The Treatment of Pelvic Discontinuity During Acetabular Revision

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Abstract: Pelvic discontinuity is frequently encountered during acetabular revision in patients with severe acetabular bone loss. Prompt recognition of the discontinuity and appropriate intraoperative management are essential for a successful clinical outcome. The treatment of the discontinuity is dependent upon the remaining host bone, the potential for healing of the discontinuity, and the potential for biologic ingrowth of acetabular components. If healing potential of the discontinuity exists, the discontinuity should be treated in compression with a posterior column plate and structural allograft or with the use of trabecular metal acting as an internal plate. If healing potential for the discontinuity does not exist, the discontinuity can be bridged and treated in distraction with either an acetabular transplant supported with a cage or with the use of a custom Triflange implant. However, the poor clinical results observed with either of these treatment modalities for a type IIIB defect with an associated pelvic discontinuity have prompted the senior author to explore the use of a trabecular metal acetabular component with 1 or 2 augments in the majority of his current type IIIB cases. The long-term clinical results of this treatment remain unknown. **Key words:** pelvic discontinuity, acetabular revision, hip revision.
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With the increasing life span of patients living with total hip arthroplasties and a trend toward indicating surgery at younger ages, the volume and complexity of revision surgery will undoubtedly increase. Cementless acetabular components have shown improved long-term survival over cemented components [1]. However, patients with cementless acetabular components fixation can present with extensive bone loss at the time of revision because of the effects of asymptomatic osteolysis and stress shielding. One of the most challenging aspects of acetabular revision surgery relates to the management of a pelvic discontinuity [2]. A pelvic discontinuity occurs when the inferior half of the pelvis is separated from the superior half of the pelvis. This condition may result from a traumatic injury or more commonly occurs because of osteolysis in patients with total hip arthroplasty. Risk factors for a pelvic discontinuity include female sex, massive pelvic bone loss, and rheumatoid arthritis [3].

Pelvic Discontinuity

Reliable and durable fixation of cementless acetabular components requires an environment with adequate biologic potential (intimate contact of viable living bone with the implant) and mechanical

stability (motion <40 to 50 μm) to allow for bone ingrowth. Bone loss can compromise both of these prerequisites for successful use of these implants. Trial components are a critical aspect of reconstructive surgery and can help determine proper component orientation and with the assessment of the remaining bone stock. The trial implants can have full inherent stability, partial inherent stability, or no inherent stability. With full inherent stability, the surgeon is able to push on the rim of the trial without displacing the trial, and a trial reduction can be performed without displacing the trial component. With partial inherent stability, the position of the trial is maintained while the trial inserter is removed. However, loading the rim of the trial implants causes displacement, and the cup position will not be maintained if a trial reduction is attempted. Finally, no inherent stability implies that support of the trial component by host bone is inadequate to maintain placement of the trial in the desired location once the trial inserter is removed.

Classification and Decision Making

The Paprosky classification is based upon the severity of bone loss and the ability to obtain cementless fixation for a given bone loss pattern [4]. Preoperative radiographic findings on the anteroposterior radiograph of the pelvis generally can be used to predict the type of defect present allowing the surgeon to plan for the acetabular reconstruction accordingly. The 4 criteria on the preoperative radiograph that are important to assess include (1) superior migration of the hip center, (2) ischial osteolysis, (3) teardrop osteolysis, and (4) position of the implant relative to Köhler line.

With a type IIIA defect, there is adequate host bone available and in contact with the ingrowth surface to obtain durable biologic fixation. The trial component in a type IIIA acetabulum will have partial inherent mechanical stability. Preoperative radiographs show superior and lateral migration of the component more than 3 cm above the obturator line (adjusting for magnification). Ischial lysis will be mild to moderate extending less than 15 mm inferior to the obturator line. Partial destruction of the teardrop will be present; however, the medial limb of the teardrop generally will be present. The component will be at or lateral to Köhler line, and the ilioischial and iliopubic lines will be intact. Pelvic discontinuity is rarely encountered in type IIIA acetabular defects.

In a type IIIB defect, there is less than 40% host bone remaining in contact with the ingrowth surface. There is no inherent stability achievable with a trial implant. The rim defect is greater than half the circumference, usually from 9 o'clock to 5 o'clock. Patients with type IIIB defects are at high risk for occult pelvic discontinuity, and this possibility must be ruled out at the time of reconstruction. (Fig. 1) Preoperative radiographs show more extensive ischial osteolysis (>15 mm below the superior obturator line), complete destruction of the teardrop, migration medial to Köhler line, and greater than 3 cm of superior migration to the obturator line. The failed component has migrated superior and medial in the type IIIB defect as compared with the type IIIA defect where the migration is superior and lateral.

