Classification and an Algorithmic Approach to the Reconstruction of Femoral Deficiency in Revision Total Hip Arthroplasty

By Craig J. Della Valle, MD, and Wayne G. Paprosky, MD

As the number of patients who have undergone total hip arthroplasty rises, the number of patients requiring revision surgery for a failed total hip arthroplasty increases as well. It is estimated that 183,000 total hip replacements were performed in the United States in 2000 and that 31,000 (17%) of these were revision procedures[1]. Femoral reconstruction at the time of revision total hip arthroplasty can be challenging both from a technical perspective and in terms of preoperative planning. With multiple reconstructive options available, it is helpful to have a classification system available to guide the surgeon in selecting the appropriate method of reconstruction. A system for the classification of

Fig. 1-A

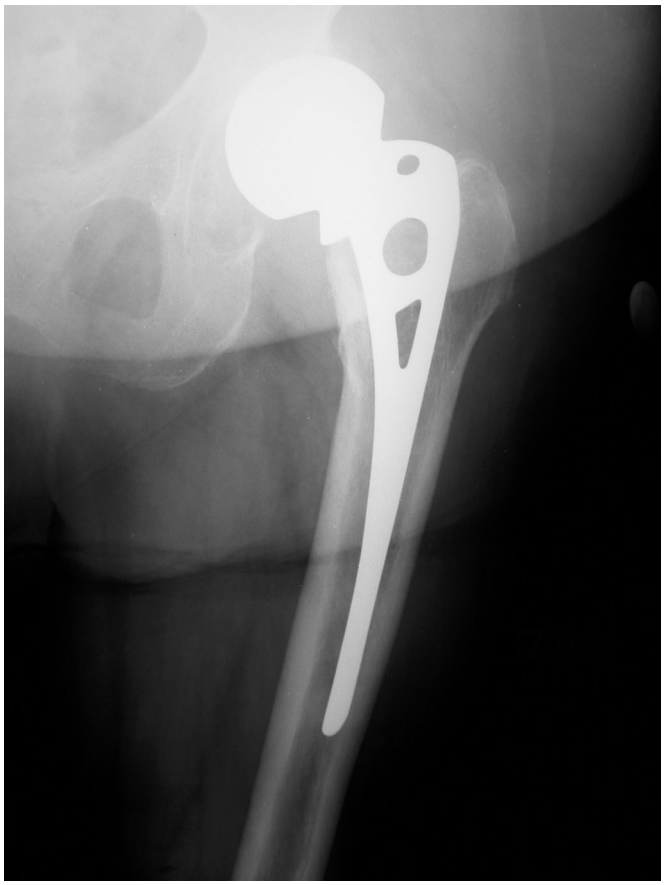

Fig. 1-B

Figs. 1-A and 1-B Type-I femoral deficiency. There is minimal loss of metaphyseal cancellous bone and an intact diaphysis.

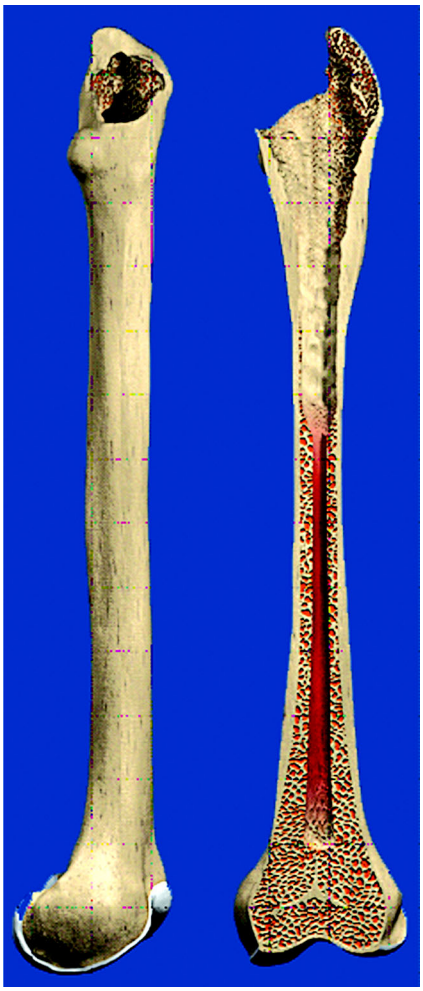

Fig. 2-A

Fig. 2-B

Figs. 2-A and 2-B Type-II femoral deficiency. There is extensive loss of metaphyseal cancellous bone and an intact diaphysis.

femoral deficiency that was developed by the senior author (W.G.P.)[2] and an algorithmic approach to femoral reconstruction are presented in the current report.

