

Case Report

## Comparison between Cases of Total Hip Arthroplasty Followed by Colonna Capsular Arthroplasty and Lorenz Cast Reduction in Patients with Developmental Dysplasia of the Hip

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Most patients with developmental dysplasia of the hip (DDH) now receive closed-reduction treatment within 6 months after birth. The long-term outcomes of patients with late-detection DDH have remained unclear. We reviewed the clinical records of 18 patients who underwent Colonna capsular arthroplasty (n=8) or closed reduction (n=10) for developmental dysplasia of the hip as infants or young children and underwent total hip arthroplasty approximately in midlife. Both the Colonna capsular arthroplasty and closed reduction groups achieved good clinical results after total hip arthroplasty. However, the operating time was longer and the improvements of hip range of motion and clinical score were significantly worse in the Colonna capsular arthroplasty group than in the closed reduction group.

**Key words:** developmental hip dysplasia, long-term follow-up, closed reduction, Colonna capsular arthroplasty, total hip arthroplasty

The closed cast reduction (CCR) procedure for developmental hip dysplasia was developed in 1896 by Adolf Lorenz and was practiced worldwide throughout the 20th century [1]. The Lorenz method first uses a manual maneuver that forces the lower limb into a frog-leg position to reduce the dislocated femoral head. The patient's hip is then immobilized for 4 months in the flexion-abduction position using a cast and then brace. However, a nonnegligible number of cases treated in this manner failed to achieve anatomical reduction [2]. Today, the Pavlik harness is generally used as the mainstream conservative treatment [3].

Closed reduction is difficult to perform in older children with developmental dysplasia of the hip (DDH).

In 1932, Colonna reported on an open reduction procedure for patients with DDH, later termed Colonna capsular arthroplasty (OR-CCA) [4,5]. OR-CCA was typically performed as a salvage procedure for DDH cases with late detection or for dislocation after open reduction [6]. Colonna's capsular arthroplasty involved wrapping the capsule around the femoral head and reduction after reaming the acetabulum/ The patient's hip was then immobilized for 2 months using a cast. Unfortunately, however, the long-term results after OR-CCA have been unsatisfactory [7,8]. Meanwhile, the frequency of delayed diagnosis of DDH has declined due to the widespread institution of early diagnostic ultrasound screening for DDH [9]. With the development of more effective surgical [10-12] and con-

servative [13, 14] therapies, OR-CCA is no longer performed. In this study, we compare the results in total hip arthroplasty (THA) cases half a century or more after Colonna capsular arthroplasty and Lorenz cast reduction for DDH.

### Patients and Methods

This study reports the outcomes of 18 patients with DDH who were treated by CCR or OR-CCA at Okayama University Hospital. They were followed for decades after the initial reduction and then received THA at the Okayama University Hospital (16 cases) and Kawasaki Medical School and Hospital (two cases). Specifically, we investigated and compared the pre- and postoperative outcomes of THA. The research ethics committees (RECs) of Kawasaki Medical School and Hospital (approval number: 5666-00) and Okayama

University Hospital (approval number: 2208-053) approved this study, which followed the principles outlined in the Helsinki Declaration.

Between 1956 and 1976, of all the patients diagnosed with DDH at Okayama University Hospital, 465 underwent CCR and 62 underwent OR-CCA. In this study we researched the results of 18 patients who underwent CCR (Table 1) or OR-CCA (Table 2) and whom the authors treated later in life with THA. These patients were followed up after the THA procedure as well by medical record. Among the 18 subjects, there were no cases of teratologic or paralytic dislocation as infants.

