Managing Bone Loss in Acetabular Revision

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Revision of cemented acetabular components is most commonly performed because of aseptic loosening with migration of the component. The most challenging aspect of acetabular revision is the management of bone loss compromising implant fixation and stability. The severity of bone loss can be pronounced, as a result of asymptomatic osteolysis and stress-shielding, prior to migration of cementless components. This bone loss is a common condition that is expected to become more common in the future.

The prevalence of revision hip arthroplasty is 18% in the United States and 8% in the Swedish registry. The indications for acetabular revision include symptomatic aseptic loosening, failure of fixation, infection, wear, osteolysis, and instability. Revision may be indicated for an asymptomatic patient who has progressive osteolysis, severe wear, or bone loss that could compromise a future reconstruction. Contraindications for revision of the acetabular component include severe bone loss precluding allograft fixation or implant fixation, uncontrolled infection, or medical comorbidities that preclude surgery.

Options for Acetabular Revision

Several options, including both non-biologic and biologic fixation, are available for acetabular revision. Non-biologic fixation refers to any method of reconstruction that achieves stability of the acetabular component through a mechanical construct without the need for osseointegration between the acetabular shell and the host bone. Biologic fixation refers to any surgical option that requires direct contact with host bone and osseointegration into the acetabular shell in order to provide long-term fixation. Nonbiologic fixation options include cementing of a polyethylene cup, use of a superior structural allograft and a cemented polyethylene cup with or without an antiprotrusio cage, impaction grafting with or without an antiprotrusio cage, and application of a total acetabular allograft. Biologic fixation options include use of a hemispherical uncemented cup at the anatomic hip center or a high hip center (>2 cm superior to the native hip center), a jumbo cup (66 to 80 mm), an oblong cup, an uncemented hemispherical cup supported by structural allograft, and a modular cementless implant system.

As the outcomes of acetabular revision have been better with cementless fixation than they have been with cement fixation, cementless fixation has become the preferred method for the majority of acetabular revisions. Templeton et al.[1] and Gaffey et al.[2] reported no cases of aseptic loosening of uncemented Harris-Galante-I components used for revisions of cemented components, whereas cemented revision acetabular components had a 14% rate of revision for aseptic loosening and a 33% prevalence of radiographic evidence of aseptic loosening[1,2]. Della Valle et al., in a study of the experience with cementless acetabular revision at the Rush University Medical Center, found aseptic loosening in two of 138 patients followed for a mean of fifteen years, with revision (for any reason) reported in nineteen of the 138 patients[3]. In a study of the results of cementless revisions performed by Harris, Hallstrom et al. reported a rate of aseptic loosening of 11% (thirteen of 122) and a rate of revision because of aseptic loosening of 4% (five of 122)[4].

Reliable and durable fixation of cementless acetabular components requires intimate contact between the implant and viable bone as well as mechanical stability (motion of less than 40 to 50 μm). Bone loss can compromise both of these prerequisites for successful use of cementless implants. The amount of host bone required to provide durable fixation is not known. Although it is difficult to measure the amount of bone supporting an implant, most surgeons believe that 50% to 60% is necessary. This value was derived from the literature and is a measure of the coverage of the acetabular component in the coronal plane as seen on an anteroposterior radiograph. However, the support of an implant is geometrically more complex than can be

determined on a two-dimensional radiograph alone. The location of the remaining supportive bone probably has a more important role in providing durable fixation than does the quantity of bone. Finally, the percentage of bone necessary to support the implant probably decreases as the implant size increases because of the increased surface area.

Inherent Stability
Although there are reports of the successful use of uncemented cups in revision surgery without the achievement of an initial press-fit[1,3], we believe that it is necessary to achieve inherent stability of the implant. Trial components are used to accomplish this goal and to assess the remaining bone stock properly. A trial implant can have full inherent stability, partial inherent stability, or no inherent stability. A trial component with full inherent stability will not be displaced by pushing on its rim or by trial reduction. A trial component with partial inherent stability will maintain its position while the inserter is removed, but it will be displaced by loading of its rim and by trial reduction. Finally, when a trial component has no inherent stability, support by host bone is inadequate to maintain placement of the component in the desired location once the inserter is removed.

Classification and Decision-Making
AAOS Classification
The AAOS (American Academy of Orthopaedic Surgeons) classification of bone defects, described by D'Antonio et al.[5,6], identifies the pattern and location of bone loss but does not quantify the defect. The bone loss is classified as contained, segmental, combined contained and segmental, pelvic discontinuity, and ankylosis. This is the most commonly used classification in the literature.

Paprosky Classification
The classification system that we use is based on the severity of bone loss and the ability to obtain cementless fixation for a given bone loss pattern[7]. The key

to the classification is determining the ability of the remaining host bone to provide initial stability to a hemispherical cementless acetabular component until ingrowth occurs. Intraoperative decisions are based on the findings when trial components are used. The amount of rim that remains determines the stability of the trial implant and is one of the variables that identifies the type of acetabular defect. A Type-I defect has an undistorted rim; a Type-II defect, a distorted but intact rim with adequate remaining bone to support a hemispherical cementless implant; and a Type-III defect, a non-supportive rim.

