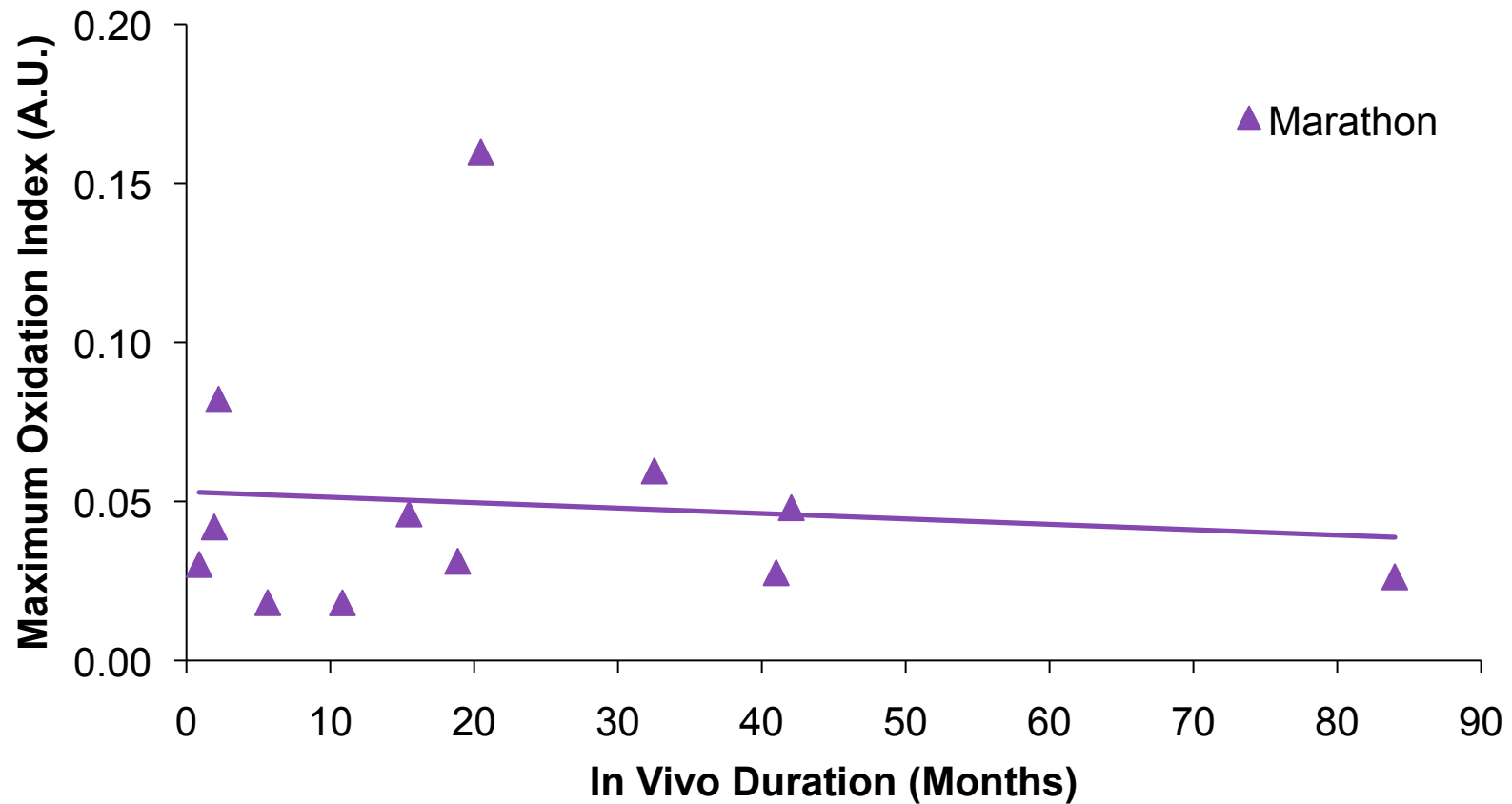
# Retrieval Analysis Methods

- FTIR: Lipid absorption, oxidation
- Nitric Oxide Staining: Oxidation potential
- Crosslink Density
- DSC: Crystallinity, melt temperature
- ESR: **Free radical content** (only E1 retrievals)

