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Reconstruction of Major Segmental Loss of the Proximal Femur in Revision Total Hip Arthroplasty

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Reconstruction of major proximal femoral segmental defects is one of the most difficult challenges in revision total hip arthroplasty (THA). One technique that has been successful is the use of a modular, long-stemmed prosthesis, cemented to an allograft proximal femur and press-fit to the host bone. Since July 1989, the authors have used this technique in 30 hips (29 patients). The trochanteric slide approach was used in all cases. Sixty pounds of weight bearing was encouraged for six weeks, then full weight bearing as tolerated. The mean follow-up period was 22 months (range, two to 46 months). All but two grafts united to the host bone clinically and radiographically. Complications included five dislocations, one graft-host nonunion, one graft resorption, and one deep infection requiring resection arthroplasty. The latter patient was subsequently reconstructed successfully using the same technique. Although the follow-up period is short, the authors have been encouraged by the early success of these allograft-prosthetic composites. Advantages of this approach include rapid return to weight bearing, physiologic loading of the distal femur, and reconstitution of vital proximal bone stock.

One of the most difficult challenges in total hip arthroplasty (THA) is reconstruction of major segmental loss of the proximal femur. Small defects, proximal to the base of the lesser trochanter, are best dealt with using calcar replacement components.[1,36,43] Major defects extending more distally, however, present a complex surgical challenge for which conventional methods of reconstruction may prove inadequate.[19,34,35,45]

Several methods of dealing with proximal femoral deficiency have been advocated in the literature. These include resection arthroplasty,[16,41] extensively porous-coated stems that are distally fixed,[14,21,39] cemented proximal femoral replacement components,[27,31,34,41] and allograft-prosthetic composites.[5,17,18,20,22,25,35,43]

The technique of reconstruction using proximal femoral allograft-prosthetic composites is appealing because the procedure adds bone stock to the deficient femur while loading the remaining host bone in a physiologic manner. Technical questions exist as to how to optimally fix the component to the allograft and the allograft to the host femur. Ideally the construct should be strong enough to provide rapid mobilization and early weight bearing.

This study presents a technique for reconstruction of major segmental loss of the proximal femur using massive proximal femoral allograft combined with a modular long-stem femoral prosthesis.

MATERIALS AND METHODS

Between June 1989 and October 1992, 30 hips in 29 patients had reconstruction for major proximal femoral bone deficiency. There were 16 men

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and 13 women, with a mean age of 62 (range, 35–84 years). The primary diagnosis was degenerative arthritis in 19, posttraumatic arthritis in five, rheumatoid arthritis in two, avascular necrosis in two, Gaucher's disease in one, and slipped capital epiphysis in one. All patients had undergone at least one previous THA, and the mean number of prior hip operations for the group was four (range, one to 16). Five patients had previously undergone resection arthroplasty for sepsis, but none were infected at the time of reconstruction. The proximal femoral defects were formidable, ranging from 10 to 25 cm in length as measured from the tip of the greater trochanter.

Each patient was evaluated before and after surgery using the Harris Hip Rating System. Postoperative radiographs were examined by the authors for evidence of loosening of the prosthesis within the allograft or host bone, for allograft–host union, and for evidence of graft resorption. Radiolucency around the cemented metaphyseal unit or subsidence of the metaphyseal unit were considered evidence of loosening of the prosthesis within the allograft. Subsidence or radiolucency about the stem or subsidence of the entire construct was considered evidence of loosening within the host bone.

All of the surgical procedures were performed in the lateral position through a trochanteric slide approach or a modification thereof.[9] This approach leaves the abductors in continuity with the quadriceps, tethered to a fragment of the greater trochanter when this is present. An extraordinary exposure is provided to both the acetabulum and to the shaft of the femur, the greater trochanter is left with a proximal and distal blood supply, and the quadriceps prevents significant proximal migration of the greater trochanter should it fail to unite to the allograft. Fresh frozen proximal femoral allografts were used in all cases. The diaphysis of the allograft was reamed 2 mm larger than the selected component to lessen the chance of fracture as the curved stem was passed through it. The metaphysis of the allograft was prepared with instruments that were 2 mm larger than the zero tolerance (ZT) or zero tolerance textured (ZTT) unit to leave space for cement (Fig. 1). Allografts that were the same size or slightly larger than the host femur were selected to avoid excessive thinning of the allograft. An oscillating saw was used to remove structurally inadequate bone from the proximal host femur. The distal canal was usually reamed to the minor diameter of the selected stem. If most of the curved stem was to be in the host femur, the medullary canal was reamed 0.5 mm larger (Fig. 2). Liquid cement was forced into the proximal allograft and was liberally applied to the modular

