Pelvic discontinuity represents a rare but challenging problem for orthopaedic surgeons. It is most commonly encountered during revision total hip replacement, but can also result from an iatrogenic acetabular fracture during hip replacement. The general principles in management of pelvic discontinuity include restoration of the continuity between the ilium and the ischium, typically with some form of plating. Bone grafting is frequently required to restore pelvic bone stock. The acetabular component is then impacted, typically using an uncemented, trabecular metal component. Fixation with multiple supplemental screws is performed. For larger defects, a so-called ‘cup–cage’ reconstruction, or a custom triflange implant may be required. Pre-operative CT scanning can greatly assist in planning and evaluating the remaining bone stock available for bony ingrowth. Generally, good results have been reported for constructs that restore stability to the pelvis and allow some form of biologic ingrowth.

Pelvic discontinuity (PD) is a rare but difficult problem that the orthopaedic surgeon may encounter, and represents a separation of the ilium proximally from the ischio-pubic segment distally. Pelvic discontinuity usually occurs in one of three distinct situations. Acute acetabular fracture patterns in the elderly commonly involve a PD. Iatrogenic fracture during total hip replacement (THR) while impacting an uncemented acetabular component may also result in a pelvic discontinuity. Finally, and most commonly, PD can be encountered during revision THR. In the revision setting, PD is typically due to osteolytic bone loss, and usually represents a more chronic stress fracture of the underlying bone. This paper reviews the evaluation, management strategies, results and complications related to the treatment of pelvic discontinuity.

Pre-operative evaluation
Accurate imaging of the acetabulum is critical in order to evaluate remaining bone stock and bony deficiencies. A well-centred antero-posterior view of the pelvis is obtained, along with obturator oblique and iliac oblique judet views of the acetabulum. A thin cut computed tomographic (CT) scan of the acetabulum is recommended, and the authors routinely request three-dimensional reconstructions. Very accurate measurements of bony defects can assist in planning component size. Additionally, remaining superior dome and ischial bony contact opportunities can be evaluated. The senior author (GH) routinely uses 3D CT to determine when a custom implant will be required, and when a more simple reconstructive strategy will suffice. Pre-operative medical optimisation is indicated for all patients, as well as routine serologic workup for infection in the revision setting.

General management principles
Four general principles of management of PD apply essentially to any situation where PD is encountered:

1) To restore continuity of the acetabulum (i.e. ‘connect’ the ilium to the ischium).
2) To graft the bone of any bony deficiencies or fracture lines.
3) To optimise contact of remaining viable bone to component surfaces with ingrowth potential.
4) To obtain a mechanically stable reconstruction.

Acute pelvic discontinuity due to acetabular fracture
Acetabular fractures in young patients are typically treated with open reduction and internal fixation (ORIF) in order to preserve the native hip joint. Modern techniques have demonstrated that the vast majority of young patients with acetabular fractures, when treated...
Acetabular fractures in elderly patients, however, commonly involve impaction of the joint in the acetabular dome or the femoral head. Studies have shown that ORIF in this setting fails very commonly, and that acute THR may be a better choice. Fracture patterns in the elderly commonly involve PD due to their involvement of both acetabular columns. The four principles outlined above are applied in the following manner: the hip is reached through a posterior approach. After performing the femoral neck cut, the posterior column is plated and the anterior column defect is grafted from bone obtained from the femoral head. The acetabulum is reamed and an uncemented trabecular metal cup is impacted. Fixation is supplemented with screws into the acetabular dome and ischium (Fig. 1). While the senior author prefers to rely on the posterior column for support of the acetabular component and places a priority on fixation of fractures involving the posterior column, fixation of certain simple anterior column fracture patterns with screw fixation, can augment overall construct stability.

The authors prefer to limit weight bearing for a minimum of six to eight weeks after such reconstructions in order to allow the fracture to unite, and cup ingrowth to occur.

**Iatrogenic pelvic discontinuity**

Although extremely rare, acute, iatrogenic PD may occur during primary THR. Excessive under-reaming, forcible impaction and elliptical monoblock uncemented components, impacted into a hemispheric bed, have been implicated as causes of iatrogenic fractures. Most intra-operative fractures are minor fissures that only involve one column, however an acute transverse acetabular fracture (PD) can occur. The unstable cup is typically removed, and the extent of the fracture is visually evaluated. Obviously, this clinical situation does not allow the benefit of CT imaging, and careful intra-operative assessment of fracture lines and...
stability is important. Posterior exposure and plating is typically required for unstable fractures. Bone grafting is liberally applied, and a multi-hole uncemented acetabular component is impacted and stabilised with multiple screws. Again, a period of protective weight bearing is recommended.

