

# Treatment of Crowe IV developmental dysplasia of the hip with cementless total hip arthroplasty and shortening subtrochanteric osteotomy

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## Abstract

**Objective:** This study was performed to document the clinical and radiographic results of consecutive patients with Crowe IV developmental dysplasia of the hip (DDH) treated by cementless total hip arthroplasty (THA) using an S-ROM femoral component with shortening derotational subtrochanteric osteotomy.

**Methods:** Twenty-three hips of 21 patients with Crowe IV DDH were treated by cementless THA combined with shortening derotational subtrochanteric osteotomy from January 2005 to January 2011. The mean preoperative modified Harris hip score (mHHS) and University of California, Los Angeles (UCLA) activity score were 40.7 and 4.2, respectively.

**Results:** The mean follow-up was 105 months. The mean mHHS and UCLA score improved to 87.0 and 9.1, respectively, at the latest follow-up. Nine of the 23 hips had a negative Trendelenburg sign. One of the 23 hips was outside the Lewinnek acetabular cup inclination safe range, and 3 of the 23 hips were outside the Lewinnek acetabular cup anteversion safe range. The probability of prosthesis survival was 100% at 5 years and 91.3% at 10 years.

**Conclusion:** Patients with Crowe IV DDH can be treated by cementless THA combined with shortening derotational subtrochanteric osteotomy. This method can greatly improve hip joint function and relieve pain without significant complications.

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## Keywords

Total hip arthroplasty, Crowe type IV developmental dysplasia of the hip, shortening subtrochanteric osteotomy, S-ROM femoral prosthesis, limb-length discrepancy, cementless prosthesis

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## Introduction

Persistence of hip dysplasia into adolescence and adulthood can lead to an abnormal gait, restricted abduction, reduced strength, and an increased rate of degenerative joint disease.<sup>1</sup> Crowe type IV developmental dysplasia of the hip (DDH) is characterized by a myriad of abnormalities of the hip joint caused by long-term dislocation of the femoral head, resulting in many obstacles to restoration of normal hip anatomy,<sup>2</sup> such as a high hip center; a small, narrow femoral canal; and increased femoral anteversion with a posteriorly positioned greater trochanter.<sup>1-4</sup>

Total hip arthroplasty (THA) has been widely accepted as the standard treatment for severe hip disease.<sup>2-8</sup> In this study, we enrolled patients with Crowe IV DDH treated by THA in which a cementless S-ROM femoral prosthesis (DePuy Orthopaedics, Warsaw, IN, USA) and shortening derotational subtrochanteric osteotomy were used. Their clinical and radiographic data were collected and analyzed. This study was performed because the findings will assist physicians in clinical practice.

## Patients and methods

We retrospectively reviewed the clinical and radiographic data of consecutive patients with Crowe IV DDH treated by cementless THA combined with shortening subtrochanteric osteotomy from January 2005 to January 2011 in our institution.

The inclusion criteria were severe pain, considerable difficulty in walking, functional impairment while performing daily activities, low quality of life, and Crowe IV DDH.<sup>2</sup> The exclusion criteria were asymptomatic high hip subluxation, a history of hip surgery (e.g., osteotomy, trauma, etc.), inflammatory or oncologic diseases in the area of the operated hip joint, neuromuscular compromise in the symptomatic extremity, and incomplete follow-up.<sup>2</sup>

All patients were evaluated preoperatively using the modified Harris hip score (mHHS); University of California, Los Angeles (UCLA) activity score; 36-Item Short Form Health Survey (SF-36); and limb-length discrepancy (LLD). Leg length measurements were performed at the clinical examination and involved calculation of the difference in the distance from the anterior superior iliac spine to the medial malleolus between the right and left leg.<sup>2</sup> A cementless S-ROM component (DePuy Orthopaedics) and cementless metal-on-polyethylene bearing (DePuy Orthopaedics) were used in all patients.

## Surgical technique

Preoperative X-ray templating was used to establish a thorough plan of acetabular reconstruction and choose the best route for the operation. Intravenous antibiotics and prophylaxis for thrombosis were also administered to all patients.

