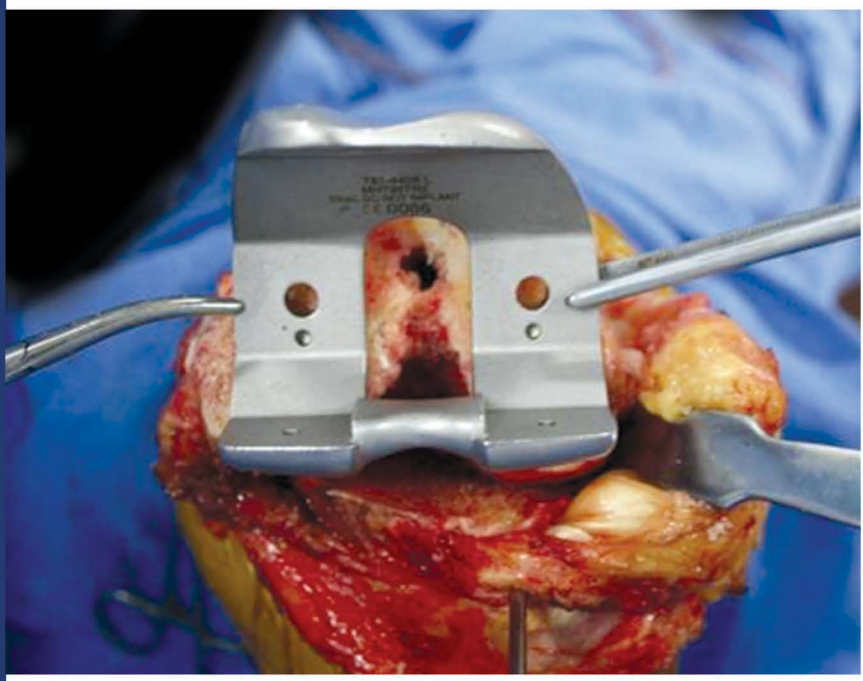
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TIPS & TRICKS

TIPS & TRICKS *in* HIP & KNEE ARTHROPLASTY (A PRACTICAL APPROACH)



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Co-author
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Foreword
Ross Crawford

JAYPEE

Includes Interactive DVD-ROM

Contents

Section 1: Hip Arthroplasty

1. Applied Anatomy **3**
- Hip Joint *3*

2. History and Biomechanics of Hip Arthroplasty **6**
- Biomechanics *9*

3. Implants and Bone Cements **14**
- Femoral Component *14*
- Acetabular Component *19*
- Ceramic on Ceramic Hips *21*
- Metal-on-metal Total Hip Arthroplasty *22*
- Hip Resurfacing vs Conventional THR *24*
- Bone Cements *24*

4. Radiographic Evaluation in Total Hip Arthroplasty **28**
- Preoperative Radiological Evaluation *28*
- Radiographs *28*
- Acetabular Conditions, Precautions and Problem Faced *28*
- Femoral Conditions, Precautions and Problems Faced *31*
- CT Scan *34*
- Magnetic Resonance Imaging *35*
- Bone Scan 35
- How to Read Postoperative X-Ray? *35*
- Follow-up Radiographs *38*
- Aseptic Loosening of Cup *38*

5. Surgical Approaches and Indications of Hip Arthroplasty **41**
- Conventional Surgical Approach *41*

6. Perioperative Management of Total Hip Arthroplasty **50**
- Preoperative Clinical Evaluation *50*
- Postoperative Clinical Management *51*

7. Primary Total Hip Arthroplasty **54**
- Neck Cut *54*
- Exposure of Acetabulum *54*

- Acetabular Reaming *58*
- Femur Preparation *58*
- Impingement *67*
- Wound Closure *70*

8. Complex Primary Total Hip Replacement **71**
- Total Hip Replacement in Protrusio Hip *71*
- Total Hip Replacement in Ankylosed Hip *73*
- Dysplastic Hip *76*

9. Complications of Total Hip Arthroplasty **79**
- Hematoma Formation *79*
- Mortality *79*
- Thromboembolism *80*
- Vascular Injury *81*
- Limb Length Discrepancy *81*
- Instability (Dislocation and Subluxation) *81*