In the CCR group, 10 hips of eight patients were treated by the Lorenz method from 1957 to 1964 at Okayama University Hospital. All patients were female, and the mean age of the patients at the time of undergoing CCR was 17.8 months (range 6-28). THA was per-

**Table 1** Patient demographics (THA after closed reduction)

Case	Side	Age at THA	KL	K&M	Crowe	Contra-hip	Discrepancy before THA (mm)
1	Right	54	IV	I	I	normal	15
2	Left	55	IV	II	I	normal	10
3*	Right	52	IV	III	I	mild OA	25
3*	Left	63	IV	I	I	THA	0
4	Both	57	IV	I	I	normal	25
5	Both	56	IV	II	I	THA	-5
6*	Right	51	IV	III	II	severe OA	-10
6*	Left	52	IV	III	II	THA	15
7	Right	51	IV	I	I	normal	5
8	Left	50	IV	II	I	normal	20

OA, osteoarthritis of hip joint; KL, Kellgren-Lawrence classification; K&M, Kalamchi and MacEwen classification; Crowe, Crowe classification.

**Table 2** Patient demographics (THA after OR-CCA)

Case	Side	Age at THA	KL	K&M	Crowe	Contra-hip	Discrepancy before THA (mm)
1	Left	51	IV	III	II	normal	30
2	Right	52	IV	II	II	normal	15
3	Left	55	IV	III	I	normal	25
4	Left	55	IV	II	I	THA	20
5	Left	54	IV	II	I	normal	20
6	Left	48	IV	III	I	normal	30
7	Left	56	IV	II	I	normal	30
8	Right	44	IV	II	II	THA	15
9	Left	53	IV	III	I	mild OA	0
10	Right	49	IV	IV	I	normal	45

OA, osteoarthritis of hip joint; KL, Kellgren-Lawrence classification; K&M, Kalamchi and MacEwen classification; Crowe, Crowe classification.

formed at Okayama University Hospital between 2007 and 2018. The first author (HE) performed THA in all patients after CCR. The mean age of the patients at the time of undergoing THA was 54 years (range 50-63), and the mean follow-up period after THA was 9 years (range 3-14). We selected muscle-sparing approaches such as the anterolateral supine approach and modified Watson Jones approach for those CCR cases that had good range of motion and less deformity ( $n=3$ ).

In the OR-CCA group, 10 hips of 10 patients were treated by Colonna capsular arthroplasty from 1965 to 1973 at Okayama University Hospital. Nine patients were female and one was male. The mean age of the patients at the time they underwent OR-CCA was 5.6 years (range 1.6-11.5). THA was performed at two institutions between 2010 and 2021. Surgeon HE performed THA in eight patients, and surgeons YN and SM performed THA in one patient each after OR-CCA. The mean age at the time of undergoing THA was 51 years (range 44-56), and the mean follow-up period after THA was 6 years (range 2-10). For these OR-CCA cases, circumflex capsular resection by additional extended exposure was performed using the ordinary posterior approach for severe hip ankylosis. In addition, we used a cemented stem to perform correct the antetorsion of femoral stem and leg-length discrepancies.

Before THA, grades of arthropathy, deformity of the femoral head, and subluxation were evaluated on antero-posterior (AP) hip radiographs according to the Kellgren–Lawrence (KL) [15], Kalamchi [16], and Crowe classification systems [17], respectively. Leg-length discrepancy was measured on AP hip radiographs before and after THA. The leg-length discrepancy was calculated as the length of the affected leg subtracted from the length of the healthy leg. (Tables 1, 2)

The operation duration, amount of blood loss, and additional procedures were recorded. We investigated whether femoral head dislocation was possible or not intraoperatively after soft tissue release during THA. Modified Harris hip scores (MHHS) [18] and hip range of motion (ROM) were measured. Mac Toukeikaiseki ver. 3.0 (ESUMI Co. Ltd., Tokyo, Japan) was used for statistical analysis. The Wilcoxon signed-rank test and Mann–Whitney  $U$ -test were used to assess the presence of significant differences ( $p < 0.05$ ).

