

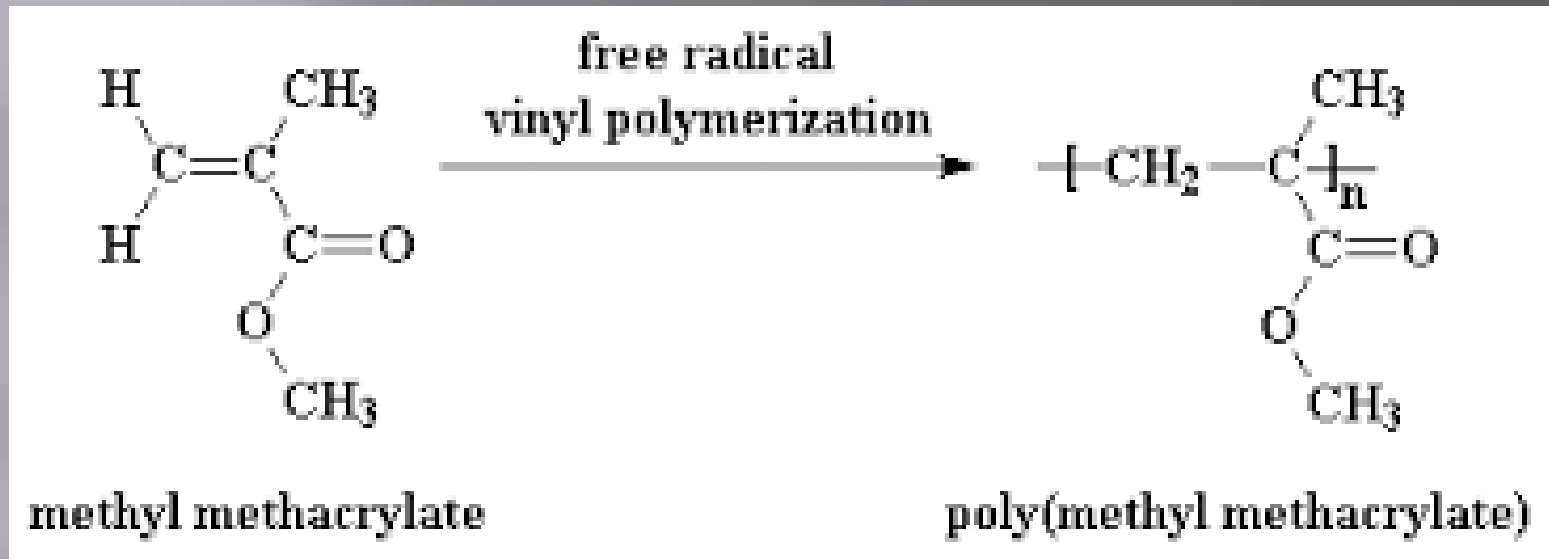
CEMENTED HIP REPLACEMENT

Steve Borland

Bone cement

- ▣ Polymethylmethacrylate (PMMA)
- ▣ First composed in 1902 (Rohm)
- ▣ Used initially as dental material
- ▣ Judet brothers developed PMMA hip implant
- ▣ Charnley started using PMMA as cement to secure materials to bone in 1959
- ▣ In 1970 Buchholz adds antibiotic to cement

PMMA



- PMMA is a polymer based on repetitions of methymethacrylate
- 2 main components
 - Powder consisting of copolymers based on PMMA
 - Liquid consisting of monomer (MMA)

PMMA

▣ Powder

- PMMA
- Starter (di-benzoyl peroxidase)
- Radioopacifier (ZrO₂, BaSO₄)
- Antibiotics

▣ Liquid

- MMA
- Initiator (N,N-dimethyl-p-toluidine)
- Inhibitor (Hydroquinone)
- Colouring (chlorophyll)

Polymerisation

- ▣ Reaction starts when liquid and powder meet
- ▣ Exothermic
- ▣ Phases
 - Mixing
 - Waiting
 - Working
 - Hardening
- ▣ Different phase time depends on type of cement, additions to mixture and room temperature

