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CHAPTER 65

Evaluation and Management of Femoral Bone Defects in Revision Total Hip Arthroplasty

M J Neil

INTRODUCTION

Restoration of bone stock in revision total hip arthroplasty (THA) is a challenging surgical problem. Simple revisions where the bone stock is adequate can be performed successfully a number of ways with equally good results using a variety of implants. However, significant segmental femoral loss (>7.5 cm from the tip of the greater trochanter) presents real difficulty in reconstruction. The use of fresh frozen proximal en bloc femoral allografts in a composite with a modular stem is discussed.

PREOPERATIVE PLANNING

Meticulous preoperative planning and workup is of paramount importance. It includes the following:

- Assessing the type of femur defect
- Evaluating the limb length
- Status of soft tissues
- To rule out infection
- Selecting the proper implant.

Important investigations to be performed preoperatively are:

1. *Calibrated X-rays:*
   - Evaluate the amount of bone loss
   - Classify the bony defect
   - Select the optimal reconstructive option.
2. *Computed tomography (CT) scan:*
   - Superior image quality
   - Three-dimensional reconstruction
   - Extremely valuable for preoperative planning and implant selection.
3. *Magnetic resonance imaging (MRI) scan*: Image quality affected by the presence of metal implant but very useful for evaluation of:
   - Integrity of soft tissue
   - Define the bone-implant interface
   - To detect the location and extent of bone defect.

OBJECTIVES OF RECONSTRUCTION

Various objectives of femoral defect reconstruction are:

- Preserve remaining bone stock
- Provide stable implant fixation
- Maintain femoral integrity
- Achieve rigid prosthetic fixation
- Restore hip biomechanics
- Equalize leg lengths (as close to opposite limb as possible).

CLASSIFICATION OF FEMORAL BONE DEFICIENCY

There are a number of classification systems, including Paprosky (Table 1), American Academy of orthopedic surgeons (AAOS) (Table 2), Gross (Table 3) and others. I prefer the Mallory-Head system (Table 4) because it is simple and indicative of treatment required and likely prognosis.

Table 1: Paprosky classification.

Type	*Description*
1	Minimal metaphyseal cancellous bone loss with intact diaphysis
2	Extensive cancellous bone loss including the whole metaphysis up to the level of lesser trochanter
3A	Extensive metaphyseal and diaphyseal bone loss with more than 4 cm of diaphyseal bone available
3B	Extensive metaphyseal and diaphyseal bone loss with less than 4 cm of diaphyseal bone available
4	Widened diaphysis that provides no support for cementless fixation

Table 2: American Academy of Orthopedic Surgeons (AAOS) classification.

Type	*Description*
1	Segmental deficiencies • Proximal partial (anterior, medial, or posterior) • Complete • Intercalary • Greater trochanteric
2	Cavitary deficiencies • Cancellous • Cortical • Ectasia
3	Combined segmental and cavitary deficiencies
4	Malalignment • Rotational • Angular
5	Femoral stenosis
6	Femoral discontinuity

Table 3: Gross classification.

Type	*Description*
1	No significant bone loss
2	Contained (cavitary) bone loss
3	Segmental bone loss less than 5 cm in length and involves the calcar and the lesser trochanter but does not extend into the diaphysis
4	Segmental bone loss of greater than 5 cm in length extending into the diaphysis
5	As in type 4 with the addition of a periprosthetic fracture

Table 4: Mallory-Head classification.

	Proximal femur	
Type	*Medullary contents*	*Cortical bone*
1	Intact	Intact
2	Deficient	Intact
3A	Deficient	Deficient to level of lesser trochanter
3B	Deficient	Deficient to level between lesser trochanter and isthmus
3C	Deficient	Most of proximal part of femur deficient

MANAGEMENT OF FEMORAL BONE DEFECTS ACCORDING TO MALLORY-HEAD CLASSIFICATION

- *Type 1— Intact cortical tube and contents*:
  - Similar surgery to primary THA.
  - *Options*:
    - Cementless proximally coated stems (Fig. 1)
    - Collared femoral stems (cemented or cementless) (Fig. 2)
- *Type 2— Intact cortical tube but deficient medullary contents*:
  - Longer stemmed devices for distal fixation ± cortical strut allograft (CSA) and/or impaction grafting.
  - *Options*:
    - Extensively porous-coated stems (Fig. 3)
    - Modular/nonmodular distal fixation fluted femoral stems (Figs. 4 and 5)
    - Distally integrating long-stem implants
    - Interlocking cementless long-stem implants (Figs. 6 and 7).
- *Type 3A— Deficient tube and contents— proximal to lesser trochanter*:

Fig. 1: Cementless proximally coated stems.