### **Treatment procedure: Two sample cases.**

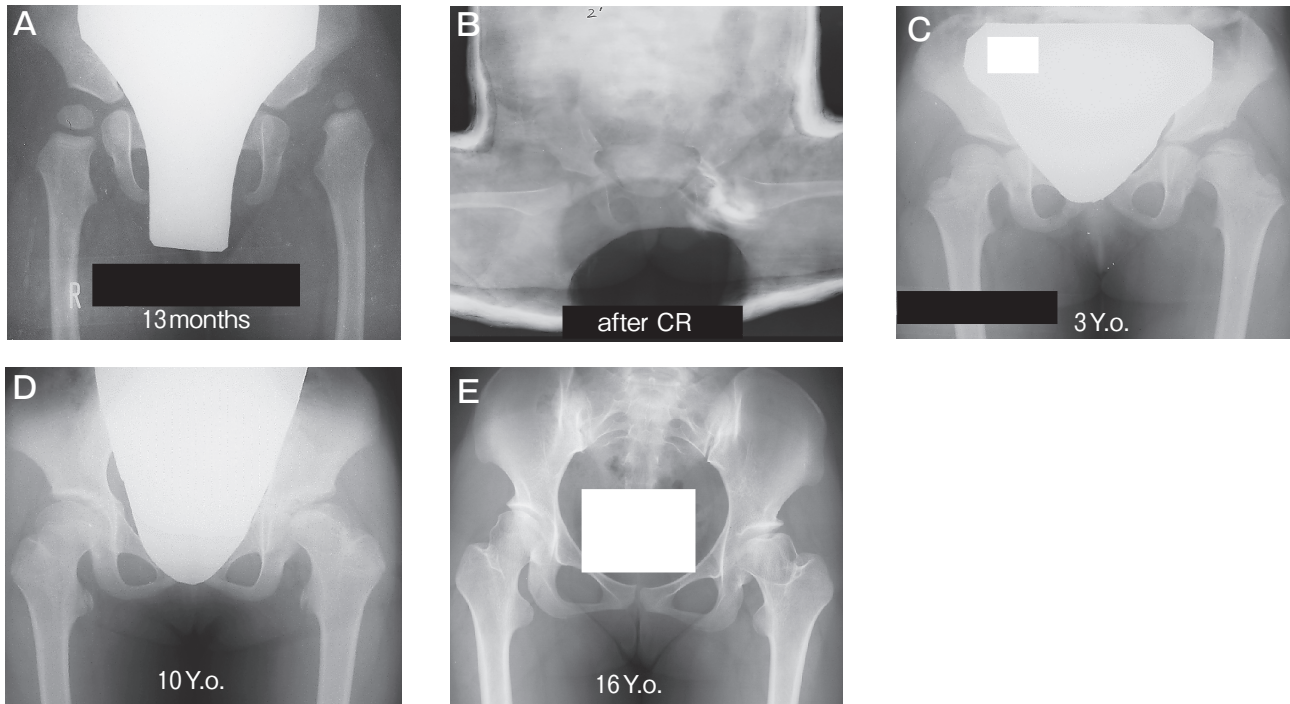
#### **1. CCR Case**

A female was found to have left DDH when she started walking at 13 months of age (Fig. 1A). She underwent hip arthrography, and reduction was performed by manipulation under general anesthesia (Fig. 1B). CCR was performed by Lorenz's procedure[1]: both hips were fixed in flexion and abduction by plaster cast for two months. Additionally, a hip abduction brace was applied for two months. This resulted in failed concentric reduction. There was AVN and poor congruity in the affected hip (Fig. 1C). At the age of 3 years, a radiograph showed AVN and a gap in the center of the affected hip (Fig. 1D). Hip joint congruency was poor at bone maturity (Fig. 1E), and she visited the hospital again for arthroplasty at 50 years of age (Fig. 2A). She underwent cementless THA via a posterior approach, and her leg-length discrepancy was surgically corrected (Fig. 2B).

