Acetabular revision using an anti-protrusion (ilio-ischial) cage and trabecular metal acetabular component for severe acetabular bone loss associated with pelvic discontinuity

Y. Kosashvili, D. Backstein, O. Safir, D. Lakstein, A. E. Gross

From Mount Sinai Hospital, Toronto, Canada

Pelvic discontinuity with associated bone loss is a complex challenge in acetabular revision surgery. Reconstruction using ilio-ischial cages combined with trabecular metal acetabular components and morsellised bone (the component-cage technique) is a relatively new method of treatment.

We reviewed a consecutive series of 26 cases of acetabular revision reconstructions in 24 patients with pelvic discontinuity who had been treated by the component-cage technique. The mean follow-up was 44.6 months (24 to 68). Failure was defined as migration of a component of > 5 mm.

In 23 hips (88.5%) there was no clinical or radiological evidence of loosening at the last follow-up. The mean Harris hip score improved significantly from 46.6 points (29.5 to 68.5) to 76.6 points (55.5 to 92.0) at two years (p < 0.001). In three hips (11.5%) the construct had migrated at one year after operation. The complications included two dislocations, one infection and one partial palsy of the peroneal nerve.

Our findings indicate that treatment of pelvic discontinuity using the component-cage construct is a reliable option.

Pelvic discontinuity associated with bone loss is a challenging condition encountered at the time of acetabular revision. It has been defined as “an uncommon condition occurring in association with total hip replacement when the hemipelvis is separated superiorly and inferiorty by loss of host bone or fracture through the acetabular columns”. Pelvic discontinuity can often be detected pre-operatively on plain radiography, but radio-opaque implants can obscure the condition and, therefore, an intra-operative examination of the hemipelvis for discontinuity is advised.

Most commonly it occurs, several years after total hip replacement (THR), as performed as a pathological fracture through an acetabulum weakened by osteolysis resulting in combined segmental and cavitatory bone loss. Occasionally, it is a consequence of an acute fracture during THR. As regards the latter it can be managed by open reduction and internal fixation with a posterior-column plate and an uncemented acetabular component, provided that this does not involve substantial bone loss.

Pelvic discontinuity compromises the inherent bony stability of the hemipelvis. Consequently, the mechanical support essential for bony integration of the uncemented acetabular component is absent. Therefore acetabular reconstructions have been performed using a posterior-column plate and a cementless acetabular component, or an anti-protrusion (ilio-ischial) cage spanning the defect with an acetabular liner cemented into the cage.

The anti-protrusion cage gives fixation by means of a superior flange fixed by screws on to the ilium and a lower flange which engages the ischium. It is used for extensive bone loss, including uncontained loss involving the acetabular columns and the dome with the loss of cancellous and cortical bone. It protects extensive acetabular bone graft by transferring some of the load from the acetabulum to the ilium and the ischium.

However, since there is no bone ingrowth into the cage, the longevity is reported to be limited because of failure of the screws or the flanges. The screws eventually break and the ischial flanges can either break or loosen, leading to migration of the cage.

The anti-protrusion cage has had poor long-term results in treatment of pelvic discontinuity have prompted exploration of alternative methods of reconstruction. For the past
six years the senior author (AEG) has been using a technique first introduced by Hanssen and Lewallen. This addresses the defect in the pelvic bone using a construct of a trabecular metal acetabular component (Zimmer, Warsaw, Indiana) which is spanned by an anti-protrusion cage into which a polyethylene liner is cemented.

Our study presents the preliminary clinical and radiological outcome of this relatively new technique in the treatment of severe acetabular bone loss associated with pelvic discontinuity in revision surgery.

### Patients and Methods

Between January 2003 and September 2007, 26 consecutive acetabular revisions were performed in 24 patients with pelvic discontinuity. This represented 5% of the total number of revisions performed during the period of study. The mean follow-up of the patients was 44.6 months (24 to 68). The mean number of previous replacement procedures on the affected hip before this reconstruction was 2.4 (1 to 5; Table I).

In all the patients pelvic discontinuity was based on the radiological findings and confirmed intraoperatively by the senior author after removal of the previous acetabular component. In these patients the hemipelvis was separated superiorly and inferiorly because of loss of the host bone or fracture through the acetabular columns.

