Should Crosslinked UHMWPE be used in TKA?

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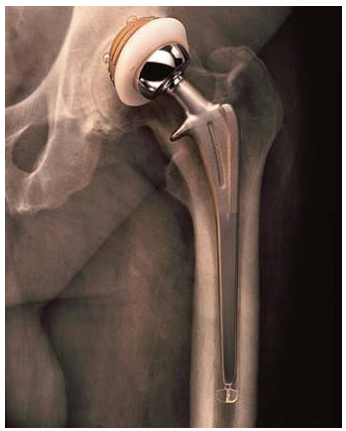


Sept 17, 2009

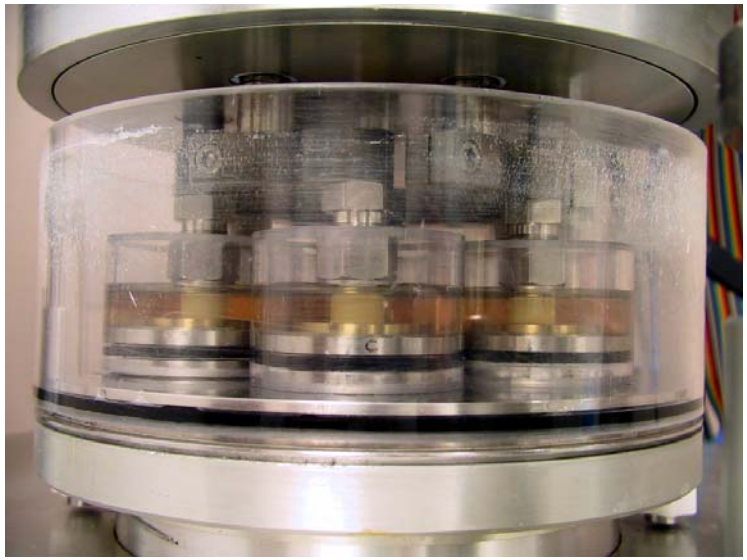
Turin, Italy

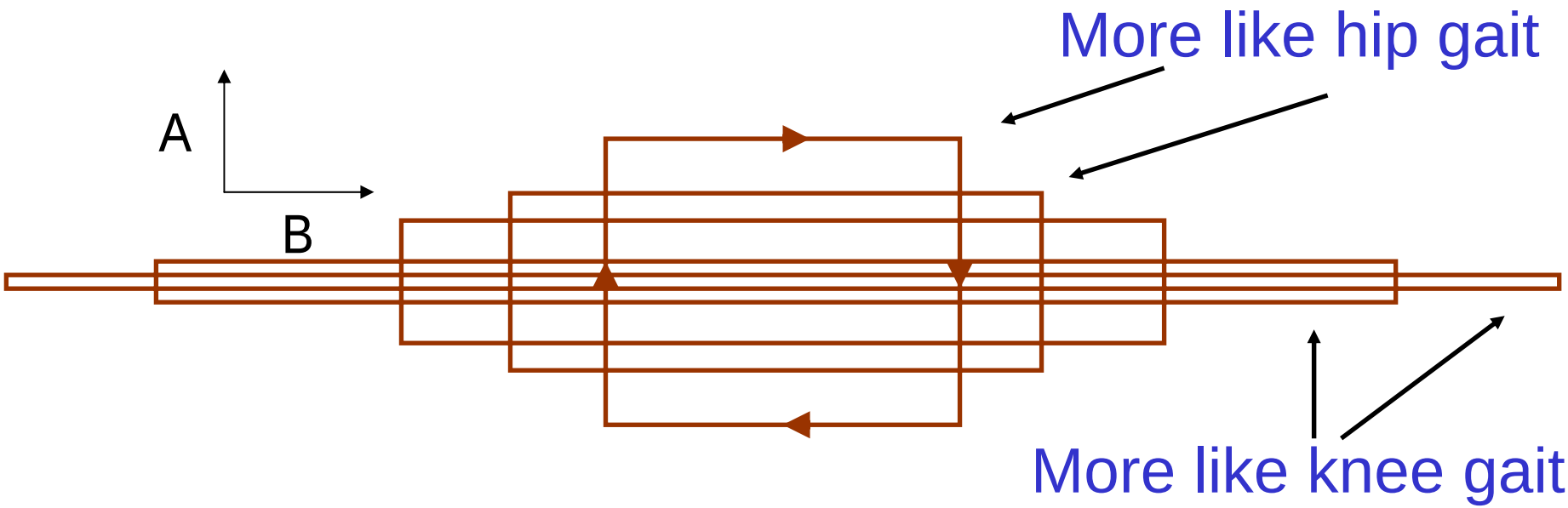
The Three Major Factors!

