Cementless total hip replacement without femoral osteotomy in patients with severe developmental dysplasia of the hip

MINIMUM 15-YEAR CLINICAL AND RADIOLOGICAL RESULTS

We describe the clinical and radiological results of cementless primary total hip replacement (THR) in 25 patients (18 women and seven men; 30 THRs) with severe developmental dysplasia of the hip (DDH). Their mean age at surgery was 47 years (23 to 89). In all, 21 hips had Crowe type III dysplasia and nine had Crowe type IV. Cementless acetabular components with standard polyethylene liners were introduced as close to the level of the true acetabulum as possible. The modular cementless S-ROM femoral component was used with a low resection of the femoral neck.

A total of 21 patients (25 THRs) were available for review at a mean follow-up of 18.7 years (15.8 to 21.8). The mean modified Harris hip score improved from 46 points pre-operatively to 90 at final follow up (p < 0.001).

A total of 15 patients (17 THRs; 57%) underwent revision of the acetabular component at a mean of 14.6 years (7 to 20.8), all for osteolysis. Two patients (two THRs) had symptomatic loosening. No patient underwent femoral revision. Survival with revision of either component for any indication was 81% at 15 years (95% CI 60.1 to 92.3), with 21 patients at risk.

This technique may reduce the need for femoral osteotomy in severe DDH, while providing a good long-term functional result.

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Patients and Methods

All patients who underwent primary THR with a pre-operative diagnosis of Crowe type III or IV dysplasia and a minimum follow-up of 15 years were identified retrospectively from our database. Clinical information, details of the operation and the results of clinical and radiological assessments were prospectively collected and recorded as part of routine practice. The data collectors (WLW, WKW, BAZ) were blinded to any particular study. Consent was obtained from all patients at the initial consultation for the use of anonymous information in ongoing and future research projects.

We identified 30 consecutive hips in 25 patients who underwent THR between May 1990 and December 1996, of which 21 were classified as Crowe type III and nine as Crowe type IV. The mean age of the patients at surgery was 47 years (23 to 89). A total of 18 patients (72%) were women and 18 THRs (60%) were performed on the left hip. In seven patients (seven THRs) a previous osteotomy had been undertaken, all of which had united. In five patients this was a femoral osteotomy, one had a pelvic osteotomy and one had both pelvic and femoral osteotomies.
The centre of rotation of the hip and measurement of leg length. We used the method described by Pierchon et al.⁶ to determine the theoretical centre of rotation of the hip, using anteroposterior (AP) radiographs (Fig. 1).

Leg length discrepancy was measured by the difference between the inter-teardrop line and the tips of the greater trochanter of both the operated and the contralateral hip (Fig. 2). A correction for magnification of the post-operative radiographs was calculated by measuring the size of the projected prosthetic femoral head on the radiograph and comparing this with its known true size. This was done independently for each hip.

Surgical technique. All operations were performed by WKW using a posterior approach, with patients in the lateral decubitus position. The acetabular reconstruction involved attempting to place a cementless component, at the level of the true acetabulum, which was identified by the transverse acetabular ligament. A small acetabular component was used with the addition of a cotyloplasty if deemed necessary, using the technique described by Hartofilakidis et al.⁸ This allowed displacement of the medial wall of the dysplastic acetabulum during reaming beyond the ilio–ischial line. This central osteotomy was then allowed to unite in a more medial position. The indication for cotyloplasty was the presence of a dysplastic acetabulum with poor bone stock in the posterior column, which could not be sufficiently expanded to allow placement of a small component within it. If the stability of the component remained unsatisfactory, or if there was a significant segmental acetabular defect, autograft was used to increase the cover of the component. Stability was assessed following screw augmentation of the cup using the presence or absence of circumferential bony support, the torsional stability of the component when inserted with an introducer, and the ‘hold’ that the screws achieved. Acetabular cotyloplasty was performed in seven hips, autograft was used in six and morcellised autograft was used in nine. It was possible to place the acetabular component at the level of the true acetabulum in all hips.

