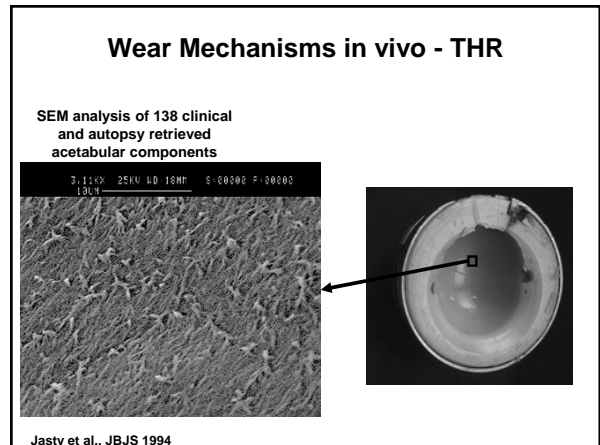
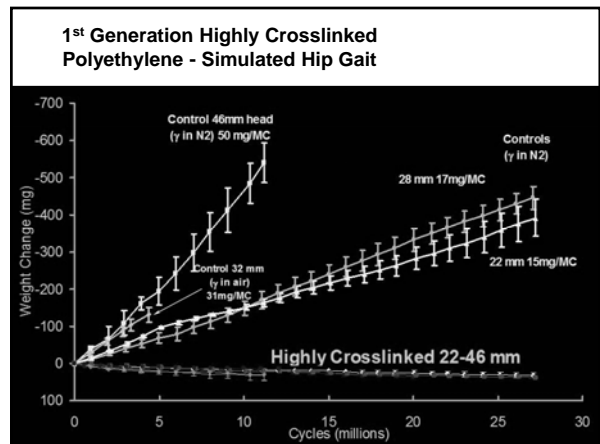


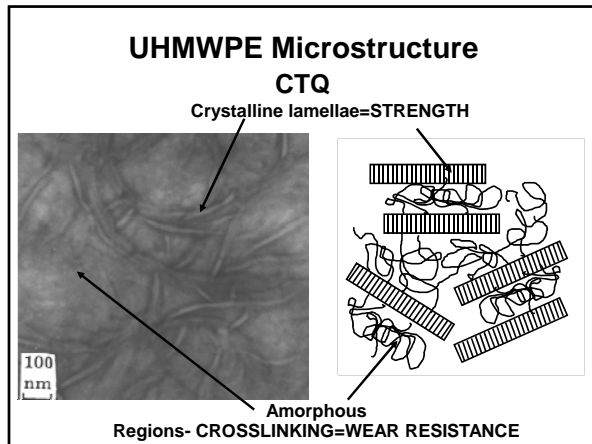
- ### Particle induced osteolysis CTQ
- Increased VEGF expression
 - Increased RANK expression
 - Increased RANKL expression
 - Macrophages produce VEGF

- ### Old, failed poly technology= BAD CTQ
- Ram extruded (calcium stearate)
 - Heat pressed
 - Hylamer (crystalline crosslinked poly)
 - Carbon reinforced (Black Plastic)
-



- ### Wear Mechanisms CTQ
- Adhesion- hips (most important for osteolysis)
 - Abrasion- hips
 - 3rd Body
 - Subsurface delamination- knees
 - Fatigue- knees
 - Oxidation- both
-





Crystallinity

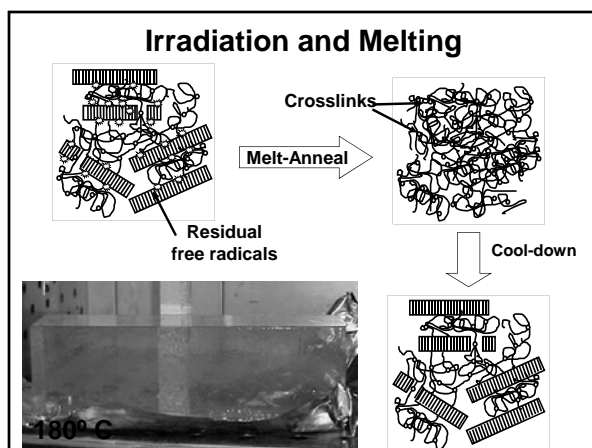
- Only amorphous segment can crosslink
- Crystalline phase associated with mechanical strength
- Optimum crystallinity 45-65 % **CTQ**
 - Too high : oxidation
 - Too low: weak poly