Cementing techniques

- ▣ 1st generation
 - Hand mixed cement
 - Finger packing
 - No canal preparation or cement restrictor

- ▣ 2nd generation
 - Cement restrictor
 - Cement gun
 - Femoral canal preparation (brush and dry)

Cementing technique

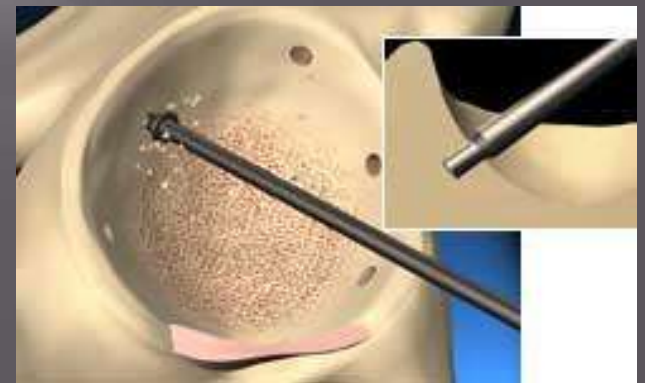


- ▣ 3rd generation
 - Vacuum mixing to reduce porosity
 - Cement pressurisation
 - Femoral canal preparation (pulsatile lavage)

- ▣ 4th generation
 - 3rd gen plus
 - Stem centralisation to ensure adequate cement mantle (min 2mm circumferentially)

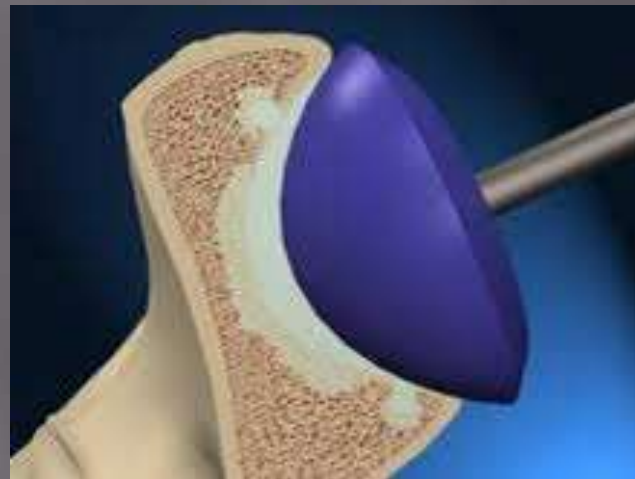
Cemented acetabulum preparation

- ▣ Ream to bleeding cancellous bone
- ▣ Oversize for a 2-3mm cement mantle
- ▣ Key holes to increase contact area for cement
- ▣ Remove soft tissue and loose bone
- ▣ Pulse lavage
- ▣ Swab +/- adrenaline or H₂O₂



Cementing cup

- Mix cement under vacuum to reduce porosity
- Apply cement to acetabulum from cement gun
- Apply pressure with acetabular pressuriser and maintain until doughy
 - Pressurisation helps achieve interlock with cancellous bone and prevents blood back flow and lamination



Cementing cup

- ▣ Insert cup in correct alignment with 2-3 mm mantle to yield good stress distribution
- ▣ Protect cup from scratched and remove all bone and cement debris to prevent 3rd body wear



Cemented femur preparation

- ▣ Ream to appropriate size – enough for stem and at least 2mm cement mantle
- ▣ Cement restrictor
- ▣ Brushing and pulse lavage – facilitates microlock
- ▣ Haemostasis with sponge +/- adrenaline or H₂O₂

Cementing femur

- ▣ Mix cement under vacuum to reduce porosity
- ▣ Apply cement to femur from cement gun distal to proximal
- ▣ Insert cement after low viscosity phase
- ▣ Proximal seal and pressurisation – cement interlocks with cancellous bone
- ▣ Distal centraliser
- ▣ Introduce stem with mantle of at least 2mm
- ▣ 2 stem theories – composite beam and taper slip