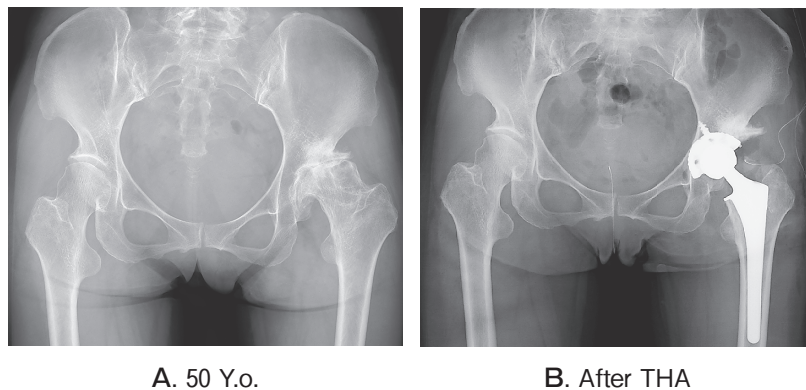
#### **2. OR-CCA Case**

A female was found to have right-side DDH at 7 months of age. She underwent CCR, but reduction could not be achieved (Fig. 3A). Open reduction was performed at the age of 10 months (Fig. 3B); however, the hip dislocated postoperatively (Fig. 3C) after walking age. She subsequently underwent OR-CCR by Collonna's procedure[4]. The greater trochanter with the attached muscle was dissected and turned upward, and the capsule covering the femoral head was also dissected free from the surrounding soft tissues. A capacious new acetabulum was formed by reaming near the original site. Then, the femoral head with its covering of capsule was placed in the new acetabulum. The greater trochanter was reattached, and a hip spica cast was applied for two months after operation. An additional derotation osteotomy of the distal femur was performed at the age of 27 months (Fig. 3D).

At the age of 10 years, a radiograph showed coxa magna in the affected hip (Fig. 3E), and at the age of 20 years, although she had no complaints of hip pain, KL Grade II arthropathy was observed (Fig. 3F). At the age of 48 years, she once again presented with complaints of pain and significant impairment in activities of daily living (Fig. 4A). Surgery was performed in the lateral decubitus position. The entire circumference of the articular capsule was incised via an extended posterior approach. The femoral head had intra-articular adhesions implying that dislocation was impossible. The



**Fig. 1** Sample case with prior CCR. **A**, Left-side developmental dysplasia of the hip at 13 months of age; **B**, Lorenz closed cast reduction was performed; **C**, X-ray imaging at the age of 3 years; **D**, X-ray imaging at the age of 6 years; **E**, X-ray imaging at the age of 16 years.