Crosslinking

- Irradiate with gamma rays
- Quench remaining free radicals
 - Melt
 - Anneal (almost melt)
 - Use radical absorber like alfa tocoopherol (vit E)

Radiation Cross Linking

- Increased radiation
 - Increased crosslinking
 - Increased wear resistance
 - **Decreased** mechanical properties **CTQ**
- Crosslinked poly has **decreased SIZE and NUMBER** of particles **CTQ**



Why elimiate free radicals?

- Free radicals combine with Oxygen over time
- Oxidized material has very poor wear performance!

1st generation free radical elimination tradeoffs

- **Annealing: heat to below melting**
 - Less loss of crystallinity and mechanical strength
 - More residual free radicals
- **Melting: Heat to above melting point**
 - Better free radical elimination
 - Lower crystallinity, weaker mechanical properties

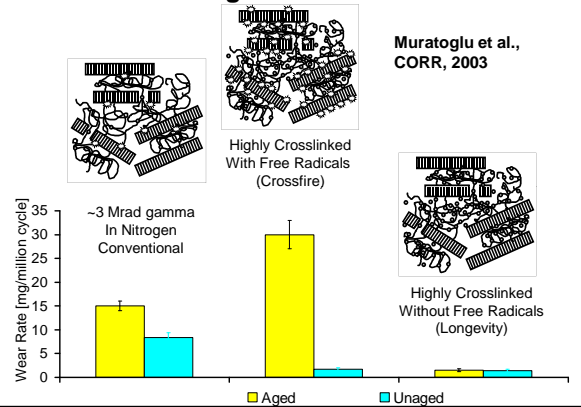
Comparison of Wear Particles

- | | |
|--------------------------|-------------------------|
| Conventional poly | Crosslinked poly |
| • More in number | • Fewer |
| • Larger | • Smaller |
| • More pointed | • Rounder |

Comparison of Wear Particles

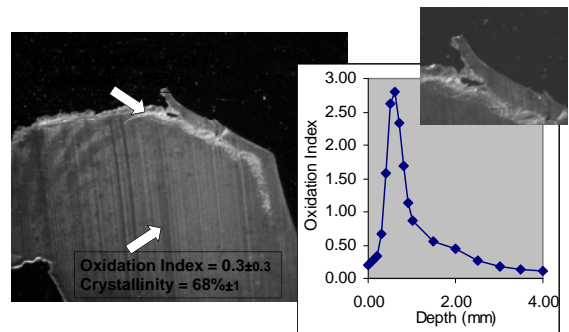
Conventional	Cross linked	Metal/Metal
- More in number	- Fewer	- Even more in number
- Larger	- Smaller	- Much smaller in size
- More pointed	- rounder	

Crosslinking And Free Radicals



ANNEALED=CROSSFIRE=BAD

Case Study: Crossfire™ explant (33 months in vivo)



**CROSSLINKED+MELTED=
REDUCED MECHANICAL
STRENGTH**

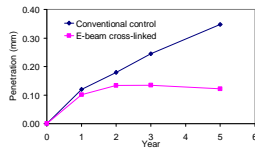


REDUCED MECHANICAL STRENGTH

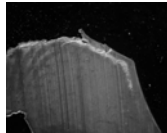
- **CRACKED ELEVATED RIMS (HIPS)**
- **BROKEN LOCKING MECHANISMS (KNEES)**
- **BROKEN POSTS (PS KNEES)**

Summary

- **In vivo wear rates of 1st generation materials corroborate in vitro wear results**