- Wear Resistance (abrasive wear in TKA)
- Oxidation Resistance (delamination wear in TKA)
- Mechanical Properties (fracture, catastrophic failure)

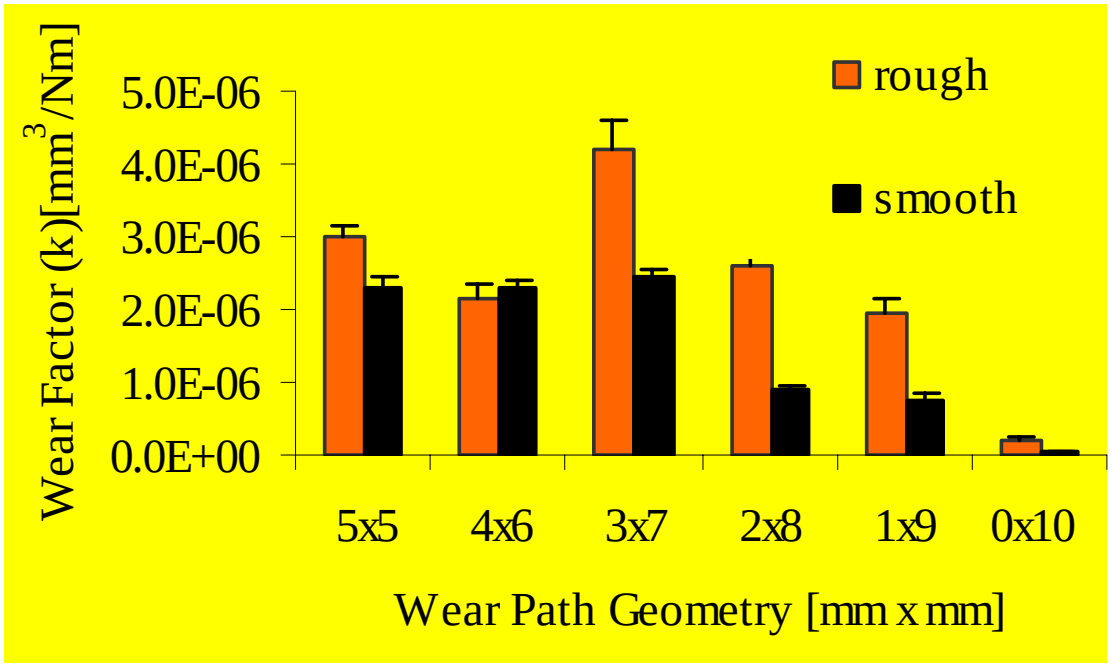
Concerns of particulate wear in XPE under conditions of abrasive wear

Wear Testing!



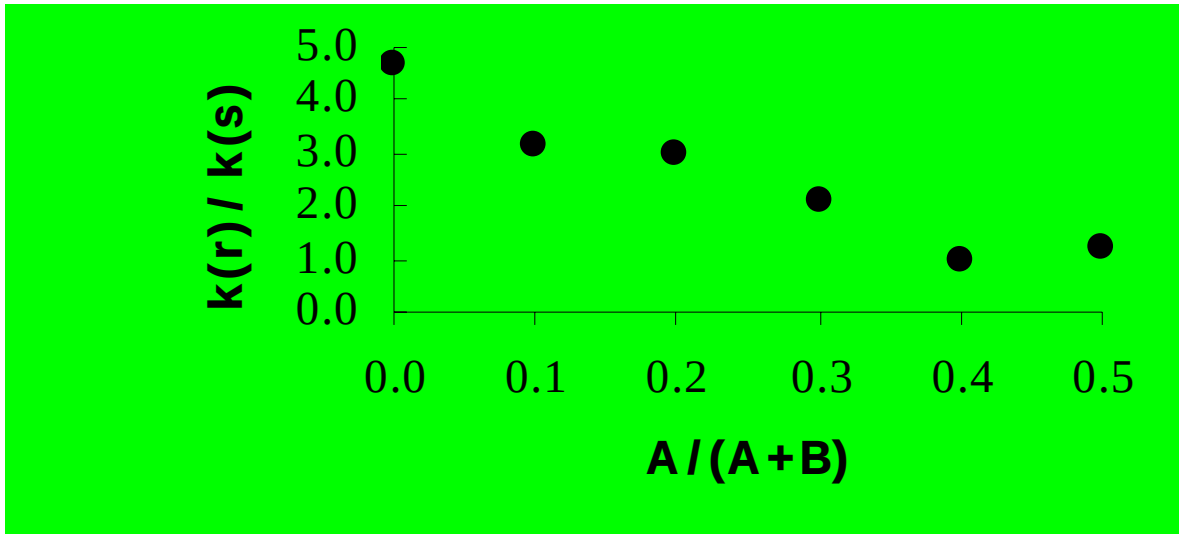


Roughness affects wear rate in knee more than in hip!