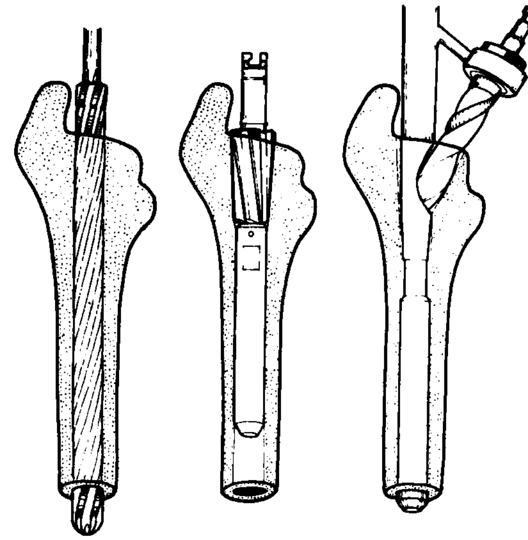

FIG. 1. The diaphysis of the allograft is reamed 2 mm larger than the selected component to lessen the chance of fracture as the curved stem is passed through it. The metaphysis of the allograft is prepared with instruments that are 2 mm larger than the zero tolerance or zero tolerance textured to leave space for cement.

metaphyseal unit. The sleeve then was selectively cemented to the allograft using the appropriate alignment instruments (Fig. 3). Trial components with the shortest available neck and head length were introduced into the allograft and reduced into the patient's acetabulum. With maximum traction on the host femur, the length of the allograft was determined. The allograft then was resected at this level. Extended stems were added to the trial components, and these were introduced into the host medullary canal. Appropriate rotation was noted and marked with methylene blue (Fig. 4). Both the allograft and host bone were protected by cerclage wires or cables to resist hoop stresses during insertion of the components. The final stem then was introduced into the allograft, and the Morse Taper of the metaphyseal unit engaged. The allograft–prosthesis composite then was introduced into the host femur in a press-fit fashion and impacted. An oscillating saw was used just before final seating to trim the interface if necessary (Fig. 5). The flutes of the distal stem were 1.2 mm to the minor diameter of the stem and provided rotational stability in most cases. Added rotational control was provided by a step cut in seven patients and onlay cortical strut grafts in two. If the trochanter was present, it was attached

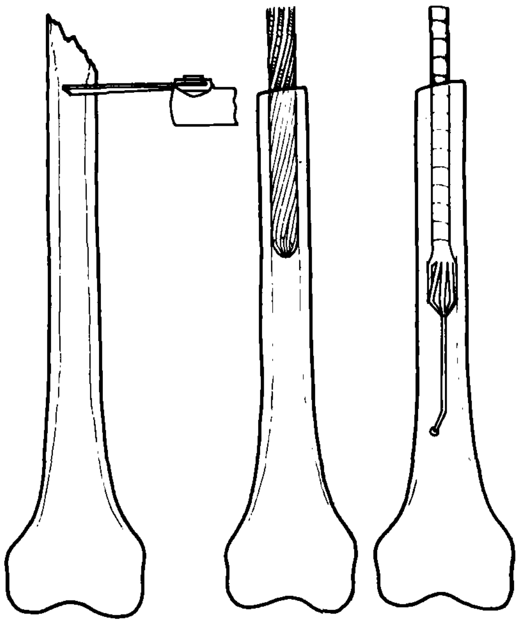

FIG. 2. An oscillating saw is used to remove structurally inadequate bone from the proximal host femur. The distal canal is usually reamed to the minor diameter of the selected stem. If most of the curved stem is to be in the host femur, the medullary canal is reamed 0.5 mm larger.

to the allograft using a Dall-Miles trochanteric grip and cables (Howmedica, Rutherford, New Jersey). In cases in which no trochanter was present, three 5.0 merseline tapes (Ethicon, Rutherford, New Jersey) were used to center the abductor–quadriceps sleeve around the trochanteric area of the allograft.

