The custom triflange is patient-specific implant for the treatment of severe bone loss in revision total hip arthroplasty (THA). Through a process of three-dimensional modelling and prototyping, a hydroxyapatite-coated component is created for acetabular reconstruction. There are seven level IV studies describing the clinical results of triflange components. The most common complications include dislocation and infection, although the rates of implant removal are low. Clinical results are promising given the challenging problem. We describe the design, manufacture and implantation process and review the clinical results, contrasting them to other methods of acetabular reconstruction in revision THA.

Indications
Indications for the use of custom triflange components in revision THA include: previous, failed, salvage reconstruction with cage or porous metal construct augments; large contained defects with possible discontinuity; known pelvic discontinuity and complex hips which have previously undergone repeated THA and with insufficient bone stock to reconstruct using other means.

The design and production process. A critical difference between other acetabular reconstruction techniques and the use of a custom triflange component is the absolute requirement that difficult acetabular reconstructions and possible pelvic discontinuities are recognised before surgery, to facilitate design and production of the component. The authors use Paprosky's acetabular defect classification and consider CT imaging of patients in whom a type 3 defect is found. Manufacturers of custom triflange implants typically have a specific CT protocol for use in these cases. Once imaging and sometimes a model device is available, the decision to proceed rests with
This decision is multifactorial and includes the acuity of the patient’s problem, individual surgeon experience, and treatment preference for large acetabular defects that are not easily treated with a porous coated acetabular hemisphere. The surgeon has to take into account the waiting time between the decision to proceed with surgery and when the custom implant will be available, which can often be four to eight weeks.

The preparation and development of a custom triflange begins with the thin-cut CT scan sent to the manufacturer, where a one-to-one scale computer-generated three-dimensional (3D) model of the hemipelvis is created (Fig. 2). Such models are substantially more accurate than plain radiographs for assessing acetabular defects and for surgical planning. The surgeon can review either an image file or an actual model of the hemipelvis. If the defect, after scrutiny, is deemed one which cannot be treated with traditional methods, then a custom triflange component is created. Before the implant can be made, the surgeon must mark on the hemipelvic model areas of overhanging bone that can be removed to make it easier to insert the triflange. This is particularly important for bone that protrudes from the ilium, pubis, or ischium and would prevent the flanges from resting flush on these surfaces (Fig. 3). The surgeon must also mark the preferred size and location of the ilial and ischial flanges for screw fixation. The size of these flanges is a balance between the area required for fixation with multiple screws and the surgical exposure required to implant a device with large flanges. We suggest that those surgeons in doubt over where this balance lies in a specific case should consult the design engineers, who typically have designed and manufactured a number of these for dif-
ferent surgeons and hence can offer authoritative opinion. A prototype of the implant is created, along with a hemipelvic model with the specified areas of bone removed to permit the surgeon to evaluate the position and fit. The implant’s centre of hip rotation, anteversion, and inclination angles are created based on anatomic landmarks including the obturator foramen, iliac wing, and pubic ramus. The ischial flange typically has between four and six holes for screw fixation, while the larger iliac flange typically has two rows of three to four screw holes. The smallest flange, for the pubis, typically has no holes.

After approval of the initial design, the final implant is created. Reverse engineering techniques are used to create the final component from the clay prototype, milling it from wrought titanium bar stock. Porous or hydroxyapatite coating is used on the medial side of the component to facilitate osteointegration.

**Surgical technique.** A standard revision THA technique is used, paying attention to wide exposure of the ischium, ilium, and pubis in order to obtain an adequate view of the defect and the surfaces required for fixation. Visualisation of the ilium can sometimes be a challenging step of the surgical exposure and a trochanteric osteotomy can be performed to facilitate this. Exposure for placement of the ischial flange can be safely performed by subperiosteal elevation of the posterior aspect of the ischium. During this portion of the exposure, however, care must be taken to avoid injury to the sciatic nerve.

A high-speed burr can be used to remove the areas of bone as marked on the pelvic model. The 3D pelvic model is typically used in the operating room and used intra-operatively for comparison with the patient’s pelvis and to ensure proper alignment of the component.

Fixation of the pubic flange requires subperiosteal elevation with meticulous avoidance of the anterior neurovascular structures.

Fixation begins at the ischial flange and between nine and 15 screws are generally used to secure the implant. (Fig. 4).

After fixation, trial polyethylene liners are then used to perform a trial reduction. The modularity of liners varies between companies and it is therefore important to know the available options pre-operatively. Lateralised, elevated, and constrained options are typically available to aid in achieving appropriate hip length, soft-tissue tensioning, and stability.