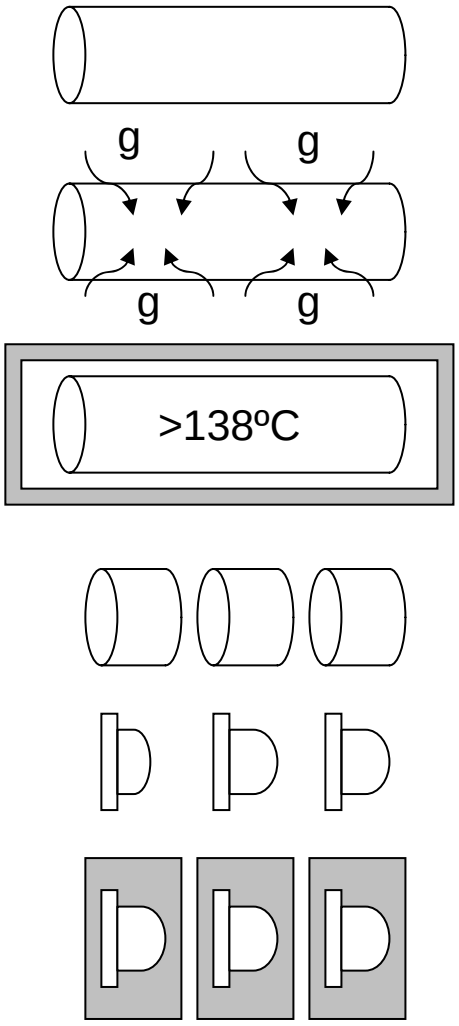
Turell M, et al, Wear (2003) 255: 1034-1039