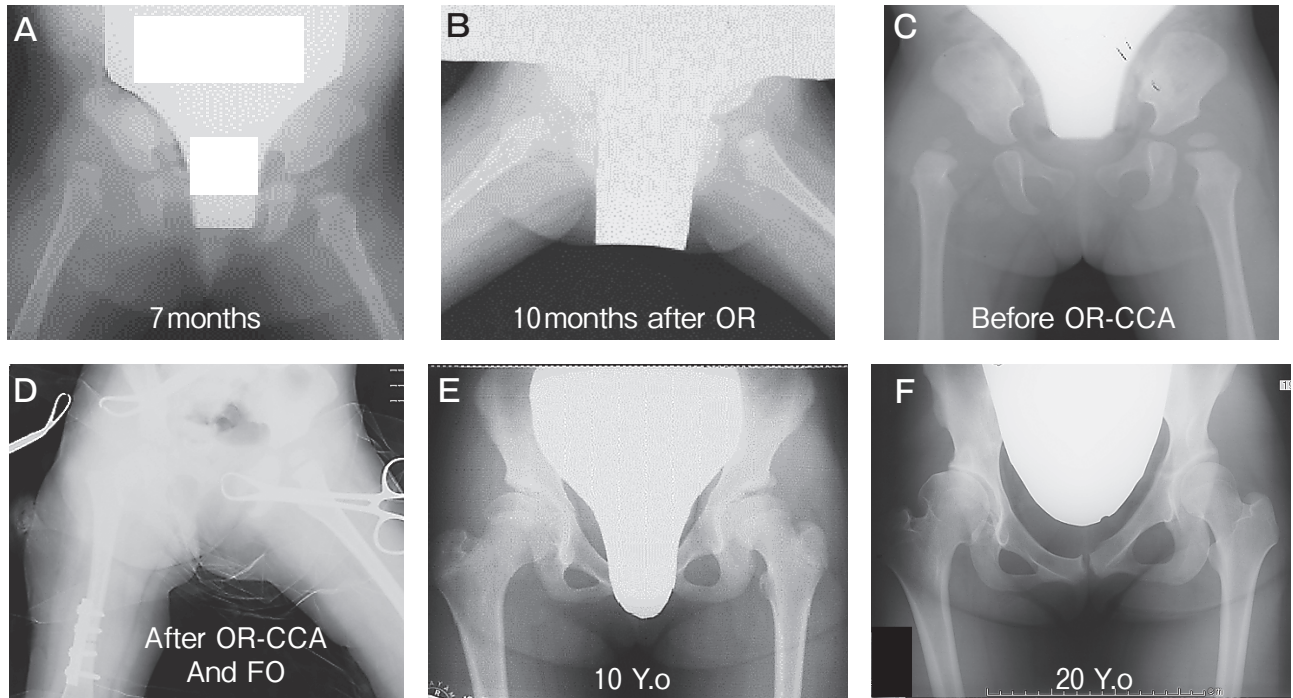


**Fig. 2** X-ray imaging in the CCR case before and after THA at age 50.

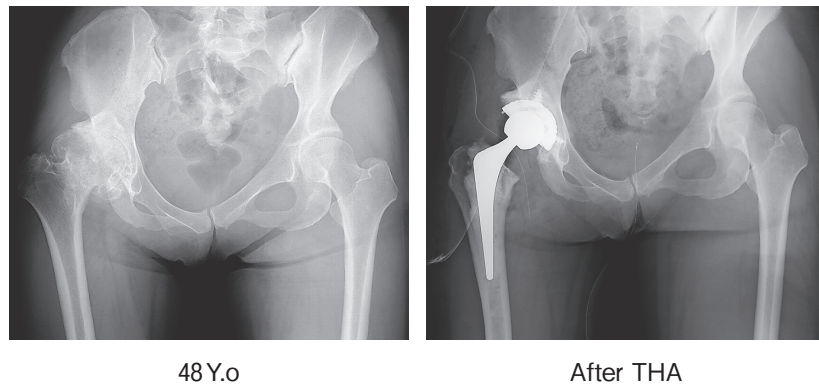
femoral neck was resected and the femoral head was removed piece by piece from acetabulum. A hybrid THA was performed using a cementless cup and a cement stem (Fig. 4B). Abduction in the supine position was up to 10°, and partial dissection of the adductor muscle was additionally performed.

### Results

In the CCR group, the mean operation duration was 102 min (range 90-120) and blood loss was 244 ml (range 100-590). Femoral head dislocation was possible in all cases, and no additional procedures were required (Table 3). Except for asymptomatic deep vein thrombosis in one patient, there were no postoperative complications.



**Fig. 3** Sample case with prior OR-CCA. **A**, Right-side developmental dysplasia of the hip at the age of 7 months after birth; **B**, X-ray imaging at the age of 10 months after birth; **C**, X-ray imaging after walking age showing redislocation; **D**, X-ray imaging at the age of 27 months of distal derotation femoral osteotomy after Colonna capsular arthroplasty; **E**, X-ray imaging at the age of 10 years; **F**, X-ray imaging at the age of 20 years.