Sir John Charnley



- ▣ Pioneer of hip replacement surgery
- ▣ Born Bury in 1911
- ▣ Graduated University Manchester 1935
- ▣ Worked in Salford and London. RAMC in Sussex during war and then RJAH in Oswestry
- ▣ Returned to Manchester after war and set up hip surgery centre in Wrightington

Sir John Charnley



- ▣ Interested in 2 main fields
 - Compression on bone healing
 - Lubrication of joints
- ▣ Convinced that collaboration with mechanical engineers was the solution
- ▣ Built a biomechanics lab in Wrightington
- ▣ Developed the theory that friction depends more on the materials used than the fluid presence

Sir John Charnley

- ▣ Began looking at a slippery substance known as PTFE (teflon)
- ▣ However initial replacements went on to fail early due to wear
- ▣ Continued to test and found that HMWPE was suitable and first implanted this in 1962
- ▣ Observed cases for 5 years before deciding this was safe and recommended other surgeons to use it.
- ▣ Worked closely with Chas F Thackray Ltd to manufacture implants

Charnley low friction arthroplasty



Charnley low friction arthroplasty

- ▣ Main caviats
 - HMWPE cup with metal stem to reduce friction
 - Size 7/8 inch femoral head (reduce torque)
 - Medialisation of centre of rotation to reduce abductor force and subsequently JRF (later discouraged)
 - Fixation of implants to bone with the used of PMMA
 - Development of a system of instrumentation

Charnley and cement

- ▣ Charnley was convinced that cement was the best way to fix the implants to bone
- ▣ Acts as a grout not an adhesive
- ▣ He documented that:
 - It had to be prepared without unnecessary additives
 - The exact constituents should be published
 - It had to be sterilised with formaldehyde
 - The package should include two measured doses of barium sulphate to allow the surgeon the choice of different degrees of radio-opacity
- ▣ CMW labs first made this cement

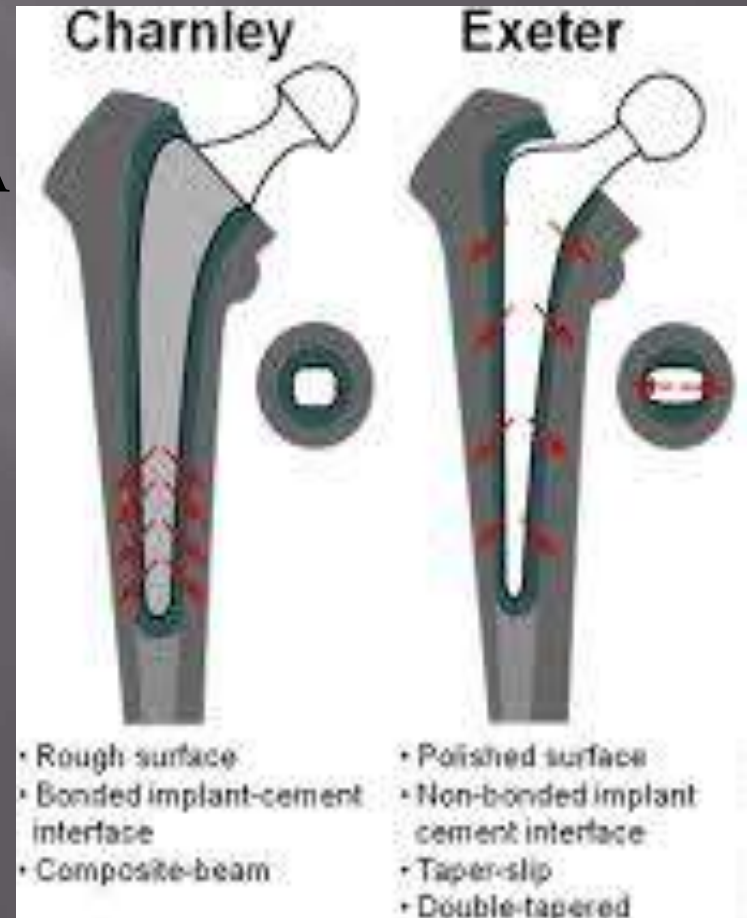
Charnley hips current

- ▣ Total cemented cups – 28441
- ▣ DePuy cemented cups – 8800
- ▣ Total cemented stems – 42533
- ▣ DePuy Charnley stem – 676
- ▣ Charnley THR has 10A ODEP rating
- ▣ Revision rates between 20-30% at 25 to 30 years