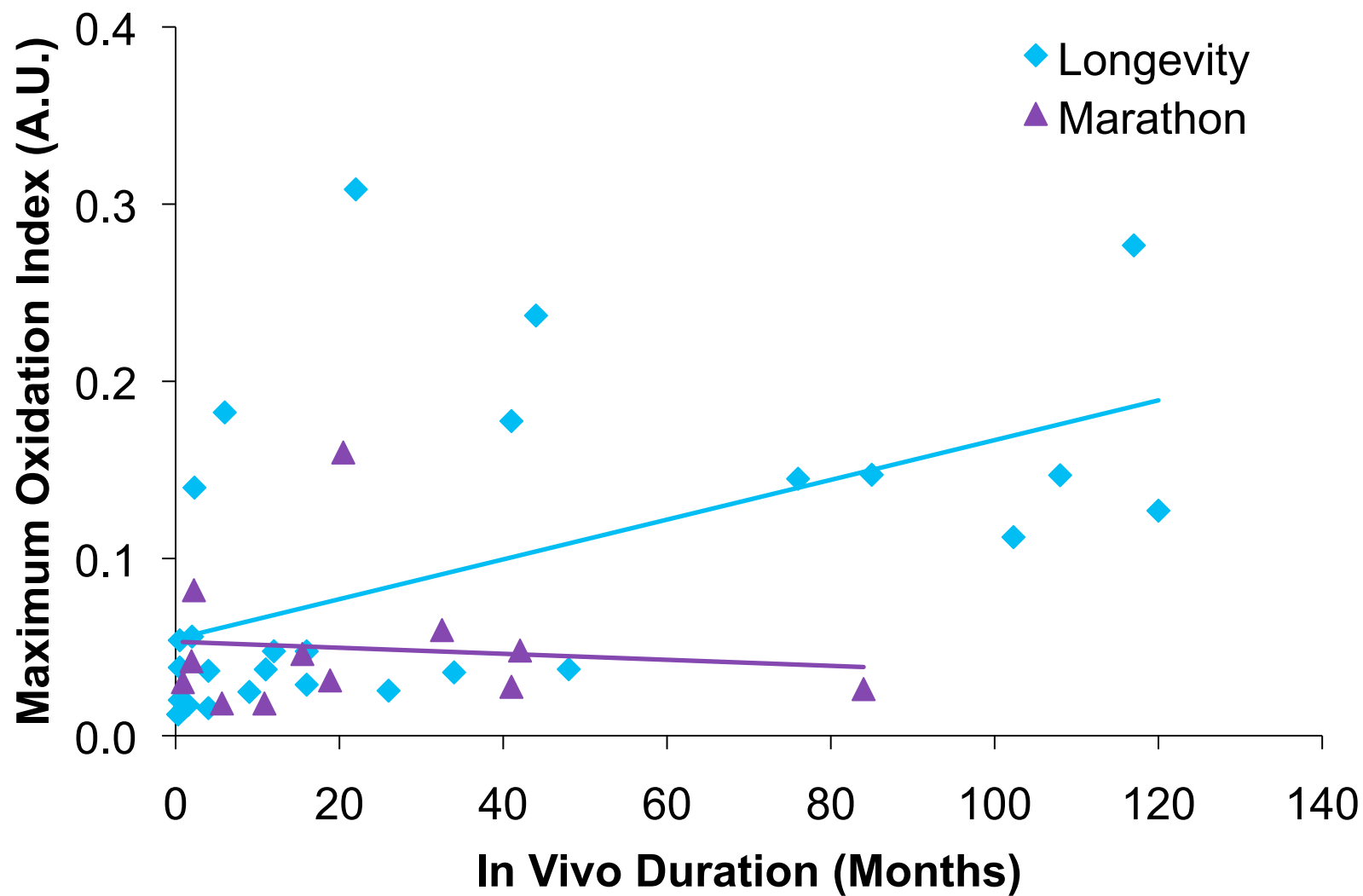


# Marathon Retrievals

	Retrievals
Maximum Oxidation	0.004 - 0.160
Cross-link Density (mol/dm <sup>3</sup> )	0.237 ± 0.017
Crystallinity (%)	53.0 ± 1.4