**Fig. 4** X-ray imaging at the OR-CCA case before and after THA at 48 years.

In the OR-CCA group, the mean operation duration was 141 min (range 109-205) and blood loss was 360 ml (range 160-700). Femoral head dislocation was impossible in 7 of 10 cases due to intra-articular adhesions, and adductor release to gain spontaneous abduction was performed in 3 of 10 cases (Table 4). There were no perioperative complications such as nerve paralysis. Dislocation at three months after THA

occurred in one case but was managed with the 3-month use of a brace; the patient had no dislocation thereafter.

On comparing the two group, the mean MHHS in the OR-CCA group were significantly lower than those in the CCR group, both before surgery and at 4 months after surgery (Mann-Whitney test,  $p < 0.05$ ). (Fig. 5). Hip ROM was measured as hip joint flexion and abduc-

**Table 3** Patient demographics (THA after closed reduction)

Case	THA (implant)	Approach**	Dislocatable***	Elongation**** (mm)	Discrepancy after THA (mm)	Operation time (min)	Bleeding (ml)	Follow-up time after THA
1	cementless	Hardinge	yes	15	0	90	300	11
2	cementless	Hardinge	yes	10	0	100	200	9
3*	cementless	Hardinge	yes	25	0	115	400	13
3*	cementless	ALS	yes	0	0	120	300	2
4	cementless	Posterior	yes	25	0	100	300	7
5	cementless	OCM	yes	0	-5	95	590	7
6*	cementless	Hardinge	yes	15	-5	105	150	10
6*	cementless	Hardinge	yes	15	0	105	100	9
7	cementless	ALS	yes	5	0	95	100	8
8	cementless	Posterior	yes	20	20	95	100	7

\*\*ALS, anterolateral supine approach; OCM, modified Watson Jones approach. \*\*\*Whether it is possible or not to dislocate femoral head spontaneously in the operation. \*\*\*\*The spontaneous elongation of leg length in the affected side by the operation.

**Table 4** Patient demographics (THA after OR-CCA)

Case	THA (implant)	Approach**	Dislocatable	Elongation**** (mm)	Discrepancy after THA (mm)	Operation time (min)	Bleeding (ml)	Follow-up time after THA
1	cementless	Posterior	yes	15	15	110	300	6
2	hybrid	Hardinge	yes	15	0	120	260	12
3	hybrid	E-Posterior	no	20	5	205	510	5
4	hybrid	E-Posterior	no	20	0	170	330	4
5	hybrid	E-Posterior	no	20	0	135	300	3
6	hybrid	E-Posterior	no	30	-5	150	160	9
7	hybrid	E-Posterior	no	30	-5	118	300	2
8	hybrid	Hardinge	no	15	0	130	700	9
9	cementless	Posterior	yes	20	-20	109	320	3
10	hybrid	E-Posterior	no	20	25	165	420	3

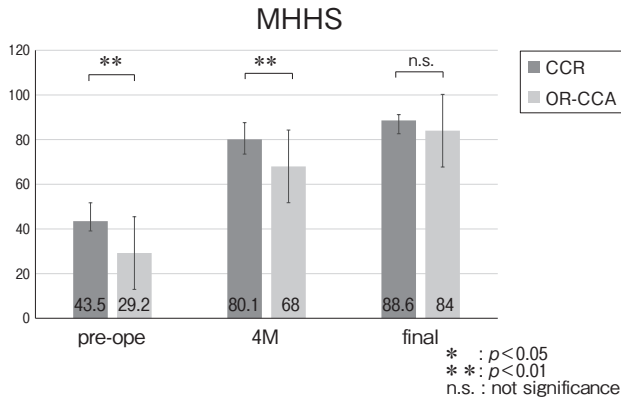
\*C-less; all cementless implant, hybrid; cementless cup and cemented stem. \*\*E-Posterior, extended posterior approach. \*\*\*Whether it is possible or not to dislocate femoral head spontaneously in the operation. \*\*\*\*The spontaneous elongation of leg length in the affected side by the operation.

tion and internal rotation and external rotation angles. In the mean hip ROM of flexion, there was a statistically significant difference both before surgery and at the final follow-up, with the CCR group having greater ROM (Wilcoxon Signed-Rank test,  $p < 0.05$ ) (Fig. 6A). In the mean hip ROM of abduction and internal rotation, there was no statistically significant difference (Fig. 6B, C). In the mean hip ROM of external rotation, there was a statistically significant difference at the final

follow-up, with the CCR group having greater external rotation (Wilcoxon Signed-Rank test,  $p < 0.05$ ) (Fig. 6D).