Stem theory

- ▣ Main two theories between
 - Composite beam
 - ▣ E.g. Charnley stem
 - ▣ Proponents are Harris in USA
 - Taper slip
 - ▣ E.g. Exeter stem
 - ▣ Proponents are Ling in UK



Composite beam stem

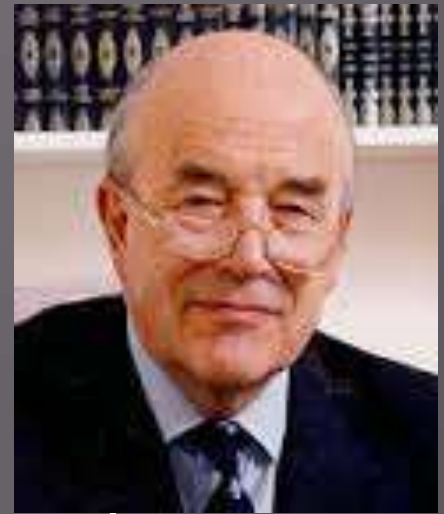
- ▣ Cement bonds to both bone and implant
- ▣ Rough stem surface to allow grouting
- ▣ Precoating may help with bonding
- ▣ Advantages perceived as firm bonding of implant to bone
- ▣ Disadvantages may be the transfer of forces from the implant to the cement



Composite beam stem

- ▣ High shear stresses at areas of load transfer
- ▣ Can predispose to failure of the interface
- ▣ Debonding of the cement implant interface increases stresses at other areas and increases risk of loosening
- ▣ May use a collar at the calcar to increase load transfer at this point
- ▣ Argument that stem can pivot at this point leading to rotational stresses

Taper slip



- ▣ Use of polished tapered stem
- ▣ Cement bonds only to bone
- ▣ Smooth unbonded interface allows stem to undergo controlled subsidence
- ▣ Void at the tip of the stem allows subsidence
- ▣ Takes into account the viscoelastic properties of cement
- ▣ Cement undergoes creep (deforms over time under constant loading)

Taper slip

- ▣ Controlled subsidence allows polished tapered stem to lock into interface limiting interface deficiencies
- ▣ In addition this tighter wedge loading results in compressive hoop stresses at the interface
- ▣ This leads to less shear stress and increased compressive loading along the femur which may limit stress shielding

Exeter stem

- ▣ Introduced by Ling and Lee in 1969
- ▣ Stainless steel, collarless, polished double tapered stem
- ▣ Matte stem introduced in 1980s with disastrous results
- ▣ Realised the need for polished stem to prevent particulate matter through interface and subsequent osteolysis

Exeter hips current

- ▣ Total cemented cups – 28441
- ▣ Total Stryker Exeter cups – 15072
- ▣ ODEP rating 10A except Rimfit (preentry)
- ▣ Total cemented stems – 42533
- ▣ Total Exeter stems – 28523
- ▣ ODEP rating 10A
- ▣ Another 10000 non Exeter taper slip designs

Cemented versus uncemented

- ▣ NJR from 2003 to 2013
 - Cemented – 36.8%
 - Uncemented – 38.7%
 - Hybrid – 16.3%
 - Reverse hybrid – 2.4%
 - Resurfacing – 5.9%

10 y Revision rates NJR

- ▣ Cemented hips
 - MOP – 3.13
 - MOM – 19.68
 - COP – 2.09
- ▣ Uncemented hips
 - MOP – 3.98
 - MOM – 21.92
 - COP – 3.73
 - COC – 4.75
- ▣ However arguments that this is multifactorial and that it is difficult to study independent variables have been made