Algorithmic Approach to Decision Making

Our algorithmic approach to revision of the acetabulum with a suspected pelvic discontinuity is shown in Fig. 2. The initial decision point relates to the superior migration of the hip center before revision. If the hip center has not migrated more than 3 cm above the superior obturator line, the probability of a pelvic discontinuity is minimal [3]. When the hip center has migrated more than 3 cm superior to the superior obturator line or the surgeon is unable to achieve full inherent stability of the hemispherical trial, the defect is a type III defect. If a trial component has partial inherent stability, there is generally enough contact with host bone to support ingrowth and is therefore a type IIIA defect. Options for reconstruction include a structural distal femoral graft with a cementless hemi-
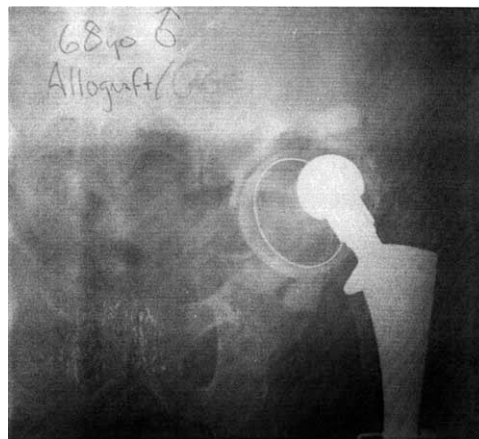
Fig. 1. Anteroposterior pelvic radiograph demonstrating a type IIIB acetabular defect. Notice that the center of the femoral head is greater than 3 cm above the superior obturator line, and Köhler line has been violated.
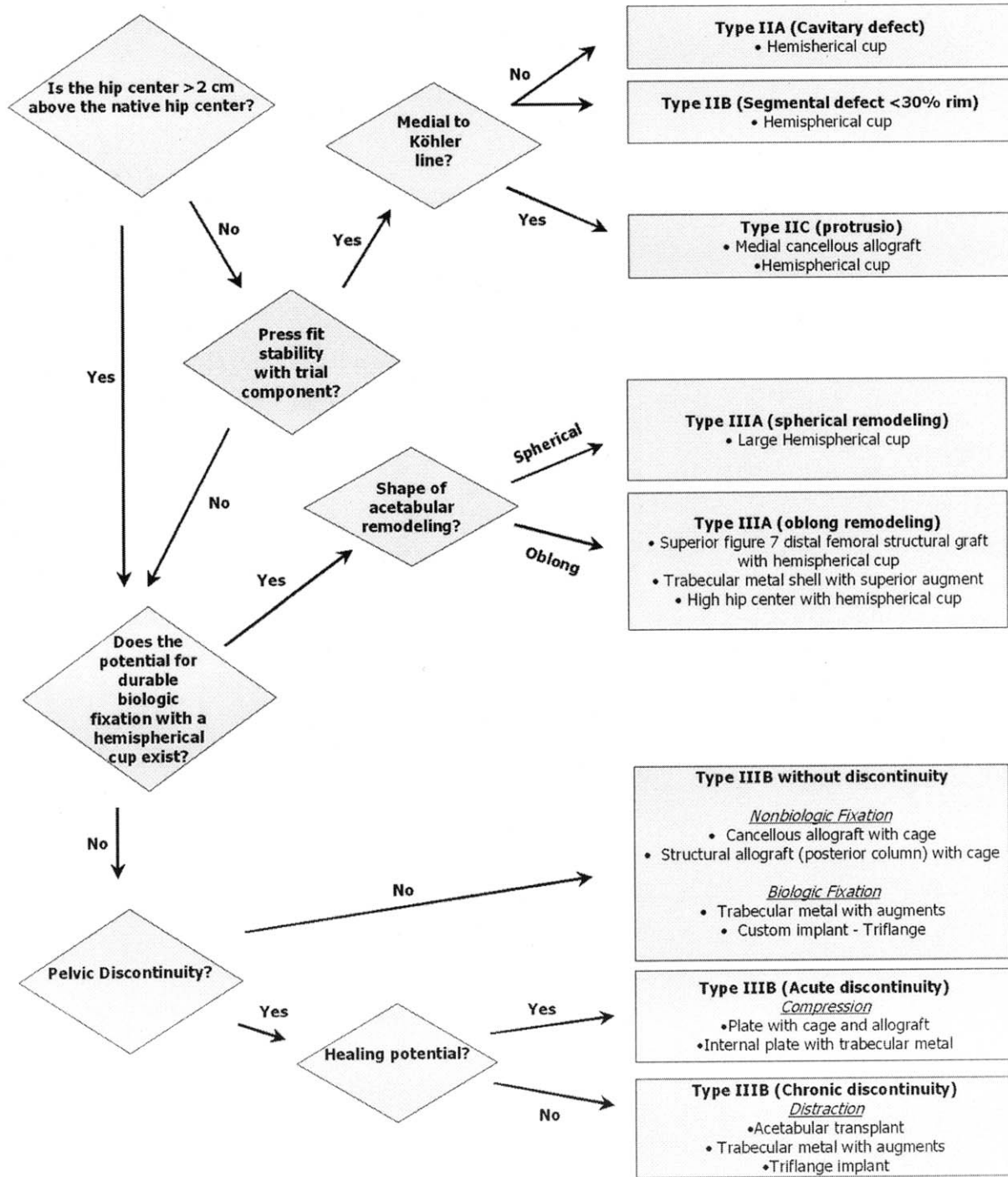
Fig. 2. Acetabular revision algorithm based the amount of remaining host bone, trial stability, and radiographic appearance.