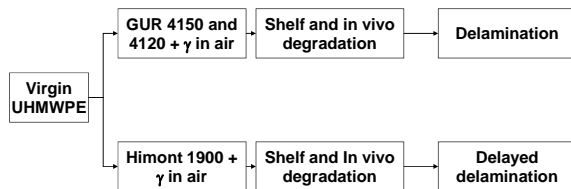
- **Irradaiton and annealing results in oxidation in vivo**



Key Features of any poly system

- **Wear resistance**
- **Oxidative stability**
- **Mechanical strength**

**Gamma in Air sterilization=
Oxidation and Delamination
(important for TKR)**



Longer shelf life associated with more oxidation!

What method of terminal polyethylene sterilization results in the greatest number of remaining free radicals within the polyethylene?

- 1-Gas plasma
- 2-Ethylene oxide
- 3-Gamma irradiation
- 4-Gamma irradiation and annealing
- 5-Gamma irradiation and remelting

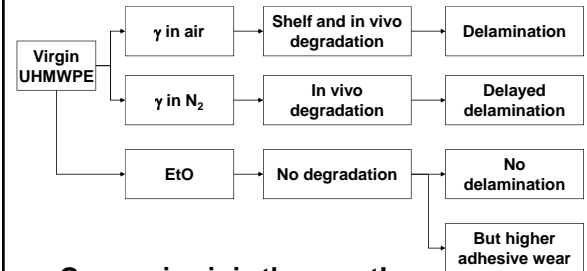
Preferred Response: 3

Reduce Delamination in TKR

- Reduce contact stress (“round on round”)
- No gamma in air sterilization
- Thicker poly inserts
 - Min thickness= 6mm!

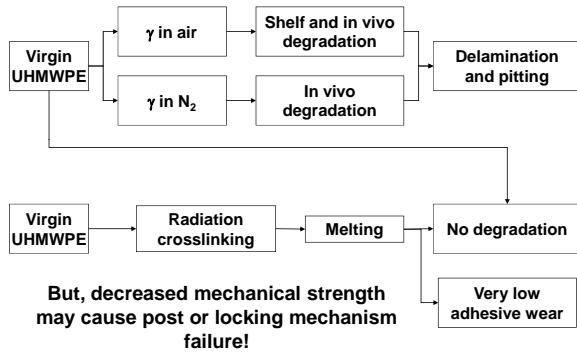


UHMWPEs for TKR: Effect of Sterilization



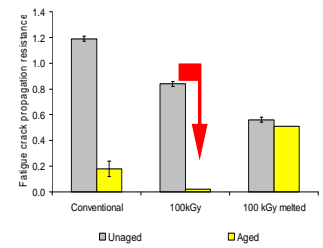
Gamma in air is the worst!

Highly Crosslinked UHMWPE for TKR

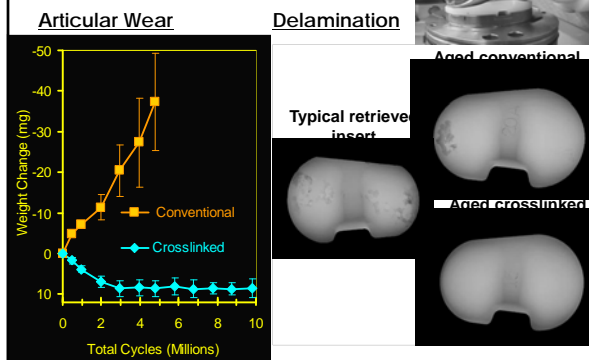


Poly aging: Aging causes oxidation

- Higher free radicals (annealing): worse oxidation
- Lower free radicals (melting): lower strength; better oxidative stability