Fig. 2: Collared stems.

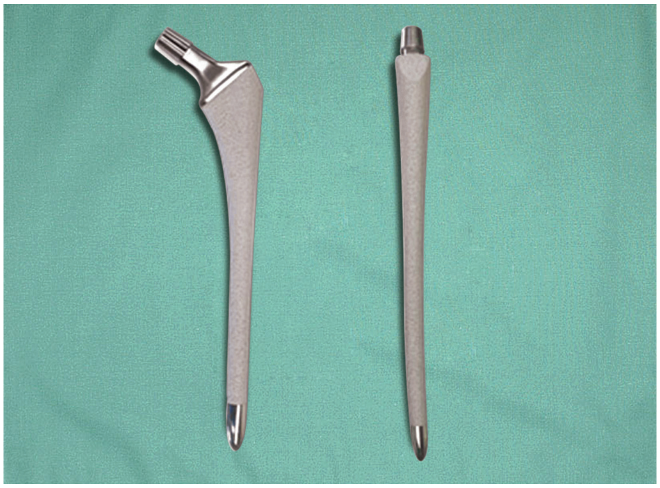
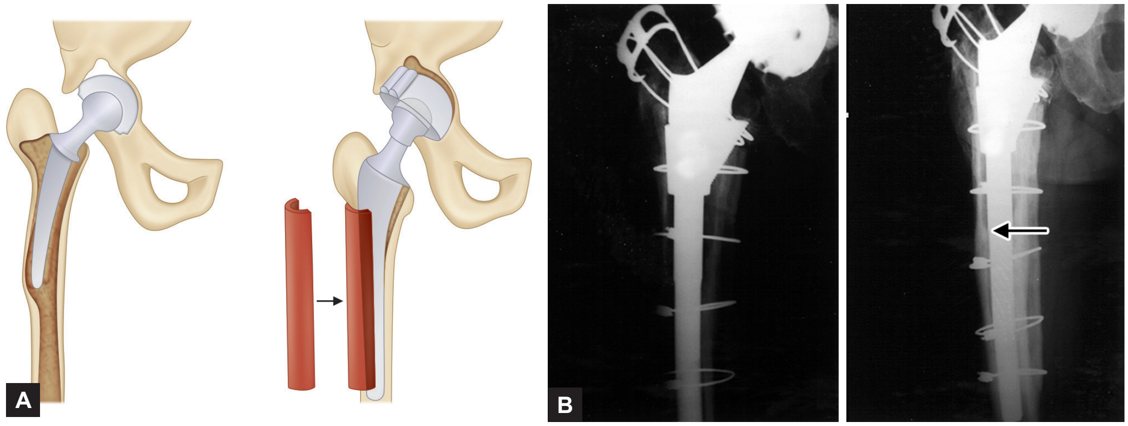


Fig. 3: Extensively coated long stem.

Fig. 5: Modular distal fixation prosthesis.

Fig. 4: Modular fluted-stem prosthesis.

Fig. 6: Interlocking cementless long-stem prosthesis.



Figs. 7A and B: Cortical strut graft with long stem prosthesis. Arrow in figure B shows cortical strut allografts (CSA) 1-year postoperative. Union rate of CSA approximately 98% in most series.

Fig. 8: Calcar replacement and neck extension stems.

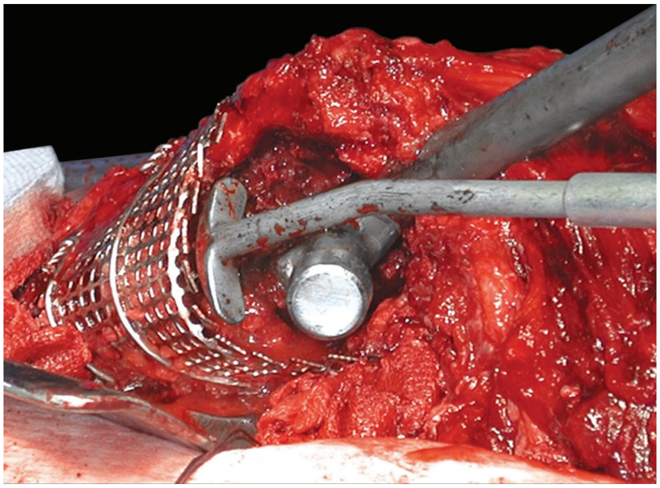


Fig. 9: Impaction bone grafting with stem fixation.

- Reconstruction of proximal femur using cortical struts and/or impaction grafting and/or implantation of long-stem prosthesis with neck/ calcar replacement.
- *Options*:
  - Long-stem prosthesis with neck extension (Fig. 8)
  - Long-stem calcar replacement prosthesis (Fig. 8)
  - Mixed Femoral Fixation technique (proximally cemented and distally press fit) (Fig. 9)
  - Impaction bone grafting with mesh (with cemented/cementless long-stem implants) (Fig. 9).

