Contemporary Ceramic Total Hip Arthroplasty in Patients with Cerebral Palsy: Does It Work?

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Background: Adult patients with cerebral palsy (CP), who have advanced degenerative arthritis of the hip, have been treated with resection arthroplasty and arthrodesis. Although total hip arthroplasty (THA) has also been used as one of the alternative options, there are few studies on contemporary bearings used in THA. Therefore, we evaluated the results of the contemporary ceramic-on-ceramic THA in adult patients with CP.

Methods: From January 2005 to December 2007, five adult CP patients (5 hips) underwent THA using contemporary ceramic-on-ceramic bearings. All patients were able to stand or ambulate with intermittent use of assistive devices at home. We retrospectively reviewed the series to determine the results of THA in terms of pain relief, improved function, and durability of prosthesis.

Results: There were 3 men and 2 women with a mean age of 35.9 years. All patients had pain relief without decline in mobility postoperatively. One hip was dislocated, which was treated successfully with closed reduction and an abduction brace for 2 months. There was no ceramic fracture, loosening, or osteolysis during the mean follow-up of 6.8 years (range, 5.8 to 8.3 years).

Conclusions: Cementless THA using contemporary ceramic-on-ceramic bearings is a useful option for the treatment of advanced degenerative arthritis of the hip in ambulatory adults with CP.

Keywords: *Cerebral palsy, Arthroplasty, Hip replacement, Osteoarthritis, Ceramics*

The muscle imbalance in cerebral palsy (CP) leads to flexion-adduction contracture of the hip, increased femoral anteversion, coxa valga, hip dysplasia and dislocation. Fifty to 75 percent of adult patients with CP have secondary degenerative arthritis of the hip, hip related gait disturbance, and difficulty with perineal hygiene.[1,2] Surgical options for pediatric patients include open reduction, femoral or pelvic osteotomies, and additional tendon releases or transfers. However, degenerative arthritis of the hip develops with age, and adult patients have been treated with resection arthroplasty, arthrodesis, and replacement arthroplasty.[3,4] Resection arthroplasty and arthrodesis should be reserved only for patients who are unable to walk and whose functional needs include improved hygiene and ease of positioning. Total hip arthroplasty (THA) offers pain relief, improved motion, comfortable gait, and high level of activity.[5,6]

Although there are limited reports on THA in CP patients, mid- and long-term follow-up studies of THA in CP patients have reported satisfactory pain relief and improved walking in most of the patients.[6,7] However, these patients are often very young and frequently have muscle spasticity and hip contracture. Although they have a low level of activity and often use crutches, the 10-year survivorship of THA with use of conventional metal-on-polyethylene articulation with cemented or hybrid component was 86% to 95%.[6]

In the 1990s, THA with use of contemporary ceramic articulation was introduced. The 10-year survival improved up to 99% after the use of this articulation with-

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out any wear, osteolysis, or implant loosening.[8] However, one concern about ceramic THA in CP patients is that spasticity would create excessive forces across the ceramic head-liner interface and result in ceramic fracture and early prosthetic loosening. To the best of our knowledge, no study has reported the durability and complication of ceramic THA in CP patients. Since the late 1990s, we have used ceramic articulation and extended the application of this system to adult CP patients.

The purpose of our study was to determine whether cementless ceramic THA would provide (1) pain relief, (2) improved function, and (3) durability without ceramic fracture in adult CP patients. We hypothesized that the same clinical results and compliance may be achieved after ceramic articulation compared to that after polyethylene articulation.

METHODS

From January 2003 to December 2007, sixteen hips underwent surgery at our institute due to painful subluxated or dislocated hip with advanced arthritis that limited functional activity and in which previous nonoperative treatment had failed. Nine hips that underwent arthrodesis or osteotomy or resection arthroplasty were excluded. Patients who had a follow-up period of less than five years were also excluded. Finally, five adult CP patients (5 hips), who underwent THA at our institute from January 2005 to December 2007, were retrospectively reviewed. There were 3 men and 2 women. The mean age at the time of surgery was 35.9 years (range, 20.2 to 55.6 years), and the mean body mass index was 22.3 kg/m^2 (range, 18.9 to 28.2 kg/m^2). The type of CP was spastic diplegia in 3 spastic tripelgia in 1, and athetoid in 1. Two patients had undergone a previous operation in the affected hip at another hospital; one (patient 5) underwent resection arthroplasty 14 years before THA and the other (patient 2) underwent open reduction in early childhood. The primary reason for performing THA was painful dislocation of the hip in two patients, arthritis secondary to hip dysplasia in two patients, pain after resection arthroplasty in one patient.