The senior author maintained a prospective database of the patients undergoing revision. The underlying pathology

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### Table I. Clinical details of the 26 hips

<table>
<thead>
<tr>
<th>Case</th>
<th>Underlying pathology</th>
<th>Reason for revision</th>
<th>Pre-revision component fixation</th>
<th>Age at operation (yrs)</th>
<th>Previous hip operations</th>
<th>Acetabular component size (mm)</th>
<th>Host-bone contact (%)</th>
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<tbody>
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<td>Osteoarthritis</td>
<td>Acetabular component migration, osteolysis</td>
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<td>10</td>
<td>Rheumatoid arthritis</td>
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<td>Cemented</td>
<td>60</td>
<td>3</td>
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<td>Acetabular component migration (protrusio) + massive osteolysis</td>
<td>Cemented</td>
<td>59</td>
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<td>Uncemented</td>
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<td>23</td>
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<td>26</td>
<td>Rheumatoid arthritis</td>
<td>Acetabular component migration, osteolysis</td>
<td>Uncemented</td>
<td>73</td>
<td>1</td>
<td>60</td>
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</table>

Mean 64.9 (44 to 84) 2.4 (1 to 5) 62.8 (56 to 76) 15.8 (0 to 40)
leading to the initial replacement, the indication for revision, the number of previous procedures, the surgical approach, the pre-revision acetabular component fixation, the size of the acetabular component and the percentage of bleeding bone encountered after reaming of the acetabular defect were documented (Table I).

The mean age of the patients at the time of surgery was 64.9 years (44 to 84). In 20 hips the acetabulum alone was reconstructed while in the remaining six both components were revised. In four a constrained liner was used because of poor abductor function.

Clinical evaluation included the use of the Harris hip score (HHS) pre-operatively, at six weeks, six months and at yearly intervals thereafter. In addition, data regarding the use of walking aids by the patient, pre- and post-operatively, including the last follow-up, were recorded. The patients included in this study had multiple hip reconstructions and required various walking aids that are not sufficiently specified in the HHS scoring system. Thus, we additionally recorded patients’ level of mobility by grading their use of walking aids from 1 to 6 (Table II). A score of 1 represented independent walking while a score of 6 indicated use of a wheelchair. These scores were based on the d’Aubigne-Postel scoring for patients’ ability to walk, criteria which were modified to include the walking aids used by our patients.

Radiological evaluation included anteroposterior (AP) and lateral views of the pelvis and the affected hip, which were taken pre-operatively and at six weeks, six months and annually post-operatively. The initial six-week post-operative radiographs served as a baseline with which all the subsequent radiographs were compared. All radiographs were evaluated by two of the authors (AEG, YK) for evidence of migration or loosening of components.

Acetabular migration (> 5 mm) was evaluated according to criteria published by Massin, Schmidt and Engh and also by the presence of any circumferential radiolucent lines around the acetabular component including the area around the screws.

Loosening of the cage was determined according to the criteria of Gill, Sledge and Muller, who classified cages to be definitely, probably or possibly loose. However, based on our radiological findings and previous experience with reconstruction using anti-protrusion cages, some modifications were made. The cages were considered to be definitely loose if at least one of three radiological findings was detected: 1) horizontal or vertical migration > 5 mm; 2) a complete and progressive radiolucent line medially and superiorly or around the screws on an anteroposterior (AP) pelvic radiograph; and 3) breakage of hardware such as flanges or screws.

Probable loosening was defined as a progressive radiolucent medially or superiorly on an AP pelvic radiograph and possible loosening as a non-progressive radiolucent which did not involve the screws. In relation to possible loosening one restriction was introduced as the presence of a non-progressive radiolucent around the tip of the ischial flange, which is a common finding and probably represents micromovement of the flange while biological stabilisation of the acetabular component takes place. Thus, such a finding was not regarded as loosening in our analysis.

In addition, the reconstructed acetabular bone stock was evaluated as an indirect measure of assessing the healing of the pelvic discontinuity. The morsellised bone graft previously placed medially to the acetabular component was examined in the follow-up radiographs to detect continuity, remodelling or resorption.

Operative techniques. The surgical approaches which facilitate acetabular exposure such as trochanteric osteotomy were used. A modified sliding or extended trochanteric osteotomy maintains vastus lateralis-abductor continuity with acceptable rates for nonunion and limping.

Following exposure, the acetabular defect is reamed by hemispherical reamers until contact is made with bleeding bone. Excessive force during reaming is not advised as it can further destabilise the hemipelvis. The acetabular defect is filled with morsellised bone graft which is packed using large round pushers and reverse reaming (Fig. 1a), while care is taken to avoid inadvertent breaching of the pelvis.

