Reconstruction of Major Column Defects and Pelvic Discontinuity in Revision Total Hip Arthroplasty

James B. Stiehl, MD, Rajit Saluja, MD, and Therese Diener, BSN

Abstract: Acetabular reconstruction with severe bone loss after failed total hip arthroplasty is a difficult problem. Defects were defined as major segmental and cavitary loss (type III anterior or posterior) or pelvic discontinuity (type IV). Seventeen cases were treated, of which 7 were type III and 10 were type IV. Bulk allograft was used in 16 of 17 cases, of which 7 were whole acetabular grafts, 2 were posterior segmental acetabular grafts, and 7 were femoral heads. Fourteen of 17 patients were female. The extensile triradiate approach was used in 12 cases. Long pelvic bone plates were applied to the posterior column and anterior brim of the pelvis in most cases. Allografts united to host-bone in 15 cases. Average follow-up was 83 months. The overall revision rate was 47%, of which 3 of 7 press-fit and 2 of 10 cemented cups had failed. The dislocation rate for the extensile approach was 50%; 2 patients had excisional arthroplasty for infection, and 2 patients had exploration of the sciatic nerve for release from migrating pelvic plate screws. Because of the overall poor results, this approach cannot be recommended for general use.

Key words: acetabulum, allograft, total hip, revision hip, hip arthroplasty.

As the indications for total hip arthroplasty (THA) increase, particularly in younger patients, the number of revision procedures carried out in the future will increase. Loss of acetabular bone stock results from removal of bone during the original procedure, subsequent prosthetic failure, and osteolysis resulting from wear particles of cement and polyethylene. In cases with massive structural failure, the acetabular rim, quadrilateral plate, and associated columns become nonsupportive and deficient. In the worst-case scenario, this deficiency can be combined with pelvic discontinuity in which structural integrity of the ilium with the ischium is disrupted. Prosthetic protrusio may result from fixation loss with medial migration of the implant. This condition may be associated with scarring of vital structures, such as the femoral vessels, femoral nerve, ureter, and bowel. For severe acetabular defects, attempts at acetabular reconstruction have included large mesh-supported cement masses with polyethylene cups [1], threaded cups [2,3], dual geometry components [4,5], porous ingrowth cups [6–12], and bipolar stems [13–16]. Often, these procedures have led to poor results because there is not enough host-bone to support the implant.

Bulk acetabular bone grafting has been used as a satisfactory short-term solution in many clinical series [7,9–11,17–23]. Many of these studies used bulk femoral heads, often multiple with limited screw fixation. Failure frequently was seen in cases in which large grafts were used. Kwong et al [24] found progressive deterioration of the fixation stability of these bone-grafts in 47% of cases at minimum 10-year follow-up, although bone stock restoration often led to a simplified revision arthroplasty. Fixa-
tion constructs have improved with the use of pelvic bone plates and metallic ring devices, such as the Birch-Schneider cage [25–31]. This article reviews a long-term experience using a combination of pelvic reconstruction plates and bulk allografts to deal with unusually severe problems, such as pelvic discontinuity and major column loss in which the entire acetabular wall became nonsupportive after failed arthroplasty and reconstruction problems.

Materials and Methods

From a consecutive series of 251 revision THAs done by the senior author (J.B.S.) from January 1988 until July 1996, there were 17 cases treated for entire loss of a pelvic column, pelvic discontinuity, or both. Major pelvic column loss is defined as total absence of the anterior or posterior column such that $<180^\circ$ of the acetabular component can be supported by the remaining ilium or ischium segments and stable press-fit acetabular fixation is not possible. Pelvic discontinuity is defined as complete separation of the superior pelvis from the inferior pelvis through the acetabulum (Fig. 1). The American Association of Orthopaedic Surgeons classification modified by Berry et al [31] was used in the current study. A type I defect is a segmental deficiency in which there is complete loss of bone supporting the acetabulum. Type II defects are cavitary, representing volumetric loss of bone. Types I and II defects may be central (medial) or peripheral (superior, posterior, or anterior). Type III defects are combined cavitary or segmental deficiencies and, for this study, were classified as anterior or posterior if the associated column was lost. A type IV defect is pelvic discontinuity. Type IVA is discontinuity with a cavitary type II or mild-to-moderate type I segmental bone loss. Type IVB has large segmental type I or a combined type III defect. Type IVC is discontinuity associated with previous therapeutic pelvic irradiation with or without cavitary or segmental bone loss [32–34].

