Review Article

Femoral Bone Loss in Revision Total Hip Arthroplasty: Evaluation and Management

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Abstract

Primary total hip arthroplasty (THA) is one of the most effective procedures for managing end-stage hip arthritis. The burden of revision THA procedures is expected to increase along with the rise in number of primary THAs. The major indications for revision THA include instability, aseptic loosening, infection, osteolysis, wear-related complications, periprosthetic fracture, component malposition, and catastrophic implant fracture. Each of these conditions may be associated with mild or advanced bone loss. Careful patient evaluation and bone loss classification guide preoperative planning and overall patient care. Historically, uncemented fixation has provided the best results, but cemented fixation is required in some cases.

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The aging of the population and the consideration of younger patients for primary total hip arthroplasty (THA) has resulted in increasing numbers of these procedures being performed annually. The revision burden is expected to increase, as well. The major indications for femoral revision include aseptic loosening, infection, instability, osteolysis, periprosthetic fracture, component malposition, and catastrophic implant failure.

Femoral revision is often complicated by bone loss or the poor integrity of the remaining bone stock. We offer an approach by which to evaluate candidates for femoral revision and define methods by which to assess and manage femoral bone loss encountered during revision surgery.

Preoperative Evaluation

Preoperative evaluation begins with a comprehensive history, physical examination, and radiographs. Key elements of the history include the location, character, timing, and duration of pain as well as provocative factors and associated symptoms.

In all cases of painful hip replacement, laboratory tests should be done, including serum erythrocyte sedimentation rate (normal, <20 mg/dL) and C-reactive protein level (normal, <10 mg/dL). In most cases, patients with elevated serum inflammatory markers should undergo preoperative hip aspiration. Synovial fluid obtained from the hip aspiration should be sent for cell count analysis, including differential, and anaerobic and aerobic cultures. A white blood cell count of 2,500 to 3,000 and a differential of >60% segmented neutrophils is considered suspicious for infection, unless the aspiration is performed in the immediate postoperative period.[1,2]

In the setting of loose femoral components—most commonly loose

Table 1

American Academy of Orthopaedic Surgeons Femoral Bone Loss Classification[8]

Type	Description
I	Segmental defect
II	Cavitary defect
III	Combined segmental and cavitary defect
IV	Femoral malalignment (rotational or angular)
V	Femoral stenosis
VI	Femoral discontinuity

cemented stems—the proximal femur often remodels into varus and retroversion (ie, proximal femoral remodeling). Recognizing the potential for such remodeling preoperatively minimizes the risk of cortical perforation, intraoperative fracture, and undersizing of the implant. Extended trochanteric osteotomy (ETO) is often useful at the time of revision, particularly in the setting of significant varus remodeling, a well-fixed uncemented implant, or a long column of cement below the stem.[3]

Plain radiographs often underestimate bone loss. CT is occasionally a useful adjunct for further defining the severity of femoral bone loss.[4] We recommend the use of CT for any cases that require further delineation of the bone loss pattern and any degree of femoral deformity that may influence the plan for femoral reconstruction.

Preoperative Planning

Surgical Approach

The surgical approach for revision surgery is based on surgeon experience and utility of the planned reconstruction. Selection of surgical approach is also influenced by additional exposure (ie, osteotomy), degree and location of bone deficits, presence of distorted anatomy (eg, heterotopic ossification), and patient factors (eg, high risk of instability). The posterolateral approach is most commonly used. It affords excellent acetabular and femoral exposure; however, it is associated with higher postoperative instability.

The locations and configurations of femoral osteotomy vary considerably. Standard single plane, trochanteric slide, Wagner, and extended trochanteric are types of osteotomy performed about the greater trochanter.[5]

The ETO, which is most commonly used in the setting of revision THA, facilitates acetabular exposure and femoral component removal.[6] The results of ETO in femoral revision THA have been favorable. Paprosky and Sporer[6] evaluated 122 revision THAs performed with the use of an ETO and reported a 98% union rate of the osteotomized fragment at a mean 2.6-year follow-up.

Femoral Component Removal

During preoperative planning, it is important to identify key osseous and functional structures that are at risk during implant removal. In addition, the surgeon must have at the ready implants that would allow reconstruction in the event that greater bone loss than anticipated is discovered intraoperatively.

To facilitate stem removal, the following instruments should be on hand: manufacturer-specific explant tools, flexible osteotomes, trephines, high-speed burrs (eg, pencil tip, carbide tip, metal cutting wheel), ultrasonic cement removal instruments, and universal extraction tools that allow attachment to the stem or taper. The decision to remove a well-fixed implant must be made carefully.[7]

Femoral Bone Loss Classifications

The American Academy of Orthopaedic Surgeons introduced a femoral bone loss classification based on the presence of segmental, cavitary, or combined defects[8,9] (Table 1). This classification is simple in its organization; however, it is not quantitative and its practical application is limited. We find the Paprosky classification to be the most useful for describing femoral bone loss.[9-11]

The Paprosky classification is based on the location of femoral bone loss (metaphyseal or diaphyseal), degree of remaining support of the proximal femur (ie, degree of cancellous bone loss), and the amount of isthmus remaining for diaphyseal fixation (Table 2). These three variables allow for objective assessment of bone loss and provide reconstructive options based on the pattern of femoral bone loss.[9,10]

With type I femoral bone loss, the proximal metaphyseal bone is maintained, and proximal femoral remodeling typically is not exhibited. Type I defects can be managed with standard length cemented or uncemented implants. We prefer to manage type I defects with a standard length extensively porous-coated implant[9,10] (Figure 1).