All patients were placed in the lateral position, and the posterior approach was applied. After detaching the external

rotators, the deformed femoral head was removed using an L-shaped osteotomy appropriate for the S-ROM sleeve.<sup>3</sup> The elongated hypertrophic joint capsule was resected.<sup>9</sup> The psoas tendon was partially released.<sup>9</sup> Our goal was to position the acetabular component in the true acetabular rotation center. After identifying the true acetabular floor, the acetabulum was prepared. The acetabular soft tissue was used to locate the original joint plane. The transverse ligament was then used to confirm an accurate position for the hip center.<sup>5,9</sup> The acetabulum was widened and deepened at a designated angle of abduction and anteversion.<sup>5,9</sup> We used a small cup dimension to obtain osseous coverage of  $\geq 70\%$  of the weight-bearing superior portion of the cup.<sup>5,9</sup> No patients needed acetabular bone grafting for augmentation of the roof. All acetabular components were placed medial to the wall in the original acetabulum.

The femur was prepared with the entry point on the osteotomy of the neck developed from within the calcar toward the greater trochanter as far laterally as necessary to allow the femoral component to be passed directly down the canal.<sup>5,9</sup> A shortening derotational subtrochanteric transverse osteotomy was required in all cases to facilitate easier hip reduction and avoid excessive limb lengthening with possible sciatic nerve stretching. About 1.0 to 1.5 cm below the lesser trochanter, the transverse osteotomy was performed using an oscillating saw perpendicular to the longitudinal axis of the femoral shaft.<sup>5,9</sup> The amount of shortening was dependent upon the preoperative radiographic measurements and the intraoperative examination with traction.<sup>5,9</sup> The femoral anteversion was corrected by derotation. During the operation, the sciatic nerve was not explored but palpated for the purpose of evaluation.

All patients underwent implantation of the S-ROM three-piece femoral component (DePuy Orthopaedics) made of titanium alloy without cement (Figures 1–3). Femoral heads of 22 and 28 mm were used in 17 and 4 hips, respectively. A porous-coated acetabular cup (Duraloc; DePuy Orthopaedics) was used in all hips with one or two dome screws for fixation. The cups ranged from 40 to 48 mm in outer diameter. No reinforcement rings, reconstruction cages, or structural femoral head autografts were used. No custom-made implants were required.

Postoperatively, oral celecoxib (200 mg once daily) was prophylactically administered as for inflammation. Physiotherapy was begun on the second day after surgery. Three days later, we usually encouraged the patients to walk with the help of walker. Two weeks later, they were able to walk on their own.

Postoperatively, the following patient-reported outcome data were collected for all patients: mHHS, UCLA score, SF-36 score, LLD measurement, satisfaction level (1 = unsatisfied, 2 = somewhat satisfied, 3 = satisfied, 4 = very satisfied, and 5 = extremely satisfied), and a binary satisfaction response (yes or no). Abduction strength was assessed with the Trendelenburg sign. All patients were then asked to return for a follow-up at 6 weeks, 3 months, 6 months, and 1 year after surgery and annually thereafter. Radiologic data were gathered at each clinical follow-up. The osteotomy site was evaluated by anteroposterior and lateral films of the pelvis, and bone union was defined based on the cortical continuity. We performed a radiographic analysis for evidence of loosening according to the methods proposed by Gruen et al.<sup>10</sup> and DeLee and Charnley.<sup>11</sup> The inclination of the acetabular cup was calculated on the anteroposterior pelvic film, and the anteversion of the cup was also measured on the film using the



**Figure 1.** Radiographs of a 50-year-old woman with left Crowe type IV developmental dysplasia of the hip

method proposed by Pradhan.<sup>12</sup> Based on the inclination and anteversion, the cup was recognized as either within the safe range ( $40^{\circ} \pm 10^{\circ}$  for inclination and  $15^{\circ} \pm 10^{\circ}$  for anteversion) or not as described by Lewinnek et al.<sup>13</sup>

### **Ethics**

This study was approved by the Second Xiangya Hospital Committee for Clinical Research (No. 2012-S231), and informed consent was obtained from the patients and the parents or guardians of the patients participating in the study. The patients and their parents or guardians provided written informed consent for the publication of

their individual clinical details and accompanying images.