The surgical technique used a posterolateral approach without trochanteric osteotomy in 5 cases, and with the extensile triradiate approach with ilioinguinal extension in 12 cases. This latter approach, described elsewhere, was used in all cases in which a long anterior column pelvic plate was applied and in which severe prosthetic protrusio presented the possibility of intrapelvic iatrogenic injury [33]. Trochanteric osteotomy was performed in 3 of the extensile approaches. Fixation used a posteriorly placed AO 4.5-mm pelvic reconstruction plate of 10 to 12 holes in 9 cases of pelvic discontinuity and 5 cases of posterior column bone loss. This plate extended from the most inferior extent of the ischium across the wall of the posterior column to a point high on the ilium. Anterior column fixation used an 8- to 12-hole 3.5-mm AO pelvic reconstruction plate that extended from the pubic symphysis across the rim of the pelvis spanning the anterior column defect, which ranged from 4 to 8 cm to the medial wall of the ilium [34,35]. This procedure was done in 8 of 9 cases of pelvic discontinuity and all 3 cases of anterior column deficiency (Fig. 2).

Bulk allograft provided by the Musculoskeletal Transplant Foundation (Newark, NJ) was used in 16 of 17 cases. The only case not using allograft was the case of pelvic discontinuity after prior pelvic irradiation. Whole pelvic acetabular transplants were used
in the 2 tumor resections for chondrosarcoma and recurrent pigmented villonodular synovitis of the acetabulum and 5 cases of severe bone loss from pelvic discontinuity. Posterior segmental acetabular allografts were used in 2 cases of posterior column absence. Femoral heads were used in 2 type III posterior column defects, 3 type IVB pelvic discontinuities with anterior column defect, and 2 type III anterior column defects. Acetabular components were cemented in 6 of 7 whole bulk acetabular transplants, 6 of 9 type IVB pelvic discontinuities, 1 type III anterior defect, and 1 type IVC defect. Press-fit fixation was used in 1 whole bulk acetabular transplant with 2 type III anterior, 4 type III posterior, and 3 type IVB defects.

Radiographic analysis included anteroposterior views of the pelvis and involved hip, true lateral view of the hip, internal (iliac) and external (obturator) Judet views of the hip, and imaging studies (arteriogram, intravenous pyelogam, computed tomography reconstruction) in selected cases. Pelvic discontinuity was detected when there was disruption of the iliointerwyal and iliischial lines with medial displacement of the inferior ischial segment and possible medial rotation. Discontinuity may be difficult to recognize if there is a large cement prosthetic mass that obscures views of these landmarks.

Cemented fixation was assessed by the method of Hodgkinson et al [36]. Implants were classified as probably or definitely loose if a complete radiolucent line of any width was present at the bone-cement interface, if there was measurable component migration, or if there was a measurable change in position. Uncemented acetabular components were considered probably or definitely loose if component migration or change in position occurred or broken fixation of screws was present [37]. Mueller templates were used to determine migration of the acetabular implant based on the tip of the inferior teardrop and a parallel line drawn to the opposite teardrop at the same anatomic point. Measurements included cranial migration of the socket, medial migration of the socket, and inclination of the socket on successive anteroposterior radiographs of the pelvis. Pelvic plates were considered loose if there was measurable migration or change in position of plate or if fixation screws backed out or were broken [38].