Three patients were ambulatory with intermittent use of assistive devices. Two patients were wheelchair bound but were able to stand or ambulate at home. All patients had a hip contracture of 10°–30° in flexion and 5°–20° in adduction. The leg length discrepancy was measured by a teleradiography in two patients, who could maintain a standing posture with knee extension according to the method described by Sabharwal et al.[9] In the remaining three patients, the leg length discrepancy was measured on anteroposterior hip radiographs according to the method described by Woolson et al.[10] In our five patients, the preoperative leg length discrepancy ranged from 1.5 to 8.3 cm (mean, 5.1 cm).

All patients had sufficient intelligence to verbalize their queries regarding functional abilities and the degree of pain. Pain was assessed by visual analogue scale (VAS) from 0 to 10. The mean pain VAS was 7.6 preoperatively (range, 6 to 10). To assess functional abilities, we used Gross Motor Function Classification System (GMFCS) categories;[11] level I patients can walk indoors and outdoors and climb stairs without limitation, level II patients can walk indoors and outdoors but can walk up and down stairs holding a railing or with physical assistance if there is no railing, level III patients are capable of walking using a hand-held mobility device, level IV patients use wheeled mobility in most settings, and level V patients are transported in a manual wheelchair in all settings but are able to stand or pivot for transfers. The preoperative GMFCS was level IV in two patients, level III in two patients, and level II in one patient.

A computed tomography scan of the pelvis was performed before THA in all five patients to measure acetabular abduction (α°) and anteversion (β°), which would be used as the guideline to align the acetabular cup during the operation, according the protocol for cup positioning by Ha et al.[12] Acetabular abduction ranged from 46° to 50° and acetabular anteversion ranged from 13° to 18°.

All surgeries were performed by one surgeon (KHK) using a posterolateral approach in a lateral decubitus position. Third-generation alumina heads and liners (BIOLOX Forte, CeramTec, Plochingen, Germany) were used in all hips. The prostheses used were PLASMACUP SC cup with BiCONTACT stem (Aesculap, Tuttlingen, Germany) in four patients and Trident cup with developmental dysplasia of the hip (DDH) stem (Stryker, Mahwah, NJ, USA) in one patient, who had a narrow medullary canal in the proximal femur. Because dislocation after THA is more likely in CP patients than in the general population, we paid special attention to the position of the acetabular component, release of flexion/adduction contracture of the hip, and tight repair of soft tissue to prevent dislocation.

We set the goal of cup position at 40° abduction and 15° anteversion as suggested by Lewinnek et al.[13] The acetabular cup was positioned according to the method described by Ha et al.[12] Before implantation of the final prosthesis, trial prostheses were implanted and we tested their stability. In case of instability, abduction and anteversion of the acetabular component were adjusted to a more stable position. After this, we also checked the residual flexion

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contracture of the hip. In all five patients, the hip was not extended to the neutral position. The interval between the abductor and tensor fascia lata was developed. The tight portion of tensor fascia lata was identified by palpation through the interval, which was divided obliquely between the greater trochanter and the anterior superior iliac spine. In two patients, the hip could not be extended even after fasciotomy and an anterior capsulotomy was performed.

After implantation and reduction of the prosthesis, the posterior capsular flap and the external rotator tendons were repaired using the technique described by Ji et al.[14] Three drill holes, 1.5 cm apart, were made in the trochanteric crest of the greater trochanter. Nonabsorbable mattress sutures were passed through the holes and the soft tissue flap including the posterior capsule and tendinous portion of short external rotators. Then, the posterior flap was tightly tied to the posterior trochanter. After performing the operation and dressing of the wound, the patient was placed in the supine position and the hip was abducted to check the residual adduction contracture. In one patient, who had abduction restricted to less than 5°, the groin was prepped, a short incision was made over the tight tendinous portion of the adductor muscle and an adductor tenotomy was performed with use of electrocautery.

