Bearing Choices in TKA

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Need for better replacements?

- Increasing group of younger/active patients
- Increasing life expectancy
- Increasing number of patients with obesity

- "Although a lifespan of 10-15 years might have been sufficient in earlier days, current (patient-) demands are such that a Total Knee Arthroplasty should last for a minimum of 20 or even 30 years."

"Factors Affecting Polyethylene Wear in Total Knee Arthroplasty'
Markus S. Kuster MD.et.al CORR Supplement 2002

Desired attributes of Bearing Materials

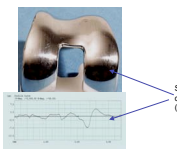
Biocompatible → Corrosion resistant → Wear resistant → Scratch or abrasion resistant to third body debris such as bone cement → Chemically and mechanically stable over extended period of time → Suitable for metal sensitive patients

Current choices of materials

- CoCr alloy (as-cast, forged or wrought)
- Ceramic-coated CoCr alloy
- Oxidized zirconium (OXINIUM©)
- Ti6Al4V alloy
- Monolithic ceramic such as yttria stabilized zirconia, alumina (Forte), zirconia toughened alumina (Delta)

CoCr Alloy

- The original alloy was improvised by Elwood Haynes with addition of Mo and W. Interestingly Elwood Haynes is also credited for developing first gasoline powered car!
- First medical use in 1930's
- Long clinical history
- Does contain Nickel which is known to cause allergic response in some patients
- Less scratch resistant to bone cement debris compared to some of the advanced bearing materials
- High elastic modulus (stiffness) may result in stress-shielding



Scratches on retrieved CoCr due to bone cement debris (Salehi et al., ISTA 2005)

Allergic response to a CoCr knee femoral (Nassar et al., AAOS 2007)

Metal Sensitivity : Should we worry ?

- Incidence of metal sensitivity among patitients with failed metal implants is approx 25 %, which is twice as high as as the general population *(Meneghini et al Inst. Coures lect 2005)*
- Other investigations report on incidence 50-60 % *(Hallab JBJS 2001)*

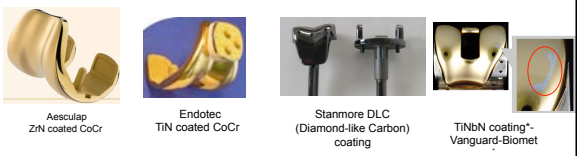
•Cutaneous hypersensitivity may not correlate to deep-tissue hypersensitivity

•Clinical significant /demonstrable metal allergy with conventional metal-on-poly is rare

•Results of cutaneous patch testing may not be a reliable assay for deep-tissue hypersensitivity *(Meneghini et al)*

Coated CoCr alloy

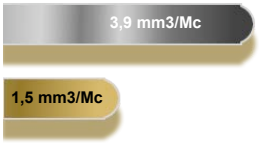
- Abrasion resistance and hardness of CoCr alloy can be increased by coating it with ceramic coatings such as diamond-like carbon (DLC), TiN, ZrN or combinations of such coatings
- Standard use, decreased risk on allergy in metal sensitive patients
- Coating adhesion critical to the performance, coating debris can scratch CoCr further



Aesculap ZrN coated CoCr | Endotec TiN coated CoCr | Stanmore DLC (Diamond-like Carbon) coating | TiNbN coating*- Vanguard-Biomet

Less wear (simulator test)

- The amount of polyethylene wear of worn-in ceramic coated implants is much lower than of non coated implants (in mm^3/million cycles)



Jones Auger Fisher- New Materials for Mobiel Bearing Knee Prosthesis TiN Chapter 21 in Hamelynck 25 years of LCS

Ceramic Coated Metal Implants

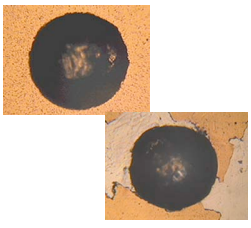
How strong is the adherance of the coating on the substrate

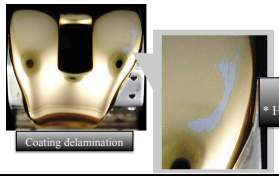
The substrate is Cobalt Chromium Alloy!

Quality of TiN coatings

Rockwell Test :

- A diamand cone penetrates the ceramic coating layer
- This will deform both the coating and the substrate
- No delamination should be seen





TiNbN coating
* Haider et. Al. Trans. 54th ORS, poster 2007, 2008

Clinical performance ?