Turell M, et al, Wear (2005) 259:984-991



1st Generation XPE

Crosslinking Process



UHMWPE Bar

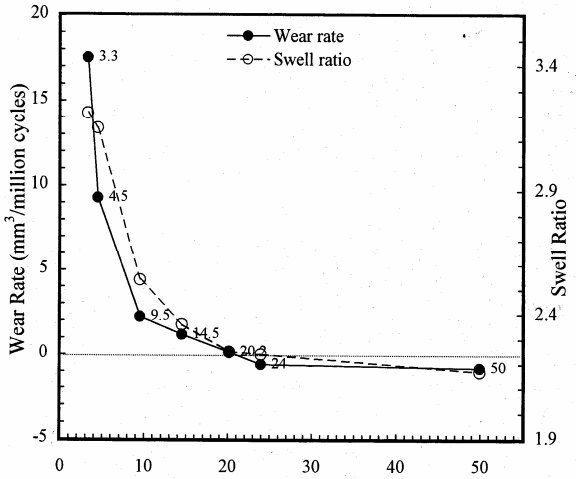
Irradiate with gamma or ebeam

Melting

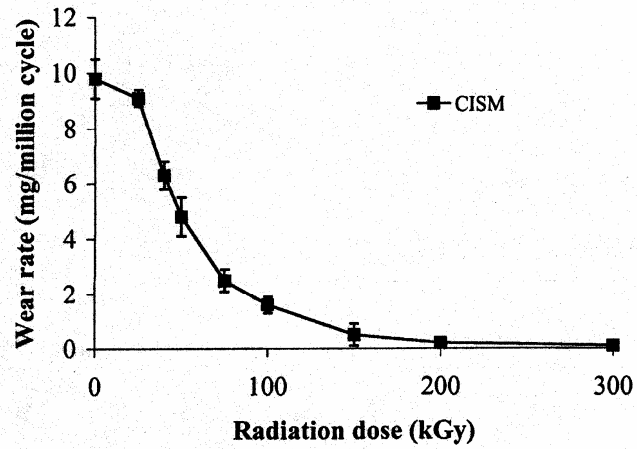
Section into puck

Machine into cup

Package and sterilize



McKellop H et al, JOR, 1999

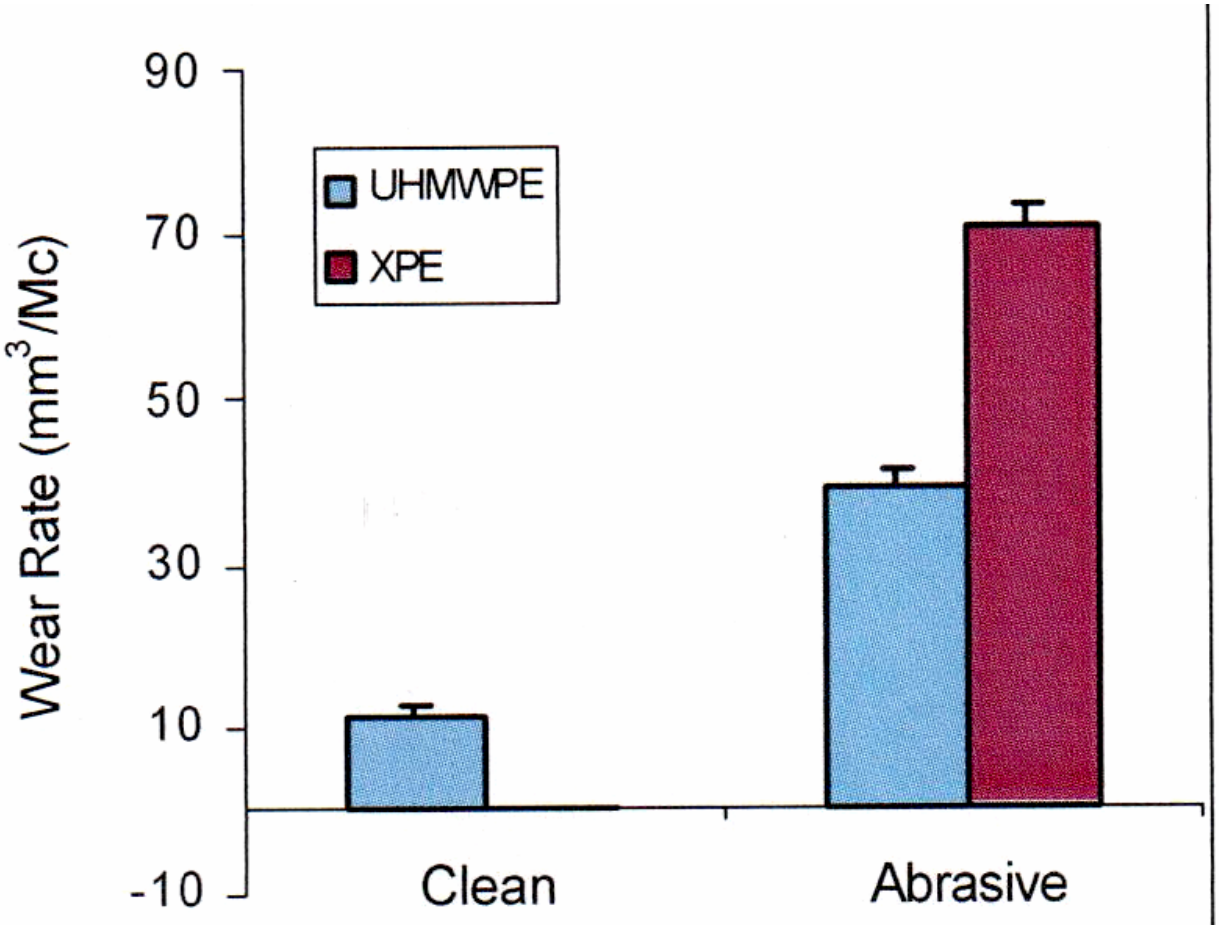


Muratoglu et al, Biomat, 1999

- Major Benefit: High wear & oxidation resistance

The Case Against 1st Generation XPE for TKA

- Knee Simulator Abrasive Wear Tests