**Pelvic discontinuity during revision total hip replacement**

This situation represents both the most common and the most problematic scenario for management of PD. The remaining bone stock is variable, defects are common, and the biologic potential of the remaining bone is often difficult to evaluate. Pre-operative CT scanning is critical in order to understand the bony anatomy fully. Although PD in the revision setting represents a spectrum of variable defects, and ‘no two are alike’, the authors generally categorise PD as simple, moderate, or severe.

‘Simple’ revision PD is a demonstration of defects that can be managed with posterior column plating, bone grafting and a ‘jumbo’ acetabular component. These are nearly identical to the acute PD situations described above. The bony deficiencies are minor, the remaining bone stock is viable, and good construct stability can be obtained. Compression can typically be applied to the discontinuity, and healing is likely to be successful.

‘Moderate’ revision PD is an example of larger defects, where a jumbo cup alone is likely to fail. Little rim support is present, and some form of augmentation to achieve cup stability is required. Trabecular metal augments, or ‘cup-cage’ reconstruction may be necessary. Cup-cage constructs utilise an uncemented trabecular metal component supplemented with a cage, including flanges that engage the ilium and the ischium. Theoretically, these provide the initial stability necessary to allow uneventful ingrowth into the uncemented acetabular component. It should be noted that the flanges of the cage have no ingrowth potential, and the success of these constructs relies on bony ingrowth into the cup itself. Often the bony ends are dysvascular, and healing of the pelvic discontinuity is unlikely. Distraction techniques that engage the ilium and ischium and bridge the defect can be useful as compression can rarely be applied in these settings.

‘Severe’ revision PD is representative of massive defects with little remaining dome bone. The amount of bone contact required to achieve successful long-term fixation of modern jumbo trabecular components remains unknown. However, in the senior author’s experience, many of these defects can span over 12 cm, with only a narrow strip of remaining proximal acetabular bone (the largest cups available from most manufacturers are typically in the 80 mm range). In such situations, cup–cage constructs are likely to fail. These extreme situations can be managed effectively by a custom triflange component (Fig. 2). These custom implants are capable of spanning any sized defect, and restore the hip centre to a more anatomically accurate position. Modern ingrowth surfaces and coatings can be applied and some manufacturers offer the option of locking screws, which stabilise the reconstructions further. These devices allow a broad footprint of contact with the remaining acetabular dome and ischium, and, importantly engage the external bone of the lateral ilium and ischium, which is often well vascularised and supportive.

The most severe discontinuities, especially in elderly, low demand patients, may require definitive Girdlestone resections. Again, pre-operative CT scanning is important in order to guide treatment and to evaluate the remaining opportunities for bony contact.

**Complications**

Due to the magnitude of these reconstructions, it is not surprising that all of the common complications associated
with revision THR have been reported: mechanical failure, instability, infection, and sciatic nerve palsy are all post-operative factors that are cause for concern. Careful posterior dissection and retraction is recommended, as well as special attention during trial stages, to ensure an impingement free range of movement.

**Results**

Several studies have investigated the outcomes of various treatment strategies for PD. In general the best results are those that allow biologic ingrowth into the acetabular component. Results with anti-protrusio devices alone (which do not offer a biologic ingrowth surface) have generally been poor and offer only a short to mid-term solution. A summary of clinical results of various constructs is found in Table I. The cost of these reconstructions is substantial as demonstrated in a recent study, which compared cup-cage and augment constructs with custom triflange constructs. The costs were nearly identical, but still substantial.

**Conclusions**

Adhering to the general principles of management of PD is important in order to minimise complications and to increase the likelihood of a durable reconstruction. Expertise is often required in both internal fixation of the pelvis and acetabulum, and in replacement techniques for treatment. In certain circumstances, the collaboration of a multidisciplinary team including both adult reconstruction and traumatology sub-specialists, is in the patient’s best interest. Constructs that achieve primary cup stability and allow biologic ingrowth appear to provide the best outcomes to date. However further follow-up is needed to