spherical cup, a modular trabecular metal augment with a hemispherical cup, or a high hip center hemispherical cup.

When the there is no inherent stability of the hemispherical trial, the defect is type IIIB. To assess

the remaining host bone, the anterior and posterior columns are compressed with a Cobb elevator, and motion between the superior and inferior hemipelvis is assessed. If a pelvic discontinuity has been ruled out, the options for reconstruction

include nonbiologic fixation with impaction allograft supported with a cage or structural allograft (acetabular allograft or distal femoral allograft) supported with a cage or biologic fixation with a modular trabecular metal system or a custom Triflange implant [5] (Fig. 3A and B).

In the presence of a pelvic discontinuity, we make an intraoperative determination whether the discontinuity appears to be acute with the potential for healing or whether it appears to be chronic without the potential for healing. If healing is possible, we will use compression and plating across the dissociation along with 1 of the reconstructive approaches described for a type IIIB defect above. On the other hand, if there is no potential for healing, we choose to distract the discontinuity and insert bone graft into the defect. The initial stability of the structural graft or the modular reconstruction is greatly enhanced with distraction as opposed to compression when there is little chance for host bone to heal the discontinuity.

Techniques

Type IIIB Defect—Total Acetabular Transplant With Cage

Acetabular reamers are used to size the acetabular cavity and identify the location of remaining bone to support the allograft. Identify the ledge of bone on the superior ilium that will abut against the allograft. Ream the acetabulum of the allograft on back table—avoid weakening the graft by excessive reaming. A cage is sized to the allograft before placement. The allograft hemipelvis 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. Avoid leaving excessive inferior bone on the allograft that prevents optimal medialization of the inferior aspect of the graft. 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 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 maintain shelf distally that will fill the defect of the acetabulum. Allograft should be placed with press fit. The graft can be secured with Steinmann pins provisionally, then with four 6.5-mm partially threaded screws and washer directed obliquely into the ilium from both the intra-articular and lateral ilium aspects of the graft. A pelvic reconstruction plate is then contoured to the posterior column with ideally 3 screws in the native ilium and ischium. A cage is recommended to protect all transplants. Place cage–host bone screws as well as cage–allograft bone screws for fixation. If possible, the inferior flange of a 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 avoiding the tendency to place the component in a vertical and retroverted position.