SMOOTH

- Ra =0.06μm
- Rpm=0.22μm
- Rpk=0.09μm

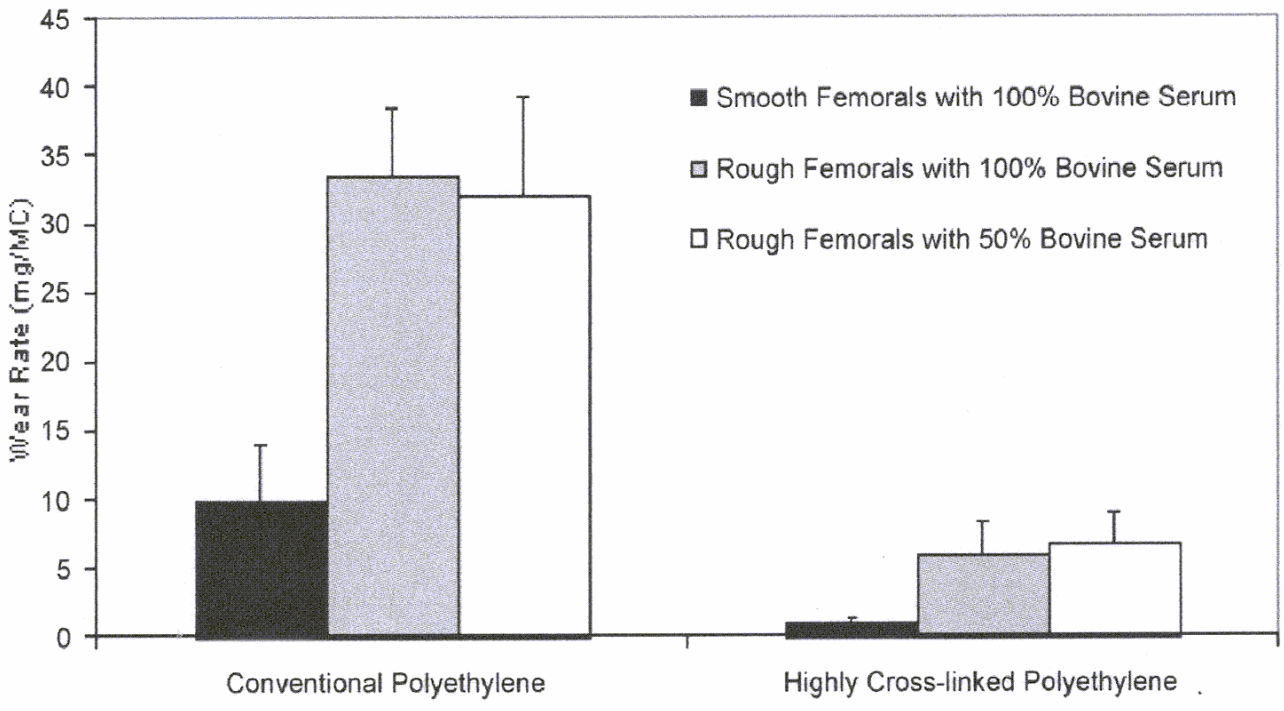
ROUGH

- Ra=0.12μm
- Rpm=0.83μm
- Rpk=0.24μm

Widding et al Trans ORS, 49:1427 (2003)

The Case for 1st Generation XPE

- Knee Simulator Abrasive Wear Tests



SMOOTH

- Ra= 0.08 μm
- Rp= 0.32 μm

EXPLANTS

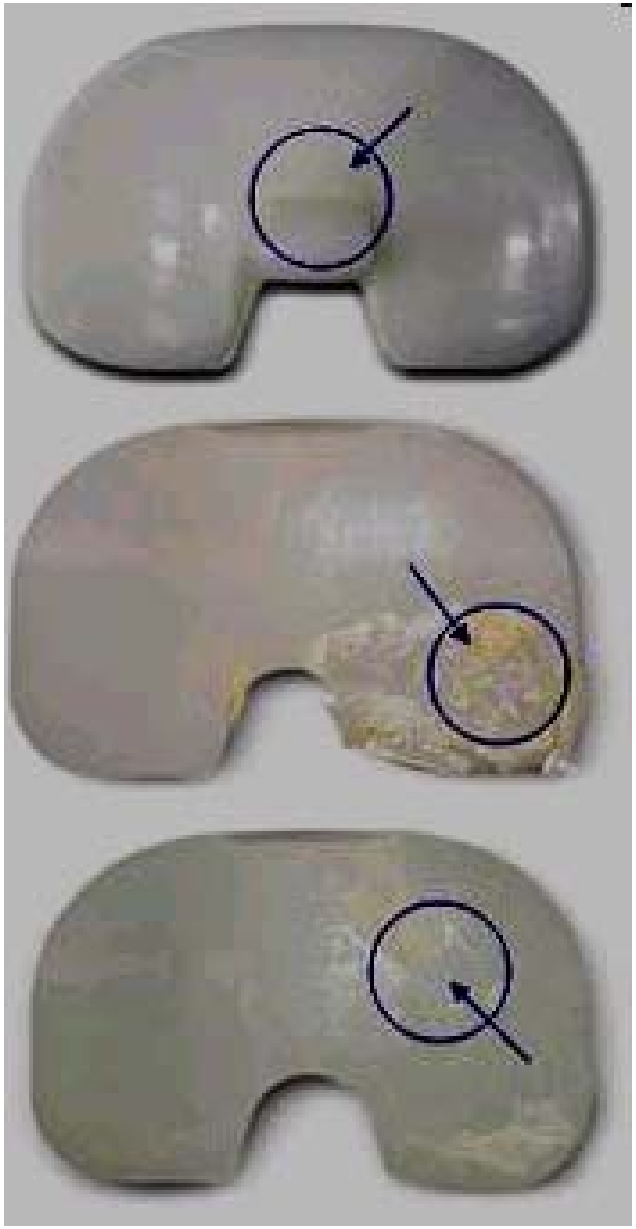
- Ra= 0.10-0.20 μm
- Rp= 0.32-0.77 μm

Muratoglu et al CORR, 428:108-113 (2004)

Time for Discussion

Concerns about delamination wear in XPE

Delamination Wear!



