Cemented acetabular component with femoral neck autograft for acetabular reconstruction in Crowe type III dislocated hips

A 20- TO 30-YEAR FOLLOW-UP STUDY

Aims
Various surgical techniques have been described for total hip arthroplasty (THA) in patients with Crowe type III dislocated hips, who have a large acetabular bone defect. The aim of this study was to evaluate the long-term clinical results of patients in whom anatomical reconstruction of the acetabulum was performed using a cemented acetabular component and autologous bone graft from the femoral neck.

Methods
A total of 22 patients with Crowe type III dislocated hips underwent 28 THAs using bone graft from the femoral neck between 1979 and 2000. A Charnley cemented acetabular component was placed at the level of the true acetabulum after preparation with bone grafting. All patients were female with a mean age at the time of surgery of 54 years (35 to 68). A total of 18 patients (21 THAs) were followed for a mean of 27.2 years (20 to 33) after the operation.

Results
Radiographs immediately after surgery showed a mean vertical distance from the centre of the hip to the teardrop line of 21.5 mm (SD 3.3; 14.5 to 30.7) and a mean cover of the acetabular component by bone graft of 46% (SD 6%; 32% to 60%). All bone grafts united without collapse, and only three acetabular components loosened. The rate of survival of the acetabular component with mechanical loosening or revision as the endpoint was 86.4% at 25 years after surgery.

Conclusion
The technique of using autologous bone graft from the femoral neck and placing a cemented acetabular component in the true acetabulum can provide good long-term outcomes in patients with Crowe type III dislocated hips.

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results have recently been reported following the use of a porous tantalum and augment construct. This augment has excellent material characteristics for acetabular reconstruction and may be used instead of bulk bone graft. However, the long-term results are still unknown. Impaction bone grafting (IBG) can restore the biomechanics of the hip and bone stock and is a widely accepted technique for revision THA in patients with a large acetabular bone defect. This procedure can be performed for patients with DDH and several studies have reported favourable clinical results. Autologous bulk bone graft with placement of a cemented component in the true acetabulum is the most commonly used technique and is advantageous as it normalizes hip biomechanics and recovers the bone stock if revision is required and several studies have reported good long-term results.

DDH is frequently classified radiologically using the Crowe classification. The wide range of acetabular deficiencies depends on the Crowe type and it is important to evaluate the results in patients with similar anatomical abnormalities. This study focused on patients with Crowe type III DDH and evaluated the long-term results, at a mean follow-up of 27.2 years, of a cemented acetabular component placed in the anatomical position in combination with autologous bone graft from the femoral neck.

We previously reported favourable short-term outcomes of this procedure for DDH in 1994. To the best of our knowledge, this is the first study to present long-term results, involving follow-up of more than 20 years, in patients treated using this technique.

Methods
Between 1979 and 2000, we performed THA using acetabular autologous bone grafting in 22 patients (28 THAs) with Crowe type III hips. In the original series, subluxated and dislocated patients were included. For this study, only dislocated patients from the previous series were included, as well as new patients with dislocations. Two patients died at nine and 12 years without acetabular loosening, one patient (one THA) was lost to follow-up at 15 years after surgery, one hip developed an early deep infection, and one developed a late deep infection, leaving 18 patients (21 THAs) followed-up for a mean 27.2 years (20 to 33). All 18 were female, with a mean age at the time of surgery of 54 years (35 to 68). Ten patients had bilateral dislocated hips, four had Crowe type I or II DDH, and four had a normal hip on the contralateral side. A total of 13 THAs were followed up for more than 25 years and three patients (three THAs) died at 23, 27, and 29 years postoperatively. In each case, the date of death and outcome of the THA were confirmed by an interview with a close family member and a review of the medical records of their family practitioner.

