The survival of support rings in complex acetabular revision surgery

Between 1980 and 2000, 63 support rings were used in the management of acetabular deficiency in a series of 60 patients, with a mean follow-up of 8.75 years (2 months to 23.8 years). There was a minimum five-year follow-up for successful reconstructions. The indication for revision surgery was aseptic loosening in 30 cases and infection in 33. All cases were Paprosky III defects; IIIA in 33 patients (52.4%) and IIIB in 30 (47.6%), including four with pelvic dissociation. A total of 26 patients (43.3%) have died since surgery, and 34 (56.7%) remain under clinical review. With acetabular revision for infection or aseptic loosening as the definition of failure, we report success in 53 (84%) of the reconstructions. A total of 12 failures (19%) required further surgery, four (6.3%) for aseptic loosening of the acetabular construct, six (9.5%) for recurrent infection and two (3.2%) for recurrent dislocation requiring captive components. Complications, seen in 11 patients (18.3%), included six femoral or sciatic neuropraxias which all resolved, one grade III heterotopic ossification, one on-table acetabular revision for instability, and three early post-operative dislocations managed by manipulation under anaesthesia, with no further instability.

We recommend support rings and morcellised bone graft for significant acetabular bone deficiency that cannot be reconstructed using mesh.

Reconstruction of the deficient acetabulum is one of the most challenging aspects of revision hip arthroplasty surgery. Bone loss may occur from polyethylene particulate debris causing aseptic loosening, stress shielding in uncemented components, and sepsis.

The various methods of acetabular revision depend not only on the availability of host bone but also on the site of bony deficiency, as this will affect the mechanical stability of any revision implant. Mechanical stability of the revision acetabular component is necessary for success; otherwise, techniques to promote biological methods of fixation will fail. Methods whereby mechanical stability can be achieved include cementing a polyethylene component, placement of a bulk allograft superiorly, impaction bone grafting with or without mesh, reinforcement rings and total acetabular allografts. Biological techniques require direct bony contact with the acetabular shell to enable osseointegration. They can help when assessing bone loss and in pre-operative planning. We routinely use the Paprosky classification, in which type III defects (either IIIA or IIIB) do not have sufficient acetabular rim for primary stability to use an uncemented cup. Type IIIB defects require additional initial support, such as screws and the type IIIB defects have host bone contact of < 40% with the acetabular shell and there is no inherent stability.

Patients and Methods
We reviewed the records of 62 patients who underwent 65 revision total hip replacements (THRs) involving complex cemented acetabular reconstruction augmented with a support ring between 1980 and 2000. Two were lost to follow-up, leaving 63 revision THRs (60 patients; 19 men, 41 women with a mean age of 62.4 years (28 to 90)).

The primary indication for surgery was osteoarthritis in 32 patients (53.3%), inflammatory arthritis in 17 (28.3%), post-traumatic osteoarthritis in six (10%), paediatric hip disorders in three (5%), previous septic arthritis in one (1.7%), and idiopathic avascular necrosis in one (1.7%). In 26 cases (41.2%) a support ring was used in the first acetabular


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revision, in 13 (20.8%) at the second, in nine (14.2%) at the third, and in 15 (23.8%) at the fourth or further revisions. The indication for revision was aseptic loosening in 30 cases (47.6%) and infection in 33 (52.4%). Of the latter cases, 11 underwent a one-stage revision and 22 had a two-stage procedure. A total of 16 cases (25.4%), mainly before 1988, were reconstructed without bone allograft or were one-stage revisions for infection and 47 cases (74.6%) used autograft or allograft bone, either morcellised or bulk. Review of pre-operative radiographs and operation notes confirmed the acetabular defects as type IIIA in 33 cases (52.4%) and IIIB in 30 (47.6%), including four pelvic dissociations (Fig. 1).

The operative technique has evolved over time. In the early cases, allograft bone was unavailable and either massive autograft was taken from the pelvis or the defect was filled with a preliminary mix of cement and the ring pressed over it. Once the cement had set, a polyethylene component was cemented into the ring, giving the appearance that the ring was unsupported (Fig. 2). When allograft bone became more readily available after 1988, other techniques were used, depending on the defect. We now prefer to contain any defect, impact allograft bone, then fix the ring to the pelvis using screws (Fig. 3). A polyethylene component is then cemented in place.

