Impaction Allografting of the Femur in Revision Total Hip Surgery

Hannah D. Morgan, MD, and Seth S. Leopold, MD

Indications: Loosening of the femoral component after total hip arthroplasty is a common indication for revision surgery; most femoral revisions are manageable with straightforward revision approaches using either cemented or uncemented stems. However, certain radiographic findings should cause the surgeon to consider the possibility that standard techniques may not suffice (Figure 1), particularly if the patient is young and bone-stock restoration is desirable for anticipated future revisions. These findings include:

- Severe bone loss, particularly if it extends into the femoral diaphysis
- Significant widening of the femoral canal (diaphysis >18-20 mm in diameter)
- Severe cortical thinning (ectasia) in portions of the femur that would be used for secure fixation of cementless devices
- Large cavitary or segmental defects that would compromise traditional fixation approaches

Femoral impaction allografting was developed to restore femoral bone stock and gain stable fixation of the revised femoral stem. While some surgeons use it for most or all femoral revisions, most series from the United States have suggested that the technique is warranted only for the more desperate situations described above. The technique involves packing morselized cancellous allograft tightly into a deficient proximal femur to create a neo-endosteum and then cementing a femoral stem into this construct.

Preoperative Evaluation: Several steps must be taken to assure that the patient is a good candidate for revision hip surgery and for impaction allografting specifically. Before performing impaction allografting, the surgeon must exclude the possibility of periprosthetic infection as a cause of the failure undergoing revision. This may be done using appropriate blood work (complete blood cell count, sedimentation rate, C-reactive protein concentration) and hip aspiration for culture if the blood work or the clinical scenario suggests that it is appropriate. Occasionally, nuclear medicine imaging (tagged white blood cell scans or other techniques) may be useful. If con-

Figure 1. Preoperative **(A)** anteroposterior and **(B)** lateral radiographs of a loose cemented femoral stem. Note the severe bone loss, cortical widening (canal diameter >20 mm), and cortical ectasia. These findings make achieving stable cementless fixation of a revision stem difficult or impossible. Characteristic migration of the femoral implant into varus is also observed. The component had been loose for a long period, and the endosteum would be expected to be polished smooth and so not ideal for cemented fixation.

Dr. Morgan is Acting Instructor, and Dr. Leopold is Associate Professor, Department of Orthopaedics and Sports Medicine, University of Washington Medical Center, Seattle, Washington.

Address correspondence to Seth S. Leopold, MD, Associate Professor, Department of Orthopaedics and Sports Medicine, University of Washington Medical Center, 1959 NE Pacific Street, Box 356500, Seattle, WA 98195 (tel, 206-543-3690; fax, 206-685-3139, Email: leopold@u.washington.edu).

Figure 2. Radiographs of the hip obtained 2 years after impaction allografting with cement for femoral component revision of the aseptically loose stem seen in Figure 1. The cortex was reinforced with cortical strut allografts and cerclage cables prior to impaction of cancellous bone. A calcar-replacing stem was chosen to restore limb length in view of bone loss proximal to the lesser trochanter. There is evidence of remodeling of the endosteal cancellous bone, the stem is stable, and the patient has no hip pain.

cern remains at the time of surgery, intraoperative frozen sections should be performed; on this test, a finding of >5 polymorphonuclear leukocytes per high-power field suggests the presence of infection.

The patient's age and any medical comorbidities should be considered. Elderly or frail patients who may not be able to tolerate a revision procedure that often runs to several hours, patients who cannot comply with the limited weight-bearing status required after the surgery, and patients of limited expected life expectancy (in whom the possibility of bone-stock restoration is not so essential) may be better served with proximal femoral replacement (tumor prosthesis or "megaprosthesis")—a much shorter and more straightforward procedure—if the femoral anatomy precludes revision with standard cementless or cemented stems.

Adequate radiographic imaging must be available. Typically this includes an anteroposterior view of the pelvis and anteroposterior and lateral views of the affected femur. Several inches of femur below the failed femoral stem must be visualized. These radiographs will assist the surgeon in deciding whether standard hip revision techniques are possible or whether impaction allografting offers a more reliable reconstruction.

Preoperative Planning: Adequate radiographs of known magnification of the hip and pelvis are essential for templating the desirable implant size and position and for determining the correct leg length. The surgeon should evaluate the films for abnormal morphologic features of the femur (bowing and angular deformity) and for cavitary or segmental defects of the proximal femur, which may need to be supported with mesh, cerclage wires, or allograft struts prior to impaction of the cancellous graft.