Type II femoral defects are the most common type. These demonstrate absent metaphyseal bone loss with an intact diaphysis. Slight proximal varus femoral remodeling is common. Excellent results have been reported using extensively porous-coated femoral implants[9,10] (Figure 2).

Type III defects are subclassified as either type IIIA or IIIB. Both type III defects exhibit metadiaphyseal bone loss with significant proximal femoral remodeling. Type IIIA defects have ≥4 cm of isthmus remaining for

Table 2

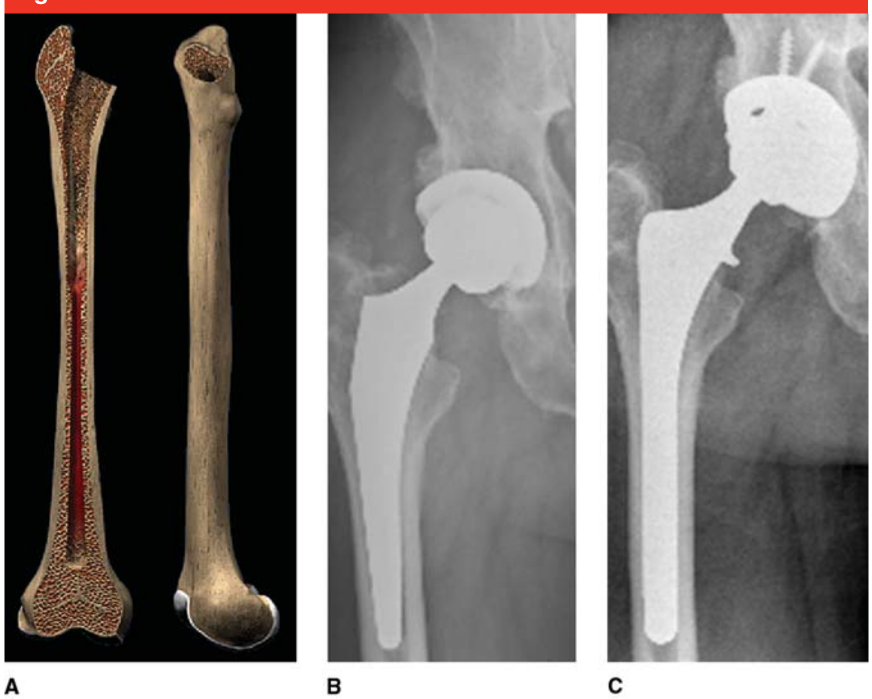
Paprosky Classification of Femoral Bone Loss[9]

Type	Definition	Proximal Metaphysis	Diaphysis	Proximal Remodeling	Reconstruction Options
I	Minimal proximal metaphyseal bone loss	Intact	Intact	None	Uncemented fixation; proximal fitting (ie, S-ROM [DePuy]) or extensively porous-coated stem
II	Moderate to severe proximal metaphyseal bone loss	Absent	Intact	Slight	Extensively porous-coated stem
IIIA	Severe proximal metaphyseal bone loss with diaphysis intact for some distance	Absent	≥4 cm of isthmus	Significant	Extensively porous-coated stem if <19 mm in diameter. If ≥19 mm in diameter, then modular tapered stem.
IIIB	Severe proximal metaphyseal bone loss with diaphysis intact for some distance	Absent	<4 cm of isthmus	Significant	Modular tapered stem
IV	Complete loss of metaphyseal and diaphyseal bone	Absent	Absent	Slight	Allograft prosthetic composite, cemented stem, or impaction grafting plus cemented stem

distal fixation (Figure 3), whereas type IIIB defects have <4 cm remaining[9,10] (Figure 4). Treatment options for type III defects include extensively porous-coated cylindrical stems, corundumized tapered stems with splines (eg, circumferential fluted projections around the tapered stem that confer rotational stability of the implant), and cemented stems with impaction bone grafting. Our preference is to manage type IIIA defects with an extensively porous-coated stem and type IIIB defects with a modular tapered stem with antirotational splines. In general, these tapered stems can obtain predictable fixation with only 1 to 2 cm of diaphyseal bone contact.