---

**Table I. Results following surgical treatment of pelvic discontinuity (NR, not reported)**

<table>
<thead>
<tr>
<th>Author/s</th>
<th>No of hips with discontinuity</th>
<th>Type of reconstruction</th>
<th>Mean follow-up (yrs) (range)</th>
<th>Revision rate</th>
<th>Clinical score *</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berry et al</td>
<td>27</td>
<td>Anti-protrusio cage, anterior-posterior plating</td>
<td>3 (0.2 to 7)</td>
<td>9/27 (33%)</td>
<td>16/27 (60%) satisfactory result (based on own criteria)</td>
<td>9 failures: 4 aseptic acetabular loosening, 4 recurrent dislocations. 1 deep infection (1.3 yrs)</td>
</tr>
<tr>
<td>Goodman et al</td>
<td>10</td>
<td>Anti-protrusio cage</td>
<td>3.3</td>
<td>5/10 (60%)</td>
<td>NR</td>
<td>Complications: 3 rings loosened, 2 ring flange fractures, 3 dislocations, 1 deep infection requiring resection replacement</td>
</tr>
<tr>
<td>Sporer et al</td>
<td>16</td>
<td>Cage, plate, allograft</td>
<td>5 (2 to 8)</td>
<td>5/16 (31%)</td>
<td>MP: 3.7 to 6.8</td>
<td>44% overall loosening rate Complications: 4 sciatic nerve palsies, 1 dislocation, 1 deep infection</td>
</tr>
<tr>
<td>Eggli et al</td>
<td>7</td>
<td>Ganz ring, anterior-posterior plating</td>
<td>8 (4.5 to 11)</td>
<td>NR</td>
<td>MP: 7.5 to 13.2. HHS: 33 to 73</td>
<td>9 failures: 4 aseptic acetabular loosening, 4 recurrent dislocations. 1 deep infection requiring revision, 1 intra-op femoral shaft fracture</td>
</tr>
<tr>
<td>Stiehl et al</td>
<td>10</td>
<td>Bulk structural allograft, anterior-posterior plating</td>
<td>6.9</td>
<td>6/10 (60%)</td>
<td>NR</td>
<td>Cementless cups that rested on a bulk allograft had high failure rates. Used extensile triradiate approach with high dislocation rate</td>
</tr>
<tr>
<td>Taunton et al</td>
<td>57</td>
<td>Custom Triflange</td>
<td>6.3 (2 to 18)</td>
<td>20/57 (30%)</td>
<td>HSS 74.8 post-op</td>
<td>3 triflange failures (5.3%): 1 aseptic loosening, 2 deep infection resections. 81% had a stable triflange component with a healed pelvic discontinuity, 98% free of revision for aseptic loosening at latest follow-up</td>
</tr>
<tr>
<td>DeBoer et al</td>
<td>20</td>
<td>Custom Triflange</td>
<td>10 (7.4 to 13)</td>
<td>No components revised</td>
<td>HHS 41 to 80</td>
<td>6/20 hips dislocated (30%), 6 hips underwent reoperation: 5 for dislocation, 1 for partial sciatic nerve palsy due to loose screws</td>
</tr>
<tr>
<td>Kosashvili et al</td>
<td>26</td>
<td>Trabecular Metal™ cup/cage</td>
<td>3.7 (2 to 5.6)</td>
<td>NR</td>
<td>HHS 46.6 to 76.6</td>
<td>2 dislocations, 1 deep infection, 1 peroneal nerve palsy</td>
</tr>
<tr>
<td>Sporer et al</td>
<td>20</td>
<td>Trabecular Metal™ cup, augments, distraction</td>
<td>4.5 (2 to 7)</td>
<td>1/20 (5%)</td>
<td>MP: 3.3 to 9.6</td>
<td>1 revision for aseptic loosening at 3 months, 4 patients had radiographic loosening with no pain, complications: 1 colonic perforation, 1 vascular injury (femoral artery), 1 greater trochanter fracture 1 superficial infection</td>
</tr>
<tr>
<td>Sporer and Paprosky</td>
<td>13</td>
<td>Trabecular Metal™ cup/augments, distraction</td>
<td>2.6 (1 to 3)</td>
<td>No components revised</td>
<td>MP: 6.1 to 10.3</td>
<td>1 patient demonstrated acetabular loosening due to screw breakage</td>
</tr>
</tbody>
</table>

* HHS, Harris hip score, MP, Merle d’Aubigne-Postel score
determine the most cost effective treatments. Careful preoperative planning can facilitate accurate, efficient management of these challenging problems.

The author or one or more of the authors have received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article.

This paper is based on a study which was presented at the 29th Annual Winter 2012 Current Concepts in Joint Replacement® meeting held in Orlando, Florida, 12th – 15th December.

References