The acetabular defect is sized for a trabecular metal acetabular component and an appropriate anti-protrusion cage which spans the defect from ilium to ischium. The acetabular component is fixed by the best-possible press-fit to natural bone allowing for a trial ilio-ischial cage component to be appropriately aligned. Although it is not always possible, at least two screws with good purchase, each aiming at the posterior column or the acetabular dome, are required to give satisfactory initial stability of the acetabular component (Fig. 1b). If necessary, new drill holes are drilled through the trabecular metal acetabular component adjacent to the available bone. The drilling through the trabecular metal acetabular component is approved by the manufacturer only in the revision model (00-7000-056-20; Zimmer). In our study the constructs were secured by a mean of five screws (3 to 8).

Preferably, fixation using screws into the ischium is avoided because of an increased rate of screw fracture associated with migration of the cage and sciatic nerve palsy. The ischial flange was fixed through a slot into the ischium in all patients (Fig. 1c).

<table>
<thead>
<tr>
<th>Walking aids</th>
<th>Ambulatory score</th>
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<tr>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>One stick</td>
<td>2</td>
</tr>
<tr>
<td>Two sticks</td>
<td>3</td>
</tr>
<tr>
<td>Frame and wheels walker</td>
<td>4</td>
</tr>
<tr>
<td>Elbow crutches</td>
<td>5</td>
</tr>
<tr>
<td>Wheelchair</td>
<td>6</td>
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</tbody>
</table>

Table II. Details of the ambulatory score
Exposure of the outer table of the ilium should be performed with care to avoid damage to the superior gluteal nerve and artery which are in close proximity. The iliac flange should be secured by at least two bicortical screws to the ilium to provide satisfactory fixation. It is imperative to avoid inadvertent drilling into the pelvic cavity in order to protect the internal iliac and obturator vessels.

Rarely, the acetabular component is best positioned with its outer margin without bony cover. In these cases a trabecular metal augment (Zimmer) is used to fill the gap between the superior flange and the ilium. An augment was not required in any of the patients in our study.

Finally, a polyethylene liner is cemented into the cage with an appropriate degree of version and inclination to maximise stability. During the cementation of the liner, the cement (SimplexP with Tobramycin, Stryker, Kalamazoo, Michigan) is pushed through the holes with standard pressurisation in the hemispherical part of the cage to fill the gap between the acetabular component and the cage. Thus, micromovement between the respective hemispherical parts of the cage and the acetabular component is essentially eliminated.

Statistical analysis. One-way analysis of variance (ANOVA) was performed to compare pre- and post-operative hip function using the HHS. The Wilcoxon test was performed to evaluate the improvement in the level of mobility by the use of walking aids. For all of the statistical tests a p-value ≤ 0.05 was considered to be significant.

Results
In all of the 26 hips the contact with the host bone was less than 50% (Table I). The mean percentage of contact with bleeding bone was 15.8% (0% to 40%). The location of the bleeding bone varied and could not be reproducibly recorded. There were no segmental defects in any of the cases and the morsellised bone graft was fully contained and packed according to the technique described above.

In 23 (88.5%) hips there were no changes in the radiological position of the acetabular component or symptoms indicative of loosening at the last follow-up. In all of these, continuity of the bone graft medial to the acetabular component was established with a varying extent of remodelling (Fig. 2). There was no evidence of resorption of the bone graft.

The level of mobility score was found to be significantly improved (p < 0.001) in these patients by a mean of 1.2 points (-1.0 to +4.0). Mobility deteriorated in two patients by one grade. One patient was not using walking aids before surgery and the other was using a walking stick. Post-operatively, they were using one and two walking sticks, respectively.

The mean HHS improved significantly from 46.6 points (29.5 to 68.5) to 76.6 points (55.5 to 92.0) at follow-up at two years (p < 0.01). It remained essentially unchanged (p > 0.5) (mean 74.7; 44.5 to 94.5) at follow-up at three years.

Dislocations occurred in two patients at five weeks and three years post-operatively. The patient with an early dislocation was treated by open reduction and an abduction brace for six weeks. At one year after the dislocation her HHS was 75 points. She uses one walking stick and has not experienced any further instability.

The patient with the late dislocation was treated by an exchange of the acetabular liner to a constrained design. Her HHS at 18 months after revision surgery was 68 points and she used two walking sticks.

