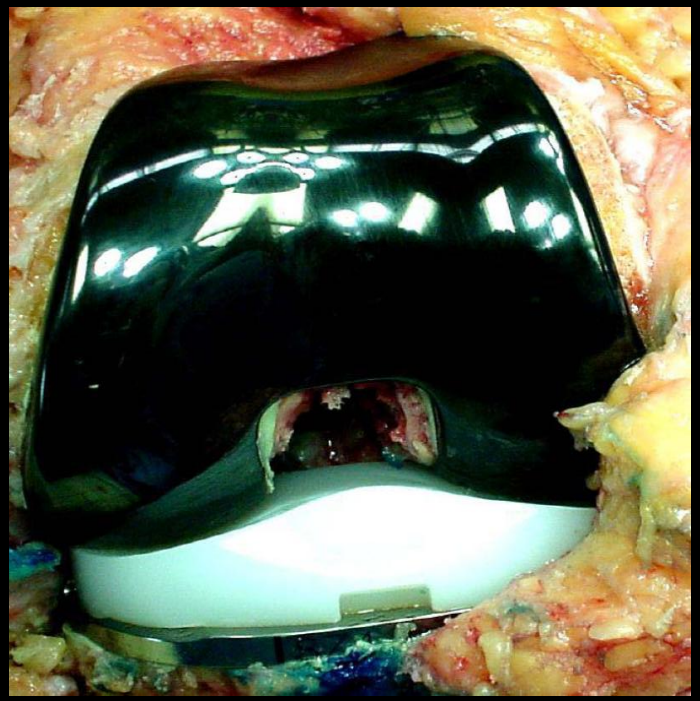
Prothèse de genou

Troisième colloque international France – USA

25 – 27 Novembre 2008

François PRIGENT

La science face à la Céramique



Une alternative au revêtement Chrome-Cobalt :

L'Oxinium (Oxyde de Zirconium)

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Actuellement
toutes les prothèse de genou fonctionnent par glissement :

Un bouclier fémoral métallique en Chrome Cobalt
glisse sur un plateau tibial en polyéthylène.

Pourquoi rechercher une surface de revêtement différente du Chrome Cobalt ?

PARCE QUE

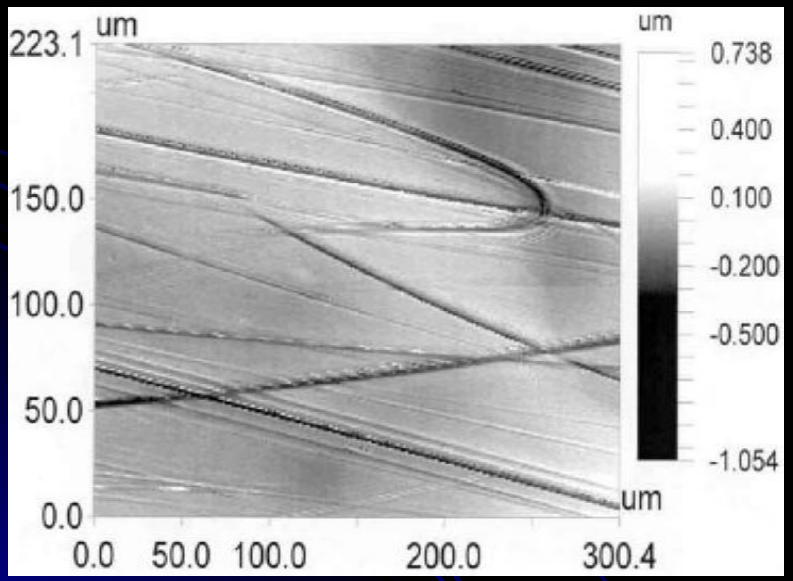
Le métal Chrome Cobalt est fragile en surface