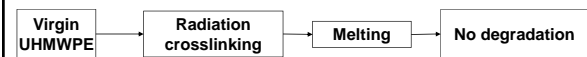


NKII Cruciate Retaining – Simulated Gait

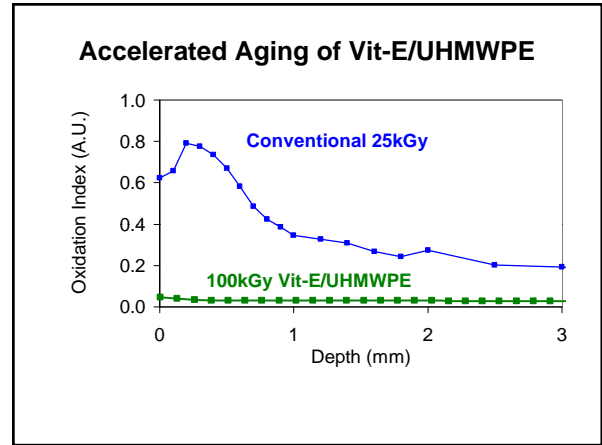
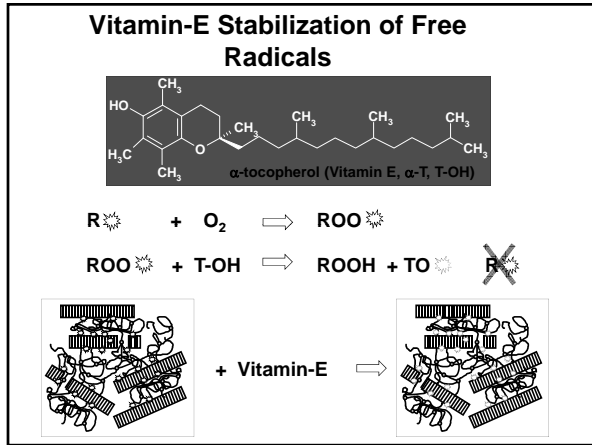
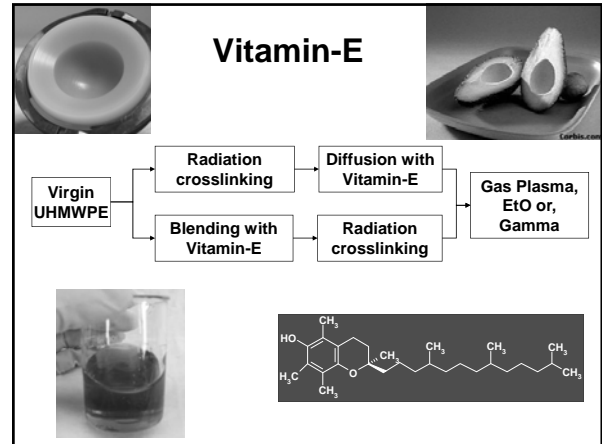
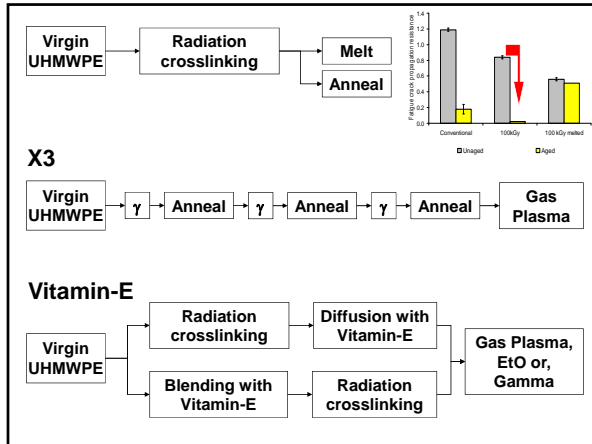


Summary

- Highly crosslinked UHMWPE in TKR:
 - Reduces articular wear
 - Reduces backside wear
 - Prevents oxidation related damage (delamination and pitting)



2nd Generation UHMWPE



- Comparison of 2nd Generation Polymers**
- In comparison to 1st generation, goals with 2nd generation were to achieve:
 - Wear resistance equivalent to 1st generation
 - High oxidative stability
 - Better mechanical properties
 - Better fatigue strength