Original Article

Two Different Total Hip Arthroplasties for Hartofilakidis Type C1 Developmental Dysplasia of Hip in Adults

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Abstract

Background: Total hip arthroplasty (THA) in developmental dysplasia of the hip (DDH) is more complex than the normal hip, with large replacement risks and many complications. Although nonosteotomy THA is convenient to perform, femoral osteotomy shortening can avoid blood vessel and nerve traction injuries. This study aimed to compare osteotomy THA with nonosteotomy to determine reasonable options for operative management of DDH.
Methods: Data on 48 DDH patients who underwent THA were analyzed retrospectively. The patients were divided into two groups: Group A 29 cases (nonosteotomy), and group B 19 cases (osteotomy). Harris and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores, limb length discrepancy (LLD), radiological data on the hip, and claudication were evaluated. Data were analyzed by using paired-sample Student's *t*-test, independent-sample Student's *t*-test, and Pearson's Chi-square test; the test level was α =0.05.
Results: Postoperative Harris (90.7 ± 5.1) and WOMAC scores (88.0 ± 10.6) were significantly improved compared with preoperative Harris (44.8 ± 5.7) and WOMAC scores (42.0 ± 5.3) in group A ($P < 0.05$). Postoperative Harris (90.4 ± 2.8) and WOMAC scores (88.2 ± 5.9) were significantly improved compared with preoperative Harris (44.4 ± 4.2) and WOMAC scores (43.2 ± 4.3) in group B ($P < 0.05$). One case of dislocation occurred in group A; after closed reduction, dislocation did not recur. In group A, 2 patients developed cutaneous branch injury of the femoral nerve, which spontaneously recovered without treatment. Postoperative LLD >2 cm was seen in one case in group A and five cases in group B. Postoperative claudication showed no significant difference between the two groups ($P > 0.05$). No patients developed infection; postoperative X-rays showed that the location of the prosthesis was satisfactory, and the surrounding bone was not dissolved.
Conclusions: THA is effective and safe for DDH. For unilateral high dislocation DDH patients with limb lengthening ≤4 cm and good tissue conditions, THA without femoral osteotomy may be considered.

Key words: Developmental Dysplasia of the Hip; Dislocation; Osteotomy; Subtrochanteric; Total Hip Arthroplasty

Introduction

Patients with developmental hip dysplasia (DDH) have a femoral head dislocation and acetabular developmental dysplasia, and may have secondary osteoarthritis. Hartofilakidis typing divides DDH into three types, with type C being high dislocation of the hip; according to positional correlation between the femoral head and the true and false acetabulum, type C can be subdivided into type C1 (false acetabulum formation) and type C2 (no false acetabulum formation).[1] Due to the high dislocation, normal anatomy of the hip changes, and bone and soft tissue deformities are obvious; the femoral head may form a pseudarthrosis in the iliac wing, with the pseudarthrosis located superior or posterior to the true acetabulum. The true acetabulum is very small; its anterior wall is relatively thin and the amount of bone is less; its posterolateral wall is very thick; the femur is usually poorly developed, the marrow canal is relatively small and irregular, the femoral head is small, and there is femoral neck

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anteversion. Therefore, total hip arthroplasty (THA) for DDH is more complex than in the normal hip, and the replacement risk is large, with many complications.[2,3] Especially, when the prosthesis is placed and the joint reset, blood vessels, and nerve bundles are easily injured; in contrast, femoral osteotomy shortening can avoid blood vessel and nerve traction injury, reduce excessive release of soft tissue, and help place the prosthesis and reset the joint.[2,4-7] However, femoral osteotomy shortening has certain risks, including leg length discrepancy and nonunion at the osteotomy site. There are some reports that THA without femoral osteotomy for treating DDH has also achieved good results.[5,7]

The objective of this study was to compare efficacy, complications, and other factors, for two different methods of THA (with or without subtrochanteric osteotomy), to provide a reasonable choice of operative method for treating DDH.