Reconstruction of the acetabular defect was performed using the Burch-Schneider ring (Zimmer, Warsaw, Indiana).
in 55 cases (87.3%), an Eichler ring (Zimmer) in six cases (9.5%), and other rings in two (3.2%). The patients were reviewed clinically and radiologically at a mean of 8.75 years (2 months to 23.8 years) post-operatively; 26 patients (27 cases) have since died, although they had attended for regular follow-up until their death, the cause of which was unrelated to the surgery. The surviving patients remain under regular review. The 51 cases with successful reconstructions had a minimum follow-up of five years.

We defined failure as revision of the acetabular reconstruction for infection or aseptic loosening. The radiographs were reviewed for evidence of graft incorporation, radiolucent lines, component migration and hardware failure. Two Kaplan-Meier survival curves were constructed. One used revision for infection and aseptic loosening as the endpoint for failure, and the other included the radiological failures (Figs 4 and 5).

Results
In total, there are 34 surviving patients (56.7%; 36 cases) who remain under review and have been seen within the past 12 months.

A total of 30 patients (32 cases) had bone grafting and showed bony incorporation, defined by the presence of clearly seen trabeculae across the graft-host junction. In three cases (9%) there was evidence of progressive radiolucency at the bone-cement interface, indicating component migration. Although these patients are asymptomatic, their constructs are considered ‘at risk’ and remain under close review. There was no case of hardware failure.

One patient required intra-operative revision for instability. There were no significant peri-operative complications apart from temporary mild femoral or sciatic neuropraxia in six cases (9.5%). All recovered within six weeks. Also, there was one case of grade III heterotopic ossification which has not required treatment.

Four acetabular reconstructions (6.3%) failed due to aseptic loosening. One failed within two years and a further reconstruction with bone graft and a Burch-Schneider cage was undertaken. Another failed within four years, presenting with recurrent dislocation and a loose, migrating support ring. The original bone allograft had incorporated, enabling further reconstruction with a cemented acetabular component. The other two reconstructions failed after 17 and 21 years, respectively. The original bone autograft had incorporated sufficiently to enable acetabular reconstruction with impaction bone allografting and a cemented component in both cases.

Six reconstructions failed (9.5%) because of sepsis. Five had previously undergone a two-stage revision. The other had an on-table revision for instability. Four underwent an excision arthroplasty and one underwent a further two-stage revision which was successful. The other two-stage revision was complicated by recurrent dislocation, which was treated successfully by revision using a captive component two months later. In total there were five dislocations (7.9%); three in the early post-operative period were treated by manipulation under anaesthesia and remained stable thereafter, and the remaining two underwent revision as described above.

In a subgroup of 16 cases (mean follow-up 114 months; 22 to 269) which underwent acetabular reconstruction without bone graft, there were only two failures, both for infection.

With acetabular revision for infection or aseptic loosening as a definition of failure, the overall success rate was 84% (53 of 63). The Kaplan-Meier survival at ten years was 85% (95% confidence interval 73 to 97), both for infection or aseptic loosening, or with radiological failure as the endpoint.

Discussion
With a failing primary acetabular component, acetabular destruction usually progresses in an orderly fashion. With
advancing bone loss, reconstructive techniques become more complex and as primary hip arthroplasty is undertaken in younger and more active patients, the incidence of revision surgery is likely to increase further.

If primary stability is unobtainable at revision, one surgical option is acetabular reconstruction using mesh and impaction bone grafting before cementing a polyethylene component. The Nijmegen group reported good results using this technique, not only with restoration of bone stock but also with survival of the acetabular component.\textsuperscript{17,18} Another option is to use a bulk allograft to fill the defect, followed by an uncemented hemispherical component. The results of this technique vary, with many short-term studies showing good graft incorporation\textsuperscript{19-22} and others reporting late graft resorption and component migration.\textsuperscript{23,24} This suggests that there was not enough initial host bone contact for long-term stability. Paprosky et al\textsuperscript{25} proposed that structural allograft, particularly with type IIIA defects, could give good long-term results if certain criteria were followed. They recommended fresh-frozen proximal tibial or distal femoral allografts to fill the acetabular defect, with the graft orientated to withstand compressive forces across the hip when axially loaded, along with secure fixation of the allograft independent of the acetabular component.