Section 2: Knee Arthroplasty

10. Applied Anatomy of Knee Joint **85**
- Knee Joint *85*

11. History and Biomechanics of Knee Arthroplasty **90**
- Biomechanics of Normal Joint and a Prosthetic Joint *91*

12. Implants and Patient Selection **94**
- Osteoarthritis of Knee Joint *94*
- Treatment *95*
- Cruciate Retaining vs Cruciate Substituting *96*
- High Flex Design *98*
- Fixed vs Mobile Knee *99*
- Gender Knees *99*
- Cemented vs Noncemented *100*
- All Polyethylene vs Metal Backed Tibia *101*
- Routine vs Judicious use of Anticoagulant Prophylaxis *102*
- Patellar Resurfacing *103*
- Extension Rods *106*
- Hinged Implants *106*
- Various Conditions and Implant Selection *106*

13. Perioperative Management of Total Knee Arthroplasty **111**
- Preoperative Clinical Evaluation *111*
- Postoperative Clinical Management *113*

14. Surgical Approaches and Technique of Primary Total Knee Arthroplasty **116**
- Surgical Approaches *116*
- Tips of Patellar Eversion 123
- Bone Cuts *123*
- Tibial Cut *123*
- Common Mistakes and their Causes *140*
- Criteria for Equalizing Flexion and Extension Gaps and Bone Cuts *145*

15. Complex Primary Total Knee Arthroplasty **146**
- Varus Knee *146*
- Valgus Knee *147*
- Fixed Flexion Deformity of Knee *148*

16. Complications of Total Knee Arthroplasty **153**
- Complications after Total Knee Replacement *153*

Index *157*

CHAPTER

3

Implants and Bone Cements

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FEMORAL COMPONENT

Femoral components are broadly divided into cemented and noncemented variety. Noncemented stems may have a porous surface for bone ingrowth or may be of press-fit varieties with surface impressions for macrointegration of bone with the implant.
Vertical offset: It is determined by base length of the prosthetic neck plus the length added by the modular head ('plus head' increases and 'minus head' decreases the length). It is also affected (more in cemented hip) by the level of neck osteotomy and depth of stem inserted in femoral canal.
Offset (horizontal offset): It is primarily a function of stem design. Some stems come in 132° (normal) and 127° (high) offsets.
Anteversion: It is determined in relation to lesser trochanter and is less likely to change in cementless implant than cemented stem. Anatomical stem have some degree of inbuilt anteversion.

Cemented Stems

Most commonly used stems are made up of cobalt-chrome alloy which has a high modulus of elasticity and it reduces stress in the proximal cement mantle. Lateral broad cross section of stem, loads the proximal cement mantle in compression. **Collared stems are believed to help in deciding the depth of insertion.** Initially stems having rough surface or impressions were believed to help in improving cement and implant bonding, but were later found to produce more debris and loosening. Currently polished collarless stems are the standard cemented femoral implant. Exeter stem is a polished collarless double tapered implant. Exeter stem is gold standard among the cemented stems. Examples of cemented stems are shown in (**Fig. 3.1**). Stems should occupy approximately 80% of the cross section of the medullary canal with an optimal **proximal 4 mm and distal 2 mm of cement mantle** (**Fig. 3.2**). Distal cement restrictor (usually 12-14 mm) or distal medullary plug and centralize



Fig. 3.1 Different cemented stems

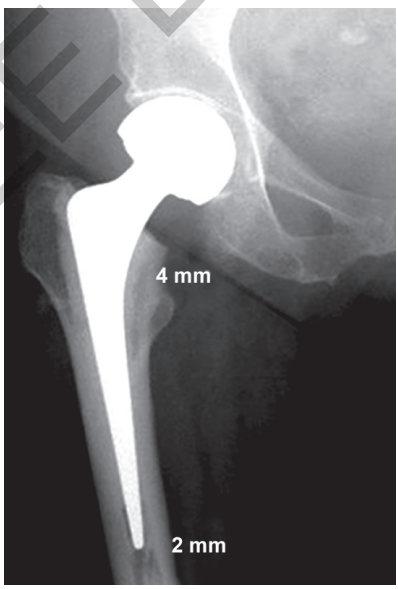
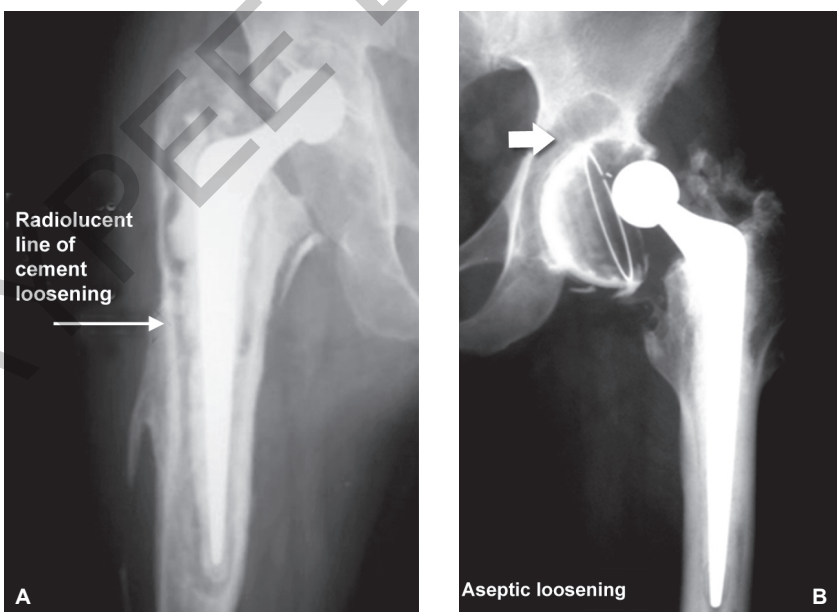