- Extensive delamination wear observed clinically and in the laboratory in oxidized UHMWPE
- Not observed in unoxidized UHMWPE and XPE
- Must prevent oxidation

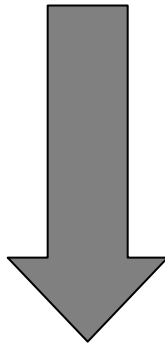
Time for Discussion

Concerns about decreased mechanical properties in XPE

Tensile Properties of XPE

Tensile Properties

Dose [Mrad]	Modulus [MPa]	Max Stress [MPa]	Strain @ break
0	495±56	315.5±31.6	1.82±0.01
2.5	433±14	284.8±18.0	1.74±0.03
5.0	412±50	237.6±12.3	1.59±0.01
10.0	386±23	185.7± 7.5	1.50±0.02
20.0	266±30	126.0±14.0	1.37±0.06



(Gomoll et al, J Orthop Res, 2002)

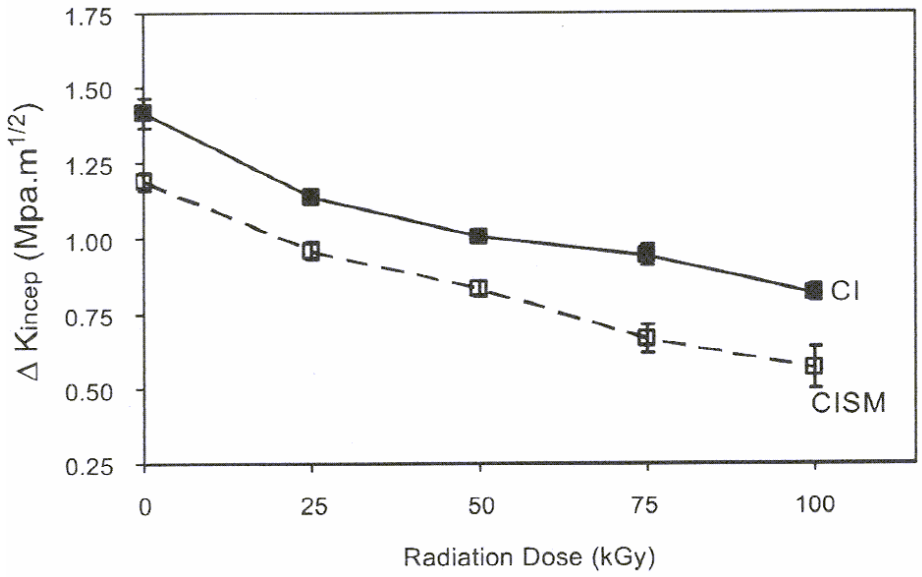
- McKellop, H., et al., J Orthop Res, 17(2): p. 157-167 (1999)
- Oral E et al, Biomaterials, 27(6):917-925 (2006)

The Case Against 1st Generation XPE for TKA

Resistance to Fatigue Crack Propagation

Dose [Mrad]	ΔK_{incep} [MPa*m$^{1/2}$]
0	1.41
5.0	0.91
10.0	0.69
20.0	0.55

(Baker et al, JBMR, 2003)