### **Statistical analysis**

All evaluable patients were included in the analysis. Analyses were performed using descriptive statistical methods. Variables following a normal distribution were evaluated using Student's t-test. For categorical variables, the chi-squared test or Fisher's exact test was applied as necessary. The significance level was set at a p value of  $<0.05$ .

### **Results**

This study included 23 hips of 21 patients (Table 1). The patients comprised 19



**Figure 2.** Postoperative radiograph of the patient 2 weeks after cementless total hip arthroplasty combined with subtrochanteric shortening osteotomy

women and 2 men with a mean age of 46.5 years (range, 37–59 years). Two patients (both women) underwent bilateral sequential THA. The interval between the first and second THA was 13 and 17 months, respectively. Of the patients who underwent unilateral surgery, 7 underwent left THA and 12 underwent right THA.

The mean follow-up was 105 months (range, 61–136 months). The mean preoperative mHHS was 40.7 (range, 25–56), which improved to 87.0 (range, 73–95) at the last follow-up ( $p < 0.01$ ). The mean preoperative UCLA score was 4.2 (range, 2–6), which improved to 9.1 (range, 7–10) at the last follow-up ( $p < 0.01$ ). The mean

preoperative SF-36 physical component summary score was 48.5 (range, 40–60), which improved to 81.8 (range, 72–89) at the last follow-up ( $p < 0.01$ ). The mean preoperative SF-36 mental component summary score was 55.2 (range, 42–76), which improved to 75.3 (range, 69–85) at the last follow-up ( $p < 0.05$ ). The mean preoperative LLD was 5.0 cm (range, 1.7–6.5 cm), which decreased to 1.6 cm (range, 0.7–2.1 cm) at the last follow-up ( $p < 0.05$ ). The average patient satisfaction level was 4.5 (range, 2–5) at the final follow-up. Nine (39.13%) of the 23 hips had a negative Trendelenburg sign, with 14 hips (60.87%) remaining either Trendelenburg-positive or fatigue-positive.



**Figure 3.** Postoperative radiograph of the patient 8 years after left cementless total hip arthroplasty

Aseptic loosening of the acetabular component occurred in two patients (8.70%) and required revision. The revisions were performed 97 and 132 months after the index operation, respectively. The original femoral stems were not removed in the revision. Radiographic evidence of aseptic stem loosening was seen in three hips in three patients (13.04%). Of these patients, one had radiolucency in Gruen zone 2, and two had radiolucency in Gruen zone 6. In one patient, the hip was revised 105 months after the index operation. In the other two patients, the hip was revised 121 and 127 months after the index operation. The 5-year prosthesis survival rate was 100%, and the 10-year prosthesis survival rate was 91.30% (Figure 4).

Details of the acetabular cup inclinations and anteversions are listed in Table 1. One (4.35%) of the 23 hips was outside the Lewinnek acetabular cup inclination safe range, and 3 (13.04%) of the 23 hips were outside the Lewinnek acetabular cup anteversion safe range. Overall cup malpositioning, whether in anteversion or inclination, was observed in 4 (17.39%) of the 23 hips. All femoral shortening osteotomies achieved union.

Three intraoperative nondisplaced fractures occurred at the level of the calcareus during femoral stem insertion but were left untreated. One patient had sciatic nerve palsy, which fully recovered in about 6 months. Neither infection nor dislocation was observed after the operation.