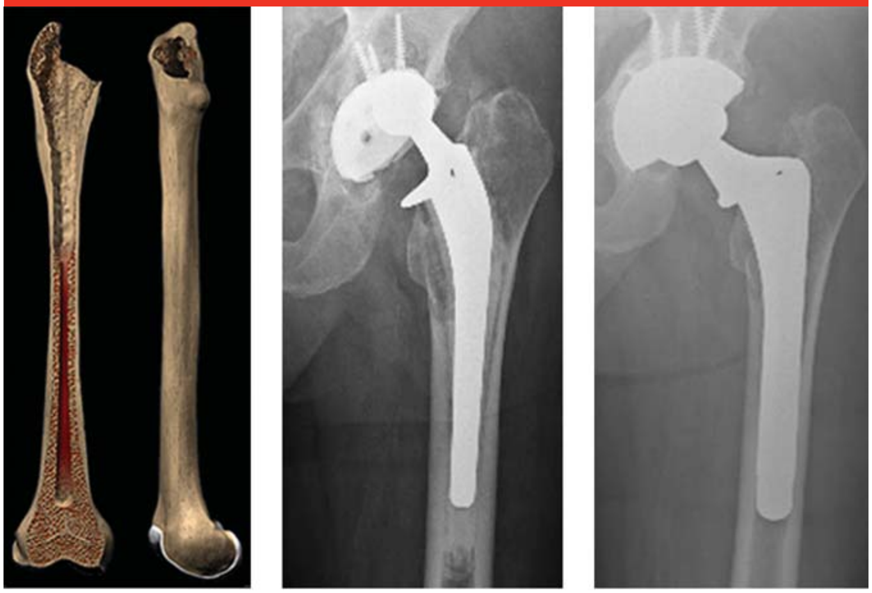
Type IV defects exhibit complete loss of the isthmus with little proximal femoral remodeling[9,10] (Figure 5). Biologic fixation is unlikely, and reconstruction typically requires the use of an allograft prosthetic composite (APC), a long cemented stem, impaction grafting with a long cemented femoral component, or proximal femoral replacement.

Figure 1



A, Illustration of a Paprosky type I femoral defect. Preoperative (**B**) and postoperative (**C**) AP radiographs of a patient treated with an extensively porous-coated stem at the time of two-stage reimplantation to manage periprosthetic infection and Paprosky type I bone loss. (Panel A courtesy of DePuy, Warsaw, IN.)

Figure 2



A B C

A, Illustration of Paprosky type II femoral defect. Preoperative (**B**) and postoperative (**C**) AP radiographs of a patient treated with an extensively porous-coated femoral stem to manage a loose cemented stem and Paprosky type II bone loss. (Panel A courtesy of DePuy, Warsaw, IN.)

Clinical Results by Reconstruction Method

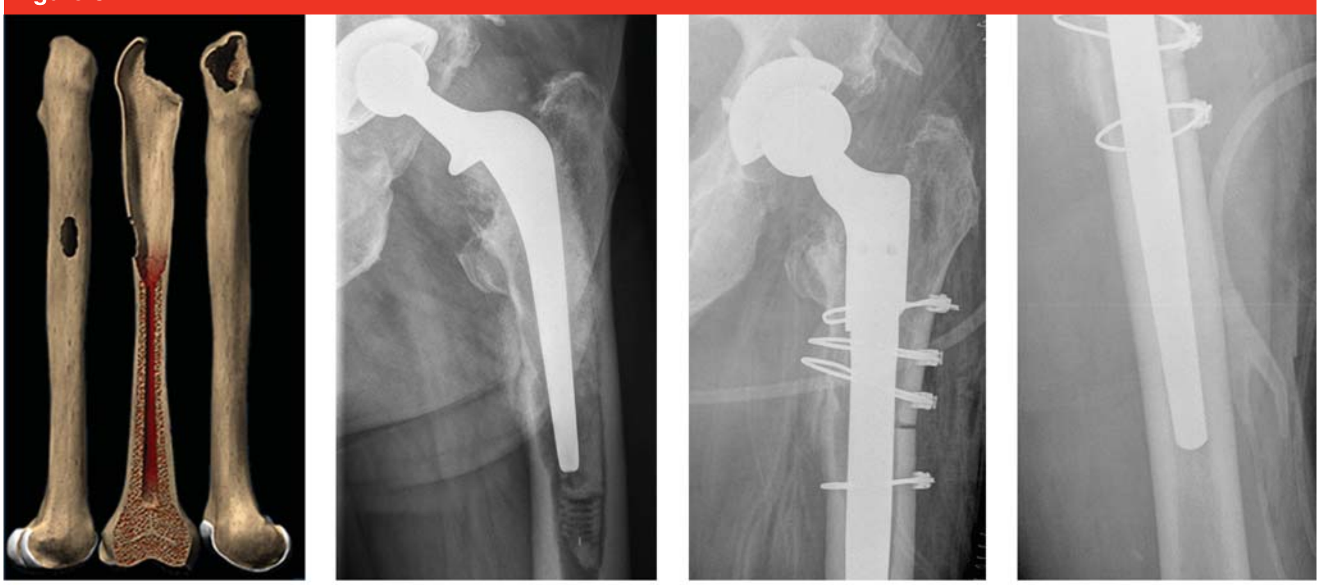
The goals of femoral component revision are to achieve rotational and axial component stability while restoring hip biomechanics. Cemented femoral revisions have demonstrated failure rates as high as 19%, compared with 4% to 6% with uncemented revisions, which rely on 4 to 6 cm of diaphyseal fixation.[12,13] When possible, uncemented biologic fixation is the preferred method of reconstruction (Table 3); however, it may be necessary to use cemented fixation (Table 4).