Fig. 3.2 A well-fixed cemented exeter stem

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TABLE 3.1 Reported advantages and disadvantages of cemented and cementless hips

	Cemented hip	*Cementless hip*
Advantages	• Gives immediate stability • Allow immediate to early mobilization • Cement can fill the minimal femoral or acetabular bone loss/defects without need of bone grafting • Less expensive • Limb length and femoral anteversion can be adjusted at the time of setting of bone cement	• Allows fixation by direct bone-to-implant osteointegration • Revision is easy • Cement related problems are not present
Disadvantages	• Technically demanding (requires expertise in cementing techniques) • Aseptic loosening **(Fig. 3.3B)** • Cement fracture /breakage • Cement related problem: Fat embolism • Revision becomes difficult due to removal of cement and bone loss	• More expensive than cemented hip • 3-6 weeks of nonweight bearing mobilization is required for osteointegration • Sometimes stem removal difficult than cemented stem



Figs 3.3A and B (A) Septic loosening of the cemented hip stem; (B) Aseptic loosening of the acetabular (arrow) and femoral components

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the stem in the femoral canal and help in achieving uniform cement mantle. Usual length of currently available stem designs varies from 120 to >200 mm. **Long stems are required in revision hip, or to bypass a cortical perforation, fracture or weak bone due to removal of screw or internal fixation devices.** Advantages and disadvantages of cemented and cementless hip are given in **Table 3.1**. **Figures 3.3A and B** shows septic and aseptic loosening.

Cementless Stem

It is indicated in active young adults, middle age and elderly patients with good bone stock. Definitive stability is provided by ingrowth of bone around the stem in the femoral canal. Most of them are proximal fitting stems. Very long stems (**Fig. 3.5B**) are distal fitting stem (*used for* revision hip). Two prerequisites for bone ingrowth include immediate implant stability at the time of surgery and intimate contact between the porous surface and viable host bone. **Figure 3.4** shows various cementless stems.

Uncemented porous coating: Commonly coated surface include titanium alloy with a porous surface of commercially pure titanium fiber-mesh or beads and cobalt-chromium alloy with a sintered beaded surface. Titanium has superior biocompatibility, high fatigue strength, and lower modulus of elasticity. But it is notch sensitive hence the porous coating should be restricted to large proximal part of the stem and should be avoided on



Fig. 3.4 Different cementless stems

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Figs 3.5A and B (A) AML stems; (B) Solution stem

lateral tensile border of the stem. Problems include fatigue strength of porous implants, ion release, and adverse femoral remodeling. Extensive coating produces adverse femoral remodeling, stress shielding and thigh-pain (AML and Solution stems). Hence, it should be restricted to proximal portion only specially in primary arthoplasty).

But fully coated stems are very useful in revision and osteoporotic bone where proximal or metaphyseal fitting is doubtful (**Figs 3.5A and B**).

Cementless stems come in two following basic shapes:

Anatomical femoral stem: It has a posterior metaphyseal bow and a variable anterior diaphyseal bow according to the geometry of the femoral canal. Anteversion must be built into the neck segment of separate right and left stems and slight overreaming is required for good fitting of implant. They are believed to transfer stress to large priority areas of contact mimicking the normal strain transfer patterns of the femur so have the long-term fixation.