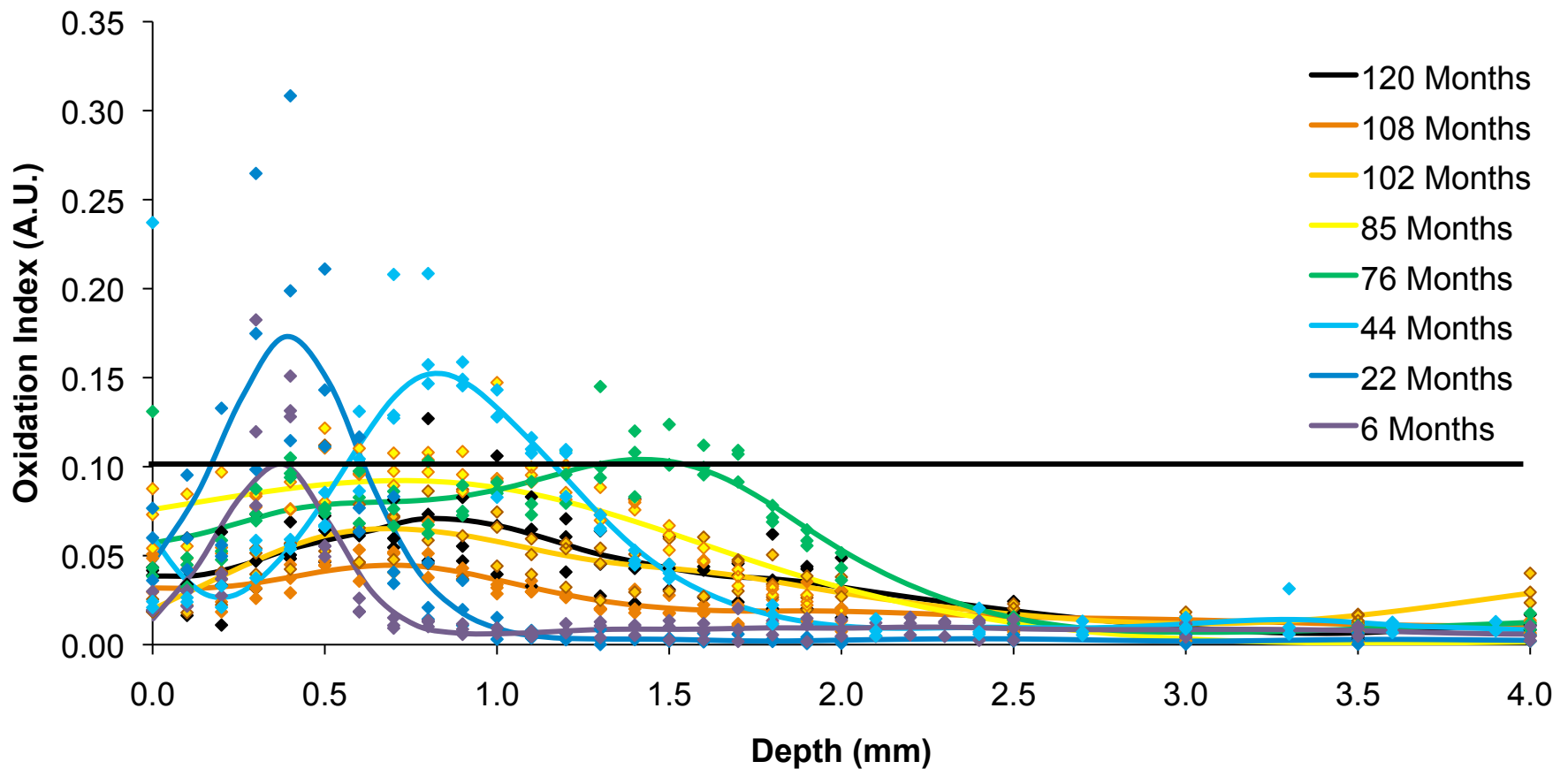


# Maximum Oxidation



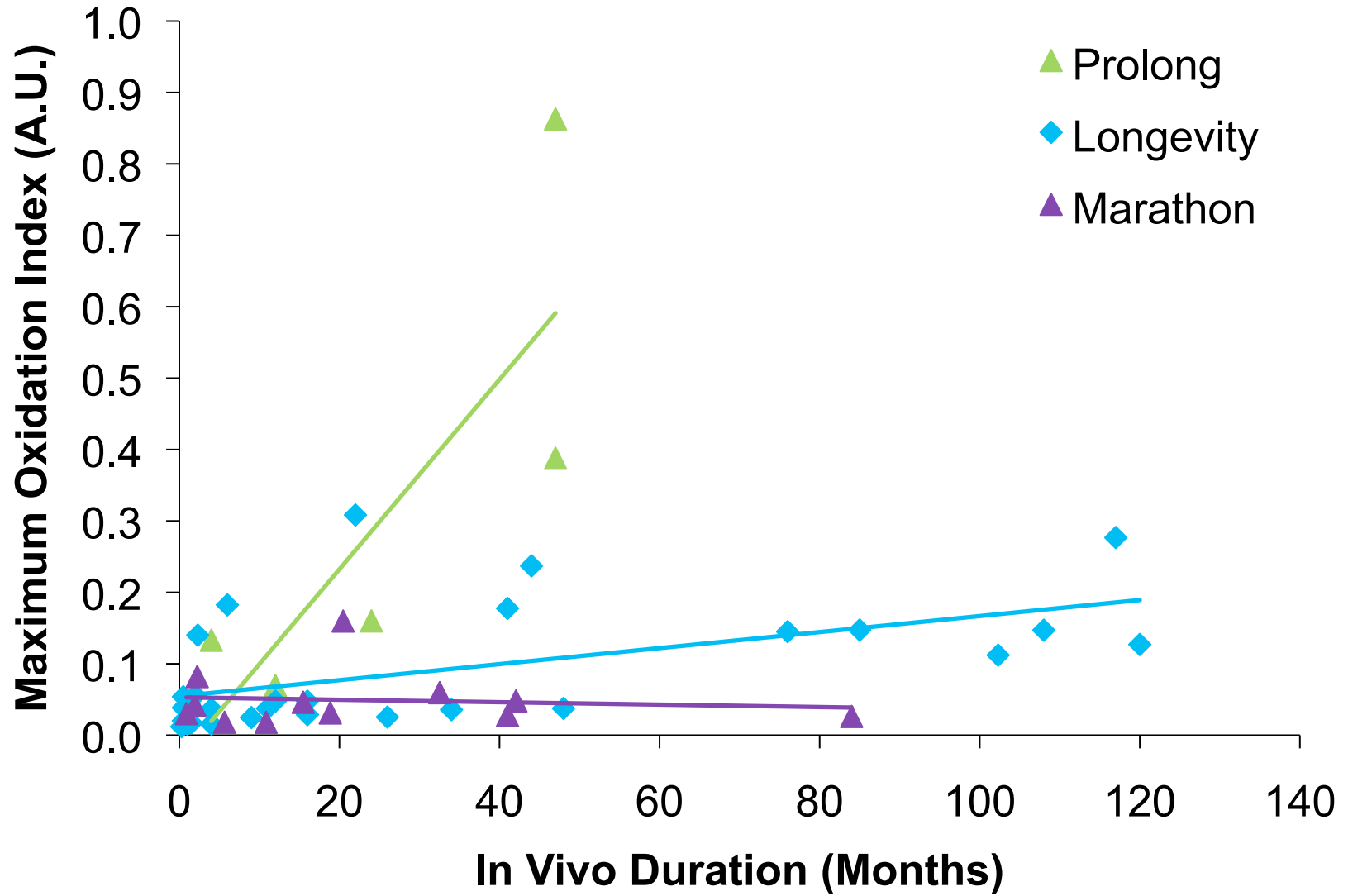
# Longevity Retrievals

	Retrievals
Maximum Oxidation	0.012 - 0.366