Radiographic Correlation
Preoperative findings on the anteroposterior radiograph of the pelvis are used to predict the type of defect and allow the surgeon to plan for the acetabular reconstruction accordingly. The four criteria that are important to assess on the preoperative radiograph include: (1) superior migration of the hip center, (2) ischial osteolysis, (3) teardrop osteolysis, and (4) position of the implant relative to the Kohler line.

Superior migration of the hip center represents bone loss in the acetabular dome involving the anterior and posterior columns. Superior and medial migration indicates a greater involvement of the anterior column. Superior and lateral migration indicates a greater

involvement of the posterior column. The amount of superior migration is measured as the distance in millimeters (adjusted for magnification) relative to the superior obturator line.

Ischial osteolysis indicates bone loss from the inferior aspect of the posterior column, including the posterior wall. The amount of ischial osteolysis is quantified by measuring the distance from the most inferior extent of the lytic area to the superior obturator line.

Teardrop osteolysis indicates bone loss from the inferior and medial aspect of the acetabulum, including the inferior aspect of the anterior column, the lateral aspect of the pubis, and the medial wall. Moderate osteolysis includes partial destruction of the structure with maintenance of the medial limb of the teardrop. Severe involvement means complete obliteration of the teardrop.

Medial migration of the component relative to the Kohler line represents a deficiency of the anterior column. The Kohler line is defined as a line connecting the most lateral aspect of the pelvic brim and the most lateral aspect of the obturator foramen on an anteroposterior radiograph of the pelvis. The medial aspect of the implant is lateral to the Kohler line with Grade-1 migration and medial to the line with Grade-3 migration. With Grade 2, there is migration to the Kohler line or slight

Fig. 1

Type-I acetabular defect. Note that the rim remains supportive and will provide full stability for a hemispherical component.
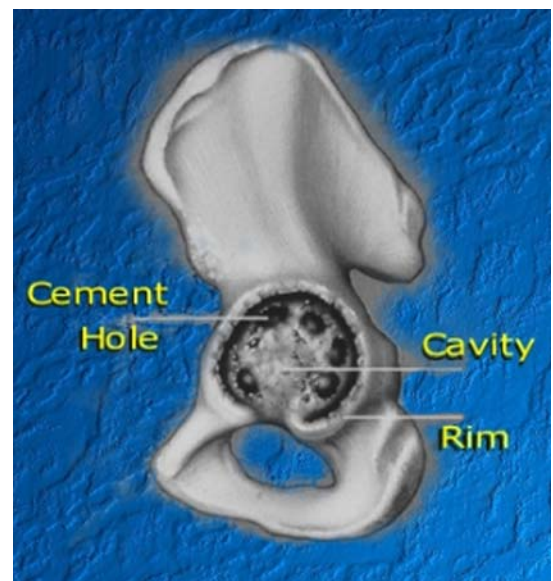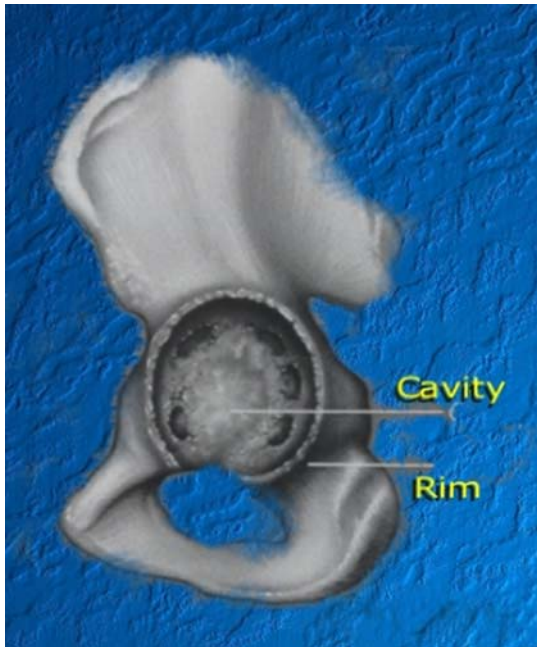
Fig. 2-A

Type-II acetabular defect. Note the rim defect. The remaining host bone is supportive and will provide full stability for a hemispherical component.

remodeling of the iliopubic and ilioischial lines without a break in continuity.

Type-I Defect

With a Type-I defect, the acetabular rim is intact and supportive without distortion (Fig. 1). The acetabulum is hemispherical, and there may be small focal areas of contained bone loss (cement anchor sites). The anterior and posterior columns are intact. A hemispherical cementless implant is almost completely supported by native bone and has full inherent stability.

The preoperative radiograph shows no migration of the component and no evidence of osteolysis in the ischium or teardrop, and the Kohler line has not been violated (the medialmost aspect of the component is lateral to the Kohler line).