**Table 1.** Patients' data

Patient	Side	Age (years)/sex	Pre-op mHHS/UCLA score		SF-36 PCS		SF-36 MCS		LLD (mm)		Trendelenburg sign	Inclination of cup	Anteversion of cup	Revisions (months)	Follow-up (months)	Latest mHHS/UCLA score
			UCLA	score	Pre-op/ Latest	Pre-op/ Latest	Pre-op/ Latest	Pre-op/ Latest	Pre-op/ Latest							
1	Left	37/Female	35 / 2	47/82	50/76	53/16	Yes	41.5°	14.6°	87 / 8	136					
2	Left	48/Female	37 / 2	52/81	57/78	65/19	Yes	42.7°	13.2°	82 / 8	135					
3	Right	50/Female	48 / 5	49/85	42/69	52/15	No	37.3°	17.5°	91 / 9	132					
4	Left	49/Female	25 / 2	42/73	47/70	18/6	Yes	41.5°	13.2°	73 / 7	130					
	Right		35 / 2				Yes	40.2°	16.3°	73 / 7	117					
5	Right	39/Female	53 / 5	51/86	63/80	52/12	No	47.5°	8.7°	90 / 8	127					
6	Right	40/Female	29 / 2	43/88	51/75	55/10	No	43.2°	19.2°	93 / 9	125					
7	Left	57/Female	50 / 5	57/80	43/78	46/12	Yes	36.1°	3.7°	85 / 8	123					
8	Right	52/Female	47 / 5	46/85	59/81	51/18	No	45.6°	9.5°	91 / 8	119					
9	Right	39/Female	38 / 4	47/78	42/71	45/12	Yes	38.7°	13.9°	88 / 8	117					
10	Left	43/Female	42 / 4	60/85	48/75	52/21	Yes	55.9°	16.5°	87 / 8	112					
11	Right	59/Female	51 / 6	47/82	57/80	65/17	No	43.6°	2.3°	93 / 9	109					
12	Right	55/Female	38 / 3	51/88	59/76	47/15	Yes	45.1°	7.9°	86 / 8	107					
13	Left	56/Male	27 / 3	48/89	61/68	56/21	No	40.3°	13.4°	95 / 10	103					
14	Right	42/Female	45 / 5	49/78	52/71	62/15	Yes	37.7°	2.1°	83 / 8	101					
15	Left	46/Female	50 / 5	40/73	60/78	17/8	Yes	38.2°	15.7°	89 / 8	98					
	Right		45 / 4				Yes	40.5°	20.1°	89 / 8	81					
16	Right	39/Female	56 / 6	55/82	54/73	52/15	Yes	39.3°	13.6°	88 / 8	85					
17	Right	41/Female	41 / 3	46/72	59/70	60/18	Yes	41.5°	18.2°	78 / 8	79					
18	Left	50/Female	35 / 4	48/77	61/85	62/15	Yes	46.3°	10.3°	82 / 8	76					
19	Right	47/Female	43 / 4	50/87	58/69	46/20	No	38.9°	11.5°	93 / 9	75					
20	Left	50/Female	35 / 4	43/86	60/74	45/12	No	46.3°	9.6°	95 / 10	68					
21	Right	47/Male	32 / 4	47/80	76/85	50/15	No	46.8°	20.1°	90 / 9	61					

Pre-op, preoperative; mHHS, modified Harris hip score; UCLA, University of California, Los Angeles; SF-36, 36-Item Short Form Health Survey; PCS, physical component summary; MCS, mental component summary; LLD, limb-length discrepancy

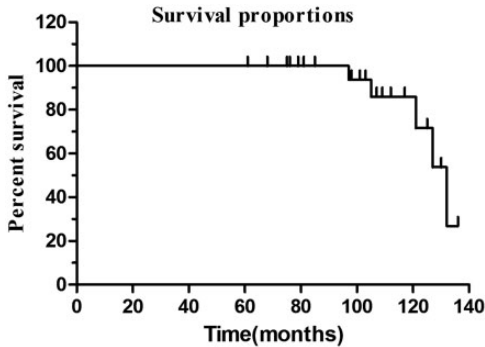


Figure 4. Survival proportions of patients

## Discussion

We have herein reported our experience of using an S-ROM cementless stem combined with shortening osteotomy for the treatment of high hip dislocation. This operative method provided an acceptable outcome during a follow-up period of 61 to 136 months. The mHHS improvement, UCLA activity score improvement, patient satisfaction level, and 5- and 10-year prosthesis survival rates in the present study compare favorably with those in other series of Crowe IV DDH.<sup>2-9</sup>

According to the safe range proposed by Lewinnek et al.,<sup>13</sup> the acetabular cup malposition rate in the present study was 17.39%.<sup>13</sup> All patients with malpositioning of the acetabular cup developed flexion pelvic tilt, which may increase the risk of inserting the cup with less or more anteversion than desired. According to our experience, the use of preoperative three-dimensional computed tomography of the hip and intraoperative radiography were beneficial for correct insertion of the acetabular cup. Although malpositioning of the acetabular cup increases the risk of dislocation, no postoperative dislocation was observed in this study. There is a lack of statistical evidence that may prove that a malpositioned hip prosthesis increases the rate of polyethylene wear, the incidence of

osteolysis, or the risk of prosthesis loosening.