Postoperative management was similar to that used after primary hip replacements. Patients were kept in pillow suspension for two to three days because of the extensive soft tissue dissection. Weight bearing up to 60–80 pounds then was encouraged, governed only by abductor strength and comfort and not by the status of the graft. At six weeks, patients were weaned from support provided there was no pain or limp.

RESULTS

All patients were severely compromised before surgery, and all required a walker or crutches. At follow-up examination, nine patients used no support, 14 used a cane for most walking, and four continued to use crutches full-time. One patient who is 88 years of age and lives in a nursing home uses a walker on a full-time basis because of poor balance. A second patient with severe rheumatoid arthritis also uses a walker. The average preoperative Harris rating was 35 (range, zero to 52). The postoperative rating averaged 78 (range, 38–90) with a mean follow-up period of 22 months (range, two to 46 months). Twenty-two of the allografts appeared to have united radiographically at final follow-up examination. Of those that united, the mean time to radiographic union was 7.3 months. A typical patient is seen in Figures 6A–D.

There were three failures. One graft completely dissolved in a 32-year-old man who had undergone multiple previous hip procedures. Radiographic evidence of this dissolution was evident at one year three months after surgery, and complete dissolution was

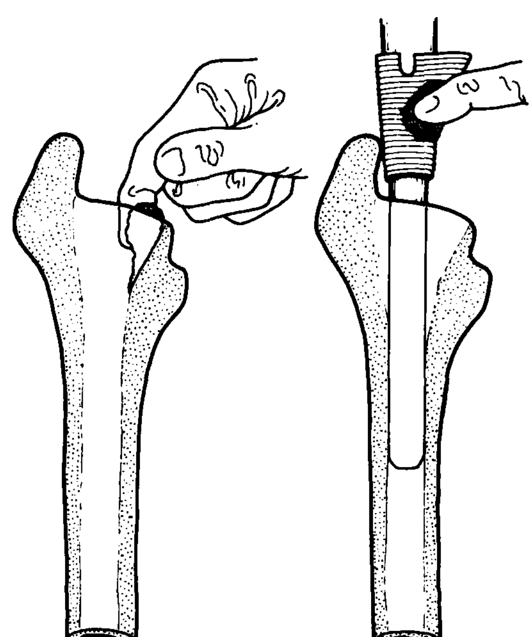

FIG. 3. Liquid cement is forced into the proximal allograft and is liberally applied to the modular metaphyseal unit. The sleeve then is cemented selectively to the allograft, using the appropriate alignment instruments.

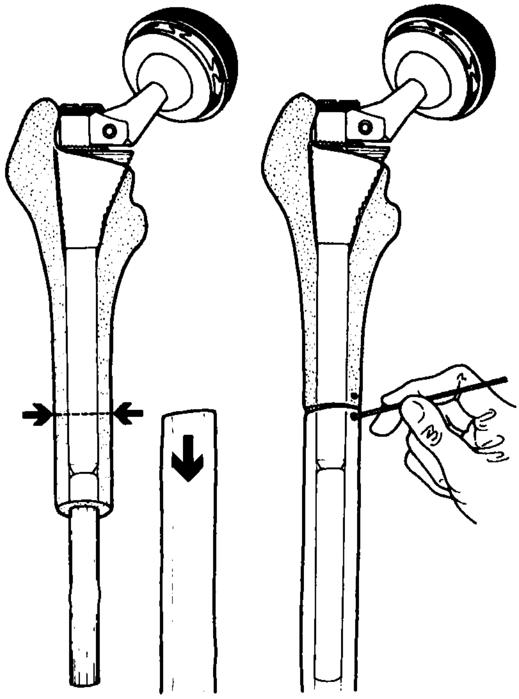

FIG. 4. Trial components with the shortest available neck and head length are introduced into the allograft and reduced into the patient's acetabulum. With maximum traction on the host femur, the length of the allograft is determined. The allograft then is resected at this level. Extended stems are added to the trial components, and these are introduced into the host medullary canal. Appropriate rotation is noted and marked with methylene blue.