Average Cross-link Density (mol/dm <sup>3</sup> )	0.293 ± 0.020
Average Crystallinity (%)	52.7 ± 1.7



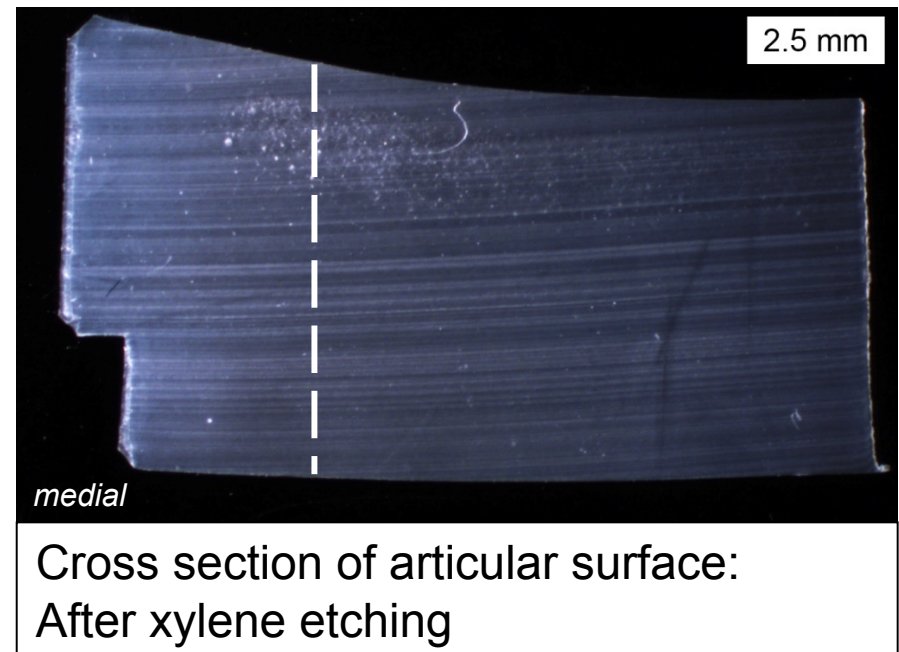
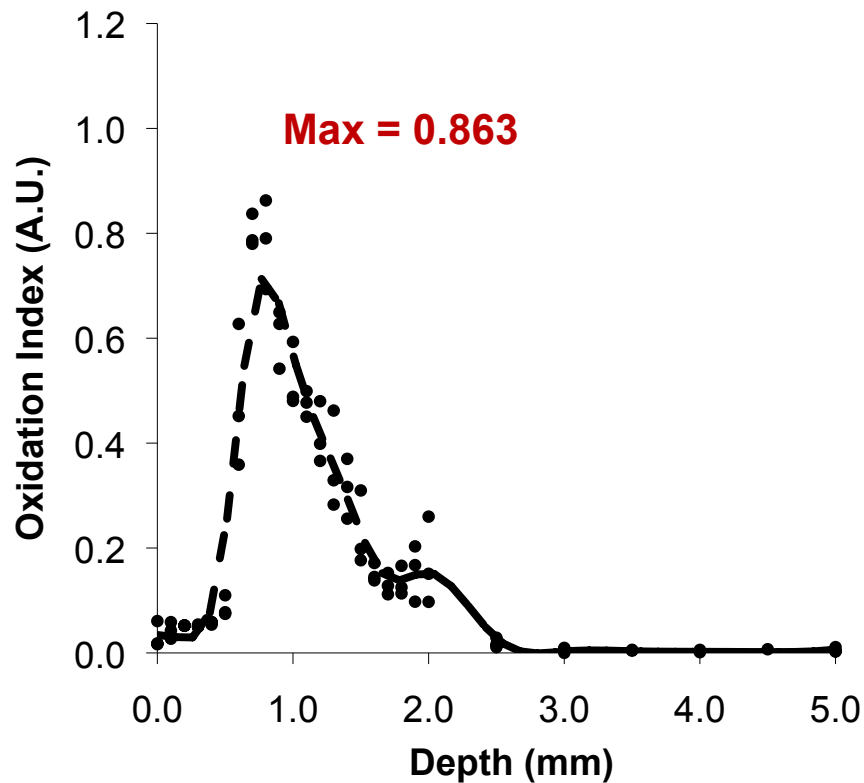