Type-II Defect

In a Type-II defect, the acetabulum is distorted but there is adequate host bone to support a cementless acetabular component (Fig. 2-A). The trial component has full inherent stability. The distortion may be superior and lateral, superior and medial, or directly medial. At least 50% of the surface area of the component is in contact with host bone for potential ingrowth, and good mechanical support can be provided

entirely by host bone. The anterior and posterior columns remain intact and supportive. The hip center can be elevated as much as 1.5 cm to achieve superior contact and support.

On the preoperative radiograph of a Type-II defect, the superior migration of the hip center is <3 cm from the superior obturator line and there is no substantial osteolysis of the ischium or

teardrop (ischial osteolysis extending <7 mm distal to the obturator line).

Type-IIA defect: The pattern of bone loss is superior and medial, allowing migration of the failed component into a cavitary defect medial to the thinned intact superior rim. In the majority of patients, the defect is treated with particulate allograft because the defect is contained. The remaining superior rim provides a buttress for containment of the allograft.

Type-IIB defect: Less than one-third of the circumference of the superior rim is deficient, and the defect is not contained. The remaining anterior and posterior rims and columns can support an implant. Allograft is used to restore bone stock and not to support the implant. The defect is segmental, and a femoral head allograft may be chosen. The majority of reconstructions are done without grafting of the segmental defect.

Type-IIC defect: There is a medial wall defect and migration of the acetabular component medial to the Kohler line (Fig. 2-B). The rim of the acetabulum is intact and will support a hemispherical component. Reconstruction of these defects is similar to the treatment of protrusio acetabuli in the

Fig. 2-B

Preoperative radiograph of a Type-IIC acetabular defect. Note the violation of the Kohler line.
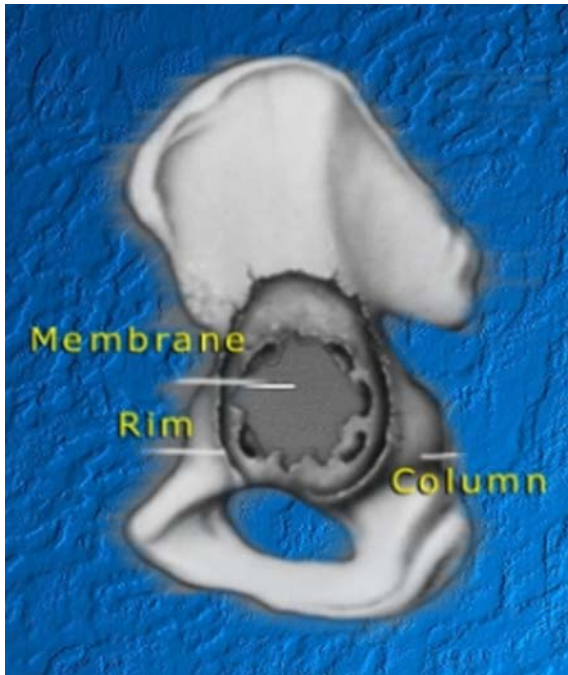
Fig. 3-A
Type-III acetabular defect. The remaining host bone is not supportive and will not provide full stability for a hemispherical component.

setting of a primary arthroplasty. Sequentially larger reamers are used until the acetabular rim is engaged. Particulate bone graft can be placed medially in order to lateralize the hip center of rotation back to its anatomic position.

Type-III Defect

The remaining acetabular rim in a Type-III defect will not provide adequate initial component stability to achieve reliable biologic fixation (Fig. 3-A). The trial implant lacks full intrinsic stability. The use of structural allograft is an option to restore the center of rotation to the proper anatomic location and to provide mechanical stability for the implant.

Type-IIIA defect: There is adequate host bone in contact with the ingrowth surface of the implant to obtain durable biologic fixation (Fig. 3-B)—i.e., more than 40% to 60% of the surface area of the cementless cup is in contact with host bone. The trial component has partial inherent mechanical stability. Support of the im-

Fig. 3-B

Fig. 3-C

Fig. 3-B Preoperative radiograph of a Type-IIIA acetabular defect. Note the superior-lateral migration and loss of the superior dome. **Fig. 3-C** Preoperative radiograph of a Type-IIIB acetabular defect. Note the superior-medial migration with disruption of the Kohler line.

plant with a structural augment or allograft is necessary in the short term to provide initial stability and thus allow ingrowth into the areas of the implant that are in contact with the host bone. The defect involves more than one-third but not more than one-half of the circumference and usually is located between the 10 o'clock and 2 o'clock positions. Preoperative radiographs show superior and lateral migration of the component <3 cm above the obturator line (with adjustment for magnification). Ischial lysis is mild to moderate, extending <15 mm inferior to the obturator line. There is partial destruction of the teardrop, but the medial limb of the teardrop usually is present. The component is at or lateral to the Kohler line, and the ilioischial and iliopubic lines are intact.