## Discussion

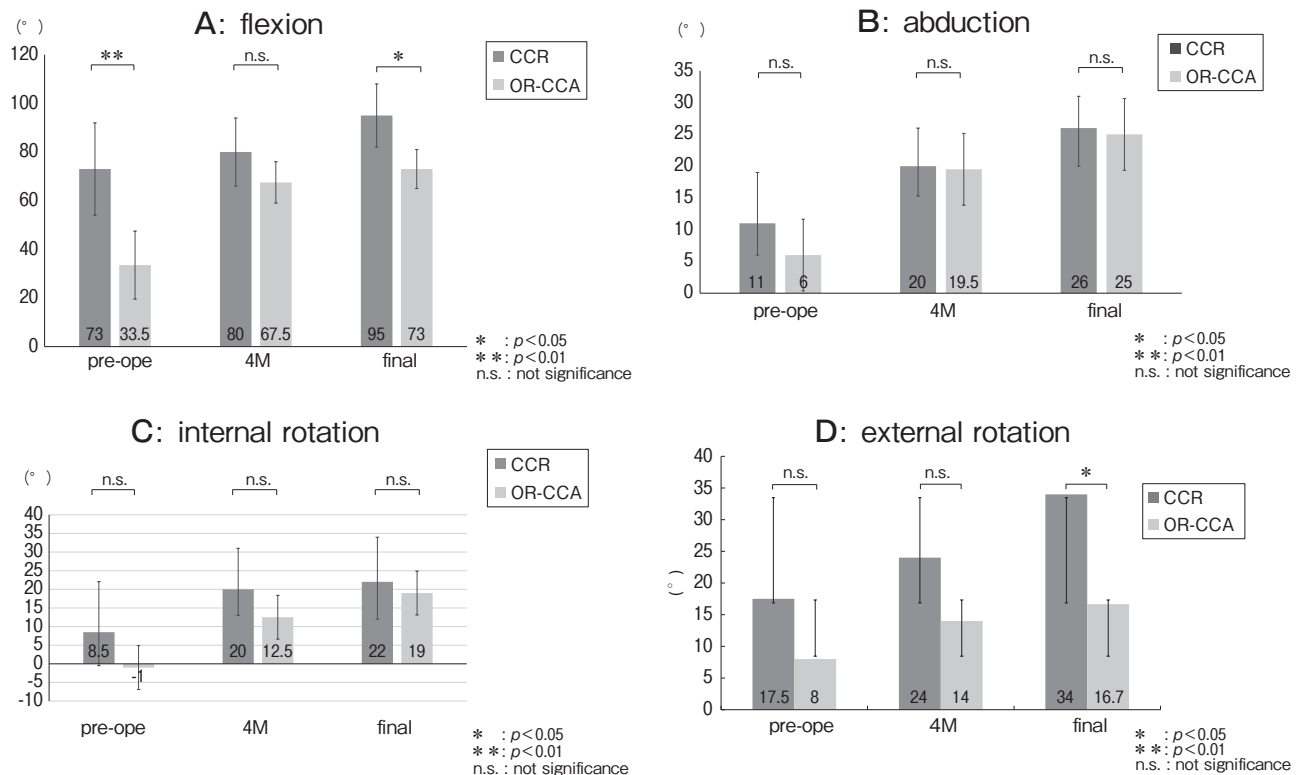
In reports about the treatment results of Colonna arthroplasty for DDH, Chung *et al.* [7] and Pozo *et al.* [8] reported that joint function was maintained for 20



**Fig. 5** Change in modified Harris hip scores (MHHS) for closed cast reduction (CCR) cases and Colonna capsular arthroplasty (CCA) cases at pre-operation, four month post-operation, and final follow-up.

years after operation and that only a few cases required THA. Boardmann *et al.* [25] investigated 16 DDH patients who underwent OR-CCA after 40 years. In their result, 12 patients underwent THA and the other hip joint preserved four patients had worse clinical scores than those who did THA. Therefore, OR-CCA is not a recommended procedure in regard of the long-term result.