Our method of bone grafting involves the use of healthy corticocancellous bone from the femoral neck, as previously described. All operations were performed by two surgeons (EG, MA) using the transtrochanteric approach, except in one patient, in whom a Hardinge transgluteal approach was used. After identifying the transverse ligament at the inferior edge of the true acetabulum, the acetabulum was expanded using a reamer, taking care to retain the anterior and medial thin walls of the original acetabulum. An optimally sized trial component was placed at the level of the true acetabulum and the shape and size of the bone defect at the lateral margin of the acetabulum was evaluated. The bone graft from the femoral neck was prepared to a shape appropriate to that of the false acetabular surface and fixed using two screws, with its cancellous surface facing the acetabular surface prepared for the graft. The bone graft was then reamed until congruent with the previously reamed host acetabulum. Care was taken to preserve the subchondral bone of the false acetabulum next to the true acetabulum. A circumferential groove, rather than a conventional anchoring hole, was made in the ilium, ischium, and pubis in order to enhance the fixation of cement. Charnley polyethylene components (Depuy, Leeds, UK) were used in all hips and fixed with cement (CMW 1 or Endurance; Depuy), 27 Charnley monoblock stems and one Harris CDH precoated stem (Zimmer, Warsaw, Indiana, USA) with a femoral head of 22 mm in diameter were used.

Method of measuring the percentage of cover of the acetabular component by graft, height of the hip centre, and abduction angle of the acetabular component. Percentage of cover by graft = (B/A) × 100. D, height of hip centre.

Kaplan-Meier curve showing the cumulative probability of survival of the acetabular component. n = 21 hips at 20 yrs; n = 14 hips at 25 yrs. +96.0% (SD 3.6%); †91.2% (SD 5.9%); ‡86.4% (SD 7.3%).
Table I. Patient characteristics, height of the hip centre, percentage of cover of the acetabular component by bone graft, abduction angle of the acetabular component, clinical results, and complications.

| Patient | Age, yrs | Follow-up, yrs | Hip centre height, mm | Graft bone cover, % | Acetabular component abduction, ° | Radiograph | Complication |
|---------|----------|----------------|-----------------------|---------------------|---------------------------------|------------|--------------|
| 1 R     | 53       | 23†            | 22                    | 32                  | 53                              | 11 yrs, loose |
| 1 L     | 60       | 16†            | 19                    | 33                  | 41                              | 3 yrs, revision | 3 yrs late infection, revision |
| 2 R     | 55       | 9†             | 22                    | 49                  | 41                              | 2 yrs brain infarction |
| 2 L     | 55       | 9†             | 21                    | 43                  | 41                              |             |              |
| 3 R     | 57       | 33             | 18                    | 42                  | 32                              | Wear, knee OA |
| 3 L     | 58       | 32             | 23                    | 60                  | 53                              | Wear, knee OA |
| 4       | 52       | 30             | 20                    | 48                  | 55                              | 27 yrs brain infarction |
| 5       | 40       | 32             | 20                    | 40                  | 55                              | 18 yrs, revision |
| 6       | 66       | 25             | 23                    | 55                  | 34                              |             |              |
| 7       | 53       | 31             | 22                    | 38                  | 54                              | 24 yrs brain infarction |
| 8       | 58       | 15*            | 21                    | 48                  | 38                              |             |              |
| 9 L     | 53       | 29†            | 17                    | 57                  | 44                              | 25 yrs, loose | Knee OA |
| 9 R     | 68       | 14†            | 28                    | 46                  | 40                              | Knee OA     |
| 10      | 50       | 30             | 18                    | 43                  | 49                              |             |              |
| 11      | 61       | 27             | 20                    | 43                  | 53                              | GT nonunion |
| 12      | 44       | 32             | 18                    | 31                  | 53                              | 30 yrs, Alzheimer’s |
| 13 R    | 47       | 27             | 22                    | 47                  | 46                              |             |              |
| 13 L    | 47       | 27             | N/A                   | N/A                 | N/A                             | Early infection, Girdlestone operation |
| 14      | 35       | 33             | 22                    | 32                  | 52                              | Wear        |
| 15      | 58       | 25             | 21                    | 60                  | 43                              | GT nonunion |
| 16      | 59       | 24             | 15                    | 44                  | 39                              |             |              |
| 17 R    | 35       | 24             | 26                    | 35                  | 42                              | Wear, knee OA |
| 17 L    | 36       | 23             | 23                    | 52                  | 41                              | Wear        |
| 18      | 54       | 21             | 21                    | 49                  | 50                              |             |              |
| 19      | 59       | 21             | 25                    | 47                  | 38                              |             |              |
| 20      | 56       | 20             | 28                    | 48                  | 35                              |             |              |
| 21      | 61       | 20             | 30                    | 54                  | 48                              |             |              |
| 22      | 48       | 12†            | 16                    | 42                  | 56                              |             |              |