Methods

Patient information

This paper retrospectively analyzed clinical data of 48 patients at Beijing Jishuitan Hospital (China) with DDH from January 2008 to December 2012. There were three men and 45 women, aged 22–60 years, with a mean age of 41.5 ± 9.7 years; body mass index was 17.7–27.5 kg/m^2, with a mean of 21.9 ± 2.4 kg/m^2. The patients were divided into two groups by the operative method. Group A consisted of 29 patients who underwent THA without subtrochanteric osteotomy; in group B, 19 patients underwent THA with subtrochanteric osteotomy. Follow-up was for 1.5–6.6 years, with a mean of 3.3 ± 1.3 years. No hip joint revision was needed. Harris and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores were used to evaluate pre- and post-operative functioning [Table 1].

Table 1: Demographics of DDH patients who underwent THA

Demographics	Group A (THA without osteotomy)	Group B (THA with osteotomy)	*t*	*P*
Number of patients	29	19		
Age (years)	41.6 ± 10.1	41.3 ± 9.2	0.104	>0.05
Female/male	28/1	17/2		
Height (cm)	158.4 ± 4.6	159.9 ± 4.5	1.114	>0.05
Weight (kg)	55.4 ± 7.4	55.2 ± 7.5	0.091	>0.05
Body mass index (kg/m^2)	22.1 ± 2.4	21.6 ± 2.5	0.694	>0.05
Preoperative Harris score	44.8 ± 5.7	44.4 ± 4.2	0.262	>0.05
Postoperative Harris score	90.7 ± 5.1	90.4 ± 2.8	0.234	>005
Preoperative WOMAC score	42.0 ± 5.3	43.2 ± 4.3	0.824	>0.05
Postoperative WOMAC score	88.0 ± 10.6	88.2 ± 5.9	0.075	>0.05
Preoperative LLD (mm)	36.8 ± 6.9	40.7 ± 8.4	1.757	>0.05
Postoperative LLD (mm)	6.8 ± 5.5	14.5 ± 8.1	3.929	<0.05
Operative time (min)	112.4 ± 18.0	145.8 ± 19.6	6.070	<0.05
Bleeding volume (ml)	512.1 ± 157.4	642.1 ± 231.1	2.322	<0.05

Values are shown as a mean ± SD or *n*. SD: Standard deviation; LLD: Limb length discrepancy; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; DDH: Developmental dysplasia of the hip; THA: Total hip arthroplasty.

The inclusion criterion was Hartofilakidis type C1 (a false acetabulum had formed, either adjacent to the true acetabulum, or with separation between the two), aged at least 18 years (adults), severe pain and limited walking. Joint replacement indications were severe pain in the affected hip, a limited walking ability that affected daily life activities. The exclusion criteria were non-DDH (infective or traumatic arthrodesis), prior hip surgery, bilateral DDH, and inability to attend follow-up.

Operative methods

Preoperative design: Before replacement, an acetabular prosthesis was placed into the true acetabular location, and then the femoral template was reset to the true acetabular location. The difference between greater trochanter height and the template greater trochanter height was measured before replacement; if the difference was more than 4 cm, a requirement for subtrochanteric osteotomy was suggested, to avoid blood vessel and nerve injury.

A posterolateral approach exposed the hip joint with the patient in the lateral position. First, the joint capsule was excised as much as possible, and the surrounding soft tissue was completely released. After the hip joint was dislocated, the femoral head and neck were resected, and the acetabulum was fully cleaned up according to the preoperative design. After confirming the true acetabulum, the anterior and posterior edges were fully exposed; the thickened scar tissue was excised; after appropriate grinding and filing, the prosthesis was placed and the fixation screws matching the acetabular prosthesis were used for strengthening and fixation. Then, the femur was prepared with the marrow canal opened. Distal reaming, proximal conical reaming, and cuff reaming at the femoral calcar were performed in sequence. According to the preoperative plan, the trial prosthesis was placed in the corresponding location, and the joint reduction was performed; by combining the reduction situation with the preoperative plan, a decision was made whether or not to perform femoral osteotomy shortening. If limb lengthening exceeded 4 cm, the femoral head dislocation, and upward shifting were obvious, and the joint reduction was difficult, subtrochanteric transverse osteotomy would be performed; after the osteotomy, the femoral trial was again placed in the proximal resection bone block, and the femur was reset into the acetabular prosthesis and tried; generally, further soft tissue release was needed. After the complex of the prosthesis trial and proximal resection bone block was reset, appropriate traction of the femoral resection block was performed, and the overlapping part between the proximal and distal ends was the amount of the osteotomy. After the osteotomy, the reduction was tried, ensuring that the sciatic nerve was not excessively dragged.