Type-IIIB defect: Host bone is in contact with <40% of the ingrowth surface of the implant. Inherent stability is not achievable with a trial implant. The defect involves more than half of the circumference of the rim, and it usually extends from the 9 o'clock to the 5 o'clock position (Fig. 3-C). Patients with a Type-IIIB defect are at high risk for occult pelvic discontinuity, and this possibility must be ruled out at the time of reconstruction. Preoperative radiographs show extensive ischial osteolysis (extending >15 mm distal to the superior obturator line), complete destruction of the teardrop, migration medial to the Kohler line, and migration >3 cm superior to the obturator line. With a Type-IIIB defect, the failed acetabular component migrates superiorly and medially, in contrast to the migration with the Type-IIIA defect, which is superior and lateral.

Algorithmic Approach to Decision-Making

Our algorithmic approach to revision of the acetabulum is shown in Figure 4. We use a posterolateral approach to the hip for all acetabular revisions. The initial decision regarding how to proceed with the operation depends on the superior migration of the hip center prior to the revision. If the hip center has not migrated >3 cm above the superior obtura-

tor line, the surgeon determines whether full inherent stability can be achieved with a trial component. If it can, the defect is classified as Type I or Type II, and a hemispherical cementless implant is utilized. If there is migration medial to the Kohler line, the defect is classified as Type IIC and the rim will support the hemispherical implant.

When the hip center has migrated >3 cm superior to the superior obturator line or the surgeon is unable to achieve full inherent stability of the hemispherical trial component, the defect is classified as Type III. If a trial component has partial inherent stability, there is generally enough contact with host bone to support ingrowth and therefore the defect is Type IIIA. Type-IIIA defects usually have an oblong shape, but occasionally they are spherical. If the defect is spherical, a jumbo cup may be appropriate. With oblong remodeling of the host acetabulum, the options include a structural distal femoral graft with a cementless hemispherical cup, a modular trabecular metal augment with a hemispherical cup, or a high-hip-center hemispherical cup. The former two options are appropriate when restoration of an anatomic hip center is desired. With both the structural distal femoral graft and the modular augment, the goal is to provide support to a hemispherical implant that has partial inherent stability until there is adequate supportive ingrowth into the cup. The advantages of a distal femoral allograft are the good results that have been seen with longer follow-up and the restoration of bone for future reconstruction if necessary. The potential advantages of a modular cup-and-augment system include less stripping of the ilium and less mobilization of the abductors, a technically easier and faster procedure, and the fact that the augment does not have the potential for resorption. The disadvantages of this method include its unknown long-term durability, the potential for debris generation at the interface, the potential for fatigue failure, and the inability to restore bone stock for future revisions.

When the hemispherical trial

component has no inherent stability, the defect is classified as Type IIIB. When pelvic discontinuity has been ruled out, the options for treatment of such defects include (1) nonbiologic fixation with an impaction allograft supported with a cage or with a structural allograft (an acetabular allograft or a distal femoral allograft) supported with a cage and (2) biologic fixation with a modular trabecular metal system or a custom triflanged implant.

In the presence of pelvic discontinuity, we determine intraoperatively whether the discontinuity appears to be acute, with the potential for healing, or chronic, without the potential for healing. If healing is possible, we use a compression plate across the dissociation as well as one of the reconstructive approaches described for a Type-IIIB defect above. When there is no potential for healing, we distract the discontinuity and insert bone graft into the defect. The initial stability of the structural graft or the modular reconstruction is greatly enhanced by distraction (as opposed to compression, with which there is little chance for the host bone to bring about healing of the discontinuity).

Techniques
General Principles
Preoperative planning based on the aforementioned classification system is critical so that the appropriate grafting material, tools for implant removal, and components are available at the time of surgery. If there has been extensive medial migration, imaging (angiography or computed tomography scanning with intravascular infusion of contrast medium) and possibly intrapelvic mobilization of vascular structures should be considered.

The patient must be positioned carefully, with particular attention paid to the orientation of the pelvis and torso relative to the floor, as internal landmarks often are distorted in the setting of revision surgery. A posterolateral approach is used. Extensile exposures often are necessary, with the incision extending toward the posterior superior iliac spine. The plane between the iliotibial band and the underlying vastus