Femoral stems that are longer than the previous implant should be considered in order to bypass areas of cortical damage and to avoid intraoperative fracture. If femoral neck defects are present, either calcar-replacing stems or calcar-reconstruction with cortical and cancellous grafts are required. Restoring leg length and soft-tissue tension will decrease the risk of postoperative Trendelenburg gait and hip dislocation.

Surgical Technique: Many approaches to the hip have been employed in impaction allografting, but it is probably best done through an extensile approach that does not involve a trochanteric osteotomy. High nonunion rates of trochanteric osteotomy (33% to 50%) have been reported with impaction allografting, so these are not recommended. Regardless of the approach chosen, you must gain adequate femoral exposure and mobility in order to perform the procedure safely.

After obtaining a satisfactory exposure, remove the loose or failed femoral implant, along with any fibrous debris. Next, remove any cement from the femoral canal. If it is necessary to go further down the canal to bypass defects and compromised cortical bone, remove the cement plug as well. You may leave the plug if it is at an appropriate level to be used in the revision procedure and the grafting system does not require a centralizing rod threaded into a distal plastic plug to be placed. If you have removed the cement plug, place a new canal restrictor after removing all the cement. Position it to allow 2 cm of graft distal to the tip of the stem.

Next, before placing the bone graft, check the canal to assure that the trial stem may be placed in neutral alignment. As noted, some systems employ a centralizing rod to help with proper alignment of the neoendosteum. Reinforce any areas of weakened or deficient bony cortex by using allograft struts and wires, mesh, or both (Figure 2). Impaction grafting creates tremendous hoop stresses in the femur, so this step is critical in order to avoid an intraoperative fracture. Then insert morselized bone graft. This may be done by hand or by using a commercially available graft-delivery system, of which there are several. The graft should fill the canal; then create a neoendosteum using progressively larger tamps. When the final tamp is in place, there should be both axial and rotational stability. Once you have confirmed this stability, perform a trial reduction and adjust the neck length so that leg length is restored and the hip is stable.

Finally, cement the femoral stem into place. Impaction allografting should be performed with cement, even if you generally prefer cementless approaches to the femur; cementless femoral impaction grafting has been associated with a high failure rate. Inject the cement in a less viscous state than usual in order to increase cement penetration into the packed cancellous graft of the neoendosteum.

Technical Tips and Pearls: One area of difficulty frequently encountered during impaction allografting is the process of removing cement and canal debris. This is evidenced by the femoral perforation rates of 5% to 24% seen in these procedures. To minimize femoral injury, ensure that the entire proximal femur is adequately exposed. Special suction devices and fiberoptic illumination tools can help in visualizing the femoral canal. Numerous cement removal instruments that can also help to reduce the danger of this process are available. Once all cement and debris are removed, carefully inspect the canal for any cortical deficiencies. Intraoperative fluoroscopy or plain radiographs may also be beneficial during this step.

Achieving correct femoral alignment is key to successful impaction grafting. Getting the anteversion correct, especially when much of the femoral neck and proximal femoral anatomy are lost, can be challenging. The surgeon must be prepared to use other landmarks to determine anteversion, such as the distal femoral condyles or the linea aspera. A trial reduction prior to cementing the permanent implant is extremely important to assure adequate hip stability. Coronal-plane alignment of the stem is important to long-term durability. The neo-endosteum must be created in neutral alignment rather than in varus. Intraoperative radiographs of the alignment rod or graft-delivery tube (depending on the system employed) can be helpful to verify coronal-plane alignment; determining this early in the procedure ultimately may save time and help avoid complications.

There is considerable controversy over the significance of implant shape, surface finish, and allograft preparation. To date, there are no published reports from controlled trials comparing different femoral stems or grafts for impaction allografting. In studies with short- and intermediate-term follow-up, smooth and roughened, collared and non-collared stems had similar results. Likewise, the way the graft has been prepared by the bone bank—irradiated or non-irradiated—has not been shown to make a difference with respect to outcome. On the other hand, freeze-dried cancellous graft and dry, brittle, or coralline bone-graft substitutes probably are not appropriate, as they lack the necessary compliance to be packed into position without crumbling or turning to powder. Premorselized fresh-frozen cancellous allograft is available from a number of bone banks and commercial vendors; using this saves significant time intraoperatively, but make certain that the graft has been morselized to an appropriate size for the procedure. Finally, it is important that the final tamp used to create the neoendosteum be larger than the final implant in all dimensions, in order to allow an adequate cement mantle to be created.

Authors' Disclosure Statement

Dr. Leopold wishes to note that he is a consultant to Zimmer, Inc., and serves on the advisory board of Zimmer, Inc. Dr. Morgan has no actual or potential conflict of interest in relation to this article.