# Maximum Oxidation

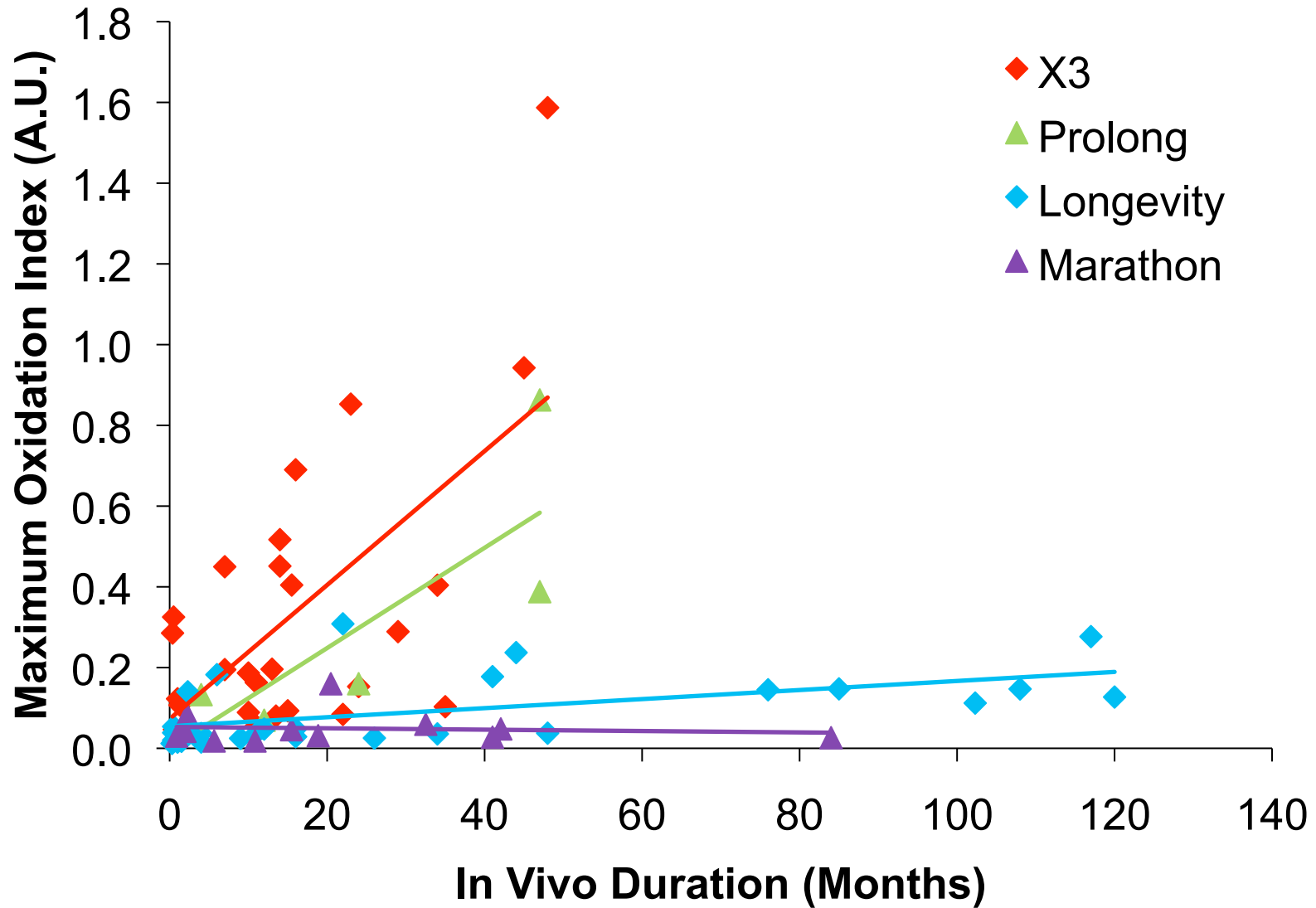


# 4 Year Prolong Tibial Insert

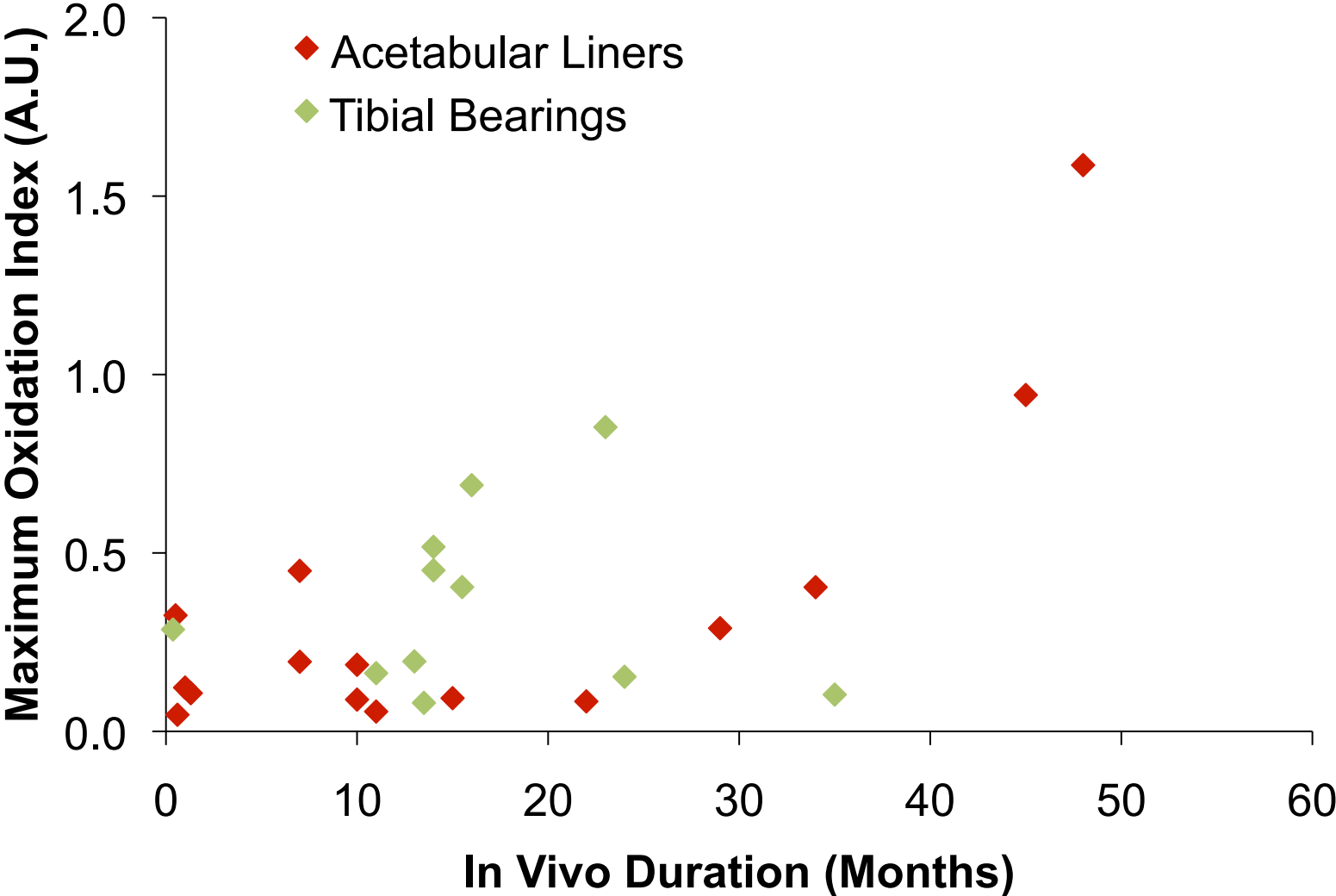
	Articular Surface	Unloaded Eminence
Maximum Oxidation	0.863	0.049
Cross-link Density (mol/dm <sup>3</sup> )	0.215 ± 0.020	0.213 ± 0.006
Crystallinity (%)	51.2 ± 1.1	50.9 ± 0.9