lateralis and the abductors (often scarred to the iliotibial band) is redeveloped. After the borders of the gluteus medius and gluteus minimus have been identified, the plane between the gluteus minimus and the capsule is identi-fied and the abductors are mobilized anteriorly. We do not routinely expose the sciatic nerve unless dissection through heterotopic ossification is necessary. A posterior capsular flap is developed off of the greater trochanter subperiosteally and is extended to the superior aspect of the acetabulum and then continued distally along the proximal part of the femur in a subperiosteal fashion. Intraoperative evaluations (a cell count and analysis of frozen sec-
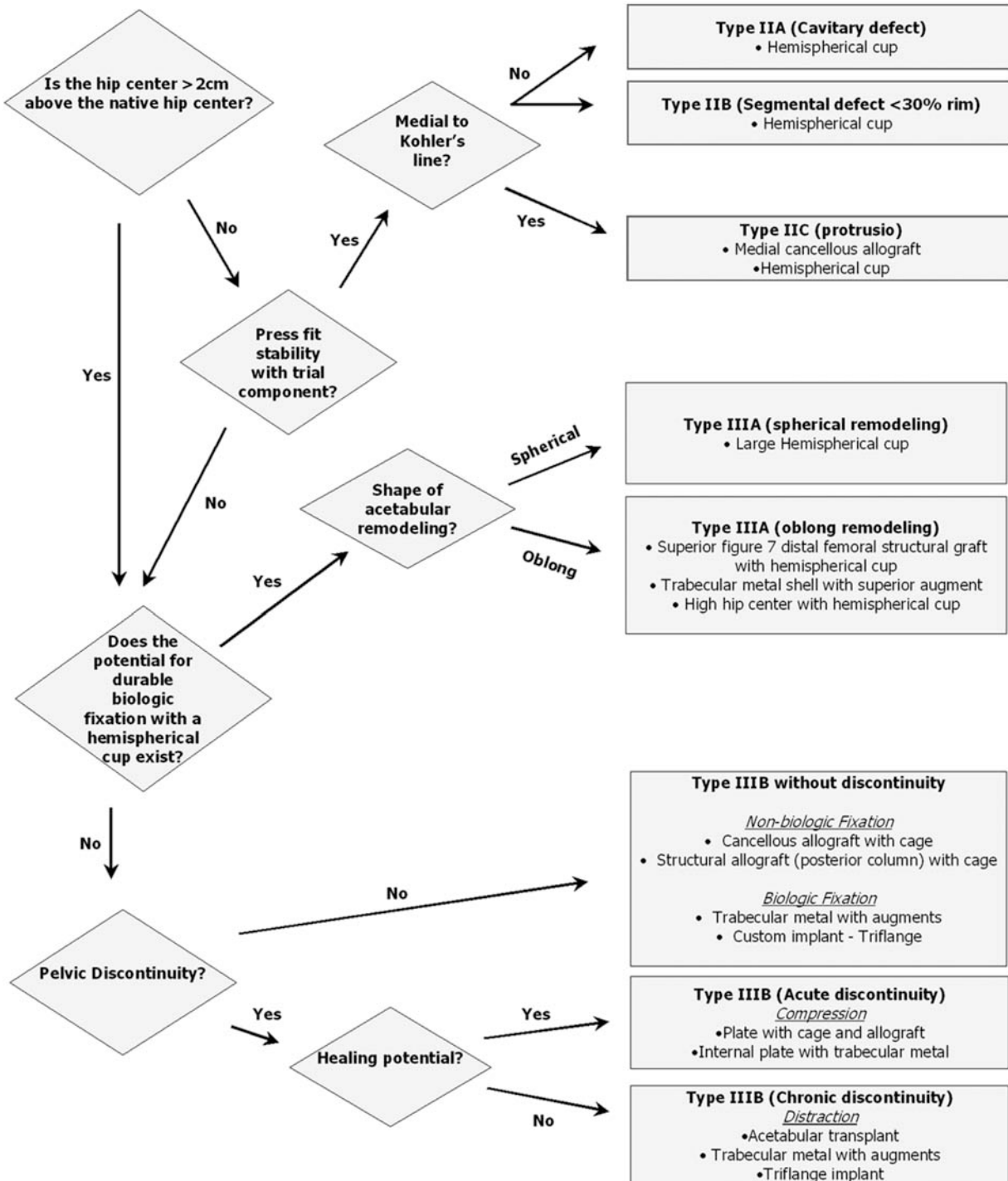

Fig. 4
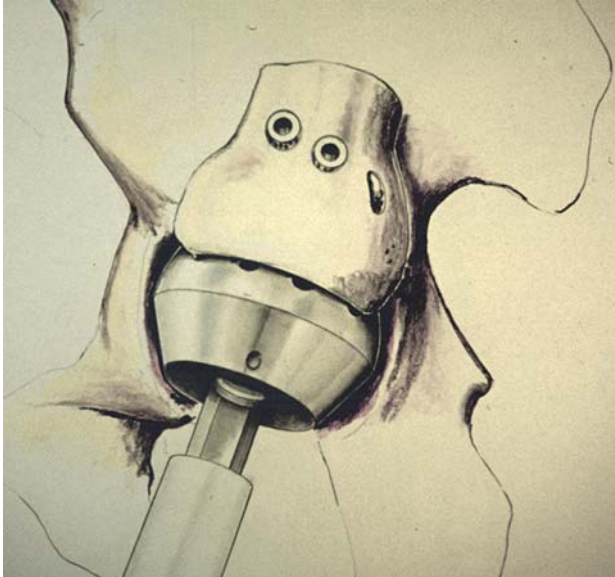Algorithmic approach to acetabular revision.