Radiographic union or consolidation of the allograft and pelvic discontinuity was considered to have occurred when bridging callous or trabecular bone was visible across the discontinuity site. Junctional healing was considered probable if there had been no obvious signs of failure, such as hardware breakage, migration, or displacement or graft displacement, but radiographs could not show bone union conclusively. Discontinuity or grafts were considered unhealed if there was significant interval displacement or there were obvious signs of nonunion, such as bone gaps or hardware breakage [25,31].

**Results**

In this series, there were 9 cases of type IVB pelvic discontinuity, of which 2 cases had tumors, including a case of chondrosarcoma and a case of pigmented villonodular synovitis. Seven of the 9 patients with type IVB pelvic discontinuity had late evidence of healing of the fracture and allograft consolidation, whereas 2 underwent early excisional arthroplasty within 3 months for infection. One type IVB patient had removal of the graft at 3 weeks after developing acute postoperative infection, but there was early junctional healing of a whole bulk acetabular allograft requiring an osteotome to break up this interface. A second type IVB patient had implant and graft removal at 3 months for chronic infection, and complete consolidation of a whole bulk acetabular allograft was noted. One patient had revision of a press-fit acetabular component at 60 months, and the type IVB pelvic discontinuity was united solidly with complete consolidation of a nonviable femoral head spanning the original anterior column deficiency (Fig. 3). A fourth patient with type IVB defect treated with a whole bulk acetabular graft was explored at 124 months postoperatively for loosening of a cemented cup, finding near-complete dissolution of the graft posterior acetabular wall and a loose posterior pelvic plate. The remaining graft had consolidated to host-bone but remained nonviable in appearance.

One patient was classified as type IVC after developing pelvic discontinuity after radiation therapy for uterine carcinoma. Satisfactory healing of the pelvic discontinuity was confirmed at 32 months when excisional arthroplasty was done for late chronic infection after urinary sepsis.

Seven patients had major column loss with severe cavitary defects, 3 anterior (type III anterior) and 4 posterior (type III posterior). Consolidation of the allograft was noted in all 7 cases within the first 12 months of follow-up. There was no evidence of plate migration or screw breakage in any case.

Eleven patients were available for recent examination by the independent evaluator with average follow-up of 83 months (range, 39–124 months). There were 9 women and 2 men. The average age was 67.5 years (range, 31–81 years). The diagnosis was type IVB in 6 patients, type III posterior in 3,
and type III anterior in 2. The average Harris hip score was 70 (range, 57–85) [39]. Three of the 11 had been revised at the time of review with acetabular loosening of a press-fit component in a type IVB, a press-fit component in a type III posterior, and a cemented metal-backed cup in a type IVB defect. One patient had been converted to an excisional arthroplasty after removal of implants and graft after 3 months of chronic infection.

The status of the remaining 6 patients was known at the time of death or last follow-up. One patient with type IVB pelvic discontinuity died at 57 months with a healed pelvis and stable cemented acetabular component (Fig. 4). One patient with type IVB

Fig. 3. (A) Pelvic discontinuity after use of a large cemented ring in a 61-year-old woman. Ilioinguinal and ilioischial lines are disrupted with medial translation of the pubis. (B) Femoral arteriogram shows displacement of the femoral artery by the protruded acetabular component cement mass. (C) Obturator Judet view of pelvis shows medial displacement of prosthesis with complete loss of the anterior column of the pelvis. (D) Reconstruction of pelvic discontinuity and anterior column with double column plating and femoral head graft for replacing the deficient anterior column.
pelvic discontinuity underwent excisional arthroplasty at 3 weeks after acute infection of a double-plating technique with a whole bulk acetabular allograft. One type IVB patient had whole bulk acetabular grafting after resection of a chondrosarcoma and was noted to have a stable graft at the time of death (62 months). One type III posterior patient with a press-fit cup and posterior column plating with femoral head graft for severe posterior column deficiency had a loose press-fit cup revised to a cemented cup before death. One patient with a type III anterior defect had undergone anterior column plating using a femoral head graft and died at 63 months with a stable implant. One patient with a type IVC pelvic discontinuity after irradiation had an excisional arthroplasty performed at 32 months after infection related to chronic urinary sepsis. The pelvic discontinuity was solidly united, and the all-polyethylene acetabular component was stable.