Highly placed acetabular cups have a tendency to be associated with early prosthesis loosening because of their poor support from limited bone stock.<sup>4,8,14,15</sup> Therefore, most authors recommend that placement of the acetabular component corresponds to that of the original acetabulum.<sup>4,8,14,15</sup> However, because of the hypoplasia of the true acetabulum, it is usually difficult to achieve sufficient coverage for an acetabular component. In such situations, we use small, deeply seated components to obtain enough cup coverage. No acetabular component loosening was observed during a mean follow-up of 105 months in this series of patients. Notably, however, placing the acetabular component at the anatomical acetabular level while keeping the femoral prosthesis in the anatomical position would extensively lengthen the leg.<sup>4,8,14,15</sup> It is widely accepted that lengthening of the leg by >4cm could impair the sciatic or femoral nerve.<sup>4,16</sup> Some authors have even proposed that for patients who have had LLD since childhood, over-lengthening by >2cm may result in nerve palsy.<sup>4,17</sup> In our study, we used transverse subtrochanteric shortening osteotomy to avoid these adverse effects. Compared with other types of subtrochanteric osteotomy such as step-cut, oblique, or chevron-shaped osteotomies,<sup>18-22</sup> transverse subtrochanteric osteotomy is much easier to perform and adjust rotational corrections.

Incongruence between the proximal and distal femoral canal diameters after subtrochanteric shortening osteotomy is a major problem in achieving secure fixation of the femoral stem in dysplastic hip arthroplasty.<sup>3,4</sup> Secure fixation of the subtrochanteric osteotomy site is desired to provide a proper environment for bone healing, maintain the corrected anteversion until bony union, and ensure osseointegration of the



femoral component.<sup>3,4</sup> In the present study, we used the modular S-ROM cementless stem and achieved a good result. The modular S-ROM stem can provide rotational stability and compression pressure at the osteotomy site with a stepped proximal sleeve and polished distal flutes and fins individually in both the proximal and distal parts of the femur.<sup>3,4</sup> The rotation alignment of the modular S-ROM stem neck can be freely adjusted around 360°, regardless of the type of rotational deformity of the proximal femur.<sup>3,4</sup> Furthermore, during implant trialing, trial sleeves on modular implants can protect the fit of the stem in the proximal bone fragment.<sup>3,4</sup> The length of the stem, which plays a critical role in the stability of the joint, must bypass the osteotomy by at least twice the diameter of the diaphysis.<sup>3,4</sup>

Few neurological complications have been reported in THA combined with shortening femoral osteotomy,<sup>7</sup> and one patient in the present study developed sciatic nerve palsy. Fortunately, the patient had complete return of function nearly 6 months after surgery. Patients with Crowe IV DDH usually have a narrow femoral canal. Use of the modular S-ROM stem in THA combined with femoral osteotomy may risk femoral fissuring or fracture. Three intraoperative nondisplaced fractures occurred at the level of the calcaneus during femoral stem insertion. We did not apply special treatment to these fractures, and fracture union was eventually achieved.

In conclusion, patients with Crowe type IV DDH can be treated by cementless THA combined with subtrochanteric shortening osteotomy. This method can greatly improve hip joint function and relieve pain without significant complications. However, the required techniques of the procedure and the potential preoperative and postoperative problems should not be underestimated.

## List of abbreviations

DDH: developmental dysplasia of the hip  
THA: total hip arthroplasty  
mHHS: modified Harris hip score  
UCLA: University of California, Los Angeles  
SF-36: 36-Item Short Form Health Survey  
LLD: limb-length discrepancy

## Availability of supporting data

All the data supporting our findings are contained within the manuscript.

## Author contributions

S.W., W.W., T.L., and G.H. conceived and designed the study. S.W., W.W., T.L., and G.H. provided the study materials. T.L. and W.W. performed the data analysis. All authors contributed to the interpretation and discussion of the results and wrote the manuscript. All authors approved the manuscript for submission.

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## Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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