Postoperative treatment

After the replacement, the diseased limb was placed in the hip joint abduction, flexion, and knee flexion position. The rehabilitation plan after a replacement was decided by the prosthesis stability at the time of the replacement and the soft tissue tension; muscle contraction exercises and deep vein thrombosis prophylaxis were provided. Six to eight weeks after the replacement, a patient could walk on double crutches with the diseased limb touching the ground; according to healing at the osteotomy site shown by the X-ray films after the replacement, weight-bearing was gradually increased.

All patients had follow-up 3, 6, 12, and 24 months after replacement, then every 2 years, as well as before the end of this study.

Imaging analysis

Before surgery, bilateral anteroposterior and lateral diseased hip joint X-rays were taken to understand the bone condition, acetabular morphology, femoral dislocation distance, and shortening. During postoperative follow-up, bilateral anteroposterior and lateral diseased hip joint X-rays evaluated the location of hip prosthesis placement, stability, and bone healing. In addition, the X-ray films were used to measure preoperative and postoperative leg length discrepancy; the bony length value of the lower limb = the connection distance from the greater trochanter vertex to the center of the ankle joint. This radiological method was used to measure the connection distances from the greater trochanter vertex to the teardrop before and after the replacement (if the greater trochanter was at the proximal end of the teardrop, the value was positive; if the greater trochanter was at the distal end of the teardrop, the value was negative), to calculate the distance of femoral downward shifting. The method of Makita *et al*.[8] was applied: Diseased limb length change (mm) = preoperative greater trochanter height – postoperative greater trochanter height – the femoral shortening length.

Two independent senior physicians performed the same measurement to verify reproducibility; the correlation coefficient of intraclass correlation analysis for the interobserver agreement was 0.930 ($P < 0.001$). The same researcher repeated the measurement 3 weeks after the first measurement; the correlation coefficient for the intraobserver agreement was 0.944 ($P < 0.001$). These two correlation coefficients indicated that the measurements were reproducible.

Statistical analysis

Measurement data were expressed as a mean ± standard deviation (SD); SPSS 13.0 statistical software (IBM, Chicago, USA) was used for data analysis. After normality and variance homogeneity tests were performed, the data were in line with a normal distribution. Comparisons of pre- and post-operative Harris and WOMAC scores and limb length discrepancy (LLD) mean differences were performed by using paired-sample Student's *t*-test; data between different groups were compared by using independent-sample Student's *t*-test; Categorical variables of claudication cases after THA was analyzed using Pearson's Chi-square test. The test level was $\alpha = 0.05$ ($P < 0.05$ statistically significance).

Results

Selection of prostheses

Femoral prosthesis: S-ROM (Johnson and Johnson Depuy, Indiana, USA) in 45 cases, SUMMIT (Johnson and Johnson Depuy) in three cases. Acetabular prosthesis: Trabecular Metal (Zimmer Company, Indiana, USA) in 35 cases, Trilogy (Zimmer Company) in three cases, Duraloc (Johnson and Johnson Depuy) in nine cases, Duraloc Option (Johnson and Johnson Depuy) in one case. Acetabular cup: Diameter 38–46 mm with mean diameter 41.5 ± 2.3 mm. Femoral head: 22 mm in 37 cases, 28 mm in 11 cases. All prostheses were cementless, with good biocompatibility; no prosthesis loosening or rejection reaction occurred.