Straight femoral stem (Fig. 3.4): It has a symmetrical cross section and fit on either side. They may have proximal tapered large canal filling portion or may have parallel-sided, less proximal canal filling to achieve good fit (proximal and distal) and axial/rotational stability by virtue of their shape. They are believed to have better fit because of extra preparation of femoral canal.

Uncemented Press-fit Stems

They have rough surface or surface impression that promotes macrointerlocking with bone after initial immediate surgical stability. They do not promote bone ingrowth without additional hydroxyaptite coating.

Modular Femoral Stem (Fig. 3.6)

These stems are required for mismatch in fit at the proximal and distal part of stem. They have separate metaphyseal and neck part independent of diaphyseal portion.

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Fig. 3.6 Versatile modular and custom made hip system

They are used in deformity of proximal femur due to surgery, trauma and congenital bowing and revision hip replacements.

Custom-made Femoral Components (Fig. 3.6)

Patients having bony deformity or bone loss from trauma, tumor, congenital conditions (DDH requires small stems) or revision surgery (calcar replacement prosthesis) require custom made or specialized femoral components.

ACETABULAR COMPONENT

Broadly divided into cemented or cementless cup.

Cemented Cup (Fig. 3.7)

Long-term survivorship is still questionable especially in beginners. Hence, these are preferred in elderly low demand patients, tumor surgery, severe osteopenic bone and revision surgery (requiring extensive bone grafting). But this is used in all age groups in many parts of the world. Cup has thick ultra high density (UHD) polyethylene with peripheral flange to pressurize the cement mantle, vertical and horizontal grooves on external surface to stabilize cement mantle and wire marker embedded in the plastic for assessomg the cup position in postoperative radiographs. Surface PMMA spacer of 3 mm helps in formation of a uniform cement mantle and prevents "bottoming out phenomenon" (cement gets pushed out below the cup and results in thin cement mantle).

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Fig. 3.7 Exeter cemented cup with raised PMMA spacers



Fig. 3.8 Cementless acetabular cup

Cementless Acetabular Components (Flg. 3.8)

Porus coated cementless cup with a UHD polyethylene or crossed linked polyethylene have become the standard in current modern cementless total hip arthroplasty. Bone integration is facilitated by initial fixation (integration occur maximum around

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this) with screw, peg/spikes, or by enlarged peripheral press fitted rim without screw. Size ranges from 40 to 75 mm with polyethylene to articulate with different head diameters (22 to 36 mm). Polyethylene is secured with the cup by plastic flanges and metal wire rings that lock behind elevations or ridges in the metal shell, and peripherally placed screws. Thickness of the polyethylene should be > 5 mm to reduce wear hence acetabular loosening. Usually, polyethylene has a posterosuperior elevation (flanged portion of polyethylene liner) which gives additional stability. It should be positioned in either posterosuperior or superior position.

CERAMIC ON CERAMIC HIPS (FIGS 3.9A AND B)

Materials related advantages and problems in old and current designs with ceramic implants are shown in **Table 3.2**.

Squeaking Sounds

The incidence of squeaking with alumina-ceramic devices reported in the literature varies widely (0.3 to 20.9%).[4,5,7]

Basic etiology: Study of the retrieved implants have shown microseparation, edge loading, and the development of stripe wear as three possible reasons for squeaking sound.[8]

TABLE 3.2 Reported material related advantages and problems with ceramic implants

	Old design	*Current design (1994 onward; third generation)*
Material	**Faulty materials**[1,2] • High porosity • Larger grain size • Low density of the ceramic	**Better materials**[3] • Higher density • Higher purity • Smaller grains
Problems	• High fracture rate (13.4%) • Osteolysis[2]	• Low fracture rate (4:100 000 or 0.004%.)[3] • Squeaky sound (0.3%–20.9%)[4,5] • Osteolysis (1.4%)[6]



Fig. 3.9A Ceramic on ceramic hip

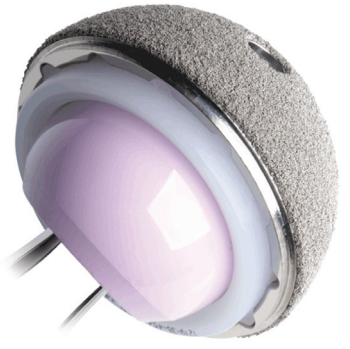


Fig. 3.9B Ceramic on polyethylene hip

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Following three factors may contribute to the above three basic reasons for production of squeaking sound:[9]

- **Surgical technique related factors:** Improper orientation of the component may lead to decreased lubrication at the articulating interface or cause an obstruction leading to sound due to contact stress vibrations. This sound may be further exaggerated due to insufficient anteversion of the cup, impingement, or third-body debris in the interface.
- **Patient related factors:** These include younger age, increased height and weight, and high physical activity.
- **Implant related factors:** Implant design and the material also play an important role. Delta (Ceramtec) has been shown to produce less sound than Forte (Ceramtec) ceramic.