Résistance de surface

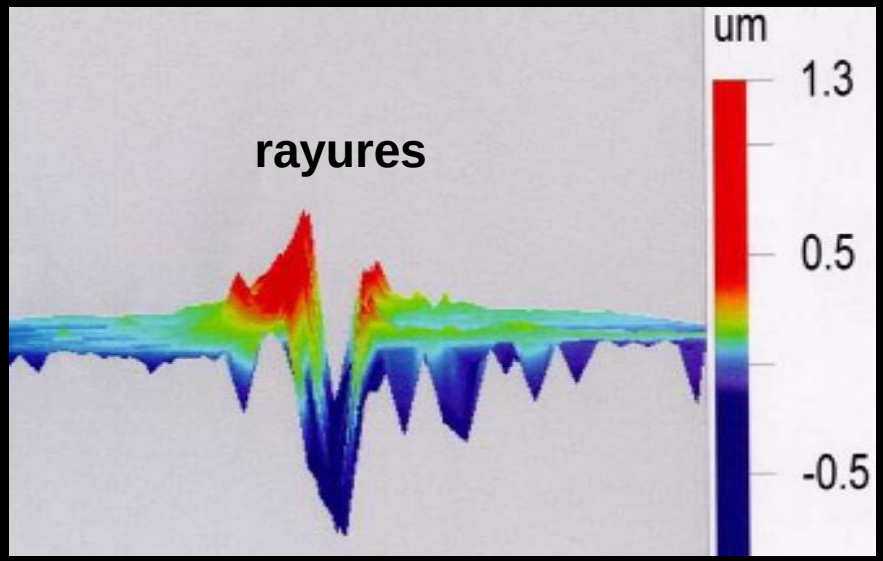
Etude portant sur 13 reprises consécutives de prothèses Chrome Cobalt.

Tous les composants condyliens présentaient <u>des rayures obliques</u>.

L'étude de ces rayures met en évidence un relief métallique bordant l'encoche



Etude microscopique de rayures sur l'implant fémoral métallique Chrome Cobalt



Mise en relief de par balayage ces même rayures sur une surface Crome Cobalt

Chrome Cobalt

Etude microscopique du relief d'une rayure sur une surface métallique Chrome Cobalt

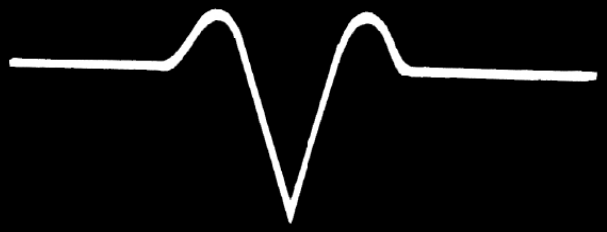
Oxinium

Etude microscopique du relief d'une rayure sur une surface métallique Oxinium

SOIT

Chrome Cobalt

Oxinium



Une rayure sur le métal Cr-Co induit un relief en bordure .

Une rayure sur l'Oxinium n'induit pas de relief en bordure .

Un relief use le plateau tibial polyéthylène en regard.

How do metal bearing surfaces roughen?

Qu'est qui raye une surface métallique ?

- **Abrasive wear scratching by hard particules**
- **Oxidative wear : shearing of oxiding surface**

Fisher et al., Proc IME, 1995

« a single scratch 2 µm deep (with 1 µm adjacent peak height) on a metal counterface can cause a dramatic increasein the wear rate of UHMWPE"

Oxinium : Oxidized Zirconium

Capability

• Reduce polyethylene wear by using alow-friction counterface that resists roughening and avoids brittle fracture