Uncemented Revision

Proximally Porous-coated Femoral Components

Proximally porous-coated uncemented stems can be used for revision THA in cases of minimal proximal metaphys-

Figure 3



A B C D

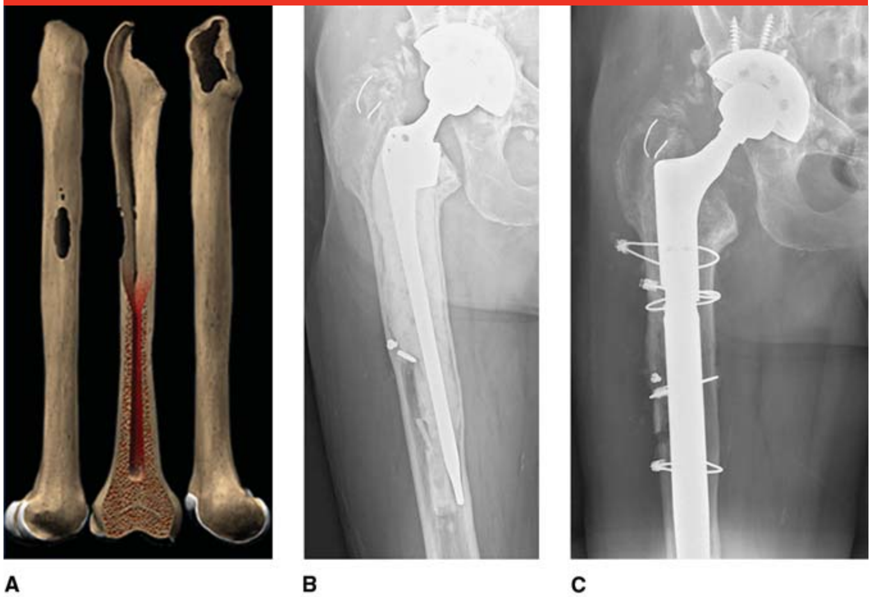
A, Illustration of a Paprosky type IIIA femoral defect. **B,** Preoperative AP radiograph of a Paprosky type IIIA defect with >4 cm of isthmus remaining for diaphyseal fixation. **C** and **D,** Postoperative AP radiographs of a patient treated with a size 20 modular tapered stem to manage an aseptically loose cemented femoral component. An extensively porous-coated stem was not chosen because of the large diameter needed for femoral reconstruction. (Panel A courtesy of DePuy, Warsaw, IN.)

eal bone loss (ie, Paprosky type I).[29] In the setting of proximal bone loss, multiple reports have indicated difficulty in obtaining stable proximal metaphyseal fixation. Berry et al[14] assessed 375 femoral revisions performed using proximally porous-coated femoral components. At 8-year follow-up, the mean survivorship was only 52%, using aseptic loosening as an end point. Poor survivorship was directly correlated with the degree of preoperative bone loss and poor integrity of the remaining proximal metaphyseal cancellous bone.

Proximally Modular Femoral Components

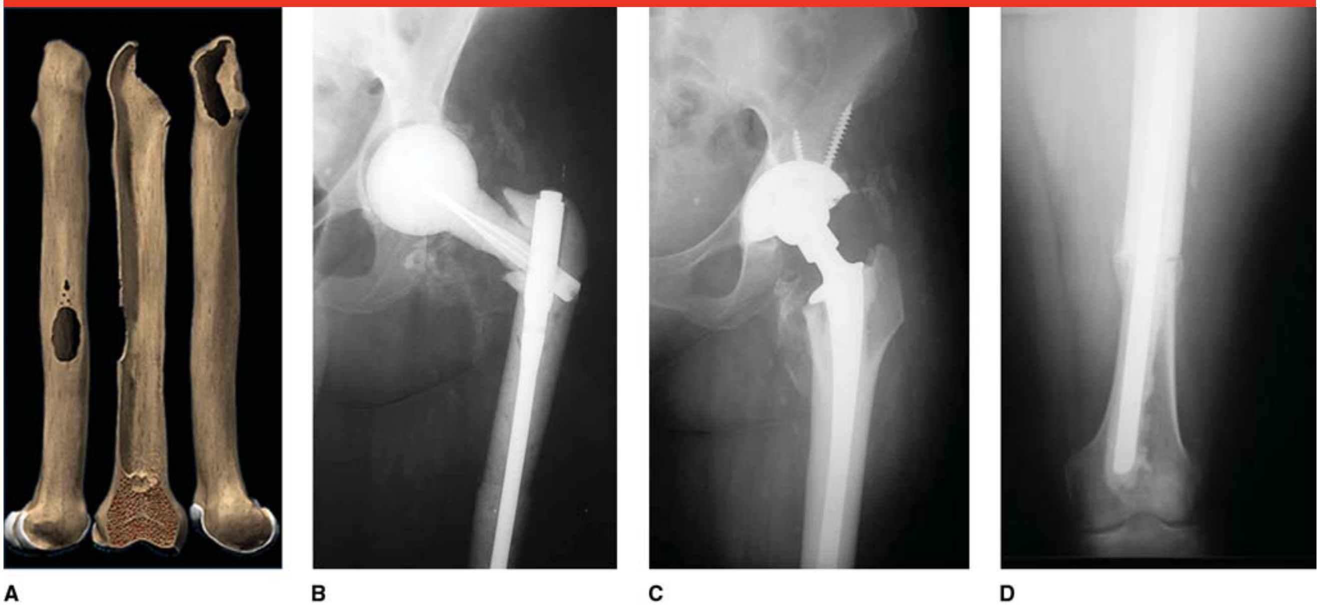
The inherent difficulty in achieving adequate initial implant stability with a monoblock proximally coated stem during femoral revision has resulted in increased enthusiasm for the use of proximally modular femoral components such as the S-ROM prosthesis (DePuy). These implants consist of a press-fit metaphyseal sleeve into which a slotted diaphyseal segment is inserted. This design allows for the metaphysis to be precisely milled to match the proximal sleeve and accommodates fluted diaphyseal stems of differing lengths

Figure 4



A, Illustration of a Paprosky type IIIB femoral defect. **B,** Preoperative AP radiograph demonstrating a loose cemented femoral stem with Paprosky type IIIB bone loss. **C,** AP radiograph following implantation of a modular tapered stem with <4 cm of isthmus remaining for diaphyseal fixation. (Panel A courtesy of DePuy, Warsaw, IN.)