Fig. 5-A

Figs. 5-A, 5-B, and 5-C The surgical technique used to reconstruct a Type-IIIA acetabular defect with a distal femoral allograft. (Reprinted from: Sporer SM, O'Rourke M, Chong P, Paprosky WG. The use of structural distal femoral allografts for acetabular reconstruction. Average ten-year follow-up. J Bone Joint Surg Am. 2005;87:761.) **Fig. 5-A** Allograft bone is secured to the superior dome with multiple 6.5-mm cancellous screws.

tions) are done to rule out infection. We assume that a white blood-cell count of <3000/μL (3.0×10^9/L) indicates the absence of infection and a count of >10,000/μL (10.0×10^9/L) indicates the presence of an infection. When the cell count is between 3000 and 10,000, we base our decision on the C-reactive protein level and on the findings of the analysis of frozen sections.

The posterior flap is retracted, and an anterior capsulectomy is done. If the femoral component is to be retained, an anterior pouch is developed for placement of the retained component during retraction. The superior aspect of the ilium and the posterior column are dissected in the subperiosteal plane to obtain the necessary exposure. An extended trochanteric osteotomy may be needed, depending on the visualization and the anticipated reconstruction of the femur. After the removal of the existing components, a systematic débridement of granulation tissue and interface membrane is carried out to assess the entire remaining acetabular bone stock and to rule out the possibility of a pelvic discontinuity.

Type-IIC Defects

In the majority of Type-IIC defects, particulate graft is placed medially. If the medial membrane is not a sufficient buttress for the particulate graft, a femoral head cut into a wafer, with the diameter of the wafer greater than the diameter of the medial bone defect, can be used as a buttress for the particulate graft. Use of acetabular reamers in reverse impacts the cancellous allograft

Fig. 5-B

Fig. 5-C

Fig. 5-B Allograft is reamed until the host anterior and posterior columns are engaged. **Fig. 5-C** A cementless hemispherical shell is inserted and is secured with multiple screws.
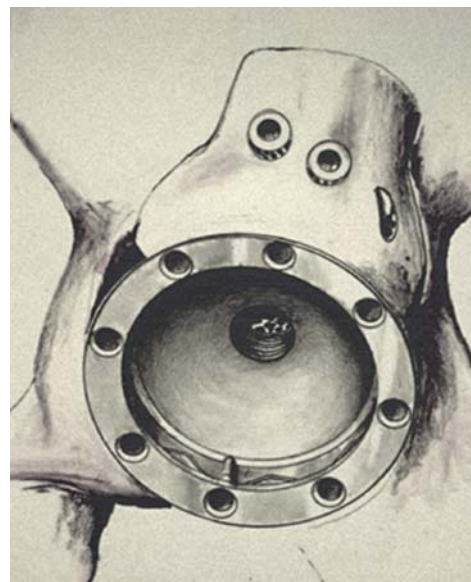
medially and recreates the hemispherical shape of the socket. As more cancellous allograft is added medially, the reamer begins to translate laterally and to catch on the rim. The reamers (used in reverse) disengage from the reamer drive shaft as they come into contact with the host bone rim. At this point, sufficient graft has been placed medially.

Type-IIIA Defects
Distal Femoral Structural Allograft with an Uncemented Acetabular Component

To optimize the outcome, an appropriate graft must be selected to match the mechanical demands of the proposed reconstruction. We do not use a femoral head allograft when the graft is to serve a structurally supportive role. Instead, we employ a fresh-frozen distal femoral or proximal tibial allograft. The trabecular patterns of the graft are oriented parallel to the direction of load to optimize stress transfer. The graft is contoured to maximize the contact surface area between it and the host bone, to optimize the chance of union. The allograft should be fixed to the host bone with 6.5-mm screws oriented parallel with one another in the direction of loading, without interfering with placement or fixation of the component. If there is pelvic discontinuity, fixation with a posterior column plate should be performed before proceeding with the allografting. The fixation of the acetabular component to the host bone-allograft reconstruction is separate from the fixation of the allograft to the host bone.

The goal of acetabular reconstruction with the use of a structural allograft is to obtain a stable construct with the hip center of rotation positioned at the level of the native acetabulum. The desired hip center is identified, and acetabular reamers are used to size and shape the acetabulum for a hemispherical cementless implant. After it is ascertained that adequate host bone is available to come into contact with the implant, a trial component is placed to determine areas of contact, inherent stability, and the location of segmental loss.

Preparation of the distal femoral allograft begins with trimming of the epicondyles so that the medial-to-lateral dimension of the allograft matches the diameter of the acetabular cavity. A female reamer that is about 1 to 2 mm larger than the acetabular cavity is then used to ream the distal aspect of the allograft in slight flexion, to avoid notching of the anterior cortex of the graft and so that the reamed condyles will be directed into the acetabular cavity. The metaphyseal portion of the allograft is then cut in the coronal plane to create the shape of the number 7, with the anterior aspect of the metadiaphyseal bone left in continuity with the distal condyles. The superior aspect of the allograft (the anterior cortex) is generally approximately 5 to 6 cm in length.