Method

• Form a ceramic surface on a metallic zirconium alloy by oxygen diffusion

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Materials

Metallic element : Zirconium

- Same family as titanium and very biocompatible

Metallic alloy by combining with Niobium : Zr-2.5Nb

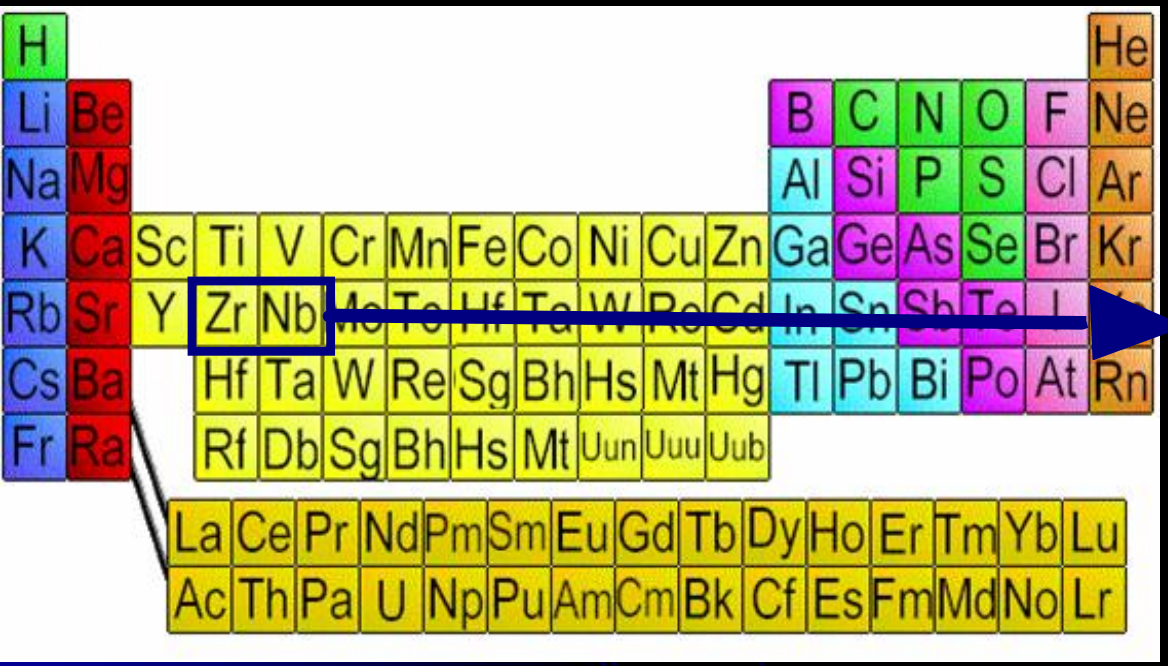
- Niobium and oxygen strengthen zirconium