Figure 5



A, Illustration of a Paprosky type IV femoral defect. **B,** Preoperative AP radiograph demonstrating Paprosky type IV bone loss secondary to periprosthetic infection. **C** and **D,** Postoperative AP radiographs following reimplantation with an allograft-prosthesis construct to manage the bone loss. (Panel A courtesy of DePuy, Warsaw, IN.)

Table 3

Results of Uncemented Reconstruction by Type of Bone Loss

Study	No. of Hips	Stem Type
Berry et al[14]	375	Proximal metaphyseal fitting
Cameron[15]	320	Proximal modular (S-ROM [DePuy])
Weeden and Paprosky[16]	170	Extensively porous-coated
Sporer and Paprosky[17]	51	Extensively porous-coated
Park et al[18]	62	Modular tapered
Garbuz et al[19]	Modular tapered stem, 31. Extensively porous-coated stem (Solution [DePuy]), 189.	Modular tapered vs extensively porous-coated
Richards et al[20]	Modular tapered stem, 103. Extensively porous-coated stem, 114.	Modular tapered vs extensively porous-coated
Grünig et al[21]	38	Nonmodular tapered
Isacson et al[22]	43	Nonmodular tapered

N/A = not applicable

[a] Paprosky classification unless otherwise noted.

[b] Class I, partial or complete cortical loss above the level of the lesser trochanter; class II, partial or complete cortical loss above a point 10 cm below the lesser trochanter; class III, partial or complete cortical loss >10 cm below the lesser trochanter.

[c] Class I, bone below the lesser trochanter is intact, and generally, a primary stem can be used; class II, subtrochanteric bone is damaged significantly and requires the use of a long stem; class III, >70 mm of the proximal femur is completely missing, which requires the use of a structural allograft.

[d] Different Paprosky classification: type 1, minimal metaphyseal and diaphyseal loss; type 2A, absent calcar below the intertrochanteric line; type 2B, absent anterolateral metaphyseal bone; type 2C, absent calcar and posteromedial bone; type 3A, B, and C, same as type 2A, B, and C but with diaphyseal extension.

and configurations. Proximal modularity also addresses proximal femoral retroversion by allowing version to be dialed in separately. Unlike proximally coated nonmodular components, the results of femoral revisions with these prostheses have been favorable.

Cameron[15] reported on 320 revisions performed with S-ROM stems (109 short, 211 long). At a mean follow-up of 7 years (range, 2 to 12 years), there were no reported revisions for aseptic loosening in the short stem group and only 3 in the long stem group (1.4%). Subsidence was >5 mm in only two hips (0.6%), and there were no cases of distal osteolysis. The author concluded that proximally coated, proximally modular stems can be used successfully in the setting of femoral revision.

Extensively Porous-coated Femoral Stems

Extensively porous-coated stems have been the workhorse for femoral revision THA. In general, 6-inch stems are sufficient for most type II and IIIA femoral defects. However, when using longer, bowed stems (eg, 8 in, 10 in), it is important to ensure adequate hip stability because suboptimal stem anteversion may be dictated as a consequence of the femoral bow.

Weeden and Paprosky[16] evaluated 170 revisions over a mean of 14.2 years. The femoral defects were classified as type I (11%), type II (30%), type IIIA (48%), and type IIIB (11%). The overall mechanical failure rate, that is, the percentage of stems that required revision surgery or were radiographically unstable, was 4.1%. Eighty-two percent of hips had radiographic evidence of bone ingrowth, and 14% had stable fibrous fixation. Four percent were unstable radiographically. There was a high rate of failure (21%) with worsening bone loss (type IIIB), and

Table 3 (continued)

Results of Uncemented Reconstruction by Type of Bone Loss

Bone Loss Classification[a]	Mean Clinical Follow-up	Re-revision Rate (%)	Survivorship
Minimal, 49; class I, 60; class II, 218; class III, 38;[b] periprosthetic fractures, 10	4.7 y	16	52% at 8 y. Worse preoperative bone loss correlated with poorer survivorship.
Class I, 109; classes II and III, 211[c]	7 y	Class I, none; class II and III, 1.4	N/A
Type I, 18; type II, 51; type IIIA, 82; type IIIB, 19	14.2 y	Overall failure rate, 4.1. Failure rate with type IIIB bone loss, 21.	N/A
Type IIIA, 17; type IIIB, 26 (15 with ≤19 mm canal diameter, 11 with >19 mm canal diameter); type IV, 8	4.2 y	Type IIIA, none; type IIIB (≤19 mm canal diameter), 6.7; type IIIB (>19 mm canal diameter), 27.3; type IV, 25	N/A
Type IIIA, 37; type IIIB, 19	4.2 y	None	N/A
Modular group: type I, 4; type II, 5; type IIIA, 29; type IIIB, 58; type IV, 7. Nonmodular group: type I, 1; type II, 15; type IIIA, 60; type IIIB, 31; type IV, 4.	Modular, 37 mo; nonmodular, 49 mo	Quality of life measures better with modular tapered stems	N/A
Modular group: types IIIB and IV, 65. Nonmodular group: types IIIB and IV, 35.	23 mo for each	Quality of life measures better with modular tapered stems	N/A
Type 1, 1; type 2A, 6; type 2B, 6; type 2C, 5; type 3A/B/C, 9[d]	47 mo	7.5, to manage stem subsidence (3 of 40)	N/A
—	25 mo	18.6, due to subsidence and instability	N/A

N/A = not applicable

[a] Paprosky classification unless otherwise noted.