- *Type 3B—Deficient tube and contents—lesser trochanter to isthmus*:
  - Complex reconstruction with cortical strut graft or proximal femoral structural allograft (PFA) is needed in this type of defect with long-stem distal fixation stems.
  - *Options*:
    - Calcar replacement long-stem prosthesis with cortical struts
    - Distal fixation stem with proximal bone graft
    - Mixed Femoral Fixation technique (proximally cemented and distally press fit) with cortical strut proximal reconstruction
    - PFA with long-stemmed prosthesis (allograft prosthesis composite)
    - Proximal femoral replacement with custom mega-prosthesis.
- *Type 3C—Deficient tube and contents—beyond isthmus*:
  - Most challenging reconstruction as there is no intact isthmus to provide adequate distal fixation of the component.

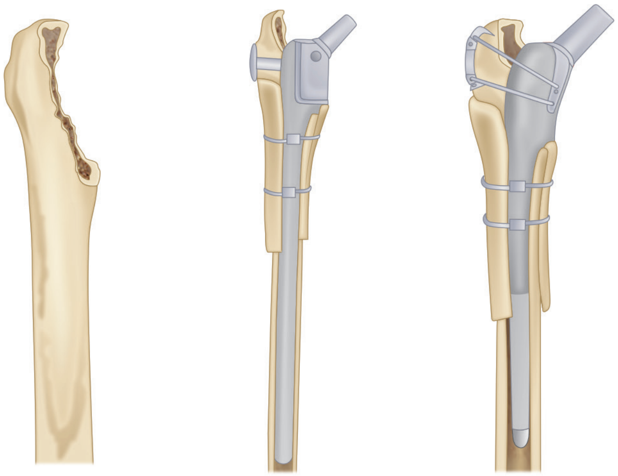


Fig. 10: Long-stem fixation with cortical strut allograft reconstruction.

  - *Options*:
    - Calcar replacement long-stem prosthesis with large CSA
    - Long distal fixation stem with CSA reconstruction (Fig. 10)
    - PFA+ long-stemmed prosthesis (Fig. 11)
    - Proximal femoral replacement custom mega-prosthesis (Fig. 12).

TREATMENT OPTIONS FOR SEGMENTAL BONE LOSS IN THA IN TYPE 3A AND 3B FEMURS (>10 CM)

- Excision arthroplasty—functional results poor
- Arthrodesis— often difficult to achieve because of bone loss
- Diaphyseal fixation—results good but

- Does not restore bone (relevant in younger patient facing further surgery)
- Stress shielding with thigh pain due to stiffness mismatch
- Stem subsidence and failure depending on quality of "potted bone"
- Fixation dependent on canal diameter (which may be very large) and isthmic bone available

- Impaction grafting—generally not possible if tube deficient
- *Custom prosthesis:*
  - Instability due to poor soft tissue envelope
  - Late fatigue fracture
  - Early loosening
  - Severe stress shielding
  - Expensive
- *Proximal femoral allograft/long-stem composite* (preferred method):*
  - Restores bone stock for future
  - Less stress shielding
  - Restores soft tissue envelope for prosthesis (better stability)
  - Can use easily available long-stem implant for construct

    But

    Technically demanding and requires access to tissue bank.

TECHNIQUE (FIGS. 13 AND 14)

- Surgical approach is posterolateral with elevation of vastus lateralis from lateral intermuscular (IM) septum.

Fig. 11: Proximal femoral allograft with long stem prosthesis.

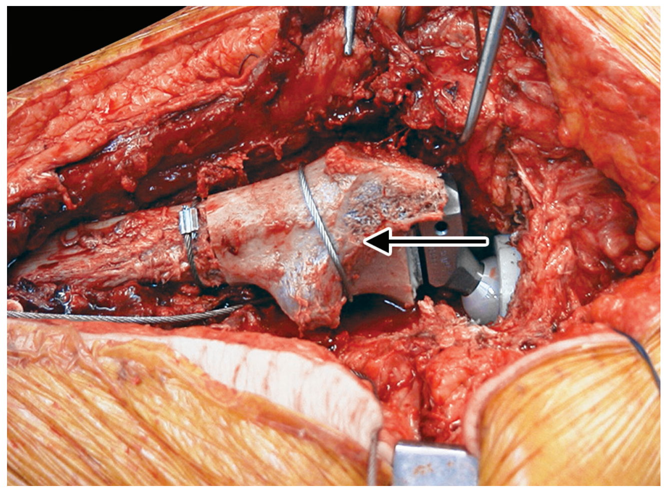


Fig. 13: Proximal femoral allograft reconstruction for 3C defect using S-ROM stem with cemented sleeve. Trochanteric slide with host bone to be reattached.