In this study, we investigated 18 patients with DDH who were followed for half a century after CCR or OR-CCA, leading to THA. Both preoperative MHHS and hip ROM were worse in the OR-CCA group than the CCR group. In the CCR group, many patients had already recovered MHHS at 4 months after THA, whereas many patients in the OR-CCA group had not. Gibson *et al.* [19] also reported that closed reduction was superior to open reduction in terms of long-term outcomes. However, it should be considered that our OR-CCA cases include those with re-dislocation after closed reduction and older children.



**Fig. 6** Changes in ROM for closed cast reduction (CCR) cases and Colonna capsular arthroplasty (CCA) cases at pre-operation, four month post-operation, and final follow-up. **A**, Change in hip flexion angle for CCR and CCA cases; **B**, Change in hip abduction angle for CCR and CCA cases; **C**, Change in hip internal rotation angle for CCR and CCA cases; **D**, Change in hip external rotation angle for CCR and CCA cases.

THA after OR-CCA required more additional procedures, and both operative time and blood loss were significantly higher than those in the CCR group. Postoperative MMHS and ROM were also significantly lower in the OR-CCA group than the CCR group. In the OR-CCA group, both MHHS and ROM significantly improved from 4 months after THA until the final follow-up. Even in cases of ankylosis of the hip after OR-CCA, ROM could be restored and clinical symptoms alleviated following THA. Thus, ongoing rehabilitation after discharge proved more important in the OR-CCA group than the CCR group.

THA is an effective treatment for patients with early-life DDH procedures. As most of the patients are relatively young at the time of THA surgery, good long-term outcomes may be achieved [26]. Among patients with DDH undergoing THA, the greater the degree of dislocation according to the Crowe classification, the longer the hospital stay and the higher the cost of surgery [27]. Increased operation duration and blood loss during THA were reported in patients with DDH who underwent pelvic or proximal femoral osteotomies during childhood [28].

In OR-CCA, the postoperative concentration of the hip joint is typically well maintained because the shallow acetabulum is reamed and the femoral head placed on a newly formed deep acetabulum. However, in some cases, intra-articular adhesions are so severe that the ROM of the hip joint is reduced and the joint is ankylosed. In almost patients who had undergone OR-CCA, the first author had to extensively dissect the soft tissues other than the gluteus medius via an extended posterior approach; however, even after release, dislocation of the femoral head was impossible. The author used a curved chisel made for periacetabular osteotomy to cut the femoral neck from the front and back and remove the femoral head. In the case of THA after OR-CCA, it is difficult to perform femoral neck osteotomy based on preoperative planning. The author preferred using a cemented stem to simultaneously adjust the length of the leg and perform stem antetorsion. Extensive soft tissue and adductor dissection is important to improve postoperative hip ROM.

The limitations of this study were the small number of cases, low follow-up rate, and short follow-up period after THA; moreover, bilateral as well as unilateral cases were included. In addition, each patient had a different background such as the age and clinician for

the original reduction procedure. Another problem may be the lack of patient-reported outcomes. In conclusion, total hip arthroplasty for the DDH cases treated by open reduction was more difficult than that for DDH cases treated by closed reduction because of the joint adhesion associated with the former. The recovery after arthroplasty was delayed in the DDH cases treated by open reduction. Surgeons should investigate the background of the DDH patients when those patients require arthroplasty.

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