Click Sounds

Possible causes include movement of a hard-on-hard bearing, soft tissue impingement, or shifting.[7]

METAL-ON-METAL TOTAL HIP ARTHROPLASTY (FIG. 3.10)

Potential advantages of metal-on-metal hips include use of large head (better stability and improved range of motion) and reduced rate of wear and osteolysis.[10,11] Disadvantages includes elevation of serum and urine metal ion levels, possible risk of carcinogenicity and teratogenic effects in human beings,[12] metal induced hypersensitivity[13] reactions and diffuse or perivascularity oriented lymphocytic infiltration with early local inflammation and pain (ALVAL-Aseptic Lymphocyte-Dominated



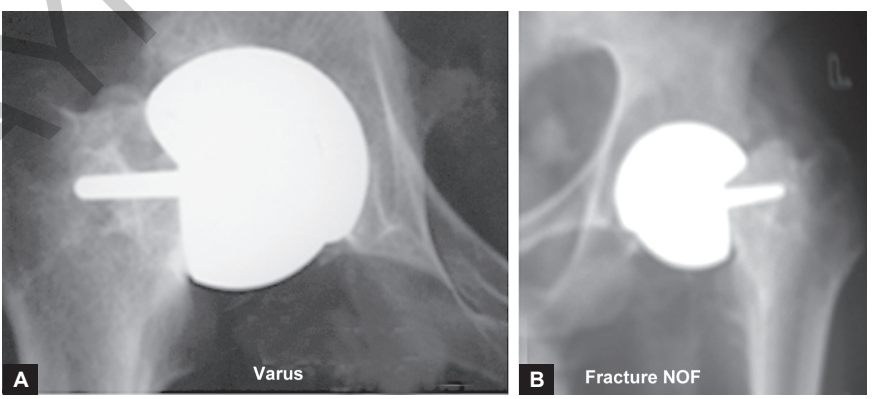
Fig. 3.10 Resurfacing (MOM) implants

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TABLE 3.3 Reported advantages and disadvantages of the hip resurfacing vs conventional THR

	Hip resurfacing	*Conventional THR*
Advantages	• Preservation of bone stock on femoral side [14,15] • Less stress shielding [16,17] • Less thigh pain [18] • Reduced dislocations [18] • Reduced osteolysis [19] • Improved biomechanics [19] • Retention of proprioception • Easy revision on femoral side	• Technically less demanding • Problems of head retention are not seen (fracture neck of femur, osteonecrosis of head of femur) • Less expensive (some implants) • Large head (36 mm) with highly cross linked polyethylene give comparable hip movements, stability and durability
Disadvantages	• Learning curve • Fracture of neck of femur (0 to 4%) • Malalignment • Aseptic loosening • Unexplained hip pain • Increased revision rate due to complications associated with learning curve • Osteonecrosis of head of femur • Problems of metal-on-metal articulation	• Range of motion is less than surface replacement in < 36 mm head • More possibility of dislocation in small heads (0.4% to 5%)

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Figs 3.11A and B Complications of resurfacing

Vasculitis-Associated Lesion) and ultimately metallosis and failure. ASR (DePuy Orthopedics) has been withdrawn from the market.[20]

HIP RESURFACING VS CONVENTIONAL THR (FIG. 3.11)

Initial reports of metal-on-metal hips were dramatic but slowly the faults associated with this technique started appearing in the literature. Initial literature was more in favor of resurfacing but now sufficient literature shows either a comparable or inferior result in comparison to conventional THR (**Table 3.3**). Now these implants have been withdrawn from the market.