[b] Class I, partial or complete cortical loss above the level of the lesser trochanter; class II, partial or complete cortical loss above a point 10 cm below the lesser trochanter; class III, partial or complete cortical loss >10 cm below the lesser trochanter.

[c] Class I, bone below the lesser trochanter is intact, and generally, a primary stem can be used; class II, subtrochanteric bone is damaged significantly and requires the use of a long stem; class III, >70 mm of the proximal femur is completely missing, which requires the use of a structural allograft.

[d] Different Paprosky classification: type 1, minimal metaphyseal and diaphyseal loss; type 2A, absent calcar below the intertrochanteric line; type 2B, absent anterolateral metaphyseal bone; type 2C, absent calcar and posteromedial bone; type 3A, B, and C, same as type 2A, B, and C but with diaphyseal extension.

the intraoperative fracture rate with stem insertion was 8.8%.

The limitations of extensively porous-coated stems in the setting of femoral revision were identified by Sporer and Paprosky[17] in a study of 51 patients with type III or IV femoral bone defects. No failures were reported in the 17 femurs with type IIIA defects. One failure was reported in the 15 patients with type IIIB defects and femoral canals <19 mm in diameter (6.7%), and an 18% rate of mechanical failure (ie, revision for aseptic loosening or radiographic evidence of instability) was reported in patients with type IIIB defects and femoral canals >19 mm in diameter (2 of 11). Additionally, three of eight patients with type IV defects treated with extensively porous-coated stems experienced mechanical failure. These authors recommended use of a modular tapered stem or impaction bone grafting in type IIIB defects with canals >19 mm in diameter and in type IV defects.

Tapered Stems

Enthusiasm for tapered stems has grown in the past decade, and they arguably have become the new workhorse for femoral revision surgery in the setting of advanced bone loss. Tapered stems can be nonmodular or modular. Final seating of these devices is sometimes difficult to predict during bone preparation. Modular designs allow more predictable restoration of length, offset, and version. However, concerns exist related to stem fracture at the Morse taper with these designs.

Modular Tapered Stems

Modular tapered revision femoral components have been successfully used in the reconstruction of femurs with moderate to severe proximal bone loss. Park et al[18] followed 62

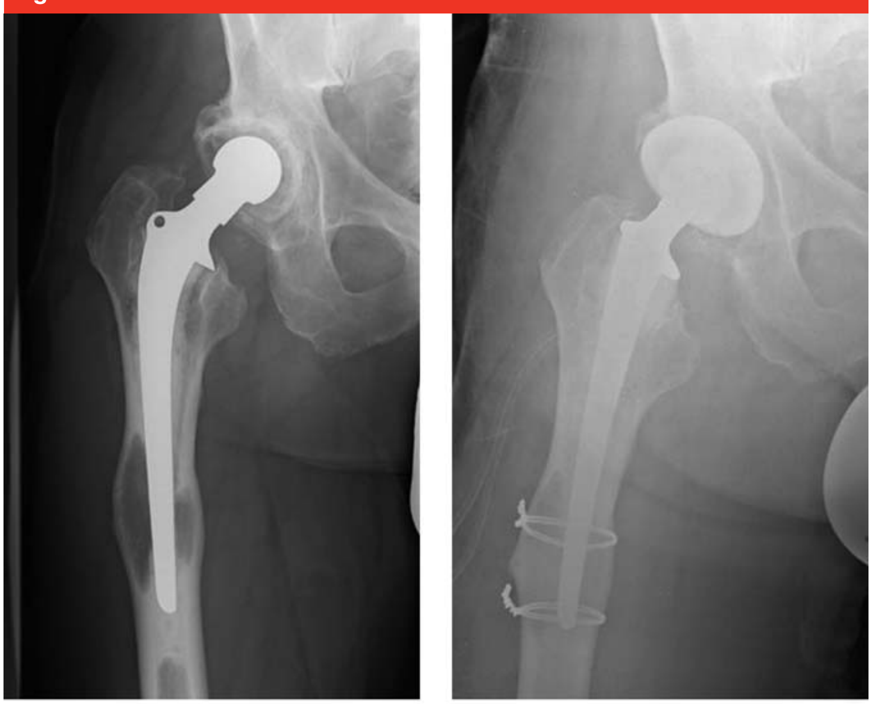
Table 4

Results of Cemented Reconstruction by Type of Bone Loss

Study	No. of Hips	Type of Reconstruction	Stem Type
Ornstein et al[23]	1,305	Cemented impaction grafting	Polished cemented
Blackley et al[24]	63	Cemented APC	Cemented
Safir et al[25]	50	Cemented APC	Cemented
Babis et al[26]	57	Cemented APC	Cemented
Malkani et al[28]	50	Cemented	Proximal femoral replacement
Haentjens et al[27]	16	Cemented	Proximal femoral replacement

APC = allograft prosthesis composite, N/A = not applicable
[a] Paprosky classification unless otherwise noted.
[b] AAOS classification of femoral bone loss: level I, bone loss up to the level of the lesser trochanter; level II, bone loss up to 10 cm distal to the lesser trochanter; level III, bone loss distal to 10 cm below the lesser trochanter (this also depicts loss of host-prosthesis contact with the need for structural bone graft).