Oral et al, Biomaterials, 2006

The Case Against 1st Generation XPE for TKA

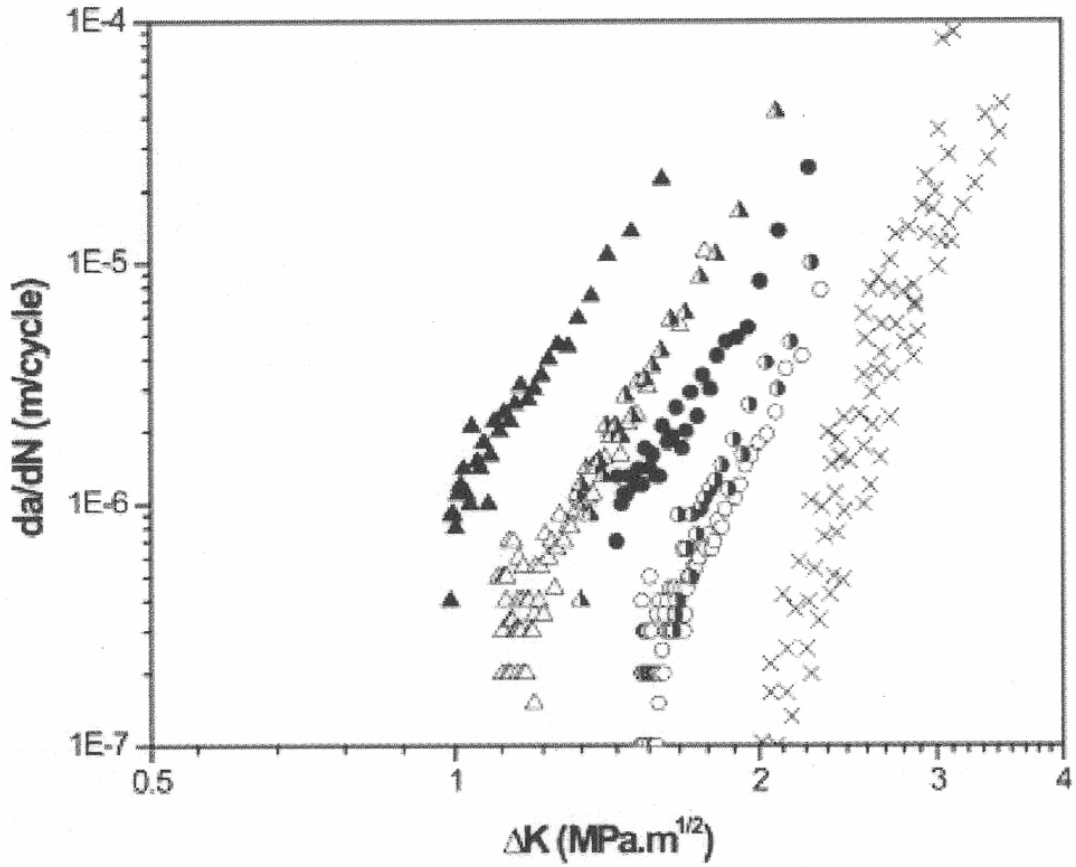
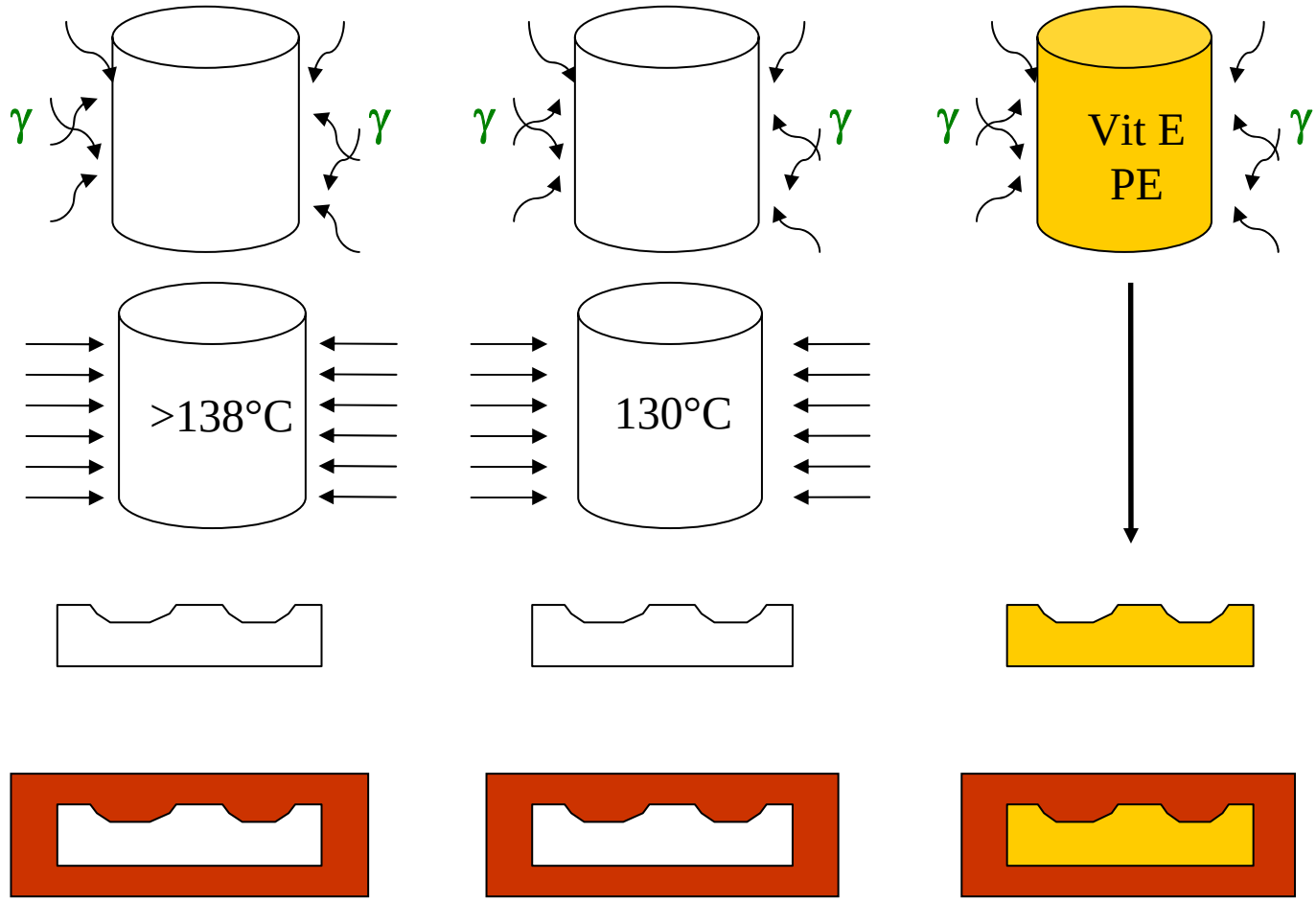