Radiological image

Postoperative X-ray films showed that in both groups the acetabular prostheses were all in the true acetabular location, and the bone around the acetabular cup was not dissolved [Figures 1 and 2]; intraoperative femoral crack plate fractures healed well [Figure 1c and 1d], and bone had healed at the femoral osteotomy site, with no prosthesis loosening [Figure 2c and 2d].

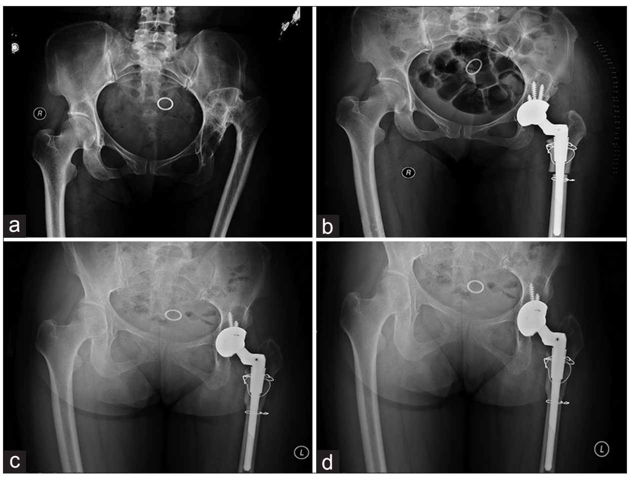

Figure 1: Preoperative evaluation and postoperative follow-up radiographs in group A (nonosteotomy group). (a) The preoperative X-ray film showed that there was right hip high dislocation; the acetabular and femoral developments were poor; the false acetabulum was formed posterior and superior to the true acetabulum; a pseudarthrosis was formed; limb lengthening was expected to be <4 cm. (b) The immediate postoperative film showed the right hip with the joint prosthesis located in the true acetabulum; there were auxiliary screws for fixation; the position was good; there was no dislocation; the intraoperative femoral crack plate fracture was fixed with steel wire cerclage. (c) (6 months after surgery) and (d) (4 years after surgery): Both films showed that the joint prosthesis was in good position; there was no obvious osteolysis around the acetabulum; the fracture site had healed well.

Functional scores

Pre- and post-operative assessment of DDH [Table 2] indicated that in each group the Harris and WOMAC scores after replacement were higher than before replacement ($P < 0.05$), with no statistically significant difference between groups ($P > 0.05$); this indicated that THA could help improve Harris and WOMAC scores, as well as postoperative pain; walking limitation also obviously improved, but a decision on whether or not to perform subtrochanteric osteotomy did not effectively improve Harris and WOMAC scores. No patients developed an infection.

Table 2: Harris and WOMAC scores before and after THA in DDH patients

Scores	Group A	Group B	*t*	*P*
Harris score				
Before operation	44.8 ± 5.7	44.4 ± 4.2	0.262	>0.05
After operation	90.7 ± 5.1	90.4 ± 2.8	0.234	>0.05
t	33.524	43.984		
P	<0.05	<0.05		
WOMAC score				
Before operation	42.0 ± 5.3	43.2 ± 4.3	0.824	>0.05
After operation	88.0 ± 10.6	88.2 ± 5.9	0.075	>0.05
t	21.152	30.910		
P	<0.05	<0.05		

LLD: Limb length discrepancy; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; DDH: Developmental dysplasia of the hip; THA: Total hip arthroplasty.