Figure 6



A B

A, Preoperative AP radiograph demonstrating femoral bone loss secondary to osteolysis. **B,** Postoperative AP radiograph following treatment with impaction grafting.

femoral revisions using a fluted modular tapered component for a mean of 4.2 years (range, 2 to 7.8 years). Thirty-seven (60%) were classified as Paprosky type IIIA, and 19 (31%) were type IIIB. None of the patients in this cohort required revision due to mechanical failure at final follow-up.

In similarly designed studies, Garbuz et al[19] and Richards et al[20] compared the results of tapered, fluted, modular titanium femoral components with cylindrical nonmodular cobalt chrome stems in revision arthroplasty. Both studies reported superior results with the modular tapered components. Richards et al[20] found that although the modular tapered cohort had worse preoperative bone defects (65% Paprosky types IIIB and IV femurs versus 35% in the nonmodular group), they had better clinical outcome scores (ie, Western Ontario and McMaster Universities Osteoarthritis Index, Oxford Hip Score, satisfaction), fewer intraoperative fractures, and better restoration of the proximal femoral host bone. Overall, modular tapered femoral components have shown excellent promise in short- to midterm studies for revision THA in patients with substantial proximal bone loss. These stem designs are widely used in revision THA, and longer-term

Table 4 (continued)

Results of Cemented Reconstruction by Type of Bone Loss

Bone Loss Classification[a]	Clinical Follow-up in Years	Re-revision Rate (%)	Survivorship
—	Range, 5–18	5.4	94% for women and 94.7% for men at 15 y
Level II and III bone loss[b]	Mean, 11	27 (graft resorption in 13 of 48 hips)	77% at final follow-up
—	Mean, 16.2	14	N/A
Type IV, 55	Mean, 12	33	69% at 10 y. Survivorship decreased with worse bone loss (ie, type IV).
Type IV, 33	Mean, 11.1	32	64% at 12 y
Not reported	Mean, 5	Not reported	N/A

APC = allograft prosthesis composite, N/A = not applicable
[a] Paprosky classification unless otherwise noted.
[b] AAOS classification of femoral bone loss: level I, bone loss up to the level of the lesser trochanter; level II, bone loss up to 10 cm distal to the lesser trochanter; level III, bone loss distal to 10 cm below the lesser trochanter (this also depicts loss of host-prosthesis contact with the need for structural bone graft).

studies are needed to determine their efficacy.

Nonmodular Tapered Stems

Elimination of the modular junction in femoral component revision decreases the risk of stem fracture, fretting corrosion, metallosis, and resultant osteolysis. However, the lack of modularity makes proper component position and restoration of hip biomechanics more difficult. Grünig et al[21] evaluated 38 revisions performed with one particular nonmodular tapered stem. At a mean follow-up of 47 months, 3 (8%) of 38 hips required revision for stem subsidence, and an additional 16 stems had subsided <1 cm by 3-month follow-up. This early subsidence did not appear to affect clinical outcome, and the authors recommended protected early weight bearing.

Isacson et al[22] reported results using the same type stem in 43 hips. At a mean follow-up of 25 months, 22 of 23 patients (96%) showed abundant new bone formation. However, 5 of 42 patients (12%) had subsidence >20 mm, and 22 (52%) had subsidence <5 mm. There were nine dislocations, of which eight required re-revision to manage instability.

Cemented Revision

Impaction Grafting

Impaction grafting is performed in an attempt to restore bone stock in young or active patients with severe proximal bone loss (ie, Paprosky type IIIB or IV defects). The old stem is extracted, and the canal is débrided of all previous cement, neocortex, and fibrous tissue or endosteal membrane. Deficient cortices are reinforced as necessary with any combination of wire mesh, strut allograft, and cerclage wires. A plug is placed distally, and morcellized cancellous allograft is tightly packed into the canal using cannulated tamps and broaches over a guide rod. The revision stem (typically a polished tapered stem) is then cemented into the reconstituted femur.

Initial reports on impaction grafting described variable outcomes. Centers with significant experience with this technique reported very good short- and intermediate-term results; however, many other centers reported high rates of femoral component subsidence as well as intraoperative or early postoperative femoral fracture. Some recent studies have demonstrated satisfactory long-term results with a high level of construct survivorship.

Ornstein et al[23] evaluated 1,188 revisions performed with impaction grafting using a polished Exeter stem (Stryker). The original cohort consisted of 1,305 revisions. Clinical and radiographic follow-up ranged from 5 to 18 years. Only 70 cases required re-revision (5.9%). The survivorship at 15 years was 94.0% for women and 94.7% for men, using any reason for revision as an end point. Survivorship at 15 years was 99.1% for aseptic loosening, 98.6% for infection, 99% for subsidence, and 98.7% for fracture. Overall, long-term results of impaction grafting are encouraging, but proper patient selection is required, and the procedure is labor intensive, requiring adequate surgeon experience (Figure 6).

