■ HIP

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

A 20- TO 30-YEAR FOLLOW-UP STUDY

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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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Introduction

Adult patients with osteoarthritis secondary to developmental dysplasia of the hip (DDH) have complex anatomical abnormalities in the acetabulum. Total hip arthroplasty (THA) for these patients is associated with technical problems related to acetabular bone deficiency. Some studies have described undertaking the procedure using a high hip centre and placing an acetabular component in the false acetabulum in the ilium.[1-5] This is a simple technique, but there are several issues including a persistent limp and a high dislocation rate.[2] In addition, many studies using cemented or cementless acetabular components have shown that high placement of the component is associated with poorer results.[3-6]

In contrast, placing the component in the true acetabulum improves the biomechanical environment of the hip joint.[7] The protrusion technique (cotyloplasty) is a method of introducing the acetabular component by inducing a controlled comminuted fracture in the original medial acetabular wall and putting bone graft into it.[8] However, several studies have shown unfavorable long-term results of this technique using both cemented and uncemented acetabular components.[9,10] Excellent clinical

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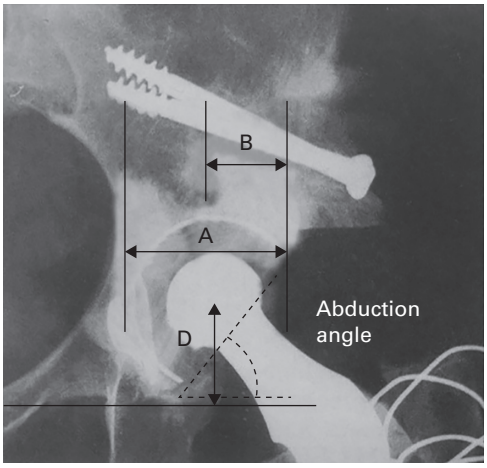

Fig. 1

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.

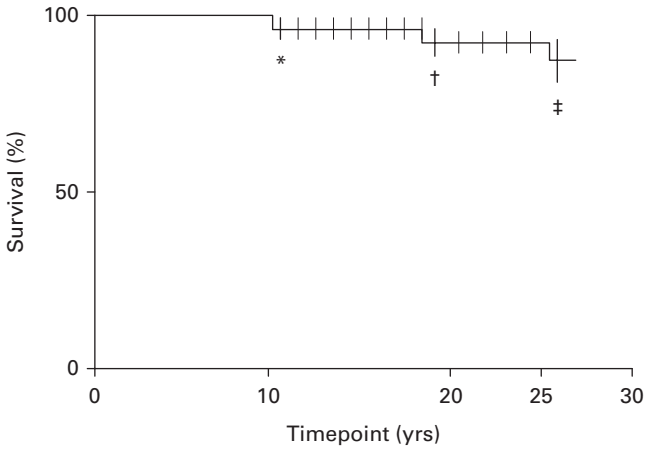

Fig. 2

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%).

results have recently been reported following the use of a porous tantalum and augment construct.[11,12] 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.[13,14] This procedure can be performed for patients with DDH and several studies have reported favourable clinical results.[15,16] 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.[17-19]

DDH is frequently classified radiologically using the Crowe classification.[20] 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 (20 to 23), 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.[21] 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.[2] 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.[22] 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.

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		
1 L	60	16†	19	33	41	11 yrs, loose	
2 R	55	9†	22	49	41	3 yrs, revision	3 yrs late infection, revision
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 (5.6)		

*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,[23] 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.[24] 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).[25] The remodeling of the graft was evaluated as described by Knight et al.[26] 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.[27] Osteolytic lesions were defined as those having a nonlinear lucency at the cement-bone interface, as described by Sporer et al.[28]

The clinical results were evaluated using the modified Merle d'Aubigné and Postel Method.[29] 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

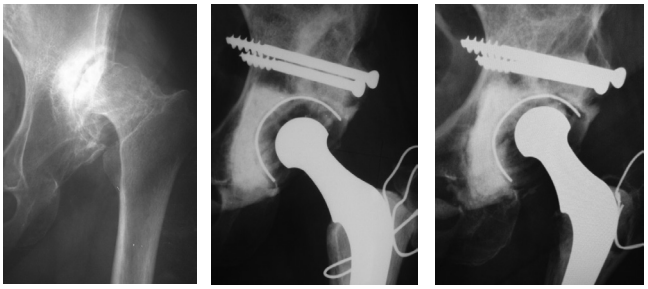

Fig. 3

Radiographs of a 57-year-old female a) preoperatively, b) three months postoperatively, and c) 33 years postoperatively.