Methods

Seventy-one consecutive femoral revision arthroplasties that involved reconstruction with an extensively coated, diaphyseal fitting stem were reviewed at a minimum of eight years[2]. Component stability was classified with use of the system of Engh et al.[3]. Femoral deficiency was classified as follows.

Type I: A femur with a type-I defect has minimal loss of metaphyseal cancellous bone and an intact diaphysis. This type of defect often is seen after the removal of a cementless femoral component without a biological ingrowth surface (Figs. 1-A and 1-B).

Type II: A femur with a type-II defect has extensive loss of metaphyseal cancellous bone and an intact diaphysis. This type of defect often is encountered after the removal of a cemented femoral component (Figs. 2-A and 2-B).

Type IIIA: A femur with a type-IIIA defect is one in which the metaphysis is severely damaged and nonsupportive and there is >4 cm of intact diaphyseal bone available for distal fixation. This type of defect is commonly seen after the removal of a grossly loose femoral component that was inserted with first-generation cementing techniques (Figs. 3-A and 3-B).

Type IIIB: A femur with a type-IIIB defect is one in which the metaphysis is severely damaged and nonsupportive and there is <4 cm of diaphyseal bone available for distal fixation. This type of defect is often seen following the failure of a cemented femoral component that was inserted with a cement restrictor or a cementless femoral component that is associated with substantial distal osteolysis (Figs. 4-A and 4-B).

Type IV: A femur with a type-IV defect has extensive metaphyseal and diaphyseal damage in conjunction with a widened femoral canal. The isthmus is nonsupportive (Figs. 5-A and 5-B).

Extended Trochanteric Osteotomy

The extended trochanteric osteotomy is frequently utilized in

TABLE I Rates of Osseointegration According to Type of Femoral Deficiency

Type of Femoral Deficiency	No. of Osseointegrated Stems
I	8 of 9
II	26 of 29
IIIA	20 of 22
IIIB	4 of 8
IV	0 of 3

our practice during revision total hip arthroplasty[4-8]. It provides a wide exposure that facilitates the removal of existing implants and cement, allows for the correction of femoral deformity (which is seen in approximately one-third of patients undergoing femoral revision in our practice), and facilitates the implantation of revision components while allowing the surgeon to reconstitute bone-stock deficiency if necessary. The osteotomy site heals predictably as the overlying soft-tissue attachments are only minimally disrupted, and the trochanter can be advanced distally if needed. The extended trochanteric osteotomy can be done prior to dislocation to assist with exposure; after dislocation but prior to femoral component removal to allow for safe component extraction; or after femoral component removal to allow for deformity correction, to assist with the removal of retained cement, or to facilitate preparation of the femoral canal.

Results

Ninety-six percent of the femoral components were bone ingrown or had fibrous stable fixation. The rates of osseointegration achieved in association with the various types of femoral deficiency are shown in Table I. When complete diaphyseal fill was obtained, fifty-one (96%) of fifty-

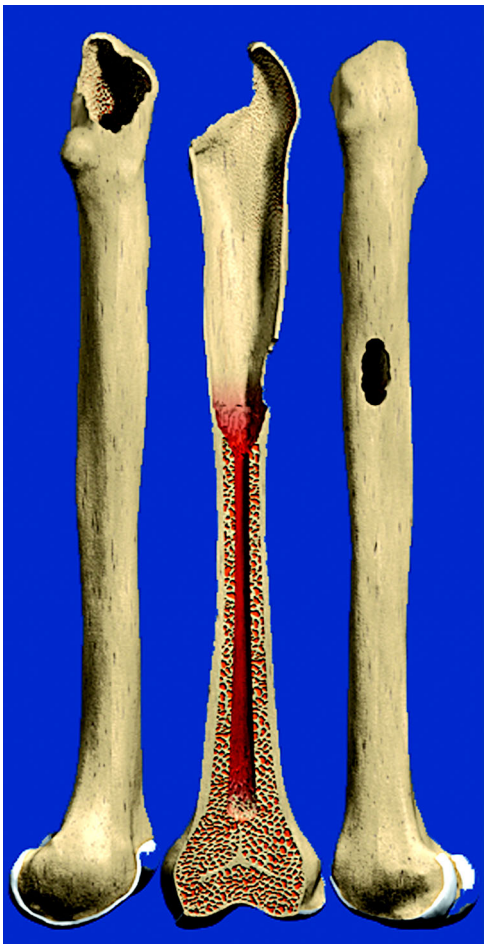

Fig. 3-A

Fig. 3-B

Figs. 3-A and 3-B Type-IIIA femoral deficiency. The metaphysis is severely damaged and nonsupportive, with >4 cm of intact diaphyseal bone available for distal fixation. The horizontal lines on the radiograph demarcate the amount of femoral isthmus available for distal fixation.