A variety of cementless acetabular components were used, including Harris–Galante porous II (n = 18) (Zimmer, Warsaw, Indiana), ABG I (n = 6) (Stryker Orthopaedics, Mahwah, New Jersey), Implex (n = 3) (Impelx, Allendale, New Jersey), Secur-Fit (n = 2) (Stryker Orthopaedics) and S-ROM (n = 1) (DePuy). All the ultra-high molecular weight polyethylene (UHMWPE) liners used were gamma-irradiated in air. The mean outer diameter of the acetabular component was 52 mm (48 to 58) in Crowe type III hips and 50 mm (46 to 54) in Crowe type IV hips. The preferred size of the femoral head was 28 mm (n = 18), but in two hips a 32 mm modular head was used, although heads of smaller diameter were used in some hips to maintain adequate polyethylene thickness (26 mm, n = 7; 22 mm, n = 3). The femoral head was of zirconium ceramic in 15 hips and cobalt/chrome in the remainder. The choice of this material corresponded to our preference for bearing surfaces available at the time the procedures were performed.

After completion of the acetabular reconstruction, optimal lengthening was determined with the use of trial components to assess abductor tension. This included manual distraction of the joint to assess axial ‘pull-out’ and palpation of the sciatic nerve to ensure that it was still mobile and free of tension. If necessary, in order to ensure that these objectives were achieved, the osteotomy of the femoral neck was made as low as the lesser trochanter. The choice of the size of the stem and sleeve was based on the intra-operative assessment of the degree of deformity of the femur combined with the pre-operative radiographs. In general, we aimed to obtain 45° of inclination and 20° of anteversion of the acetabular component, with 15° of femoral stem–neck anteversion. However, the final orientation of components was individually adjusted to optimise the stability of the hip and minimise impingement. The
modularity of the S-ROM stem enabled correction for excess anteversion, bony deficiency, abnormal offset and previous osteotomy, as well as restoring appropriate leg length. By performing the reconstruction in this manner, trochanteric osteotomy was avoided (Fig. 3).

If there was any concern about the tension of the sciatic nerve post-operatively, the epidural was discontinued in the recovery department to enable the function of the nerve to be assessed. Post-operative management included 48 hours of intravenous antibiotics, low molecular weight heparin and thromboembolic deterrent stockings until patients were sent home. Patients were mobilised to fully weight-bearing as comfort allowed.

**Clinical evaluation.** Evaluation included the Harris hip score (HHS). Outcomes were classified as excellent (90 to 100/100), good (80 to 89/100), fair (70 to 79/100) or poor (< 70/100). Overall satisfaction was also recorded in a similar manner. Clinical assessments were undertaken by the senior author (WKW) one, two and five years post-operatively, and every five years thereafter.

**Radiological evaluation.** Radiographs were performed post-operatively and at three months, one year, two years, five years and every five years thereafter. These included an AP view of the pelvis and a lateral radiograph of the hip. Femoral radiographs were assessed using the seven zones described by Gruen et al. The zones described by DeLee and Charnley were used in the assessment of the acetabular components. Osteolysis was defined as scalloped erosion at the bone–prosthesis interface. Implants were also graded for osteo-integration using the radiological and stability score for cementless implants of Engh et al., looking for spot welds, radiolucencies, stem ingrowth, stem failure and stem migration. Acetabular loosening was defined as > 2 mm vertical migration or > 5° of tilting of the component measured in relation to the inter-teardrop line, or radiolucency of > 2 mm at the bone–implant interface. Heterotopic ossification was recorded using

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**Fig. 3a** Anteroposterior radiographs taken a) six months after surgery (the pre-operative radiograph is shown in figure 1) showing a small acetabular component has been used in conjunction with a cotyloplasty, a low resection of the femoral neck was used with a modular cementless stem, b) after 16 years, polyethylene wear of the liner with associated osteolysis in the ischium and greater trochanter and c) after 18 years the acetabular component has been revised, along with alumina ceramic-on-ceramic bearing surfaces.
Brooker’s classification. All radiographs were analysed independently by specialist senior arthroplasty fellows.