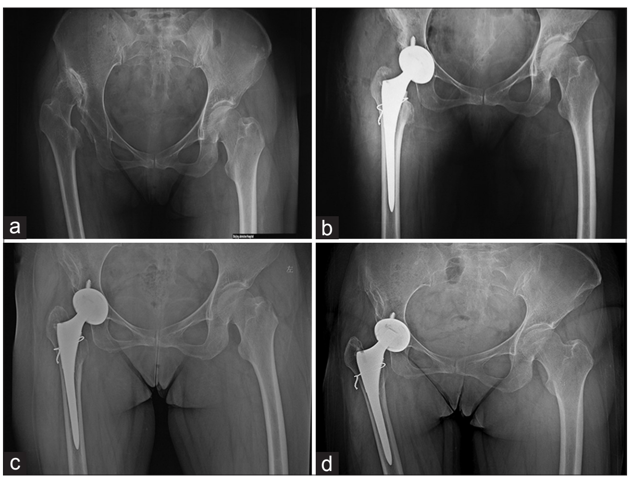

Figure 2: Preoperative evaluation and postoperative follow-up radiographs in group B (osteotomy group). (a) The preoperative X-ray film showed that there was left hip high dislocation; the acetabular and femoral developments were poor; a pseudarthrosis was formed posterior and superior to the true acetabulum; the limb lengthening was expected to be >4 cm. (b) The left acetabular prosthesis was located in the true acetabulum, with auxiliary screws for fixation; there was a left femoral subtrochanteric transverse osteotomy; the S-ROM prosthesis fixed the osteotomy site; there is auxiliary steel wire for fixation. (c) Six months after surgery, the follow-up film showed that the joint prosthesis was in good position; there was no dislocation; the fracture line of the femoral osteotomy site is indistinct. (d) Three years after surgery, the follow-up film showed that the prosthesis position was satisfactory, and the osteotomy site was well-healed.

Group A had shorter operative times ($t = 6.070$, $P < 0.05$) and less bleeding volume than group B ($t = 2.322$, $P < 0.05$) [Table 1].

Complications

Five cases in group A had proximal femoral crack fractures requiring steel wire fixation. In group B, seven cases had proximal femoral crack fractures and one had a cleavage fracture at the distal femoral osteotomy site, and received steel wire fixation; one case had a greater trochanteric fracture and received steel plate fixation; no reoperation was needed. Intraoperative fractures all healed during postoperative follow-up, and no nonunion occurred. In 1 case in group A, dislocation occurred, closed reduction under anesthesia was performed, and there was no recurrence [Figure 3]. In group B, no dislocations occurred. In group A, two cases had a femoral nerve cutaneous branch injury, with numbness in the knee and superomedial skin; they spontaneously recovered; no patients had sciatic or femoral nerve palsy. Group B had no nerve damage. After surgery, there was 13 claudication in group A and 6 in group B. Both groups had claudication to different degrees, but there was no significant difference between groups ($\chi^2 = 0.843$, $P > 0.05$). Five cases in group A, and 12 cases in group B, had postoperative LLD >1 cm; 1 case in group A and 5 in group B had postoperative LLD >2 cm. Postoperative LLD for each group [Table 3] was significantly improved, compared with preoperative LLD ($P < 0.05$), there was also significant difference between groups ($P < 0.05$); the limb lengthening in group A was more significant than in group B ($t = 5.553$, $P < 0.05$) [Table 3].

Discussion

DDH progression is variable, and may include poor coverage of the femoral head, femoral head subluxation, femoral head dislocation, and acetabular developmental

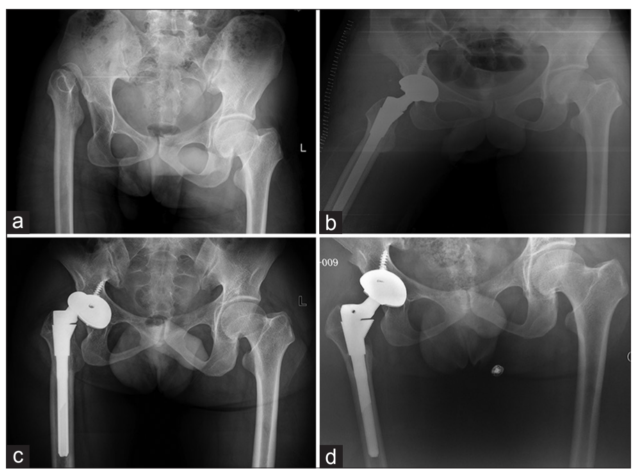

Figure 3: A special dislocation in group A (nonosteotomy group). (a) Preoperative radiographs. (b) The immediate postoperative X-ray film revealed that the joint prosthesis was in the correct position. (c) The film taken 1-year after surgery showed that the femoral prosthesis had dislocated from the acetabular component. (d) The joint prosthesis has regained good position through closed reduction under anesthesia.