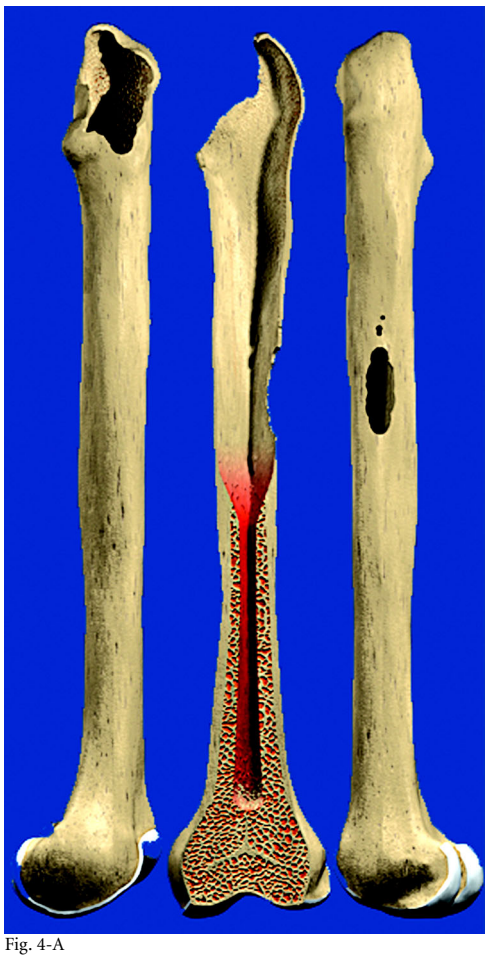

Fig. 4-A

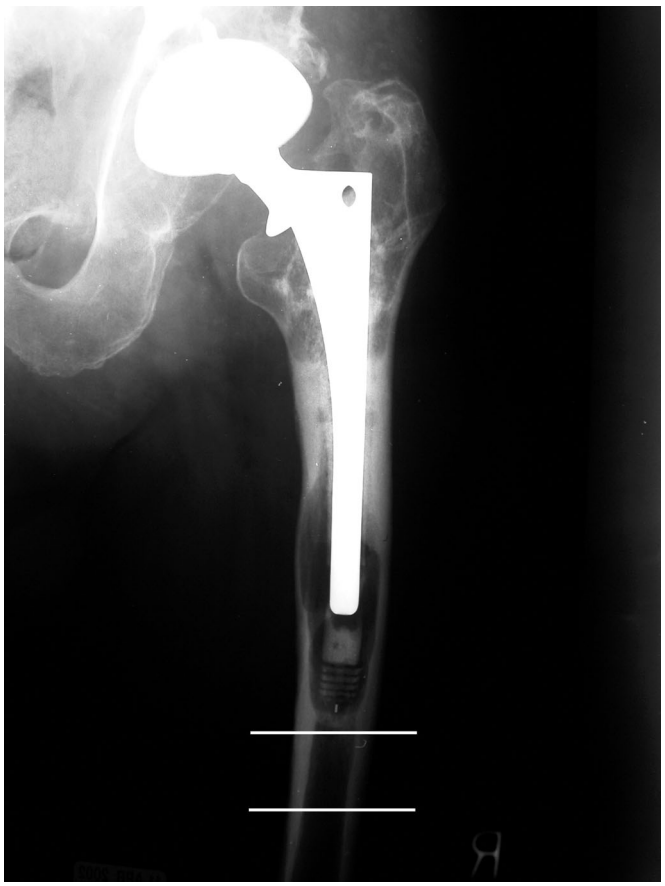

Fig. 4-B

Figs. 4-A and 4-B Type-IIIB femoral deficiency. The metaphysis is severely damaged and nonsupportive, with <4 cm of diaphyseal bone available for distal fixation. The horizontal lines on the radiograph demarcate the amount of femoral isthmus available for distal fixation.

three stems in femora with type-I, II, and IIIA defects had bone ingrowth.

Discussion

An extensively porous-coated, diaphyseal fitting femoral component reliably achieves successful fixation in the majority of patients undergoing revision arthroplasty[9-11]. The surgical technique is straightforward, and we continue to use this type of device for most revision total hip arthroplasties. However, in the case of a severely damaged femur (that is, a femur with a type-IIIB or IV defect), other reconstructive options may provide improved results. On the basis of our results, the following reconstructive algorithm is recommended for femoral reconstruction at the time of revision total hip arthroplasty.