confirmed at the time of revision for a loose acetabular component three years after surgery. At the time of exploration, the femoral component was noted to be tightly fixed in the distal femur and, in spite of the lack of proximal support, he continues to function at a high level with a Harris rating of 86. The second failure was a gross nonunion with symptomatic instability at the graft–host junction in a 42-year-old woman who had undergone nine prior hip procedures. She did well initially and did not develop clinical evidence of nonunion until one year after her surgery. She has subsequently been revised. The third failure was a patient who developed a *Staphylococcus aureus* infection after surgery. She was treated with resection arthroplasty, an antibiotic-impregnated polymethylmethacrylate spacer, and six weeks of intravenous antibiotics. A subsequent allograft–prosthetic reconstruction was successful, and two and a half years since this procedure, she remains without infection and the graft has united.

Five patients sustained postoperative dislocations. One of these patients eventually required revision for recurrent dislocation. Healing of the greater trochanter to the allograft was difficult to assess on the basis of postoperative radiographs. In five patients, the trochanter was absent before surgery. In most cases, the host trochanter remained adjacent to the allograft trochanteric bed. In three

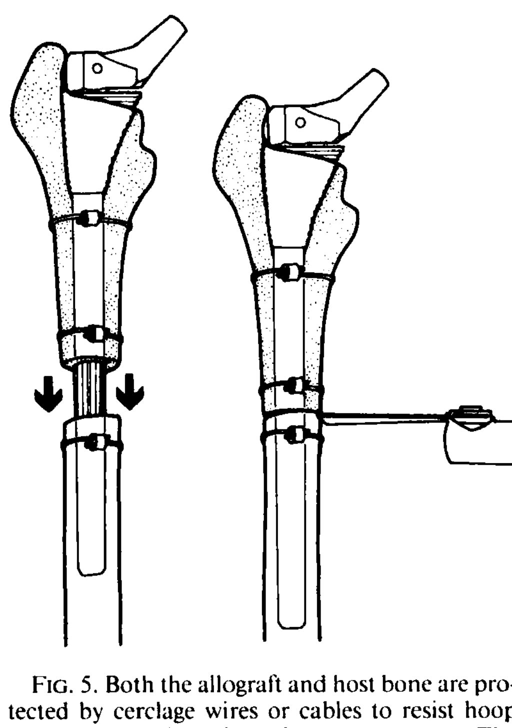

FIG. 5. Both the allograft and host bone are protected by cerclage wires or cables to resist hoop stresses during insertion of the components. The final stem then is introduced into the allograft and the Morse Taper of the metaphyseal unit engaged. The allograft–prosthesis composite then is introduced into the host femur in a press-fit fashion and impacted. An oscillating saw is used just before final seating to trim the interface if necessary.

FIG. 6A–6D. (A) This 75-year-old woman had a resection arthroplasty because of an infected proximal femoral allograft. This preoperative view shows the large proximal femoral defect with antibiotic-impregnated cement spacer and beads in place. The well-fixed uncemented acetabular component was not removed because this was an acute infection. (B) At seven weeks, the junction of the graft and the host is obvious. (C) At eight months, there is radiographic evidence of graft–host consolidation. (D) At 26 months, the graft–host junction appears healed and there is no evidence of prosthetic loosening. There has been no proximal migration of the greater trochanter, despite the fact that there is a nonunion.

cases, there was superior migration of the trochanteric fragment greater than 1 cm (range, 1.2–2.0 cm.). Associated fracture of the Dall-Miles cables was present in every case of superior migration.

DISCUSSION

Segmental bone loss below the level of the lesser trochanter presents a formidable challenge to the reconstructive surgeon. Several methods of dealing with this challenge have been proposed, including resection arthroplasty, cemented proximal femoral replacement components, distally fixed and extensively porous-coated uncemented components, and allograft–prosthetic composites.