The overall revision rate was 47%, with revision in 2 type IVB patients for infection, 1 type IVC patient for infection, 2 type III posterior patients for implant loosening, 2 type IVB patients for implant loosening, and 1 type IVB patient for recurrent implant dislocation. The 4 loose cups were revised to a cemented all-polyethylene component. In all 4 cases of implant loosening, the implants had been placed on <50% host-bone. There have been no rerevisions in any of these cases.

Dislocation postoperatively occurred in 8 patients, of which 6 had undergone the extensile triradiate approach. The occurrence of dislocation was noted in 50% of cases in which this extended approach was used. The hip stabilized in 7 of 8 patients with prolonged immobilization with casting or hip abduction orthosis. In 1 case, the problem resolved after changing the femoral head to a longer length and performing a soft tissue reconstruction about the prosthesis.

There were no immediate postoperative sciatic nerve injuries, but 3 patients developed late sciatic palsy. In 1 patient, plaster immobilization possibly had caused direct pressure over the fibular head, causing chronic peroneal palsy. Two patients underwent additional exploration of the sciatic nerve for late entrapment at 46 months and 24 months caused by migration of screws from the posterior column plate. Sciatic nerve symptoms resolved in 1 and significantly improved in the other.

Two patients suffered from bladder infections postoperatively, 1 developing late infection of the prosthesis with the same organism isolated from infected urine. Another patient developed superficial phlebitis of the lower leg that resolved with rest and anticoagulant therapy.

**Discussion**

Pelvic discontinuity and major column bone loss are rare difficult conditions, and most cases have been mentioned as subgroups of larger series of revision THA [7,9,11,17,19,20,40–42]. Paprosky et al [43,44] reported 100% healing of 17 whole acetabular allografts in acetabular revision but noted migration of most grafts. Three had failed at 2-year follow-up, and complications were high, with 35% dislocating and 23% infected. Garbuz et al [28] defined a subgroup in which major acetabular allografts supported >50% of the cup after major

![Fig. 3. (Continued.)](#)

(E) Revision of loose acetabular component at 5 years reveals healed pelvic discontinuity with persistence of nonvascularized graft of the anterior column. (F) Final follow-up radiograph shows stable implant fixation and graft union at 122 months.
column bone loss. Their results indicated a revision rate of 45% at 7.1 years without the need for additional grafting in 7 of 15 revised cases. The remainder had significant graft resorption fragmentation or nonunion, however [28]. Berry and Müller [25] reported the use of antiprotrusio cages with bulk femoral heads for type III cavitory and segmental structural defects, finding 71% successful results without loosening at an average 5-year follow-up.

Berry et al [31] reviewed the overall Mayo Clinic experience for revision THA, finding pelvic discontinuity in 0.9% of all cases. Of 31 cases, 28 occurred in women with the predominant diagnosis of rheumatoid arthritis. In that series, the Burch-Schneider cage was successful in healing the discontinuity in 11 of 12 cases, but follow-up was too short to determine the outcome of cup fixation or graft longevity. None of the double-plating techniques led to healing of the defects, but several cases had constructs in which multiple bulk allografts were used.