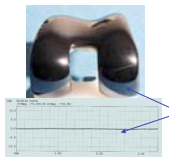
- In literature only few clinical papers on coated CoCr components in TKA
- Clinical experience with DLC coating in France for two decades
- TiN coatings clinical experience ± 10 y

Oxidized Zirconium (Oxinium)

- Component is shaped from a block of Zirconium +Niobium (97,5%-2,5%)
- The surface is oxidized under high temperature and pressure (not a coating)
- Zirconium oxide is stable monoclinic phase, no long term issue of phase tranformation
- Zirconium is one of the five most biocompatible elements (titanium, zirconium, niobium, tantalum and platinum)

OXINIUM Attributes

- Ceramic (zirconium oxide) surface two times harder than CoCr
- Shown to reduce wear of polyethylene by at least 50% in laboratory tests
- Abrasion resistant to third body debris such as bone cement particles
- Suitable for patients with metal sensitivity
- Substrate (Zr-2.5Nb) is softer so care must be exercised not to damage during implantation



No scratching on retrieved OXINIUM due to bone cement debris
(Salehi et al., ISTA 2005)

The rash did not appear when the hypersensitive patient was implanted with OXINIUM
(Nassar et al., AAOS 2007)

Clinical performance

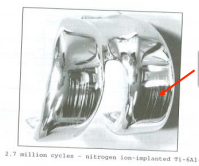
- Over 200,000 femoral components in TKA implanted worldwide
- Only short term clinical FU *(Laskin et al CORR 2003, Australian registry)*
- Can only be used in cemented application (Recall 2004 uncemented femoral implants)

Titanium alloy (Ti-6Al-4V)

- Not a favored material for articulating application
- Predominant use of Ti6Al4V as a tibial tray, hip stems and acetabular cups
- Hardness of Ti6Al4V is about 30% less than that of CoCr
- Some type of hardening either with ceramic coating or diffusion hardening essential for use in bearings applications
- Substantial reduction of wear compared to standard CoCr
- Promoted as an alternate to CoCr for metal sensitive patients

Clinical Performance

- Very little clinical data on Titanium alloy (Ti-6Al-4V) with ceramic coated / Ti-nidium surface hardening process
- Ti-nidium nitrogen diffusion hardened Tivanium(Ti6Al4V), hardening depth is small (<1 micron) and will eventually wear through and scratch the femoral leading to increased wear of polyethylene



Scratching of Tinidium-Ti6Al4V
(Shetty et.al., ASTM- STP, 1272,1996)

Monolithic Ceramics

- Yttria stabilized zirconia, Alumina and zirconia toughned alumina (ZTA or Delta) are preferred materials of choice, predominantly used in Japan
- Ceramics have excellent wear properties
- Difficult to put porous structure for non-cemented use
- Full ceramics can be brittle and break
- Once wear occurs it is accelerated by third body wear from its own wear debris

Yttira stabilized zirconia ceramic from JMM, Japan

Biolox Delta-CeramTec AG

Clinical Performance Ceramics

- *Akagi JBJS-A 2000*: no loosening in 223 PS cemented alumina femoral components at 6 y FU
- *Koshino J Arthroplasty 2002*: no loosening in 120 cemented alumina femoral components in RA at 56 months FU

Clinical Performance Ceramics

- Oonishi in Japan, experience since 1984
- First uncemented generation, high incidence of early loosening.
- Later cemented design, clinical results identical to CoCr at 3-18 y FU (*Key engineering Materials 2001*)

Uncemented first generation Kokuritsu Osaka Minami Hospital TKA

Alumina femoral cemented component

Retrieved Ceramic components

- Oonishi (*Key Engineering Materials 2002*): 3 femoral components at 6m to 6 y
- Scanning with electron microscopy and compared to same CoCr design retrieved 3 y postop.
- Alumina femoral components mild surface burnishing compared to metal component
- One component retrieved at 23 y: no scratches or other changes related to wear (*Key Engineering Materials 2003*)

Comparison of key attributes

	Biocomp	Abrasion resistance	Wear resistance of poly	Stability	Macro-damage resistance	Suitable for metal sensitive patients
CoCr	±	-	±	+	+	-
Coated CoCr	±	+	+	+	-	±
Oxinium	+	+	+	+	±	+
Delta / ceramic	+	+	+	+	±	+
Ti6Al4V	+	-	±	+	-	±

Excellent + / Acceptable ± / Inferior -

Conclusions

Only few reports available on bearings other than standard CoCr / PE

In vitro investigations suggest decreased PE wear rates

Alternative bearings decrease the possible occurence of metal sensitivity (current incidence?)

Not all alternative bearings are supported by clinical data

Although not supported by scientific data, alternative bearings possibly could eliminate PE entirely from TKA articulations in the future?