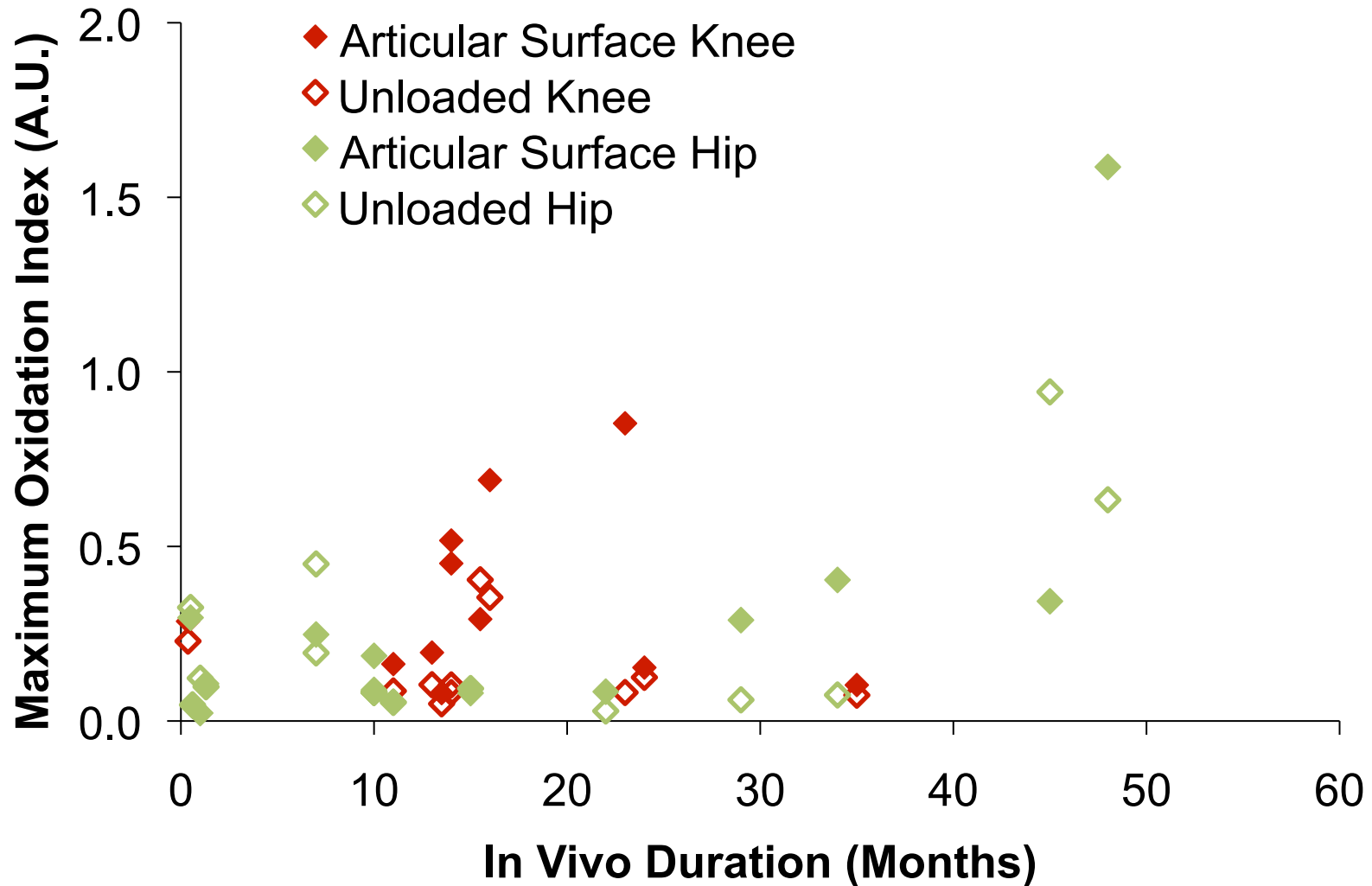
# Maximum Oxidation



# Acetabular Liners vs. Tibial Bearings

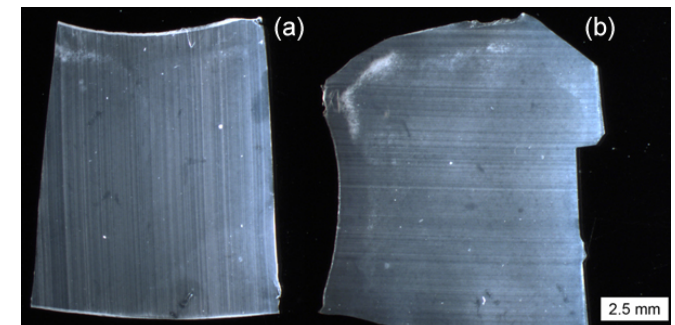
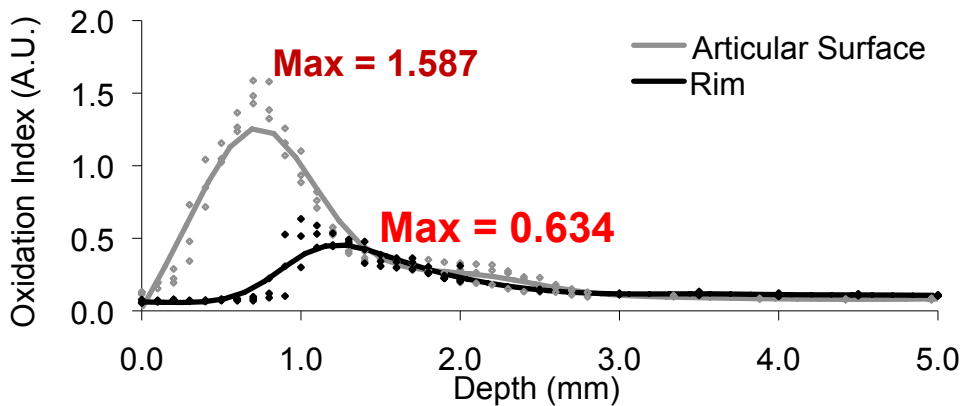
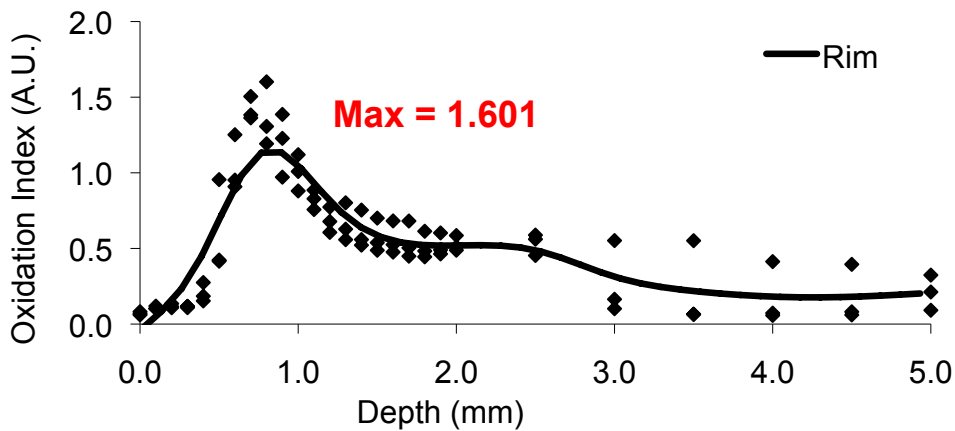


