Cementless Fixation in Primary Total Knee Replacement

Philippe NEYRET, Julien WEGRZYN

Centre Albert Trillat – Hôpital de la Croix-Rousse
8 rue de Margnolles
69300 Caluire – Lyon - France

Cemented fixation

Currently the gold standard

> 95% success rates at > 15 years FU

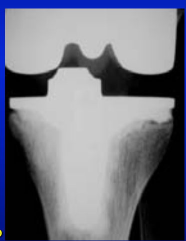
Ritter RA et al. CORR 2001

However…

Worse survivorship for younger patients (40-59 y-o)

≈ 85% success rates at 15 years FU in several series

♀ 59 yo
17 months po



Duffy GP et al. JOA 2007

Mechanisms of aseptic loosening

2 modes in cemented TKR:

- ✓ Failure related to osteolysis (polyethylene wear)
- ✓ Mechanical failure due to fragmentation and debonding of the cement mantle (implant/cement)

Lonner JH et al. CORR 2000

Why cementless TKR?

Need for more durable long term fixation
in younger and more active patients

More biologically fixation method:

- ✓ Greater implants osseointegration
- ✓ More iso-elastic behavior with adjacent bone

Meneghini RM et al. J Knee Surg 2008

Long-term outcome of cementless TKR

Study	No. of patients	TKR	Type of cementless fixation	10-year survivorship
Buechel et al. CORR 2001	309	LCS (Depuy-Mitek)	Titanium porous-coated	97%
Hardeman et al. Knee 2006	115	Profix (Smith & Nephew)	Titanium porous-coated	97.1%
Hofmann et al. CORR 2001	176	Natural knee (Zimmer)	Titanium porous-coated (CSTi)	95.1%
Ritter et al. JOA 2009	73	AGC (Biomet)	Titanium porous-coated	97.2%
Epinette et al. JBJS Br 2007	74	Omnifit-HA (Osteonics)	Hydroxyapatite-coated	98.1%
Oliver et al. JBJS Br 2005	106	IB-II (Cresmacoli)	Hydroxyapatite-coated	94.9%
Cross et al. JBJS Br 2005	1000	Active TKR system (ASDM)	Hydroxyapatite-coated	99.14%

However…

Despite encouraging results,
cementless fixation = controversial (USA+++)

Due to past failure in the early generation
of cementless implants designs

Failure attributable to various design flaws such as:
✓Patch-porous coated => tibial osteolysis
✓Fatigue fracture of the femoral component
✓Failed metal-backed patellar components (metallosis)

Cementless femoral component

Generally fared well in long-term outcome

Success related to inherent stability of the press-fit femoral component (multiple chamfers)

Rare failure due to fatigue fracture of the thin implant regions

Avoidance of porous-coated pegs (stress-shielding)

Campbell MD et al. CORR 1998

Cementless tibial component

Tibial fixation and implant design still debated

Conditions of success =
✓ Maximizing tibial contact (ingrowth surface area)
✓ Avoidance of screws
✓ Circumferential and fully coating tibial tray

Screw tracks & patch-coating undersurface =
✓ Egress of PE debris
✓ Osteolysis and loosening

→ Hybrid TKR

Peters PC et al. JBJS Am 1992

Metal-backed patellar component

Most commonly reported complication in cementless TKR:
✓ Dissociation of metal-PE
✓ Shear failure of peg-baseplate junction
✓ Excessive PE wear and metallosis

→ Cemented patellar resurfacing +++

Berger RA et al. CORR 2001

Cementless implants

Hydroxyapatite-coated implants

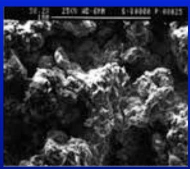
Highly porous metal
✓ Titanium porous-coated
✓ Porous tantalum

→ **Osteoconductive materials**

Hydroxyapatite-coated implants

HA-coating:

- ✓ Plasma-sprayed HA particles
- ✓ Roughened substrate surface



Optimal HA-coating:

- ✓ High cristallinity and low porosity (to avoid early dissolution)
- ✓ Thickness ≈ 75 µm (to avoid fracture fatigue)

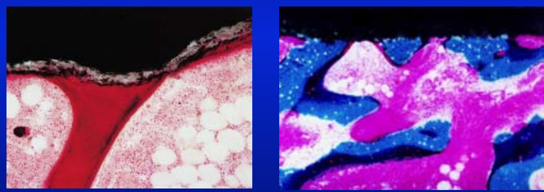
Dumbleton J et al. JBJS Am 2004

HA-coating:

Accelerate short-term bone apposition and ingrowth

Mechanisms:

1- Relative dissolution: release of calcium and phosphate
2- Initiation of osteoblastic activity
3- New bone formation at both bone and coating surfaces



2 weeks

Kilpadi KL et al. J Biomed Mater Res 2001

HA-coating:

Enhancement of non-porous implants stability

Promotion of early bone in growth against implant

High success rate at 10 years FU

Prevention of PE particles ingress due to interface implant / bone sealing

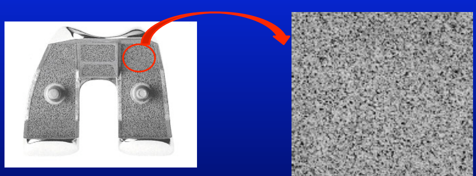
Rahbek et al. JBJS Br 1999

Porous-coated implants

Titanium porous-coating: example of the CSTi® (Zimmer)

Pure titanium powder sintering onto CoCR alloy

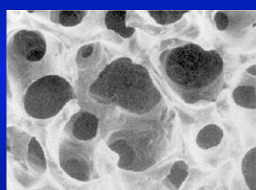
Excellent biocompatibility of Ti
+
Optimal structure for bone ingrowth



Structure similar to trabecular bone

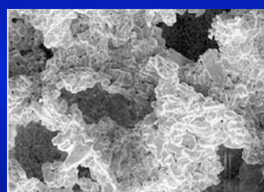
Interconnected pores network for bone ingrowth

Surface roughness providing adequate implant stability



Trabecular bone

Pore size = 400-500 µm
Pore volume = 60-77%



CSTi

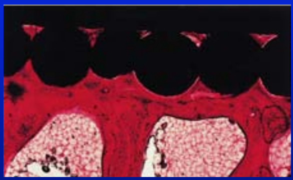
Pore size = 480-560 µm
Pore volume = 45-68%

Mechanisms of bone ingrowth
≈ fracture healing process

1- Inflammatory process
with activation of osteo –blast and –clast cascade

2- Formation of woven bone at the interface into the pores

3- Remodeled to lamellar bone



48 months

Bauer TW et al. Skeletal Radiol 1999

Trabecular metal implants

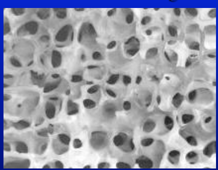
Tantalum (73Ta) =

Inert transition metal with excellent biocompatibility

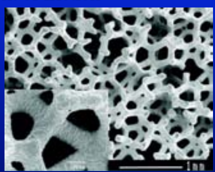
Repeating dodecahedrons in an open-cell structure

Trabecular metal characteristics:

- ✓ High volumetric porosity (> porous-coated implants)
- ✓ Low modulus of elasticity (> sub-chondral bone)
- ✓ High surface coefficient of friction



Trabecular bone



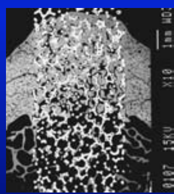
Trabecular metal

Bobyn JD et al. JBJS Br 1999

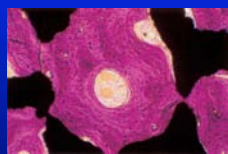
Canine model:

- ✓ New bone formation > 2/3 pores at 16 weeks
- ✓ Evidence of Haversian remodeling within the pores at 52 weeks
- ✓ Complete host bone incorporation at 1 year after implantation

Direct bonding to bone with excellent bone in-growth



16 weeks

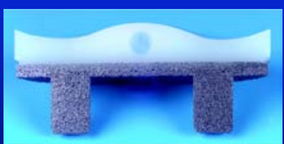


52 weeks

Bobyn JD et al. JBJS Br 1999

Primary TKR = Monoblock tibial component (Zimmer)
Compression molded UHMW-PE bearing surface

Early encouraging results in prospective multicenter study
72 implants at ≈ 2 years FU :
No radiolucent lines
No revisions



4 y

4 y

Bobyn JD et al. JBJS Am 2004

Conclusion

Cementless fixation = biological fixation

Encouraging results on implant stability and longevity

At least similar to cemented implants

Major advances in osteoconductive materials such as

- ✓ Hydroxyapatite coating
- ✓ Porous tantalum

→ Toward life-time TKR???