Oxidize to form ceramic - Zirconia : zirconium oxide

- Low-friction and resists roughening
- Brittle; low fracture toughness

OXINIUM : 2 hightly biocompatibles metals

97.5 % Zirconium
+ 2.0 % Niobium
+ Oxygen and Hext



22 47.90
Ti
Titanium
4.5

23 50.94
V
Vanadium
5.96

40 91.22
Zr
Zirconium
6.4

41 92.91
Nb
Niobium
8.4

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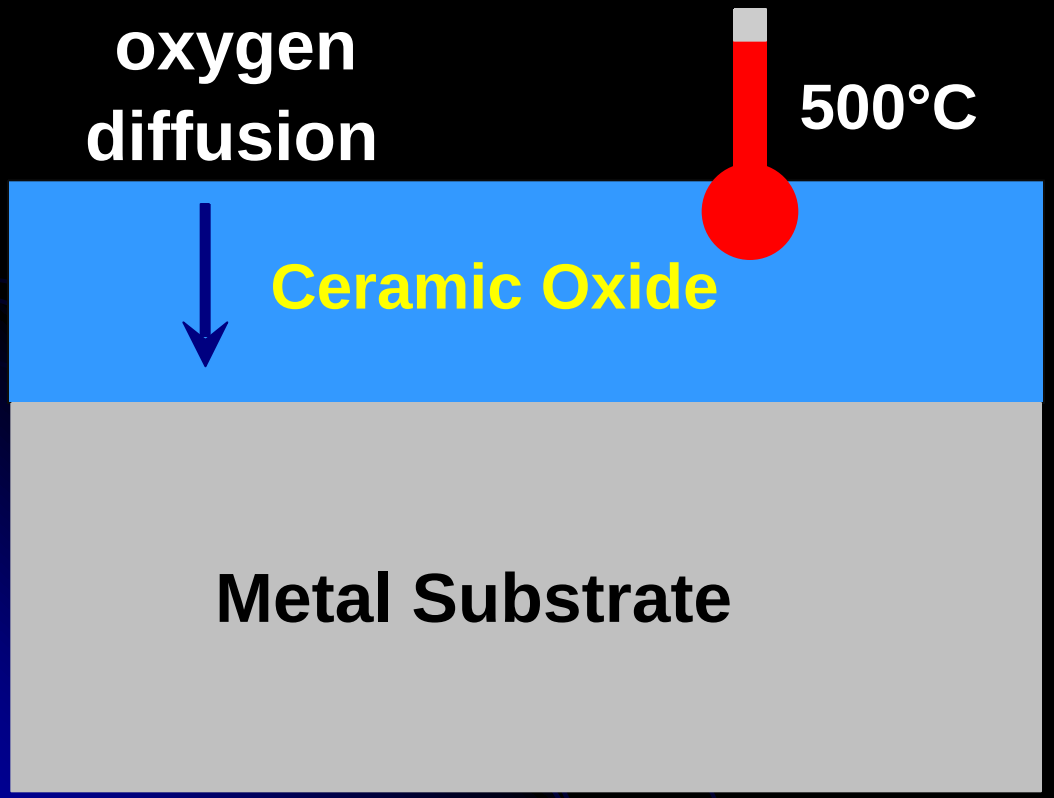
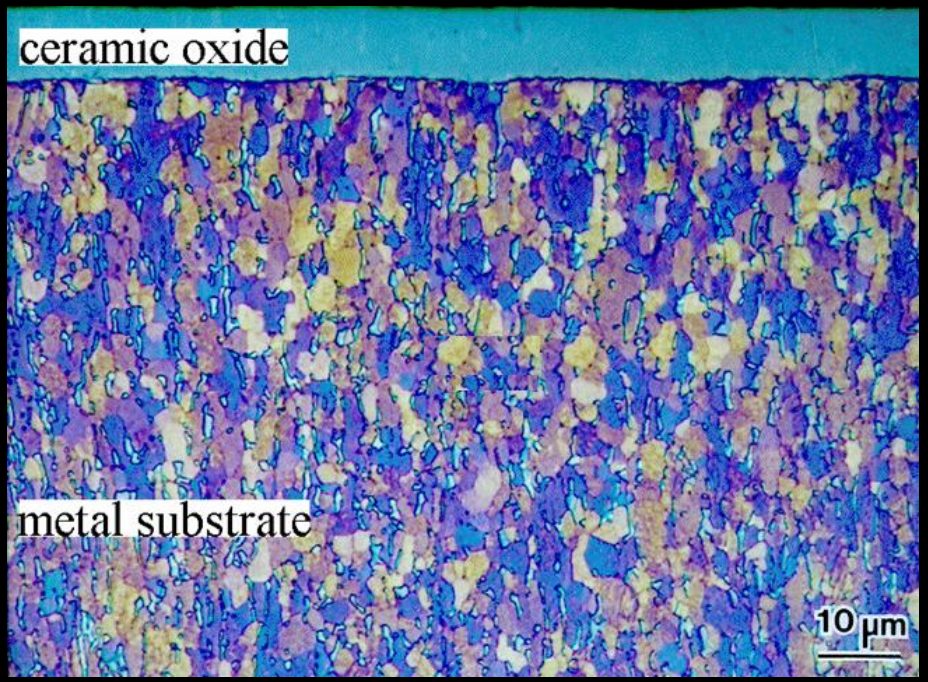
Oxidation Process

- Wrought zirconium alloy component is heated in air
- Metal surface transforms to ceramic, not a coating
- Ceramic oxide is uniformly about 5 μm thick





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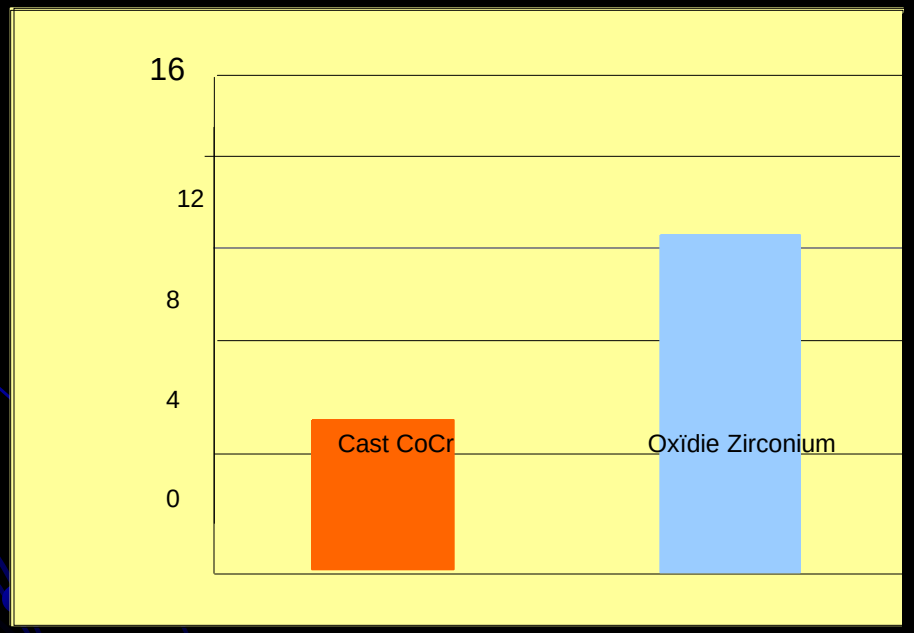
Hardness