Mean (SD) 54.0 (6.9) 23.4 (5.9) 21.5 (3.3) 46.0 (6.0) 44.7 (6.6)

*Patient dropped out.
†Patient died.
GT, greater trochanter; N/A, not available; OA, osteoarthritis.

Loosening of the acetabular component was defined radiologically as the presence of a circumferential clear zone, or migration as described by Hodgkinson et al., and loosening of the stem as the presence of 2 mm or greater subsidence, cement fracture, or a circumferential clear zone, as described by Harris et al. Survival of the acetabular component was evaluated using the Kaplan-Meier method, with radiological loosening or revision arthroplasty as the endpoint. The abduction angle of the acetabular component and the vertical distance from the inter-teardrop line to the centre of the femoral head (hip centre) were measured on radiographs taken within three months after the surgery. Leg lengthening was evaluated by comparing the distance from the inter-teardrop line to the most medial point of the lesser trochanter on the radiographs taken before and after surgery. The amount of cover of the acetabular component by the bone graft was determined as the percentage of the horizontal distance from the lateral edge of the component to the most medial point of the graft, and the width of the acetabular component was measured using the most medial point and the lateral edge of the component, as described by Shinar and Harris (Figure 1). The remodeling of the graft was evaluated as described by Knight et al. The amount of linear wear of the acetabular component was determined by comparing radiographs taken soon after surgery with those taken at the last follow-up examination, as described by Livermore et al. Osteolytic lesions were defined as those having a nonlinear lucency at the cement-bone interface, as described by Sporer et al.

The clinical results were evaluated using the modified Merle d’Aubigné and Postel Method. This study was approved by the Institutional Review Board of Toyooka Chuou Hospital.

Results

Of the three loose acetabular components, two were loose at 11 and 25 years, and those patients died at 16 years and 29 years after the initial operation without revision. One was revised 18 years after surgery. Two THAs developed early and late infection, one patient had undergone a Girdlestone procedure, and another had a revision THA three years after the initial operation. Two patients died at nine and 12 years without acetabular loosening. The rate of survival of the acetabular component was 96.0% at 20 years and 86.4% at 25 years after surgery (Figure 2). Two stems were loose at seven and 26 years after surgery and one stem fracture occurred 30 years after surgery. The mean abduction angle of the acetabular component was 44.7° (SD 5.6°; 32° to 56°) and the mean vertical distance of the...
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Discussion