One calcar fracture occurred during the insertion of femoral stem, which was fixed with wires. No prophylaxis against heterotopic bone formation was given. All patients were instructed to wear an abduction brace for 6 weeks after THA. After removal of the drain at 2 days postoperatively, the patients were encouraged to walk with toe-touch weight-bearing using two crutches for 6 weeks and then were allowed weight-bearing as tolerated. Routine follow-up visits were scheduled at 6 weeks, 3, 6, 9, 12 months, and 6 years thereafter. Patients who had not returned during the regularly scheduled visits were contacted by telephone. The VAS and GMFCS[11] were assessed at the final follow-up.

The radiographic evaluation was performed by two independent observers who did not participate in the operations. Implant position was evaluated on the 6-week radiographs. Abduction and anteversion angles of the acetabular component and alignment of the femoral stems were measured on the 6-week anteroposterior radiographs. The abduction angle of the acetabular component was measured using the method described by Engh et al.[15] Anteversion of the acetabular component was calculated using the method described by Woo and Morrey[16] and Nho et al.[17] Cups with an abduction angle of ≤ 30° or ≥ 50°, or with an anteversion angle of ≤ 5° or ≥ 25° were considered as outliers of the optimal cup position. The equalization

of leg length discrepancy was evaluated by the 6-week teleradiography in two patients and by anteroposterior hip radiographs in three patients as described above.

The 6-week anteroposterior and cross-table lateral radiographs were considered to be the baseline studies for radiographic evaluation of implant stability, wear, osteolysis, and heterotopic ossification. The fixation of the femoral component was classified with use of the method described by Engh et al.[15] and the fixation of the acetabular component was classified with use of the method described by Latimer and Lachiewicz.[18] The wear of the liner was calculated according to the method developed by Livermore et al.[19] Osteolytic lesions were defined according the criteria of Engh et al.[15] The lesions were recorded according to the three zones described by DeLee and Charnley[20] on the acetabular side and the seven zones described by Gruen et al.[21] on the femoral side. Heterotopic ossification was classified according to the system of Brooker et al.[22] whenever present.

All patients were followed for a minimum of five years (range, 5.8 to 8.3 years; mean, 6.8 years). The design and protocol of this retrospective study were approved by the Institutional Review Board, which waived the requirement for informed consent.

RESULTS

The cup abduction angle was 32° to 42° (mean, 38.2°) and the cup anteversion angle was 19° to 27° (mean, 21.8°). The mean leg length discrepancy improved from 4.3 cm (range, 1.2 to 8 cm) to 1.2 cm (range, 0.1 to 3.5 cm). The calcar crack, which occurred during the operation, healed completely and osseointegration of the prosthesis was achieved. One patient fell down and the hip was dislocated at 10 weeks postoperatively. The dislocation was reduced under fluoroscopy and the patient wore a brace for 2 months. There was no recurrence of dislocation until the latest follow-up.

Three patients had complete pain relief and two patients had reduction in preoperative pain. The mean pain VAS was 1.4 (range, 0 to 4) at the latest follow-up. Three patients returned to their GMFCS level before the onset of hip pain and two patients returned to their preoperative GMFCS levels. Three patients became community ambulators with the aid of crutches or a cane and 1 patient became ambulatory without an assistive device (Table 1). During the follow-up, none of the hips demonstrated radiographic signs of wear or osteolysis (Fig. 1). None of the acetabular or femoral components were classified as loose (Fig. 2). None of the patients had heterotopic ossification.

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Table 1. Adult Patients with CP Who Underwent Total Hip Arthroplasty with Contemporary Ceramic Bearings

Patient	Sex/age (yr)	BMI (kg/m^2)	Type of CP	Previous surgery	Preoperative VAS	VAS at the last FU	Preoperative GMFCS	GMFCS at the last FU	FU duration (yr)
1	Female/20	18.9	Spastic triplegia	No	6	0	Level IV	Level III	5.8
2	Male/29	22.2	Spastic diplegia	Open reduction	10	0	Level III	Level II	6.5
3	Male/42	21.6	Spastic diplegia	No	9	0	Level II	Level I	8.3
4	Male/56	28.2	Spastic diplegia	No	6	4	Level III	Level III	6.6
5	Female/41	20.4	Athetoid	Resection arthroplasty	7	3	Level IV	Level IV	7.2