Table 3: Pre- and post-operative leg length discrepancy values and limb lengthening (mm)

Variables	Group A	Group B	t	P
Preoperative LLD	36.8 ± 6.9	40.7 ± 8.4	1.757	>0.05
Postoperative LLD	6.8 ± 5.5	14.5 ± 8.1	3.929	<0.05
t	17.524	12.434		
P	<0.05	<0.05		
Limb lengthening	34.8 ± 4.7	26.2 ± 6.0	5.553	<0.05

LLD: Limb length discrepancy.

dysplasia. For DDH patients with a high dislocation, THA with placement of an acetabular cup in the false acetabulum is simple, but cannot prevent limb shortening and the high prosthesis loosening rate; in contrast, placement of the acetabular cup in the true acetabulum can restore a normal anatomic center, balance low limb length, and improve abductor strength and gait; this maximizes recovery of the hip joint's normal physiological function, reduces postoperative joint instability, lowers the incidence of acetabular cup loosening, and achieves greater efficacy.[4,9-11] However, for DDH with a high dislocation, the dislocation distance is large; thus, directly resetting the hip into the true acetabulum is very difficult; forcible reduction can cause nerve injury.[12,13] The most current literature indicates that femoral osteotomy shortening can be helpful for the reduction, and can also protect the sciatic nerve and restore equality of double leg lengths.[6,8,14,15] The femoral osteotomy plane location can be at the greater trochanter,[16] subtrochanter, or distal femur.[17]

This study used subtrochanteric osteotomy, which is currently widely used, to avoid damage to the proximal femoral anatomy caused by greater trochanteric osteotomy. Postoperative X-rays showed that with THA in both groups, the acetabular cup was placed in the true acetabular location, and there was no prosthesis loosening. Postoperative Harris and WOMAC scores and symptoms and function all are improved. With regard to nerve damage, none occurred in group B (osteotomy group); in group A (nonosteotomy group), two cases had a partial injury of the cutaneous branch of the femoral nerve. Although this healed without treatment, this demonstrated that femoral shortening by subtrochanteric osteotomy has an advantage in avoiding nerve and blood vessel injury, consistent with the conclusion reported by most of the literature. In addition, the limb lengthening in group A was more significant than in group B. Therefore, the greater the limb lengthening, the greater the attention that should be paid to prevent nerve damage.

In group B, 19 cases healed at the osteotomy site, with a nonunion incidence lower than the 8–29% rate at the osteotomy site reported by the literature.[18] This was consistent with the 100% healing rate at the subtrochanteric osteotomy site after THA with the cementless S-ROM prosthesis reported by Biant *et al*.[19] Thus, THA with subtrochanteric osteotomy is effective and feasible; the modular S-ROM prosthesis includes the porous coating module, which promotes bone healing to some degree. The modular S-ROM prosthesis also has a high degree of suitability, which can fix and hold the proximal and distal ends of the osteotomy site, respectively, decreasing the use of other internal fixation objects and simplifying the operative procedure. In the nonosteotomy group, S-ROM could adjust the anteversion angle of the femoral head and neck, by adjusting the rotational direction between the full cylindrical femoral stem prosthesis and the proximal module; in the osteotomy group, S-ROM could be used to stabilize proximal and distal resection bone blocks through conical pressure fit between two parts of the prosthesis; therefore, this prosthesis had certain advantages compared with others.

DDH patients with a high dislocation undergoing arthroplasty usually present with high joint tension, which leads to lower incidence of dislocation. In the past, dislocations occurred and were difficult to treat through closed reduction. The dislocation in group A was caused by a fall 1-year after surgery. The joint tension decreased compared with the immediate postoperative status. The joint also regained a good location through closed reduction under anesthesia.