- Oxidized Zirconium surface is over twice as hard as CoCr
- Underlying oxygen-rich zone promotes adherence to substrate

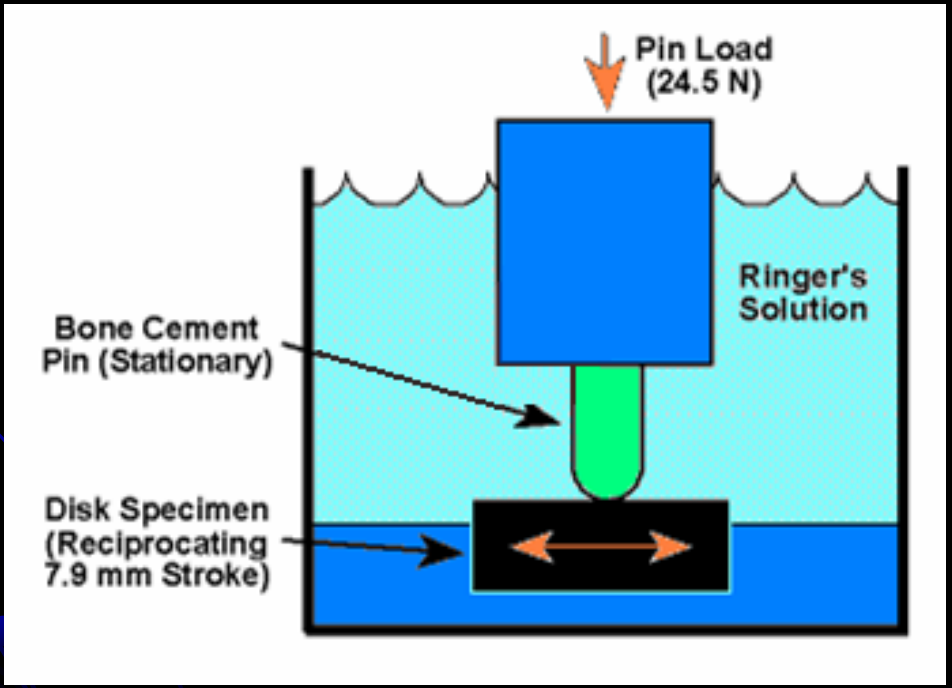


Abrasion resistance

Oxinium reduced abrasion against bone cement by over 4900 X

Oxidized Zirconium post-test roughness was over 160 X less

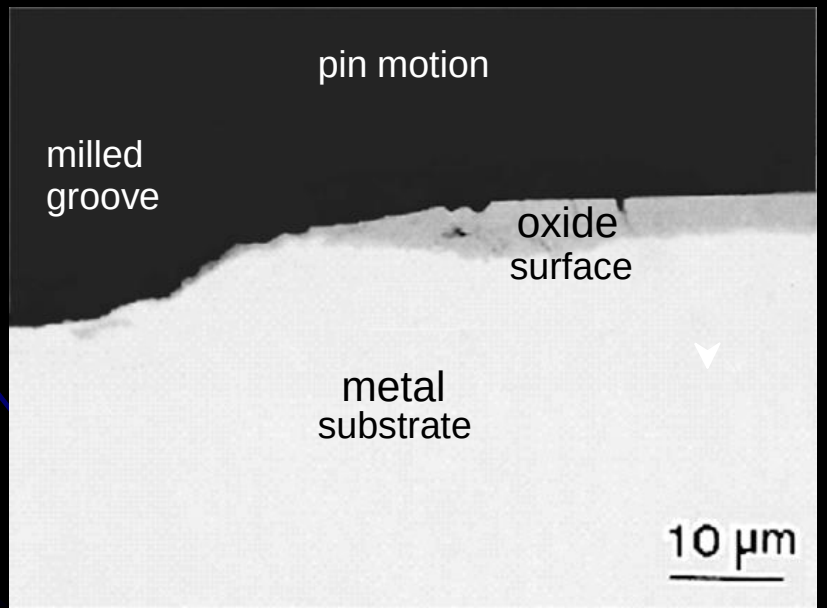
- 10 **million cycle pin-on-disk test represents 10 years of cement debris in joint**