The results of the current study suggest that major column bone loss and pelvic discontinuity are serious problems for which the methods used here resulted in high revision and complication rates. Similar to the study of Berry et al [31], 14 of 17 cases were found in women, but rheumatoid arthritis was noted in only 2 cases. With the exception of the tumor cases, massive pelvic column erosions and

Fig. 4. (A) Dramatic prosthetic protrusio with obvious pelvic discontinuity in a 65-year-old rheumatoid patient. Medial displacement and rotation of the pubic/ischial segment of the pelvis are present. (B) Arteriogram shows position of the femoral artery and external iliac artery in relation to the protrused component. (C) Radiograph of anterior pelvis shows successful double plating of the discontinuity with the use of a cemented acetabular component at 2-year follow-up.
severe prosthetic protrusion accompanied osteolysis most likely from third-body wear generation in cemented metal-backed or all-polyethylene components.

The initial goals of the extensile triradiate approach used in this series were to avoid catastrophic injuries by direct exposure of vital structures and to allow stable anterior column plate fixation [33,34]. Both goals appear to have been met in that no neurovascular injuries occurred, and stable durable allograft consolidation and healing of pelvic discontinuity were accomplished in most cases. Long pelvic plates that securely stabilize the pelvis and allografts carefully opposed to host-bone may explain success in this series as opposed to difficulties encountered by other authors [35].

The extensile triradiate approach led to an unacceptable dislocation rate of 50%, and infection occurred in 2 of 12 cases. This approach probably should be limited only to cases in which a whole bulk acetabular allograft is used in younger healthy patients. Other methods, such as the posterior approach with trochanteric osteotomy and the use of the antiprotrusio cage, appear to be easier and simpler for higher-risk elderly patients.

Numerous authors have cautioned against press-fit fixation with large bulk acetabular allografts. This study reaffirms that the acetabular component should be cemented into the allograft when >50% of the prosthetic interface is nonviable. Acetabular revision for loosening was seen in 3 of 7 cementless implants, whereas only 2 of 10 cemented implants failed.

In this series, single cortical allografts of the acetabulum were used in most cases after 1990 with the belief that this bone would last longer if fixed rigidly and partially protected by the pelvic reconstruction plates. Early optimism arose from the high healing rate of the pelvic discontinities and the consolidation of most bulk allografts in the series. This opinion has been tempered by the revision of 1 of the whole bulk acetabular grafts after 10 years of successful pain-free use in a young active man. There was nearly complete dissolution of the posterior cortical wall adjacent to the pelvic plate, making

<table>
<thead>
<tr>
<th>Table 1. Classification of Acetabular Deficiencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I. Segmental deficiencies</td>
</tr>
<tr>
<td>Peripheral</td>
</tr>
<tr>
<td>Superior</td>
</tr>
<tr>
<td>Anterior</td>
</tr>
<tr>
<td>Posterior</td>
</tr>
<tr>
<td>Type II. Cavitary deficiencies</td>
</tr>
<tr>
<td>Peripheral</td>
</tr>
<tr>
<td>Superior</td>
</tr>
<tr>
<td>Anterior</td>
</tr>
<tr>
<td>Posterior</td>
</tr>
<tr>
<td>Type III. Combined deficiencies</td>
</tr>
<tr>
<td>Anterior column</td>
</tr>
<tr>
<td>Posterior column</td>
</tr>
<tr>
<td>Type IV. Pelvic discontinuity</td>
</tr>
<tr>
<td>A. Cavitary type II or mild-to-moderate type I segmental</td>
</tr>
<tr>
<td>B. Large segmental type I or combined type III</td>
</tr>
<tr>
<td>C. Pelvic irradiation with or without cavitary or segmental loss</td>
</tr>
<tr>
<td>Type V. Arthrodes</td>
</tr>
</tbody>
</table>