The literature has reported that LLD >20 mm can cause abnormal gait, and about 50% of patients will have this abnormality.[20] In group A (nonosteotomy group), the number of patients with postoperative LLD >20 mm was less than that in group B (osteotomy group), demonstrating that nonosteotomy has an advantage for postoperative LLD; however, there was no statistically significant difference in claudication between the groups. This demonstrates in a different way that the correlation between LLD and claudication needs to be further verified. The literature reports that the incidence of intraoperative proximal femoral fracture is 5–22%.[21] In the current study, the overall incidence of intraoperative fracture in both groups was 29.2%, which is slightly higher. However, the incidence of intraoperative fracture in group A without osteotomy was 17.2%, indicating that THA without osteotomy had an advantage in avoiding intraoperative fractures, and that the operative trauma was less than in the osteotomy group.

Lai *et al*.[5] performed bone traction for 8–17 days before THA, and still placed the acetabular cup into the true acetabulum without osteotomy, so that a relatively good effect was achieved; demonstrating that THA without femoral osteotomy shortening is also effective and feasible for treating DDH with a high dislocation. However, preoperative bone traction results in prolonged hospital stay, and the pin canal of the traction pin may become infected, later affecting joint replacement, with increased overall infection risk.

Currently, the major difficulty for limb length adjustment in THA lies in the upward shifting of the proximal femur. The literature has reported that the femoral head dislocation in type C2 with a high dislocation is higher by 18 mm than in type C1 dislocation; in addition, the proximal femur is irregular, leg length discrepancy is large, and placement of the acetabular prosthesis in the true acetabulum location requires more soft tissue release or subtrochanteric osteotomy; therefore, operative trauma increases.[22] It is recognized that limb lengthening more than 4 cm increases the risk of nerve damage.[3] All DDH patients in this study were type C1, and the dislocation distance of the femoral head was smaller than in type C2; for DDH patients with limb lengthening ≤4 cm, preoperative nontraction reduced the risk of infection; during surgery, direct THA without subtrochanteric osteotomy was decided on by combining the reduction situation with the preoperative plan, with avoidance of damage to the nerves during and after the operation. For patients with limb lengthening more than 4 cm, THA with subtrochanteric osteotomy shortening was performed. There was no difference in postoperative Harris and WOMAC scores, claudication, or LLD between the osteotomy and nonosteotomy groups; however, the osteotomy group had less operative trauma, and the operation was simpler, demonstrating that nonosteotomy treatment of type C1 DDH patients with a high dislocation is effective and feasible. However, for type C1 DDH patients, it is necessary to confirm the proper indications, carefully read the X-ray films, test the template, prepare the proper joint prosthesis before the operation, obtain sufficient exposure, carefully operate, protect nerves and blood vessels, and avoid injury to important structures during the operation. For type C1 DDH patients with limb lengthening ≤4 cm, THA with subtrochanteric osteotomy shortening could lessen the difficulty with replacement and reduce the risk of nerve damage; however, the replacement surgery is complex and technical requirements are high; therefore, THA without subtrochanteric osteotomy may be considered. However, this study also has disadvantages: First, the study was retrospective, with relatively few cases; second, the same surgeon did not perform all the operations; third, the study provided medium-term follow-up, and long-term follow-up had not been achieved in some of the patients. Nonetheless, this retrospective study already has relatively many cases of type C1; further study is needed to increase case numbers and follow-up time, enabling more convincing conclusions.

In conclusion, for unilateral high dislocation DDH patients with limb lengthening ≤4 cm and with good tissue conditions, THA without femoral osteotomy can be considered; preoperative preparation should be improved, intraoperative details should be emphasized, and the appropriate prosthesis should be selected, to avoid intraoperative fracture due to proximal femoral canal mismatch.

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Conflicts of interest

There are no conflicts of interest.

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