Type I: In a femur with a type-I defect, there is minimal loss of cancellous bone and an intact diaphysis and thus cemented or cementless fixation can be utilized. If cemented fixation is selected, great care must be taken during removal of the often-encountered neocortex to allow for appropriate cement intrusion into the remaining cancellous bone[12].

Type II: In a femur with a type-II defect, there is extensive loss of metaphyseal cancellous bone and thus fixation with cement is unreliable[13]. In the present study, successful fixation of an extensively porous coated, diaphyseal fitting implant was achieved in twenty-six (90%) of twenty-nine femora with a type-II defect. However, as the metaphysis is supportive, a cementless implant that achieves primary fixation in the metaphysis can be utilized[14].

Type IIIA: In a femur with a type-IIIA defect, the metaphysis is nonsupportive and an extensively coated stem of adequate length should be utilized to ensure that >4 cm of scratch fit is obtained in the diaphysis. In the current series, this technique was successful in twenty (91%) of twenty-two reconstructions. We believe that this type of implant is most appropriate in these cases.

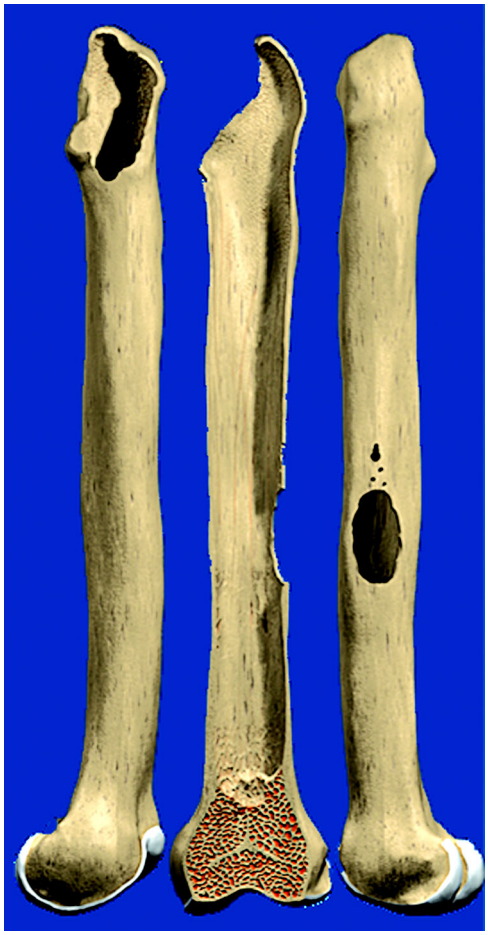

Fig. 5-A

Fig. 5-B

Figs. 5-A and 5-B Type-IV femoral deficiency. There is extensive metaphyseal and diaphyseal damage in conjunction with a widened femoral canal. The isthmus is nonsupportive.

Type IIIB: On the basis of the poor results that were obtained in association with the use of a cylindrical, extensively porous-coated implant (with four of eight reconstructions failing), our current preference is to treat type-IIIB defects with a modular, cementless, tapered stem with flutes to obtain rotational stability. Excellent results have been reported in association with this type of implant[15] and, by virtue of its tapered design, the stem can achieve excellent initial axial stability even in a femur with a very short isthmus. Subsidence has been reported as a potential problem with these implants, and they can be difficult to insert. However, with the addition of modularity to many systems that employ this concept of fixation, improved stability can be achieved by impacting the femoral component as far distally as needed and then building up the proximal segment to restore the appropriate leg length.

Type IV: In a femur with a type-IV defect, the isthmus is completely nonsupportive and the femoral canal is widened. We have found that cementless fixation cannot be reliably used in such cases because it is difficult to obtain adequate initial implant stability to allow for osseointegration. Reconstruction can be performed with impaction grafting[16-18] if the cortical tube of the proximal part of the femur is intact. This technique, however, can be difficult to perform, time-consuming, and costly given the amount of bone graft that is often required. Although this technique has been associated with implant subsidence[19,20] and periprosthetic fracture[16,21-23] (both intraoperatively and postoperatively), it can provide an excellent solution for difficult femoral revisions when cementless fixation cannot be utilized. Alternatively, an allograft-prosthesis composite can be utilized in an attempt to reconstitute bone stock for younger patients[24], whereas a proximal femoral replacing endoprosthesis can be used for more elderly patients[25]. ■

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The authors did not receive grants or outside funding in support of their research or preparation of this manuscript. They did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. A commercial entity (Zimmer) paid or directed, or agreed to pay or direct, benefits to a research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

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