# Loaded vs. Unloaded Regions of Oxidation



# Two 4 Year X3™ Acetabular Liners

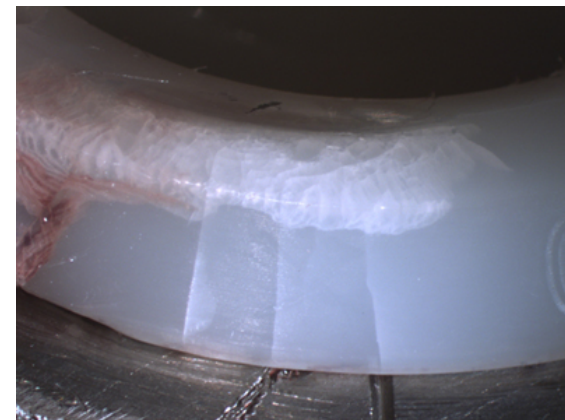
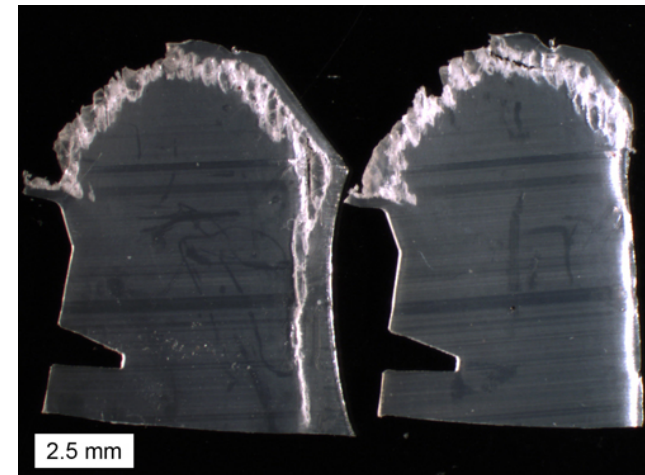
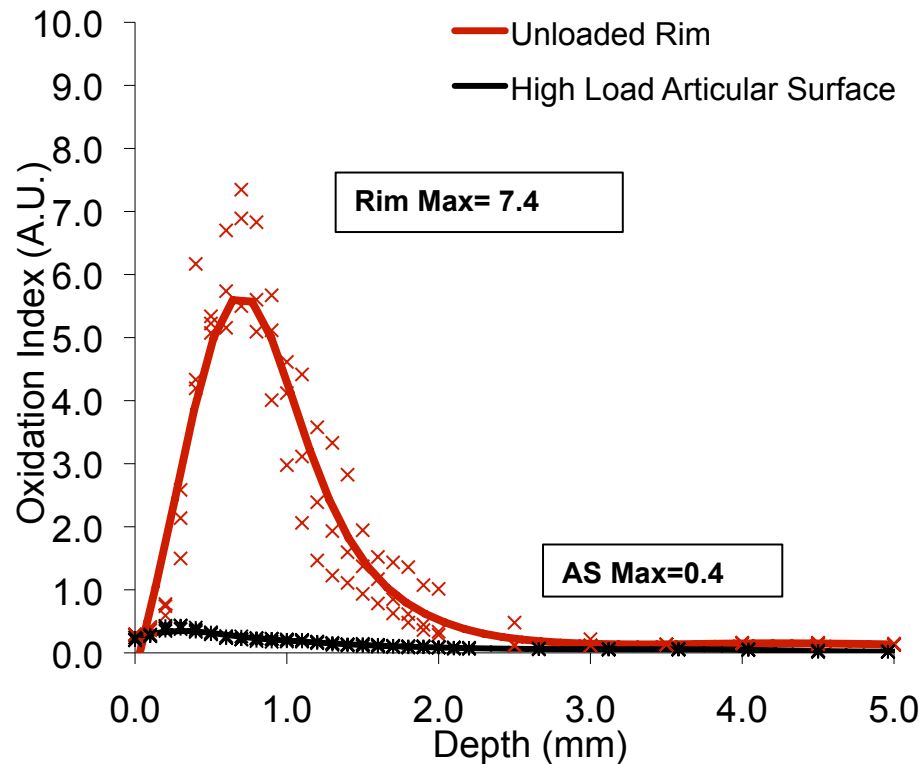
	All Retrievals	45 Month Retrieval	48 Month Retrieval
Maximum Oxidation	0.023 – 1.601	1.601	1.587
Cross-link Density (mol/dm <sup>3</sup> )	0.213 ± 0.036 (0.120 - 0.331)	0.192 ± 0.041	0.167 ± 0.039
Crystallinity (%)	62.2 ± 2.3 (58.3 – 69.3)	60.6 ± 1.3	65.1 ± 2.9



(a) Articular surface and (b) Rim

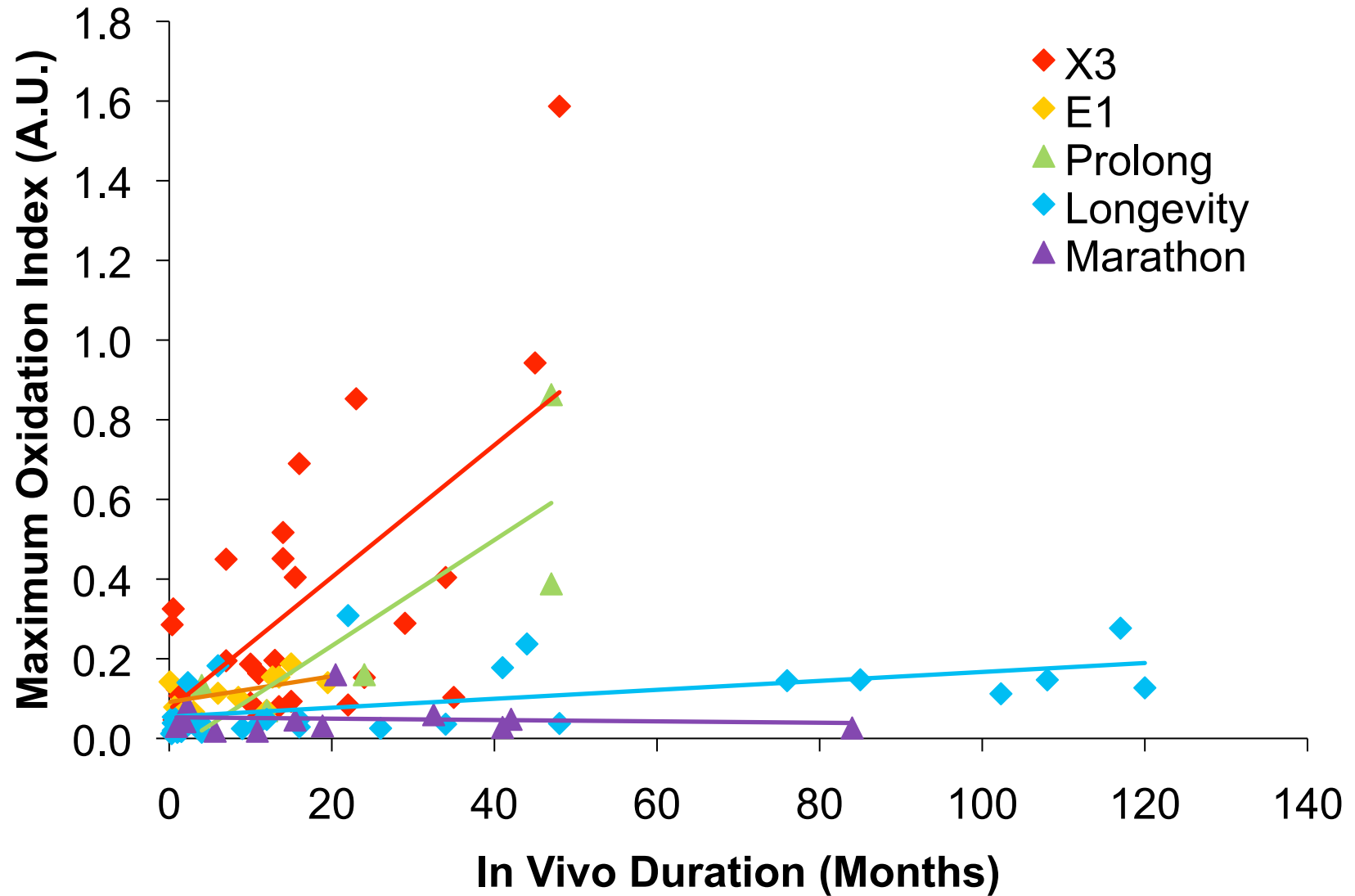
# Case Study: 10 Year Crossfire

	Never Implanted Control*	<3 Year Retrievals*	10 Year Retrieval
Maximum Oxidation	0.16 ± 0.02	0.22 - 5.81	7.35
Cross-link Density (mol/dm <sup>3</sup> )	N/A	N/A	0.079 ± 0.29
Crystallinity (%)	64.9 ± 0.51	64.4 - 79.2	78.2 ± 1.7



\* Wannomae, et al.