In cases where host bone deficiency precludes either reconstruction with rim mesh and impaction grafting or bulk allograft fixation, the use of reinforcement rings should be considered.\textsuperscript{26} These provide primary mechanical stability as they allow good fixation\textsuperscript{26} using screws. The ring spans the defect and provides a large contact area with host bone, changing point loading into surface loading. The resultant load sharing enables osseous integration. Opinion is divided as to whether bulk or particulate graft should be used. The former gives better structural support in the early post-operative period but takes longer to incorporate, and may be associated with graft resorption, instability and component migration.\textsuperscript{27,28} Filling the defect with cement can lead to early failure,\textsuperscript{29} although this was not seen in our series.

As biological fixation is not possible with a Burch-Schneider ring, migration is likely if primary stability is not achieved. Perka and Ludwig\textsuperscript{29} reviewed 63 Burch-Schneider rings at 5.5 years’ follow-up. Bony defects were filled with either bulk or particulate allograft. All aseptic loosening failures had type IIIIB defects with deficiency in the posterior column. There were further radiological failures, most commonly associated with caudal acetabular defects. These failures were independent of bulk or particulate allograft. However, when primary stability and support are obtained, good long-term results can be achieved with Burch-Schneider rings. Wachtel et al\textsuperscript{30} report a 92% survival rate, at a mean follow-up of 12 years.

A principle of acetabular reconstruction using reinforcement rings is the restoration of the hip centre of rotation. Failure to achieve this can lead to early failure. Van Koev eringe and Ochsner\textsuperscript{31} reviewed 33 hips that had undergone reconstruction with a Burch-Schneider ring. At five years’ follow-up there was one failure due to sepsis, and a further nine (27%) showed component migration. All migrated cages showed higher hip centres of rotation initially compared with reconstructed hips that did not migrate.

When acetabular defects are significant, reinforcement rings provide the bony stability to enable graft incorporation. Rosson and Schatzker\textsuperscript{32} found that isolated segmental or cavitary defects confined to one or two sectors can be treated with a Müller ring, whereas large medial segmental defects, extensive cavitary defects and combined deficiencies should be addressed with a Burch-Schneider ring. Whether the bone graft for the defect should be structural or particulate is unclear.

Udomkiat et al\textsuperscript{33} reviewed 62 patients at a mean of 4.6 years and found mechanical failure in 17%. This was attributed to defects filled with particulate graft, where the support ring had < 60% host bone contact. In such circumstances, they recommended bulk allograft. Böhm and Banzhaf,\textsuperscript{34} in a series of 103 acetabular revisions, reported 26 cases using Burch-Schneider rings, with a success rate of 83% at a mean follow-up of 4.5 years. Positive outcomes were associated with bulk allografts protected by a support ring.

Haddad, Shergill and Muirhead-Allwood\textsuperscript{35} reviewed 48 cases in which morcellised graft filled the acetabular defect protected by a Burch-Schneider ring. Clinical and radiological review at a mean of 64 months revealed excellent results, with only two failures for sepsis. Winter et al\textsuperscript{36} reported similar success in 38 hips with massive acetabular deficiency. At 7.3 years’ follow-up all hips showed good bony consolidation, with no measurable migration or component displacement.

More recent studies have also shown favourable results with support rings in revision hip surgery. Pieringer, Auer sperg and Böhler\textsuperscript{37} reviewed 90 Burch-Schneider rings implanted in primary and revision surgery and demonstrated 93% survival at just under 12 years, with ring explantation as the endpoint. Radiolucent lines were commonly seen, but osteolysis was not. Schlegel et al\textsuperscript{38} reviewed 164 Müller support rings and found 90% survival at eight years, using implant removal or re-revision as an endpoint. They associated their failures with allograft collapse/resorption or deep infection.

Our earlier cases demonstrated that, before the widespread availability of allograft, good cementing technique can still produce good long-term results even with significant acetabular defects. However, we feel that the gold standard is impacted morcellised allograft, protected by a support ring firmly fixed to the ilium and ischial tuberosity, unless the defect is so extensive that a bulk acetabular allograft is required.

**Supplementary material**

Tables showing the details of the patients and the radiological findings are available with the electronic version of this article at www.jbjs.org.uk
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References