Autologous grafting using bone from the femoral neck and an acetabular component placed in the true acetabulum has the advantage of normalizing the biomechanics of the hip and recovering the bone stock if revision THA should be required. Watts et al. reported that a hip centre located within 35 mm from tear drop line significantly decreased aseptic loosening in patients with Crowe type II DDH treated with a cemented acetabular component while Schuller et al. reported that bone grafting normalized load transfer in the superolateral region of the acetabulum in a biomechanical study. The vertical height of the hip centre of the patients in our study ranged from 14.5 mm to 30.7 mm (mean 21.5 mm (SD 3.3)), suggesting that placing the acetabular component in an anatomical position allowed a favourable biomechanical environment to be obtained. As a result, there were high rates of survival of the acetabular component (86.4%) and favourable clinical results 25 years after surgery. Autologous bone graft with a cemented acetabular component has been the most commonly used technique in these patients, and several studies have reported good long-term results from this procedure. Kobayashi et al. reported a survival rate of 100% at 19 years, de Jong et al. reported a survival rate of 78% at 20 years, and Iida et al. showed a survival rate of 75% at 15 years. However, Shinar and Harris reported a survival rate for a cemented acetabular component with autologous bone graft of only 40% at 16.5 years and the results in patients with cover of the acetabular component by bone graft exceeding 50% were especially unfavourable. Nevertheless, Kobayashi et al. and Iida et al. showed good results using this technique, and also reported that cover of the acetabular component by bone graft is an important factor in acetabular loosening and should be less than between 40% and 50%. Kobayashi et al. and Iida et al. showed a mean cover of the acetabular component by bone graft of 46% (SD 6%; 32% to 60%) and there were only six hips in which cover by graft exceeded 50%. This may be one of the causes of the high survival rate in this study.

IBG has been an effective method of reconstruction in revision THA for patients with large acetabular bone defects. Iwase et al. reported excellent results of IBG with metal mesh and autologous bone for patients with DDH and cover of the acetabular component by graft of > 50% and survival of 96.6% at eight years postoperatively. Colo et al. also reported excellent results of primary THA using IBG and lateral mesh rim. The 15-year survival with aseptic acetabular loosening as the endpoint was 90%. We have recently performed operations using autologous bulk bone graft and a Kerboull reinforcement plate (Biomet, Valence, France) for hips when the cover of the acetabular component by bone graft might exceed 50% on preoperative radiographs. Another factor in the favourable results of this study is that the mean linear acetabular wear was 0.069 mm/yr (0.005 to 0.131). Sochart, in a series of 235 hips,
reported 25-year survivorship that exceeded 90% for Char- 
ne THAs with a mean annual rate of wear of the acetabular 
component of < 0.1 mm/yr. In a series of 206 patients (292 
hips), Chougle et al44 also reported 20-year results of a Char- 
ne acetabular component for DDH with a mean annual rate 
of wear of 0.07 mm/yr in the 60 patients who did not undergo a 
revision procedure.

All 22 patients in this study were female and 16 had 
bilateral DDH. They were thought to engage in only low 
levels of physical activity, which may correlate with the 
lower linear acetabular wear and low rate of loosening. 
We also used bone graft from the femoral neck which has 
several advantages and differs from the technique of Shinar 
and Harris25 which involved using the whole degenerative 
femoral head. Our method uses healthy cancellous bone 
and thick, structurally strong cortical bone. The healthy 
cancellous surface faces the acetabular surface prepared 
for the graft and is fixed with two screws inserted from the 
surface of the cortical bone. Care is taken to preserve 
the hard subchondral bone of the false acetabulum next to 
the true acetabulum. This technique provides good stable 
bone graft and creates a healthy bone bed for the cemented 
acetabular component.

Only a few studies have reported the long-term outcomes 
of THA in patients with Crowe type III hips. In a long-term 
study using a cemented acetabular component in 27 patients, 
Chougle et al35 reported a survival rate of 42% at 20 years 
after surgery using a Charnley acetabular component, but 
bone graft was not used in two-thirds of the cases. Sochart 
et al46 also reported that the Charnley acetabular component 
was maintained in seven of 13 Crowe type III cases 25 years 
after surgery using a Charnley acetabular component, but 
was not used in the remaining cases. The results of this study, 
the rate of survival of the acetabular component with mechanical 
loosening or revision as the endpoint was 86.4% at 25 years after the 
surgery. This technique can provide good long-term outcomes in patients with 
Crowe III dislocated hips.

Take home message

- Patients with Crowe III dislocated hips underwent total 
hip arthroplasty using bone graft from femoral neck and 
cemented acetabular component.
- The rate of survival of the acetabular component with mechanical 
loosening or revision as the endpoint was 86.4% at 25 years after the 
surgery.
- This technique can provide good long-term outcomes in patients with 
Crowe III dislocated hips.

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