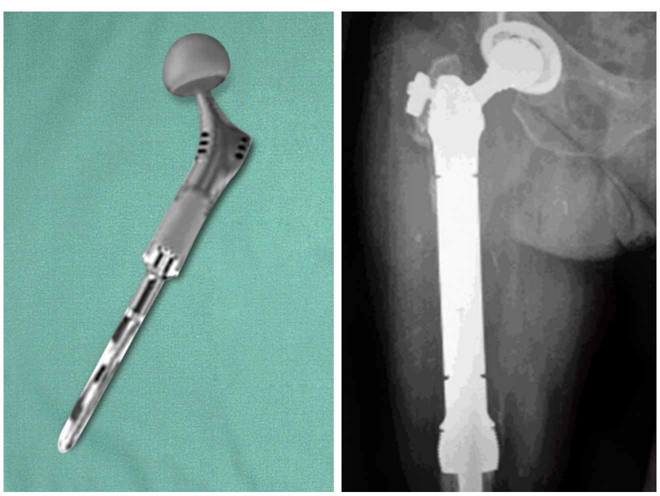


Fig. 12: Custom mega prosthesis.

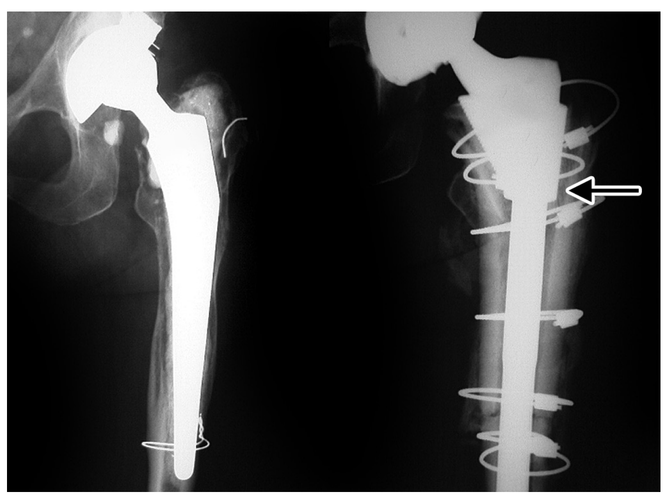


Fig. 14: Arrow shows proximal femoral allograft reconstruction for 3C defect. Pre- and postoperative X-rays.

Transfemoral osteotomy with proximal segment split sagittally with soft tissue envelope.

- Distal femur (usually wider than graft) reamed gently line-to-line for size. Prophylactic cable around proximal end to prevent hoop stress fracture.
- Graft prepared on side table with distal reaming, metaphyseal reaming and calcar milling (as for routine S-ROM hip). Sleeve cemented into allograft.
- Following trial reduction to assess leg length and graft tension, composite reduced and final impaction of long stem through graft and into distal segment, being careful to correct rotation. Docking site invariably stable to rotation with this technique, so CSA not needed.
- Soft tissue envelope of autologous struts and muscle advanced and wired with trochanteric segment.
- Traction 5 days, intravenous (IV) antibiotics 5 days, then 4 weeks oral.
- Crutches TWB 3–6 months until union.

RESULTS

Gross et al.:

Gross et al. JBJS Am. 2001;83:346-54.

Best long-term follow-up study in the literature. 1984:63 THA with PFA in 60 patients.

- Average length of graft:15 cm
- Average age of patients: 62.5 years
- Average number of previous operations: 3.8
- Looked at HHS, XR features, failure defined as reoperation (actual or pending)
- *Results*: At average 11-year follow-up, success rate 78%.

Neil et al. (unpublished):

Personal series

Nov1993-Aug2002: 25 THA with PFA in 25 patients.

- Average length graft: 13 cm
- Average age of patients: 64 years
- Average number of previous operations: 2.7
- *Results*: At average 6-year follow-up, success rate 84%
  - Two infections, requiring redo surgery
  - Two trochanteric escapes
  - No docking site nonunions
  - No dislocations.

SUMMARY

The use of PFA in complex revision THA with extensive bone stock loss is a well-established technique with excellent long-term results. It is technically demanding and requires a revision team approach, as well as access to fresh frozen segmental allograft bone. The use of the S-ROM stem may enhance the rate of union because of stability in rotation and distally, as well as decreasing the risk of dislocation, because leg length offset and version can be adjusted accurately before final fixation, without the need for step-cut osteotomy.