Table 2. Data on Patients With Pelvic Discontinuity and Major Column Defects

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age at Follow-up (yr)</th>
<th>Defect</th>
<th>Approach</th>
<th>Cup Fixation</th>
<th>Graft</th>
<th>Plates</th>
<th>Revised</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>77</td>
<td>III</td>
<td>Anterior</td>
<td>Press</td>
<td>Head</td>
<td>Anterior</td>
<td>No</td>
<td>Dislocation, late sciatic palsy</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>78</td>
<td>IVB</td>
<td>Extensile</td>
<td>Press</td>
<td>Head</td>
<td>Double</td>
<td>Yes</td>
<td>Acute infection</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>Dead</td>
<td>Anterior</td>
<td>Extensile</td>
<td>Press</td>
<td>Head</td>
<td>Anterior</td>
<td>No</td>
<td>Dislocation</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>69</td>
<td>IVB</td>
<td>Extensile</td>
<td>Press</td>
<td>Head</td>
<td>Double</td>
<td>Yes</td>
<td>Acute infection</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>81</td>
<td>IVB</td>
<td>Extensile</td>
<td>Press</td>
<td>Head</td>
<td>Anterior</td>
<td>No</td>
<td>Dislocation</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>53</td>
<td>IVB</td>
<td>Extensile</td>
<td>Press</td>
<td>Head</td>
<td>Double</td>
<td>Yes</td>
<td>Dislocation</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>68</td>
<td>III</td>
<td>Anterior</td>
<td>Press</td>
<td>Head</td>
<td>Double</td>
<td>Yes</td>
<td>Dislocation</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>76</td>
<td>IVB</td>
<td>Extensile</td>
<td>Press</td>
<td>Head</td>
<td>Double</td>
<td>Yes</td>
<td>Dislocation</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>54</td>
<td>IVB</td>
<td>Extensile</td>
<td>Press</td>
<td>Head</td>
<td>Double</td>
<td>Yes</td>
<td>Dislocation</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>31</td>
<td>III</td>
<td>Posterior</td>
<td>Press</td>
<td>Posterior segmental pelvis</td>
<td>Posterior</td>
<td>Yes</td>
<td>Late infection and sciatic palsy</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>72</td>
<td>III</td>
<td>Posterior</td>
<td>Press</td>
<td>Posterior segmental pelvis</td>
<td>Posterior</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>F</td>
<td>64</td>
<td>III</td>
<td>Posterior</td>
<td>Press</td>
<td>Head</td>
<td>Posterior</td>
<td>Yes</td>
<td>Late sciatic palsy, loosening</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>68</td>
<td>III</td>
<td>Posterior</td>
<td>Press</td>
<td>Head</td>
<td>Posterior</td>
<td>No</td>
<td>Dislocation</td>
</tr>
</tbody>
</table>
subsequent revision tenuous. Although the long-term result was spectacular given the complexity and limited options facing this young patient > 10 years ago, the reality is that virtually all graft material, including dense cortical grafts, ultimately may fail if used for implant fixation. Patients should understand this problem and be fully aware of the inevitable risks.

The final issue has to do with indications for these procedures, which have been technically difficult with long operating times. The 2 patients who became infected after whole bulk acetabular transplants were elderly and high risk with multiple comorbidities. Both ultimately became wheelchair bound after excisional arthroplasty, although reasonably satisfied with their outcome. Complex acetabular allograft procedures as used here are relatively contraindicated in these elderly patients in favor of lesser operative methods that are simpler, require less surgical exposure, and can be performed in an expeditious fashion; this would include the use of antiprotrusio cages or excisional arthroplasty.

Summary

This article reviews the long-term results of treating severe bone compromise of the acetabulum with major column deficiency and pelvic discontinuity. The techniques used allowed stable healing of the pelvic discontinuity in most cases. A high revision rate was noted primarily as a result of infection and failure of implant fixation into bulk allograft. These results are considered to be relatively poor, and this approach should be avoided in elderly and debilitated patients in favor of simpler methods. Reconstructions of this nature should be limited to younger patients with the expectation that long-term failure of the allograft and implant fixation is inevitable.

References

44. Paprosky WG, Sekundiak TD: Total acetabular allografts. Instr Course Lect 48:67, 1999