**Statistical analysis.** Survival analysis was performed using the Kaplan–Meier method, with all 30 hips included in the analysis. Patients lost to follow-up or those who died prior to revision surgery were not included in the number at risk. The 95% confidence intervals (CI) were calculated using the ‘effective number at risk’. Pre-operative and final follow-up HHSs were compared using the paired Student’s t-test, as the data were normally distributed, and significance was set at p < 0.05.

**Results**

Of the 25 patients (30 THRs), one patient (two THRs) was lost to follow-up at 6.4 years. This patient was checked against the Australian National Joint Replacement Registry and it is not recorded that revision had been undertaken elsewhere in Australia or that she had died. Three patients (three THR) died before the minimum 15-year follow-up, all for reasons unrelated to their surgery. None of these had undergone revision and all were symptom-free when they were finally reviewed at a mean of 8.6 years (3.6, 7.4 and 14.8 years, respectively). There were 21 patients (25 THRs) with complete clinical and radiological assessments at a mean follow-up of 18.7 years (15.8 to 21.8).

The mean pre-operative HHS was 46 (29 to 63). This improved to 90 (73 to 98) (p < 0.001) at final follow-up. In all, 19 patients (23 THRs; 92%) had a good or excellent result, with the remaining two patients (two THRs) having a fair result. The mean post-operative HHS for the

15 patients (18 THRs) with Crowe type III dysplasia was 91 (80 to 98) and that for the seven patients (seven THRs) with Crowe type IV was 87 (71 to 96). In 20 patients (24 THRs) increased function and decreased pain were reported at final follow-up. All these patients stated that they were satisfied with their operation. At final follow-up, 15 patients (15 THRs) were able to walk without aids and reported functioning without restriction, including heavy work. A total of 18 patients (18 THRs) were able to mobilise outdoors for more than one hour. All 21 patients (25 THRs) were able to mobilise outdoors for at least 30 minutes.

**Complications and revisions.** A total of 15 patients (17 THRs; 57%) underwent revision of the acetabular component at a mean of 14.6 years (7 to 20.8). All revisions were performed for acetabular or trochanteric osteolysis secondary to polyethylene wear. Only two patients (two THRs) were clinically symptomatic and both had loose acetabular components. All patients were revised successfully with morcellised bone graft and a cementless acetabular component with screw fixation. Ceramic-on-ceramic (CoC) bearing surfaces were used in all revisions. All these hips remain under review and are included in the clinical and radiological results.

A total of two patients (two THRs) sustained an intra-operative fracture of the calcar which was stabilised with cerclage wires at the time of surgery. There was one dislocation treated by open reduction. No patient had a nerve palsy or deep infection.

Survival with revision of either component for any indication as the endpoint was 86% at ten years (95% CI 77.5 to 94.5; number at risk (NAR) = 23), 81% at 15 years (95% CI 60.1 to 92.3; NAR = 21) and 28% at 20 years (95% CI 13.3 to 41.8; NAR = 8) (Fig. 4).

**Radiological results.** Brooker grade I or II heterotopic ossification was seen in five THRs. Radiolucent lines were present around the acetabular component in three THRs. Focal peri-acetabular osteolysis was present in the six patients (eight THRs) that remained unrevised. Osteolysis was seen predominantly in acetabular zones 1 and 3. There was proximal osteolysis in zones 1 or 7 around the femoral stem in ten THRs. There was no osteolysis in any distal zone of the 21 patients (25 THRs) at 15 years. There were no radiolucencies around the proximal ingrowth surface of any component. All stems had the radiological appearance of stable bone ingrowth, with no evidence of distal migration.