BMI: body mass index, CP: cerebral palsy, VAS: visual analogue scale, FU: follow-up, GMFCS: Gross Motor Function Classification System.
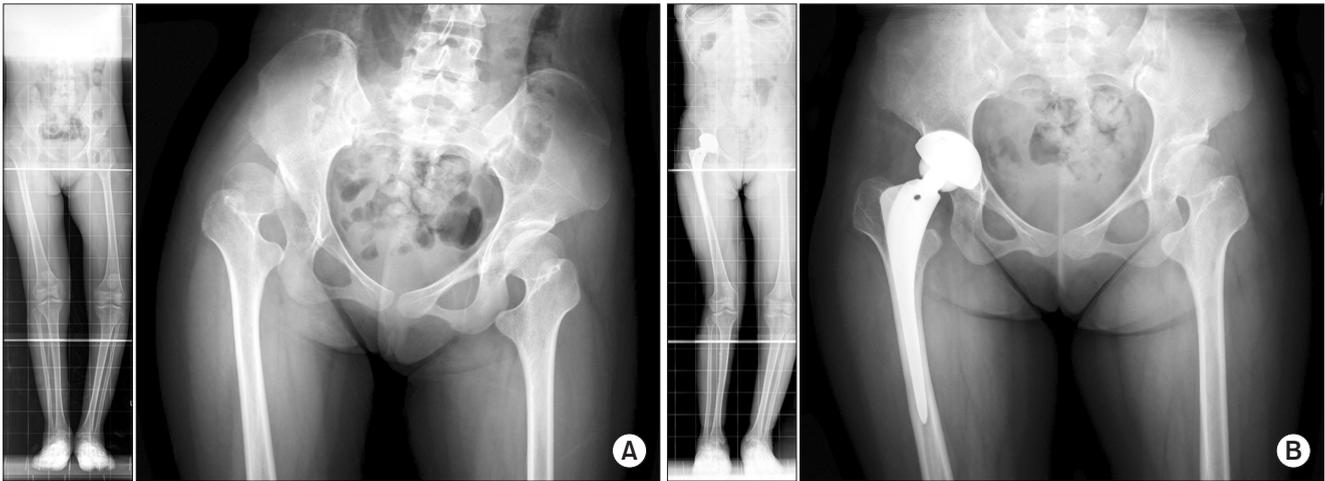
Fig. 1. (A) Radiograph of a 20-year-old woman (patient 1) with spastic triplegia shows a highly dislocated hip with deficient and stiff acetabulum. (B) Radiograph at 6 years after total hip arthroplasty shows no evidence of implant loosening or osteolysis.
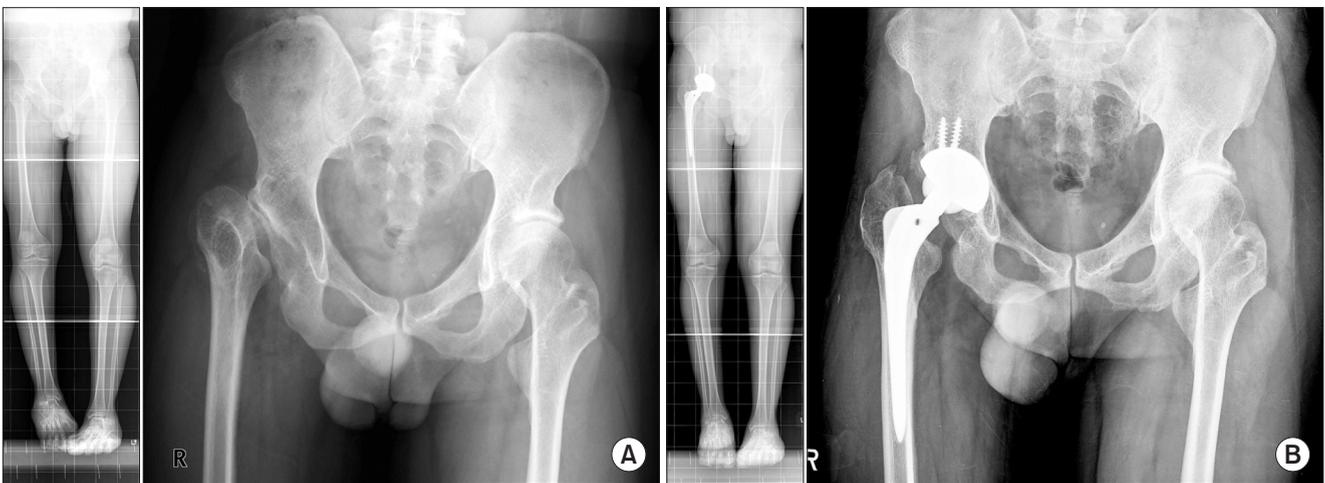
Fig. 2. (A) Radiograph of a 29-year-old man (patient 2) with spastic diplegia shows a highly dislocated hip. The leg length discrepancy is 8 cm on teleradiogram. (B) Radiograph at 6.5 years after total hip arthroplasty shows no evidence of implant loosening or osteolysis. The postoperative leg length discrepancy is 3.5 cm.