Type IIIB Defect—Modular Trabecular Metal

Size the acetabular defect with acetabular reamers in the desired location to find the dimension of the cavity until 2 points of fixation are achieved
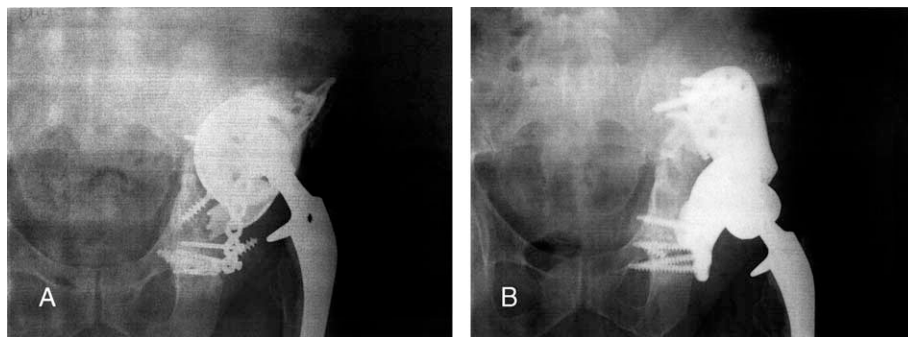
Fig. 3. A 68-year-old woman with (A) failed acetabular cage and a type IIIB acetabular defect. (B) Acetabular defect reconstructed with a custom Triflange component.
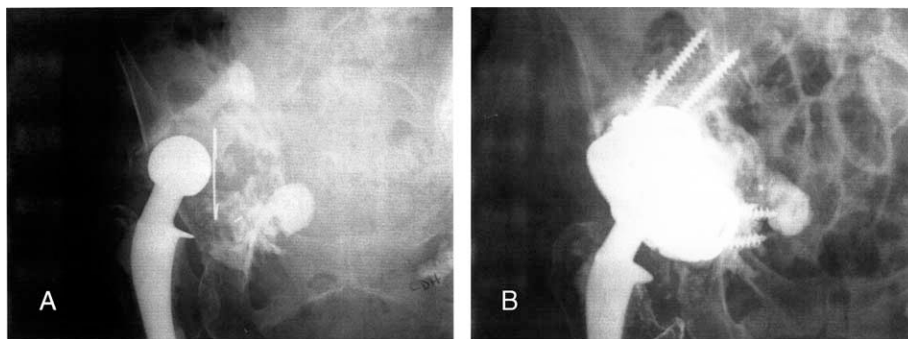
Fig. 4. A 62-year-old man with (A) failed cemented component and a type IIIB acetabular defect. (B) Acetabular defect reconstructed with a trabecular metal acetabular component and a superior and inferior augment.

(anterior to posterior, anterior-inferior to posterior-inferior, posterior-superior to anterior inferior). Use augments to decrease acetabular volume and restore a rim to support a revision cup. The location and orientation of the augments are highly variable depending of the bone loss pattern. Augments are often placed on the medial aspect of the ilium, or they may be stacked (Fig. 4). It is more common to use the augments with the wide base placed laterally and the apex medially (this is the opposite of how the augments are often used in the type IIIA defect. The revision acetabular cup will have direct contact with the augments, and this interference fit will be required to achieve trial stability. Similar to 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 to optimize the surface area contact between the revision shell and the augments. Particulate bone graft is then placed into any remaining cavities before the hemispherical revision shell is impacted into place. Similar to a type IIIA defect, the interface between the revision shell and the augments is cemented (these interfaces should be in compression). Multiple screw fixation is used through the revision shell.

Outcomes of Revisions

Type IIIB acetabular defects treated with an acetabular transplants and a cemented acetabular components (without a cage) have shown poor clinical results [6]. The senior author followed up 16 patients at a minimum 8 years (average 10-year follow-up) and showed 6 hips functioning without loosening, 6 hips revised for aseptic loosening at an average 2.9 years, and an additional 4 hips radiographically loose. Due to the poor results observed with unsupported structural allograft, the senior author then began to use reconstruction cages. The 2- to 8-year follow-up of 45 hips where a cage was used for a type III defects showed 20 hips functioning without loosening, 9 hips revised for aseptic loosening, and an additional 9 hips radiographically loose.

The poor clinical results observed in type IIIB defects have prompted the senior author to explore the use of a trabecular metal acetabular component with 1 or 2 augments in the majority of his current type IIIB cases. Modular trabecular metal revision systems have not been used long enough to report follow-up results at the present time; however, we are encouraged by the outcomes in the early phase.

Conclusion

The prevalence, younger age, and greater life expectancy of the arthroplasty population promise a continued need for solutions in patients requiring an acetabular revisions in the face of severe bone loss. The algorithmic approach we have outlined is an approach that allows the surgeon to predict findings in the operating room, make plans for treating the expected bone loss patterns, and make appropriate judgement regarding reconstructive technique to achieve the best possible durable treatment. Our preference is to achieve cementless biologic fixation when possible and alternative solutions when stability is not achievable.

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