Infection occurred in one patient. The offending organism could not be isolated despite repeated attempts. The
infection could not be eradicated despite irrigation and debridement without removal of hardware. The patient has been treated with antibiotics and wound care, and his implants remain in situ. He walks unaided and has an HHS of 81 points at four years after surgery.

One patient had a partial peroneal nerve palsy with a drop foot and still uses an ankle-foot orthosis at latest follow-up. This patient walks without an aid and at the last follow-up his HHS score was 89 points. In addition, two patients died from unrelated causes at one and three years post-operatively.

In three patients, loosening was seen at one year after surgery. In one patient failure was attributed to post-operative trauma leading to dislocation and loosening of the construct. The partially-restored bone-stock allowed the use of a large trabecular metal acetabular component (78 mm). At follow-up at three years there was no clinical or radiological evidence of loosening. The patient used a frame and wheels walker and the HHS was 70 points.

In the second patient migration of the acetabular component was due to the lack of bone ingrowth because of an unsatisfactory host-bone blood supply per-operatively. The construct was replaced by an anti-protrusion cage and a large-column structural bone-graft fixed by screws to the ilium. At the last follow-up, two-years after revision reconstruction there was no clinical or radiological evidence of loosening of the cage; she uses a frame and wheels walker and the HHS was 56 points.

The third patient is scheduled for a revision procedure. The ischial fixation appeared to be inadequate leading to the escape of the ischial flange which left the acetabular component secured only by the screws to the ilium.

Since the first two patients had 40% contact of the trabecular metal acetabular component with bleeding bone...
and the third had zero contact, we could not determine a correlation between the percentages of bleeding-bone-acetabular component contact and failure of the construct.

Discussion

Acetabular reconstruction for pelvic discontinuity is very challenging even in experienced hands. Reconstruction with an anti-protrusion cage has a reported rate of failure of 25% at five years. These rates are doubled in the presence of pelvic discontinuity. The lack of bony ingrowth and biological fixation exposes them to repeated cyclical loading resulting in failure of hardware, typically screw breakage or migration of the ischial flange.

These modest results have prompted several surgeons including the senior author to use the technique described. The rationale for this construct is that the anti-protrusion cage provides initial stability and shields the trabecular metal cementless acetabular component from mechanical forces until biological stabilisation has taken place, which gives the entire construct its long-term stability. Previous reports have indicated that bony ingrowth may occur into trabecular metal acetabular components even under unfavourable conditions, such as the limited contact with bleeding bone which often accompanies pelvic discontinuity.

In addition, unlike the structural bone grafts, morsellised bone can undergo creeping substitution and subsequent restoration of bone stock for future revisions.

Many patients undergoing this form of surgery are at the risk of instability because of repeated hip operations and poor abductor function. Hence, ancillary measures to enhance stability may be required. However, under these borderline mechanical and biological conditions for acetabular component fixation and bony ingrowth, a constrained liner may further destabilise the construct and should in our opinion be avoided. Since impingement is a cause of instability, larger prosthetic femoral heads, which increase the primary arc of movement without creating pull-out forces typical of constrained liners, may be advantageous.

If a late dislocation does occur after the acetabular shell has integrated with bone, revision surgery to replace the liner to a constrained design does not risk loosening of the acetabular component and may be an appropriate option. In our series a constrained liner was used at the initial procedure in four patients. In one other patient, a late dislocation was treated by conversion to a constrained liner without changing the acetabular component or the cage.

Creeping substitution and healing of the discontinuity could not be directly determined, but continuity of the morsellised bone graft medial to the acetabular component at varying stages of remodelling was seen in all of the 23 successful reconstructions.

Our results were attained despite the fact that contact with bleeding bone was well below 50% in all patients. In only eight was contact with bleeding bone greater than 25%. Moreover, in 12 patients there was no contact between the acetabular component and natural bone. In these cases the acetabular component was resting completely on the morsellised bone graft. Despite this, our results may be explained by the forgiving nature of the trabecular metal acetabular components, which may allow ingrowth despite poor conditions.

Although a longer follow-up is required before reaching definitive conclusions, our preliminary results indicate that the treatment of severe acetabular defects associated with pelvic discontinuity by this technique is a viable option and offers a substantial improvement of symptoms and in the quality of life. Patients need to be followed up rigorously to detect migration of the acetabular component which can occur until satisfactory bony ingrowth takes place.

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References