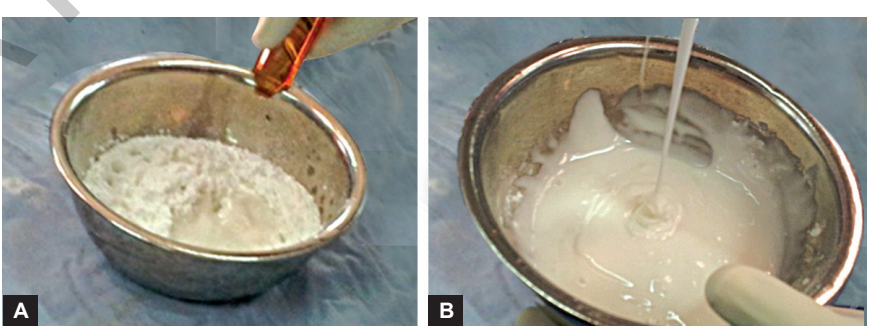
Fracture neck of femur: It is a very disturbing complication (**Figs 3.11A and B**) of surface replacement. Surgeon's experience appears to be the most important factor for this complication. Other contributing factors include age, sex, body mass index, femoral neck notching, cysts on the femoral head, neck lengthening, and varus alignment of the femoral component.[21]

BONE CEMENTS (FIGS 3.12A AND B)

There are following three types of bone cement based on their viscosity:

1. **Low viscosity:** It has a long waiting phase (sticky phase) of 3 minutes; viscosity rapidly increases during the working phase and has a hardening phase of about 1-2 minutes. Surgeon has to act quickly for cementing.
2. **Medium viscosity:** It has a long waiting phase of 3 minutes; viscosity increases slowly during working phase and has a hardening phase between one minute 30 seconds and two minutes 30 seconds.
3. **High viscosity:** It has a short waiting phase followed by a long working phase. Viscosity remains same till the end of the working phase. Surgeon gets more time for cementing.

The green color of Palacos Cement is believed to have reduced waiting time for dough-up and its green color gives better visibility. Simplex P is believed to have a better fatigue strength and Simplex P Speed Set cement has better strength and a faster setting time. Low viscosty cements are used in THR with cement gun



Figs 3.12A and B Cement mixing technique

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(CMW 3). High viscosity cements are used in TKR with digital application (CMW 1). Low temperature (during storing and mixing) and high humidity prolongs setting time while high temperature speeds up the setting of bone cement. Temperature during hardening phase may increase up to 70°C to 120°C (*in vitro*) and up to 56°C (*in vivo* for 2-3 minutes).



Fig. 3.13A Distal medullary plug



Fig. 3.13B Distal centralizer in femoral cemented stem

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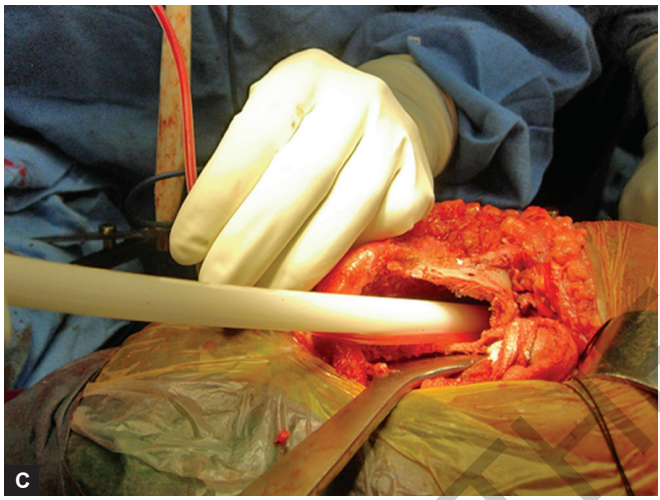


Fig. 3.13C Use of cement gun, retrograde filling

Functions of bone cement: It helps in fixation of components, reinforces the bone structure, transfers the mechanical stress to bone and may deliver antibiotic (if impregnated with cement).

Modern cementing techniques (Figs 3.13A to C) include pulsatile lavage, medullary brush (to remove free bone, blood or debris), cement restrictor (for distal blockage of cement) **Fig. 3.13A**, packing of medullary canal with gauze tape soaked in hydrogen peroxide, medullary centralizer over distal tip of stem (to centralize stem in the canal) **Fig. 3.13B**, cement preparation (reduction of porosity by vacuum mixing, centrifugation), and cement gun for retrograde insertion and pressurization **Fig. 3.13C**. **Complications of bone cement includes** pulmonary embolism due to fat or cement pressurization (more in elderly patient or having patent foramen ovale); aseptic loosening and breakage.

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