The angle between the condyles and the anterior cortex on the posterior aspect of the allograft is contoured with a burr to optimize the contact between the allograft and the host ilium. If a ledge of bone is present between the lateral margin of the ilium and the depth of the acetabular cavity at the site of the defect, the allograft should be cut at a more acute angle. This "tongue-in-groove" effect will provide tremendous stability at the graft-host junction.

The superior limb of the allograft is contoured to the lateral aspect of the ilium and is secured provisionally with Steinmann pins. It is important to tap the allograft screw-holes, in order to minimize the risk of fracture, before placing four parallel 6.5-mm cancellous screws with washers. The screws should be oriented obliquely into the ilium in the direction of loading to compress the graft against the remaining ilium. The acetabular cavity then can be reamed to contour the portion of the graft that will be in contact with the component. Smaller reamers initially are used, and then the reamers are sequentially increased in size to obtain the dimensions of the desired acetabular cavity. Care must be taken to prevent removal of additional host bone or inadequate reaming of the allograft that can cause failure of contact between the remaining host bone and the component. Remaining voids are filled with particulate allograft, and a cementless cup is impacted into the newly sculpted acetabular cavity and fixed with multiple screws for adjunctive fixation (Figs. 5-A, 5-B, and 5-C).

Modular Trabecular Metal System

Treatment of a Type-IIIA defect with a modular trabecular metal system begins with use of acetabular reamers to identify the desired location for the cup placement and to determine the location of all remaining supportive host bone (which is usually anterior-superior and posterior-inferior). Progressive reaming is performed to engage the bone of the anterior and posterior columns in order to achieve partial inherent stability of the trial acetabular component. With the trial component in the appropriate amount of version and abduction, the posterior-superior augment is placed against the host bone. The augment can be placed in any position or orientation to improve the initial stability, and the bone or the augment can be contoured with a barrel burr to optimize the surface contact area. With the trial component in place, the augment is secured to the host bone with screws. The augment is then packed with bone graft, leaving the portion facing the cup exposed. Polymethylmethacrylate cement is placed directly onto the trabecular metal revision cup but only in the areas mating with the augment. The acetabular component is then firmly impacted to achieve a press-fit against the host bone. We recommend the placement of multiple screws for initial fixation. If the liner is cemented, one should consider placing bone wax into the end of the screws to facilitate removal if needed.

Type-IIIB Defects
Total Acetabular Transplant with a Cage

Acetabular reamers are used to size the acetabular cavity and to identify the location of all remaining bone to support the allograft. The ledge of bone on the superior aspect of the ilium that will abut against the allograft should be identified. The acetabulum of the allograft is reamed on the back table, with care taken not to weaken it by excessive reaming. A cage is sized to the allograft prior to placement. The allograft hemi-

TABLE I Clinical Results of Cementless Acetabular Revision				
Author	Year	No. of Hips	Mean Duration (Range) of Follow-up (yr)	Results
Templeton et al.[1]	2001	61	12.9 (11.5-14.3)	3.5% radiographically loose
Leopold et al.[9]	1999	138	10.5 (7-14)	1.8% radiographically loose
Silverton et al.[10]	1995	138	8.3 (7-11)	0.7% failure
Garcia-Cimbrelo[11]	1999	65	8.3 (6-11)	10.8% failure; 28% loose
Whaley et al.[12]	2001	89	7.2 (5-11.3)	4.5% failure
Lachiewicz and Poon[13]	1998	57	7 (5-12)	No failures
Dearborn and Harris[14]	2000	24	7 (5-10.3)	No failures
Weber et al.[15]	1996	61	6.5 (5-8)	1.6% radiographically loose
Chareancholvanich et al.[16]	1999	40	8 (5-11)	12.5% failure
Paprosky et al.[7]	1994	147	5.7 (3-9)	4.1% failure
Lachiewicz and Hussamy[17]	1994	60	5 (2-8)	No failures
Tanzer et al.[18]	1992	140	3.7 (2-5.5)	1.4% failure
Padgett et al.[19]	1993	138	3.6 (3-6)	No failures
Moskal et al.[20]	1997	32	4.8 (3-9.5)	6.3% failure
Jasty[21]	1998	19	10 (8-11)	No failures due to loosening

pelvis is cut in a curvilinear fashion from the greater sciatic notch to the anterior superior iliac spine to maintain a portion of the ilium attached to the acetabulum. The pubic and ischial portions of the allograft are cut distal to the confluence of the acetabulum with enough length to accommodate the inferior defects. One should avoid leaving excessive inferior bone on the allograft that prevents optimal medialization of the inferior aspect of the graft as this can result in vertical cup placement and lateralization of the hip center. Medialization of the hip center is desired.