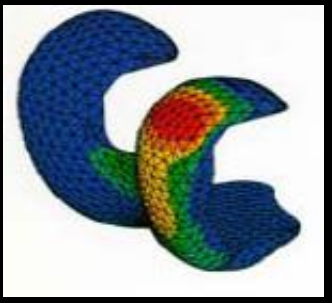
Damage Tolerance

Ceramic oxide surface adheres even if damaged by :

- **Punching crater through oxide (hardness test)**
- **Abrading bone cementpin for 10 Mcycle (modified abrasion test)**

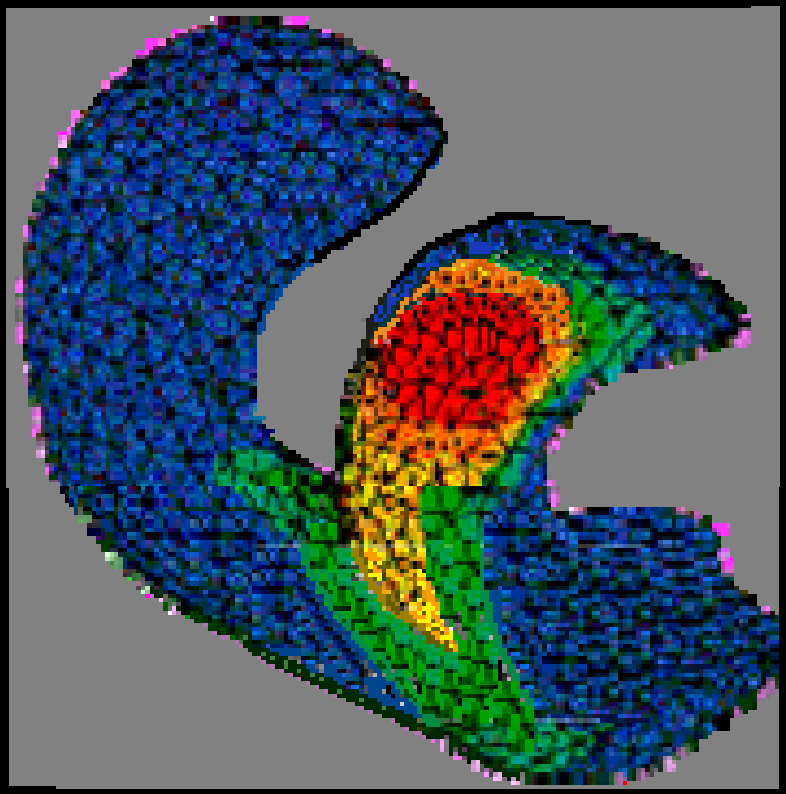


Strength



Ox. Zirconium device strength is equivalent to CoCr

- Supported 4.4 kN (1000 lbf) in 10 Mcycle fatigue test
- Physiological worst-case: single condyle, no bone support full flexion



Biocompatibility

Zirconium is one of five most biocompatiblemetals

- Other four metals: niobium, titanium, tantalum, and platinum
- Based on self-passivation and lack of biological function

Alloy biocompatibility confirmed per ASTMF748

- Cytotoxicity (L929 MEM Mouse Fibroblast)
- Sensitization (Kligman Maximization)
- Genotoxicity (Ames Mutagenicity and Mouse Micronucleus Assay)
- Implantation (Rabbit 90-Day Intramuscular and Rabbit 6-Month Transcortical)
- Intracutaneous Reactivity (Rabbit Intracutaneous Injection)
- Acute Toxicity (Mouse Systemic Injection and Rabbit Pyrogenicity)
- Haemocompatibility (Rabbit Hemolysis)

Metal Sensitivity

- Reports of metal hypersensitivity (especially nickel)

- Very low impurity content in Oxidized Zirconium

- Maximum specified impurity levels inalloys:

  - CoCrMo : 1% nickel
  - Ti-6Al-4V : 0.1% nickel
  - Zr-2.5Nb : Not detectable (0.0035%nickel)

Sumary

Less Polyethylene Wear Than CoCr

- Harder Material
- More Resistant to Scratching /Roughening Than CoCr
- Less Friction Than CoCr

Excellent Biocompatibility

- Strength of Metal; Tribology ofCeramic
- Harder Material
- More Resistant to Scratching Roughening Than CoCr
- Less Friction Than CoCr

Thank-you !

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