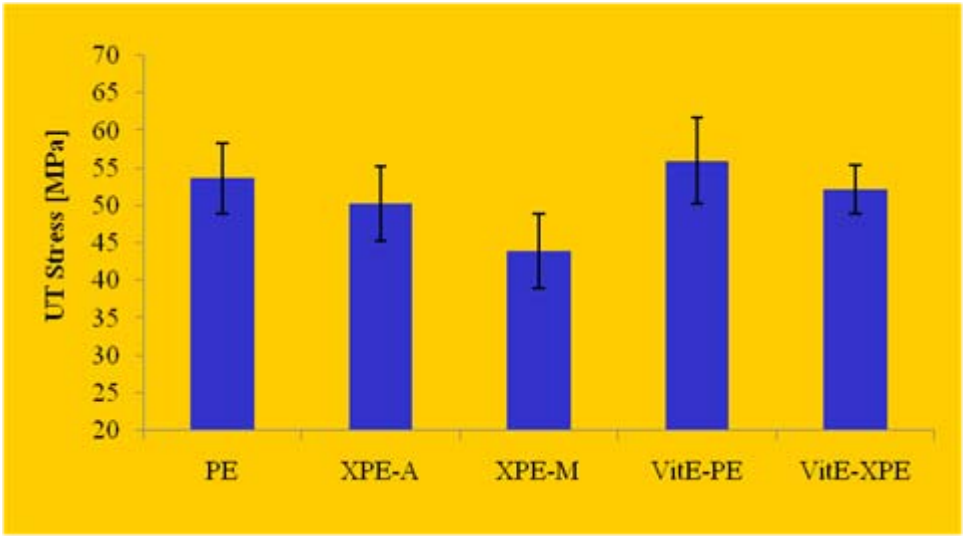
Figure 5. Fatigue crack propagation curves for β50, (○); β50R, (●); β50A (◑); β150, (△); β150R, (▲); and β150A, (◭) materials. Data corresponding to ram-extruded virgin GUR 1050 UHMWPE, (×), were adapted from Gencur et al.[15]

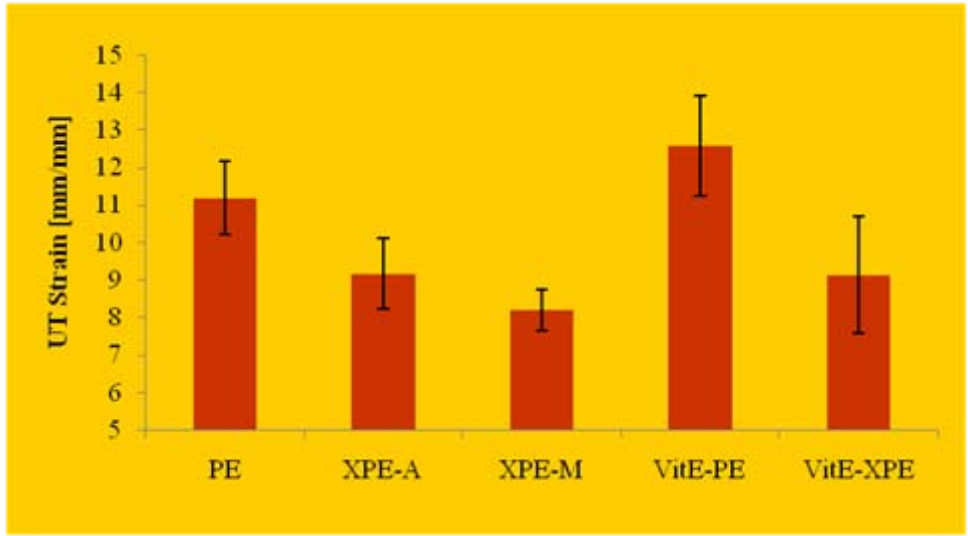
Medel et al JBMR:Appl Biomat 83(2):380-90 (2007)

Crosslinking Processes



Tensile Properties of PE and XPEs





Bearing Materials for TKA

- No need to use very high dose XPE

- Stabilized XPEs that avoid thermal treatment but preserve oxidation resistance may be preferable

VERSUS

- Use scratch-resistance counterface with uncrosslinked, non-oxidizing UHMWPE (Will NOT prevent 3rd body wear!!)

Time for Discussion

Thank you