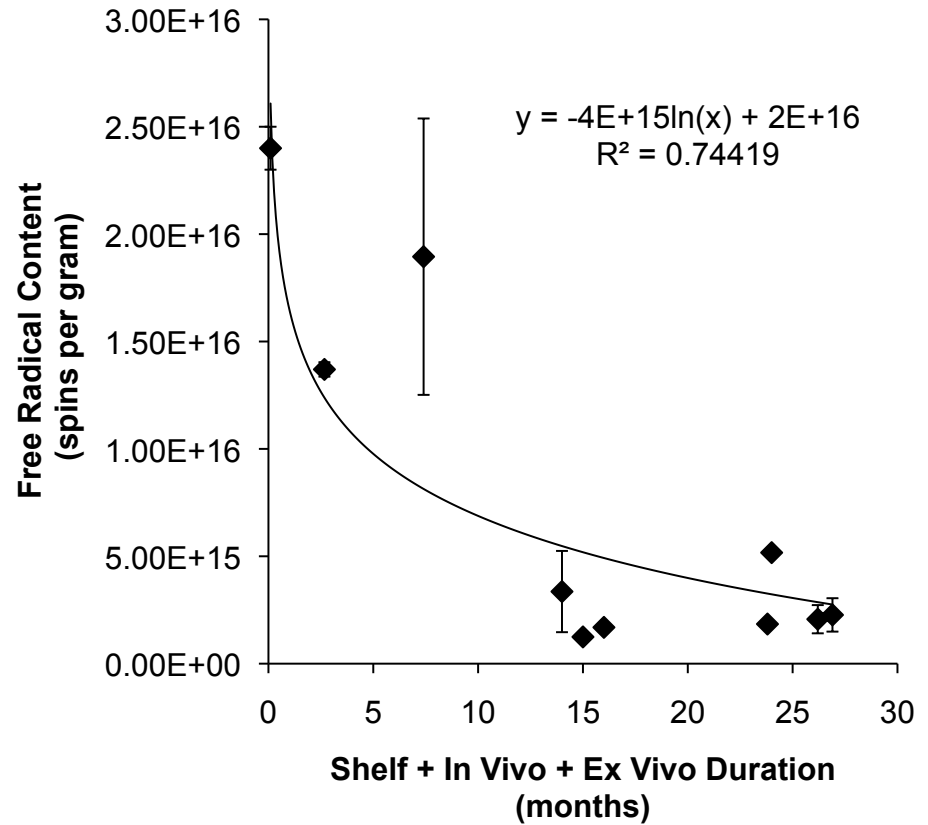
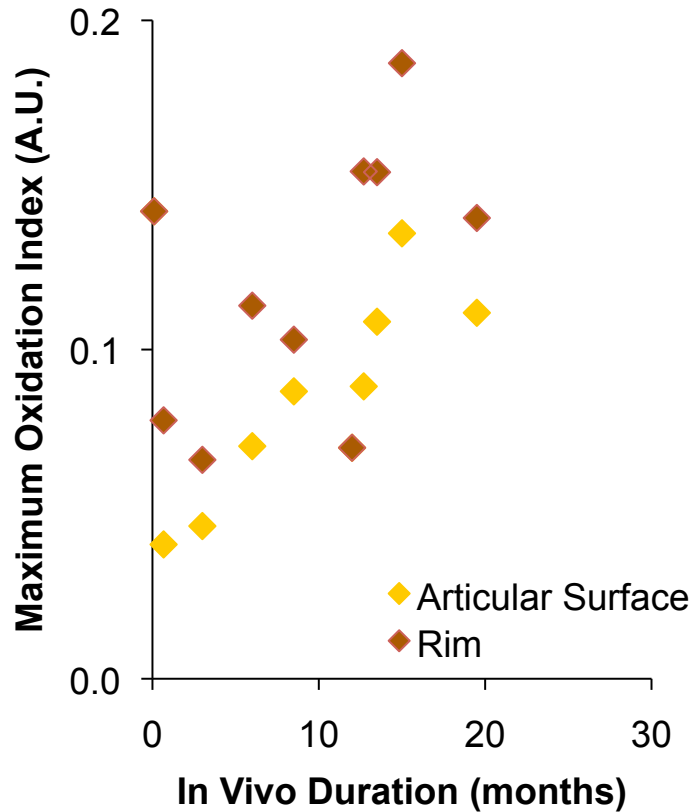
# Maximum Oxidation





# E1 Retrievals

	Never Implanted Control	Retrievals
Maximum Oxidation	0.029 - 0.060	0.041 – 0.187
Average Cross-link Density (mol/dm <sup>3</sup> )	0.275 ± 0.015	0.289 ± 0.023
Average Crystallinity (%)	58.8 ± 2.2	58.6 ± 1.9



# Observations

- Both first and second generation highly cross-linked retrievals show signs of oxidation otherwise not predict by the current standard of in vitro testing
  - Lipid absorption
  - Cyclic loading
- In vivo oxidation is consistently in the form of subsurface peaks regardless of loaded or unloaded regions
  - Ex vivo studies (Muratoglu, JBJS, 2010)

# Limitations and Questions

Larger sample sizes and/or comparable retrievals

- Matched physical variables
  - Hips vs. Knees
  - Liner design
  - In vivo durations
- Patient variables
  - Matched lipid profiles
  - Activity levels and weight

Establish baseline controls for all materials

- Pre-implantation material variations

# Acknowledgements

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