**Published results.** Seven papers providing level IV evidence are presently available, which comprise retrospective case series of 19 to 78 patients. They range in follow-up from a mean of 31 months to 123 months (24 to 215). To our knowledge, there are no prospective trials comparing custom triflange revision to other forms of acetabular reconstruction for the treatment of Paprosky 3A/3B or AAOS Type-III or IV defects. The results of published series are summarised in Table I.19-23

The rates of complications in the studies varied. Instability was the most common complication, with an incidence ranging from 0% to 30%. Rates of infection were reported to range from 0% to 8%. Injury to the superior gluteal and sciatic nerves was also described.

Taunton et al18 compared the cost of custom triflange implants with a trabecular metal cup-cage construct equivalent and found implant costs to be similar at $12,500 and $11,250, respectively.
The results of the custom triflange are compared with other reconstructive options in Table II; these techniques include porous metal augments, cage reconstruction, and cup-cage constructs.

Discussion

The primary disadvantages of this technique are the complexity of the pre-operative planning process and the time required to manufacture the device. This disadvantage is, however, overcome by the relatively uncomplicated surgical technique without the need to shape, fit, or fix allograft or to bend and fix cages, cups, or augments. Such a solution does, however, require perfect design prior to surgery, as the implant cannot be modified intra-operatively.

The triflange cup provides a viable solution for difficult acetabular reconstructions involving severe bone loss or pelvic discontinuity. By achieving stable and rigid initial implant fixation on host bone, through its ability to re-distribute load anatomically, its restoration of the native hip centre, and its ability to support osseointegration, the triflange cup accomplishes the major goals of reconstruction.

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G. P. Goodman: Writing the paper.
C. A. Engh Jr: Writing the paper.

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References


Table I. Review of case series of custom triflanges

<table>
<thead>
<tr>
<th>Reference</th>
<th>No. of hips</th>
<th>Type of defect</th>
<th>Mean follow-up (mths)</th>
<th>Clinical results</th>
<th>Dislocations (n, %)</th>
<th>Triflange removal (n, %)</th>
<th>Aseptic loosening (n, %)</th>
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<td>4</td>
<td>24</td>
<td>Paprosky Type 3B</td>
<td>57</td>
<td>Post-op HHS score</td>
<td>65</td>
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<td>18</td>
<td>57</td>
<td>Pelvic Discontinuity</td>
<td>76</td>
<td>Post-op HHS score</td>
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<td>23</td>
<td>78</td>
<td>AAOS Types III/IV</td>
<td>53</td>
<td>Post-op HHS score</td>
<td>82.1</td>
<td>12 (15.6)</td>
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<td>19</td>
<td>26</td>
<td>Paprosky Type 3B and AAOS Types III/IV</td>
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<td>Post-op HHS score</td>
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<td>20</td>
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<td>58</td>
<td>Modified Merle d’Aubigne and Postel</td>
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<td>Post-op HHS score</td>
<td>63</td>
<td>5 (26)</td>
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</table>

HHS, Harris hip score; AAOS, American Academy of Orthopaedic Surgeons

Table II. Comparison with other techniques of revision total hip arthroplasty

<table>
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<tr>
<th>Reference</th>
<th>No. hips</th>
<th>Type of defect</th>
<th>Mean follow-up (mths)</th>
<th>Clinical results</th>
<th>Dislocations (n, %)</th>
<th>Implant removal (n, %)</th>
<th>Aseptic loosening (n, %)</th>
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<td>26</td>
<td>38</td>
<td>Winter et al 2003</td>
<td>88</td>
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<td>AAOS III and IV</td>
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<td>Merle d’Aubigne and Postel improved</td>
<td>9.3</td>
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<td>4 (12)</td>
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<td>3 (16.7)</td>
<td>2 (11)</td>
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<td>14</td>
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<td>AAOS III</td>
<td>5</td>
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<td>1 (2.4)</td>
<td>12 (28.5)</td>
<td>5 (12)</td>
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<td>Paprosky Illa</td>
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<td>0 (0)</td>
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<td>45</td>
<td>HHS improved from 55 to 76</td>
<td>7 (7.2)</td>
<td>8 (8.2)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

HHS, Harris hip score; AAOS, American Academy of Orthopaedic Surgeons

Post-op, post-operative; HHS, Harris hip score; AAOS, American Academy of Orthopaedic Surgeons