Resection arthroplasty of the hip is at best a salvage procedure, and patients are seldom satisfied, particularly if it is performed for nonseptic problems.[3,10,16,38,46] With major proximal femoral segmental defects, resection arthroplasty is even less satisfactory because of the shortening and instability caused by excessive segmental bone loss.[7,25,40]

Cemented proximal femoral replacement prostheses have been used extensively in tumor surgery.[7,22–29,31,33,42,44,47] However, in the authors' experience, their longevity in an active patient with a failed THA is not satisfactory. In tumor patients, the remaining femur has not been violated, but all the patients in this study have had a previous stem, and the eburnated host femoral canal does not allow satisfactory cement intrusion. Cemented long stems also can cause stress shielding of the already compromised host femur, making a later reconstruction even more difficult.

The authors have no experience with fully sintered, long-stemmed femoral devices, but reports by Engh, Glassman, and Paprosky show that fixation can be achieved within the diaphysis of the femur.[14,15,21,36] The prosthesis substitutes proximally for the deficient femur, but such massive components may compromise the host bone because of stress shielding.[4,6,12,13,39] A later revision because of sepsis or malpositioning can be very difficult.

It is more appealing to reconstruct the proximal femur with allograft bone and to load the distal host bone in a more physiologic way. This can be accomplished with a massive proximal femoral allograft, combined with a prosthetic femoral component. If the allograft unites to the host, this makes the construct even more stable, and more bone stock is available if later revision is necessary. There are several unanswered questions concerning the optimal technique of allograft–prosthetic constructs.

The first technical question is whether the femoral component should be cemented to the allograft. The authors have tried uncemented femoral components within allografts with disappointing results because bone ingrowth can not occur.[9] Uncemented prostheses without collars usually subside, and uncemented prostheses with collars have split the allograft because of the high contact loads beneath the collar. It would seem more logical to cement the prosthesis to the allograft than to use an uncemented component against dead bone.

The second technical question is how to fix the allograft to the host bone. Potential solutions include allograft struts, metal plates, long stems that are cemented to both the graft and to the host, and long stems that are cemented to the graft but press-fit within the host medullary canal.

The authors have had good success with onlay cortical allograft struts, used to stabilize fractures below a well-fixed femoral component, but these struts become markedly weaker as they incorporate.[8] In most instances, the fracture heals before the allograft struts fail. The authors have applied this technique to attach an allograft to the host femur, but union is so slow between the allograft and the host bone that fracture of the cortical struts frequently occurs. The authors now feel that struts used in this application are not adequate by themselves to stabilize the allograft–host junction.

There are favorable reports concerning the use of metal plates to attach the allograft to the host femur, but this technique has the disadvantage that proximal screws may interfere with the cement mantle of the femoral stem.[22,24,32] Screw holes are stress risers that can lead to fractures of the allograft or the host bone. Finally, a plate with screws above and below the junction of the graft and the host can potentially prevent impaction and lead to nonunion.

Long stems, cemented to the allograft and to the host bone, have been used to stabilize the graft–host junction, but this technique has several disadvantages.[11,20,30,34] Nonunion can result because of extrusion of cement at the graft–host junction, and because cement above and below the junction site may prevent impaction of the graft to the host bone. Because a stem has usually been used previously in the distal femur, the bone is often eburnated, and loosening of the distally cemented stem also may occur.

The best technique would seem to be to cement the prosthesis to the allograft but to press-fit the stem to the host femoral canal. This provides secure fixation of the prosthesis to the allograft and encourages impaction of the graft to the host. This construct is also strong enough to allow early weight bearing. Piezoelectric forces appear to be important in lower extremity fracture healing and probably contribute to the healing of allografts to host bone as well.[2]

The final question is what the optimal configuration of the stem should be. The ideal stem is one that is canal filling and has a constant diameter that resists bending forces and has flutes to resist rotational stresses. Of the various stems that the authors have tried, the

S-ROM (Joint Medical Products, Stamford, Connecticut) has proven the best. The modular metaphyseal unit can be selectively cemented to the allograft, while the stem is used in a press-fit manner within the host bone. There are nonfluted tapered stems available from other manufacturers that could be used, but it is much more difficult to selectively cement these stems to the allograft without having cement extrude at the allograft–host junction and a step cut or onlay struts are routinely necessary to provide rotational stability.

Although the follow-up period is short, the authors have been encouraged by the early success of these allograft–prosthetic composites. Advantages of this approach include rapid return to weight bearing, physiologic loading of the distal femur, and reconstitution of vital proximal bone stock.

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