**Correction of the centre of rotation of the hip and leg length discrepancy.** The extent of restoration of the centre of rotation of the hip using the Pierchon’s technique is shown in Table I. Using the teardrop as a reference point, the mean correction in offset of the centre of the femoral head to the theoretical centre was 15 mm (6 to 35). The mean correction of offset was 10 mm (6 to 15) for patients with Crowe III dysplasia and 29 mm (20 to 35) for those with Crowe IV dysplasia.
The mean post-operative increase in leg length was 21 mm (6 to 56). For those with Crowe III dysplasia, the mean increase was 18 mm (6 to 22) and for those with Crowe IV dysplasia it was 33 mm (24 to 56) following correction for magnification. The mean leg length discrepancy was 11 mm (0 to 16).

**Discussion**

It is generally accepted that ideally the acetabular component should be introduced in the normal anatomical location in patients with DDH who undergo THR. However, placement of the component within the true acetabulum is not straightforward. There are structural deformities in these patients, including poor bone stock and a shallow acetabulum that is often excessively anteverted, with segmental defects in the anterior and/or superior segments. Various solutions to these abnormalities have been described, including femoral head autograft, cotyloplasty, protrusio components, and the use of very small components.

In this series we successfully restored the centre of rotation of the hip to a value which is near to normal. These results have been achieved by using small acetabular components combined with the occasional use of a central acetabular osteotomy and femoral head autograft. Secure fixation of the cementless acetabular component was obtained in most patients, with the component being placed posteromedially within the true acetabulum.

A total of 15 patients (17 THRs, 57%) required revision surgery during the study period, all for acetabular or trochanteric osteolysis and polyethylene wear. Only two of the acetabular components were found to be loose at revision. All other components revised were to prevent further osteolysis and the associated complications of loosening and fracture. We attribute this high rate of revision to the bearing surfaces which were used. The acetabular components used in all patients were metal-backed and had multiple holes, which may have contributed to access of polyethylene debris to the underlying acetabular bone. Fluid pressure and pumping through these holes have been associated with the aggressive osteolysis often seen with the polyethylene liners gamma-irradiated in air which were used in our patients.

All these patients underwent successful isolated revision of the acetabular component to CoC bearing couples. We have previously reported this technique with excellent rates of survival and function, including in patients with less severe DDH.

It has been our practice for the last 15 years to use CoC bearings for all primary THRs because of the improved wear characteristics. We have previously reported excellent ten-year survival rates of primary THR in younger patients with no signs of osteolysis or wear, and anticipate similar results in patients with DDH using these bearings. The advent of CoC bearing surfaces may also help reduce the need for autograft in patients with severe DDH, as smaller acetabular components can be used without the associated concerns of the thickness of the polyethylene liner.

Femoral shortening osteotomy, whether proximal or distal, is the most commonly reported and accepted method of reducing a high-riding femoral head in patients with severe DDH. However, there is associated morbidity reported with these osteotomies in conjunction with uncemented stems, such as nonunion, with some authors recommending augmentation using allograft strut grafts and cables for torsional stability.

There are important limitations to this study, which include the relatively small number of patients, with no control group for comparison. Of this cohort, only nine patients had Crowe IV dysplasia, and it is these hips with more significant leg length discrepancy that often require a femoral shortening osteotomy. Although the mean lengthening in patients with Crowe IV dysplasia was 33 mm, the greater number of hips with Crowe III dysplasia meant that, using this technique, the mean lengthening for all hips was 21 mm.

Survival in this study was influenced by the use of first generation cementless acetabular components and standard UHMWPE liners which were gamma-irradiated in air. This could result in thin liners with some sizes of head. In addition, the heterogeneity of the acetabular components, the sizes of femoral head and bearing surfaces used in this cohort make comparisons difficult.

In conclusion, in this small group of patients, at long-term follow-up we have demonstrated a successful technique which combines a low femoral neck osteotomy with the use of a cementless, modular, femoral component to allow restoration of the centre of rotation of the hip, without the need for femoral shortening osteotomy.

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