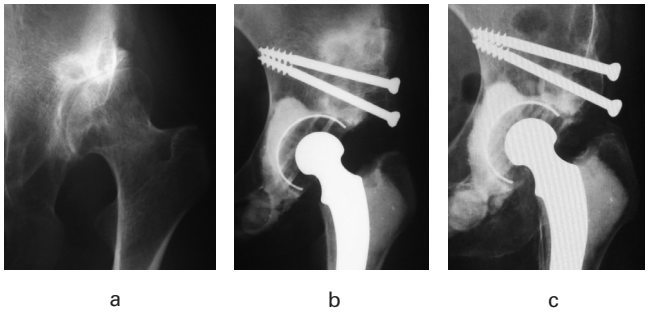

Fig. 4

Radiographs of a 44-year-old female a) preoperatively, b) two months postoperatively, and c) 32 years postoperatively.

hip centre was 21.5° (SD 3.3°; 14.5° to 30.7°). The mean cover of the acetabular component by graft was 46.0% (SD 6.0%; 32% to 60%) and the cover in the three hips that showed loosening was 33%, 40%, and 57% (Table I). The mean leg lengthening was 23.6 mm (9 to 36). Bridging trabeculae at the graft-host interface were noted two to five months after the operation. Remodeling of the bone graft was observed within 12 months and trabecular reorientation was observed by the fifth year after surgery. The mean linear wear of the acetabular component was 0.069 mm/yr (0.005 to 0.131). One patient developed a massive osteolytic lesion and two had a minor femoral osteolytic lesion. Two THAs (7.4%) had nonunion of the greater trochanter.

The mean functional scores were 2.2 (SD 0.40) for pain, 2.4 (SD 0.56) for walking ability, and 3.5 (SD 0.56) for range of motion before surgery, and they improved to 5.5 (SD 0.47), 4.4 (SD 0.32), and 4.1 (SD 0.50) respectively at a mean of 12.1 years (10 to 15) postoperatively. At the most recent examinations at a mean of 27.2 years (20 to 32) after the operation, all patients were free of pain or had slight or intermittent pain on starting to walk (5 and 6 points) and the mean pain score was 5.7 (SD 0.45). Three patients required a wheelchair due to cerebral infarction or Alzheimer's disease, seven could walk long distances using of a stick (4 points), and eight walked with a slight limp without a stick (5 points), with a mean of 4.0 (SD 0.50) for walking ability. Seven hips had more than 160° total range of motion (5 points), eight had a total range of motion of between 100° and 160° (4 points), and six hips had a total range of motion of < 100° (2 to 3 points) with a mean of 3.9 (SD 0.35).

The radiographs of two patients without loosening are shown in Figures 3 and 4.

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[30] 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[31] 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[17] reported a survival rate of 100% at 19 years, de Jong et al[18] reported a survival rate of 78% at 20 years, and Iida et al[19] reported a survival rate of 75% at 15 years. However, Shinar and Harris[25] 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.[24] Nevertheless, Kobayashi et al[17] and Iida et al[19] 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%.[17,19] We found 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.[13,14] Iwase et al[15] 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[16] 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%.[16] 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.[32] 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,[33] in a series of 235 hips,

reported 25-year survivorship that exceeded 90% for Charnley 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 al[34] also reported 20-year results of a Charnley 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 Harris[25] 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 al[35] reported a survival rate of 42% at 20 years after surgery using a Charnley acatebular component, but bone graft was not used in two-thirds of the cases. Sochart et al[36] also reported that the Charnley acetabular component was maintained in seven of 13 Crowe type III cases 25 years after surgery, but bone grafting was performed in only a few cases, and they suggested that the poor outcomes were caused by inadequate superolateral cover. The comparatively poorer outcomes in these similarly long-term studies show the value of bone grafting for cemented acetabular components. Although the small number of cases and the fact that one patient was lost to follow-up are limitations of this study, the results are reliable because these were long-term outcomes of THA using the same polyethylene Charnley acetabular component and the same technique.

We are currently working to improve the cement technique and polyethylene, which may further enhance the long-term outcomes of cemented THA in these patients. As the results of this study show, the method of using autologous bone graft from the femoral neck and placing a cemented component into the true acetabulum can provide successful long-term results for Crowe type 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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H. Umeda: Evaluated the data, Performed the statistical analysis.
M. Otsubo: Followed the patients, Evaluated the data.
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