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Table 2. Reports of Total Hip Arthroplasty in Patients with Cerebral Palsy

Study	No. of patients	Average follow-up (yr)	Articulation	Pain	Function	Survivorship (yr)
Raphael et al.[6] (2010)	59	9.7	Polyethylene	Complete relief in 81% of patients	Improved in 88% of patients	10-Year survival of 85%
Schorle et al.[27] (2006)	19	4.6	Polyethylene	84% of patients were pain-free	Improved in 100% of patients	-
Weber and Cabanela[26] (1999)	16	9.7	Polyethylene	Good to excellent relief in 87% of patients	Improved in 79% of patients	-
Buly et al.[7] (1993)	18	10	Polyethylene	Complete relief in 89% of patients	Improved in 94% of patients	86% with removal for any reason
Current study	5	6.8	Ceramic-on-ceramic	Reduced in 100% of patients	Improved in 60% of patients	No loosening, wear, and fracture

DISCUSSION

The incidence of painful hip subluxation or dislocation with arthrosis in adolescent CP patients was reported to range from 23% to 79%.[23-25] These deformities can result in painful hip disability, and can limit sitting, standing, and walking. THA has been successful in terms of pain relief and improvement of function in these patients. In previous studies reporting the results of THA in CP patients, conventional polyethylene articulation and cemented or hybrid prosthesis were used, and the duration of follow-up was variable (Table 2).[6,7,26,27]

Despite the young age of CP patients at the time of THA, concerns about component failure were not addressed seriously, so far. Polyethylene has an advantage of reduced fracture risk in THA; however, there is a significant increase in the linear wear rate at a point between 5 years and 10 years of wear debridement even if highly cross-linked polyethylene was used.[28,29] Improper alignment or positioning of the acetabular component is thought be related to a higher wear rate.[30] In patients with CP, the possibility of acetabular component malposition is relatively higher due to high incidence of hip dysplasia. In previous reports, 5% to 14% of CP patients needed revision within 10 years after arthroplasty.[6,7]

The 10-year survival rate of THA with use of contemporary ceramic-on-ceramic bearings was 99% without detectable wear, osteolysis, or loosening of the implant.[8] We believe that improved ceramic-on-ceramic bearing implants are a reasonable option for young patients with CP. However, there are no data on the results of ceramic THA in CP patients. One concern is the risk of ceramic fracture because these patients have muscle spasm and contracture, which create excessive force at the ceramic head-liner interface. Therefore, the purpose of this retrospective study

was to evaluate the results of ceramic THA with cementless prosthesis in CP patients in terms of (1) pain relief, (2) improvement of function, (3) implant durability, and (4) incidence of ceramic fracture.

To the best of our knowledge, this is the first study to report the results of THA using contemporary ceramic bearings and cementless prosthesis in adult patients with CP, which showed satisfactory mid-term results without any wear, osteolysis or loosening of prosthesis, and ceramic fracture. Contemporary primary THA was a satisfactory procedure in adult patients with CP. There were several limitations to our study. First, it was a retrospective study performed in a small number of patients. However, there has been reluctance to perform THA in patients with CP due to high rate of perioperative complications and early prosthetic loosening.[30] Thus, previous studies included a limited number of patients, used various bearings and different prostheses, and had a wide range for the duration of follow-up.

In our series, all patients underwent THA using one contemporary ceramic bearing with a cementless prosthesis and all patients had a minimum of 5 years follow-up, the follow-up period was relatively uniform (range, 5.8 to 8.3 years; mean, 6.8 years). Second, all operations were performed by an expert hip surgeon, which might have affected the surgical results. The mid-term outcome of THA with use of contemporary ceramic bearing and cementless prosthesis was satisfactory in our group of patients with CP and excellent longevity of the implant can be expected.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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