Allograft Prosthetic Composite

The use of an APC should be considered in the setting of severe circumferential femoral bone loss. With this technique, the deficient proximal femur is osteotomized and removed. A long-stem prosthesis then is cemented into the bulk proximal femoral allograft, and this APC is mated to the host bone while the distal part of the stem is press-fit or cemented into the host femoral canal. Stable fixation between the APC and host is enhanced by press-fitting the distal stem and by creating a step cut at the APC-host interface, thereby increasing the surface area for creeping substitution. Cerclage wires are also used to enhance junctional stability.

Advantages of reconstruction with an APC over a proximal femoral prosthesis include the ability to restore bone stock in young patients and the ability to reattach host soft tissues. One disadvantage is the potential for disease transmission. The risk of viral transmission with fresh-frozen, unprocessed allograft is approximately 1 in 500,000 (range, 440,000 to 600,000).[30] There is also a risk of secondary bacterial infection. Other disadvantages include difficulty obtaining the appropriate allograft, the risk of nonunion or graft resorption, and greater technical demands.[31]

Several studies, most from the orthopaedic oncology literature, have reported encouraging results with the use of this technique in revision THA, although most demonstrate short-term clinical follow-up. Blackley et al[24] reported on 63 consecutive revisions using an APC construct. With a mean follow-up of 11 years (range, 9 years 4 months to 15 years), the success rate was 77% for the 45 patients who were alive at the latest follow-up. The nonunion rate was 6% at the host-allograft junction, and all patients required treatment with autograft. Allograft resorption was seen in 27% of patients who were followed for at least 9 years. Four of the 63 hips dislocated, and 2 of these required acetabular revision. Five hips developed deep infection, all of which required reoperation. There were only three cases of aseptic loosening, and all occurred at the implant-cement interface. The average time to loosening was more than 10 years.

Safir et al[25] recently published a retrospective study with an average clinical and radiographic follow-up of 16.2 years (range, 15 to 22 years). They reported the results of 50 hips out of an original cohort of 93. Seven APC constructs were revised for any reason. The authors concluded that proximal femoral allograft in revision THA is a durable option for most patients with severe femoral bone loss.

Babis et al[26] evaluated the use of APC in the setting of complex revision THA for severe proximal femoral bone loss. A total of 57 hips was available at a mean follow-up of 12 years (range, 8 to 20 years). APC survivorship at 10 years was 69%, with 19 hips (33.3%) requiring revision at a mean follow-up of 44.5 months (range, 11 to 153 months). Survivorship was significantly affected by the degree of preoperative bone loss (ie, Paprosky type IV) (P = 0.019), the number of previous hip surgeries exceeding two (P = 0.047), and the length of the APC graft (P = 0.005). Satisfactory results were seen with the use of APC to manage severe proximal bone loss in revision THA.

Megaprosthesis (Proximal Femoral Replacement)

The use of proximal femoral–replacing prostheses (ie, megaprostheses) has substantial disadvantages and should be limited to elderly and low-demand patients with massive bone loss for whom the alternative is resection arthroplasty. Disadvantages include problems with fixation and early loosening,[11,32,33] instability secondary to inadequate soft-tissue attachment,[27,34] severe stress shielding and late fatigue fracture, limb-length discrepancy, sciatic nerve palsy, and cost.[35,36] Additionally, further loss of bone stock makes subsequent revision more challenging. The one advantage is that implantation can be done quickly, which makes this an attractive reconstructive option for elderly patients in poor health.

Few reports describe the use of megaprostheses in the setting of femoral revision THA. Malkani et al[28] published long-term results using a proximal femoral replacement for non-neoplastic disorders. Thirty-three of 50 hips were revised to address femoral bone loss. The mean clinical follow-up was 11.1 years (range, 5.1 to 18.8 years). Overall survivorship was 64% at 12 years. Sixteen components in 12 patients required revision for any reason (32%). Eleven hips dislocated (22%), 4 of which required re-revision. Additionally, 27% of patients had moderate to severe pain, and 48% of patients had a severe limp or were unable to walk. Harris Hip scores improved from 46 points preoperatively to 76 points at latest follow-up.

Haentjens et al[27] evaluated 16 patients treated with proximal femoral replacement for salvage of a failed THA. At a mean follow-up of 5 years (range, 2 to 11 years), all patients reported pain relief, but all patients also required an assistive device for ambulation. Four patients sustained an intraoperative fracture, seven had a dislocation, and two had deep infection. Given the high rate of complications and limited postoperative function provided by the megaprostheses, revision with this type of construct should be considered only as a salvage procedure.

Summary

Management of femoral bone loss during revision THA begins with proper preoperative evaluation. In patients who require femoral component revision, bone loss should be classified to help determine an appropriate prosthesis and fixation strategy. For Paprosky types I, II, and IIIA bone loss, cylindrical fully porous-coated uncemented femoral components have been associated with predictable long-term fixation. In our experience, type IIIB defects are generally best managed with modular tapered fluted stems; however, some centers have had good long-term results with impaction bone grafting. APC and megaprostheses should be considered part of the armamentarium for managing type IV femoral bone loss.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 2, 4, 6-29, and 31-36 are level II studies. Reference 1 is a level III study. Reference 3 is level V expert opinion.

References printed in **bold type** are those published within the past 5 years.

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