A female reamer, 1 to 2 mm larger than the acetabular reamer used to size the acetabulum, can be used to mark and shape the medial aspect of the graft to fit the defect. A groove is made in the superior aspect of the ilium of the allograft to correspond to the ledge of bone along the superior aspect of the native acetabulum. This tongue-and-groove junction provides a stable buttress between the host and the allograft. A burr is used to debulk the inner table of the ilium on the allograft and to maintain a shelf distally that will fill the acetabular defect. The allograft should be press-fit and then secured with Steinmann pins provisionally. It is then fixed with four 6.5-mm partially

threaded screws with washers directed obliquely into the ilium from both the intra-articular and the lateral iliac aspects of the graft. A pelvic reconstruction plate is then contoured to the posterior column, ideally with three screws in the native ilium and ischium. It is recommended that a cage, secured with cage-host bone screws as well as cage-allograft bone screws, be used to protect all transplants. If possible, the inferior flange of the cage is inserted into a slot in the ischium for fixation. A metal shell or a polyethylene liner is then cemented into the cage-allograft composite, with the surgeon avoiding the tendency to place the component in a vertical and/or retroverted position.

Modular Trabecular Metal System

When a Type-IIIB defect is treated with a modular trabecular metal system, the acetabular defect is sized with reamers in the desired location to find the dimension of the cavity until two points of fixation are achieved (anterior to posterior, anterior-inferior to posterior-inferior, or posterior-superior to anterior-inferior). Augments are used to decrease acetabular volume and to restore a rim to support a revision cup. The location and orientation of the augments are highly variable, depending on the bone-loss

pattern. Augments are often placed on the medial aspect of the ilium or they may be stacked. It is more common to use the augments with the wide base placed laterally and the apex placed medially, which is the opposite of how the augments are often used in Type-IIIA defects. The revision cup will have direct contact with the augments, which will be necessary in order to achieve a press-fit. As is done for a Type-IIIA defect, the augments are initially secured to the host bone with the use of multiple screws. Portions of the augments may need to be removed with a burr or a reamer in order to optimize the surface area contact between them and the revision shell. Particulate bone graft is then placed into any remaining cavities before the hemispherical revision shell is impacted into place. As is done for a Type-IIIA defect, the interfaces between the revision shell and the augments are cemented. (These interfaces should be in compression.) Multiple screw fixation is used through the revision shell.

Outcomes of Revision

Several authors have reported durable results at a minimum of ten years following acetabular revision with the use of a hemispherical cementless socket (Table I). Because of these predictable

clinical results, hemispherical cementless sockets are now used for almost all Type-I and II acetabular defects. Type-IIIA acetabular defects can be treated with a distal femoral allograft, a bilobed implant, or a trabecular metal acetabular component with a superiorly placed trabecular metal augment. The long-term clinical results of acetabular reconstruction with the use of a trabecular metal system are currently unknown. However, trabecular metal appears to allow extensive bone ingrowth and is associated with high initial frictional resistance.

The midterm results of revisions with bilobed acetabular components have been disappointing. These implants were designed to lower the hip center of rotation and to obtain fixation, both in the true acetabulum and in the ilium. Chen et al. reported a 24% failure rate in thirty-seven hips followed for an average of forty-one months postoperatively[8]. In contrast, the midterm results of revisions with a distal femoral allograft and a hemispherical cementless acetabular component have been acceptable. After a minimum of seven years and an average of ten years of follow-up of twenty-two hips, the senior one of us (W.G.P.) found that seventeen hips were functioning well without loosening and only four had been revised (at an average of 5.5 years postoperatively).

Treatment of Type-IIIB acetabular defects with an acetabular transplant and a cemented acetabular component (without a cage) has had poor clinical results. The senior one of us (W.G.P.) followed sixteen patients for a minimum of eight years (average, ten years) and found that six hips were functioning without loosening, six had been revised because of aseptic loosening at an average of 2.9 years, and an additional four had radiographic evidence of loosening. Because of these poor results following use of an unsupported structural allograft, we began to use reconstruction cages. At two to eight years following use of such a cage in forty-eight hips with a Type-III defect, twenty hips were functioning without loosening, nine had been revised because of aseptic loosening, and an additional nine had radiographic evidence of loosening.

The poor clinical results observed after treatment of Type-IIIB defects recently prompted us to use a trabecular metal acetabular component with one or two augments in the majority of Type-IIIB cases. Modular trabecular metal revision systems have not been used long enough for us to report follow-up results at the present time; however, we are encouraged by the early outcomes.

Overview

In conclusion, the increasing prevalence of arthroplasties and the younger age and greater life expectancy of the patients who receive them promises a continued need for solutions for patients requiring acetabular revision in the face of severe bone loss. The algorithmic approach that we outlined allows the surgeon to predict the findings in the operating room, plan the treatment of expected bone loss patterns, and make appropriate judgments regarding the reconstructive technique that will achieve the best possible results. Our preference is to achieve cementless fixation when possible and to use alternative solutions when initial stability cannot be obtained.

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