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Sequential one-stage combined procedure for treating bilateral developmental hip dysplasia after walking age

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Abstract

Objective: This study aimed to evaluate outcomes of the sequential one-stage combined procedure for treating bilateral developmental dysplasia of the hip (DDH) that was diagnosed after walking age.

Methods: Thirty-five patients (70 hips) with late-presenting bilateral DDH were treated with the sequential one-stage combined procedure. Hips were reclassified according to the operative time and divided into the first and the second operated hips. The outcomes were compared clinically and radiographically between the two sides preoperatively and postoperatively.

Results: The mean interval time between the two procedures was 5.9 months (range: 2–9 months). The first operated hip achieved better results than did the second operated hip. A total of 68.6% (24/35) of the patients in our series had an asymmetric outcome.

Conclusions: The sequential one-stage combined procedure is a challenge, but a reasonable alternative surgery for bilateral DDH in children after walking age. An asymmetric outcome is a special complication of this procedure.

Keywords

Developmental dysplasia, hip, bilateral case, one-stage procedure, walking age, asymmetric outcome

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Introduction

Despite implementing sonographic screening for early detection of developmental dysplasia of the hip (DDH) for many years, late-presenting cases still occur because of delayed or missed diagnosis and failed conservative or operative treatment.[1] In some children with bilateral involvement, hip dislocation tends to be more difficult to diagnose than unilateral DDH until a typical waddling gait is obvious when the child has started to walk.[2] After walking age, there are a wide variety of treatment modalities, but the ideal choice remains controversial. The one-stage combined procedure is available for late-presenting DDH.[3] Nevertheless, management of bilateral DDH is even more challenging and there is controversy regarding the best treatment protocol in terms of timing and methods of reduction.[4]

Patients with bilateral DDH account for approximately 20% of total DDH cases and are more likely to have failure after open reduction compared with those with unilateral DDH.[5] To the best of our knowledge, there have only been a few studies on bilateral successive innominate osteotomy for treatment of bilateral late-presenting DDH.[6,7]

The primary aim of the study was to evaluate outcomes of the sequential one-stage combined procedure for treating bilateral DDH that is diagnosed after walking age. Our secondary aim was to compare the outcomes between the first and the second operated hips.

Materials and methods

This retrospective study included all patients with bilateral DDH who were diagnosed after walking age in our institution from 2010 to 2015. Inclusion criteria were as follows: (1) hips were treated with one-stage open reduction and Salter osteotomy, which were combined with femoral shortening and derotation osteotomy if necessary; (2) patients who had surgery were aged at least 18 months; and (3) the minimum follow-up time was longer than 2 years. Exclusion criteria comprised the following: (1) patients with neuromuscular, teratological, or syndromic hip dislocation, and (2) patients who had surgery elsewhere or experienced failure after conservative treatment.

The study was approved by the Zhejiang University Ethics Committee and written informed consent was obtained from all parents.

Surgical technique

The one-stage combined procedure (open reduction combined with Salter innominate osteotomy in association with femoral shortening or derotation) was performed one at a time for each hip by senior pediatric orthopedic surgeons. The side with the highest degree of dislocation was preferred to operate on. According to the operation time, hips were reclassified and divided into the first and the second operated hips.

A standard S-P surgical incision was made. The iliopsoas tenotomy was routinely transected distal to the pelvic brim. A "T"-shaped capsulotomy was performed. After incision of the capsule, the ligamentum teres was totally excised and the transverse acetabular ligament was routinely incised. All fibro-fatty tissue was released in the acetabular fossa. The limbus was everted and released by radial cuts. A Salter-type iliac osteotomy and femoral shortening were carried out at the level of the subtrochanteric region through a separate lateral incision. We usually shortened the femur by 1 to 2 cm to achieve a force-free reduction. Derotation of the femur was performed simultaneously and the amount of rotation and shortening was decided intra-operatively under direct visualization. Postoperative immobilization in a one-and-a-half spica cast was applied for 6 weeks.

Non-weight bearing hip range of motion exercise was started after the spica cast was removed. When radiological signs of healing were observed, patients were gradually allowed unrestricted activities. The contralateral hips were operated on with similar procedures until the first operated hip recovered. The internal fixation was removed after the second side recovered.

Radiographically, the degree of hip dislocation was evaluated according to the Tönnis grading system.[8] The acetabular index (AI) was measured preoperatively, immediately after the operation, and at the final follow-up. Late postoperative outcomes were graded on the basis of the most recent follow-up radiographs. The Severin and Makay classification system was used to evaluate the radiographic and clinical results.[9,10] The Kalamchi and MacEwen classification system was used for signs of avascular necrosis of the femoral head (AVN).[11]

Preoperative asymmetry was defined as the two hips having more than one grade of Tönnis classification or a 5° difference in the AI. If there was more than a one grade difference in the Severin or McKay classification between the two hips or when the limb-length discrepancy was >1 cm, the outcome was considered to be asymmetric postoperatively.[12]

Statistical methods

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 19.0 (IBM Corp., Armonk, NY, USA) for Windows. Demographic variables were compared between the two groups using the independent samples *t*-test, chi-squared test, or Fisher's exact *t*-test. Statistical significance was determined as $P < 0.05$ with the 95% confidence interval.

Results

The study included 35 patients with bilateral DDH who were diagnosed after walking age, including 28 girls and 7 boys. The mean (± standard deviation) duration of follow-up was 40.3 ± 13.6 months in the first operated hip and 34.3 ± 13.6 months in the second operated hip. The mean age of the first surgical procedure was 38.6 months (range: 18–89 months). The mean interval time between the two procedures was 5.9 months (range: 2–9 months). There was no significant difference in Tönnis grading between the two sides (Table 1). The Tönnis grade of both hips was equal in 26 of the patients and different in the remaining nine patients. Four patients had a difference of 5° in the AI and 12 were considered as having preoperative asymmetry.

The mean AI in the first operated hip decreased from $36.6° \pm 5.3°$ before the operation to $20.4° \pm 3.2°$ immediately after operation ($P < 0.001$) and to $17.2° \pm 4.2°$ at the final follow-up ($P < 0.001$). The mean AI in the second operated hip decreased from $36.7° \pm 5.1°$ before the operation to $20.2° \pm 3.3°$ immediately after the operation ($P < 0.001$) and to $16.9° \pm 3.8°$ at the final follow-up ($P < 0.001$). However, there were no significant differences in the AI between the two sides. The mean length of femoral shortening was not significantly different between the two sides (Table 1).

According to the Severin classification, in the first operated hips, 30 (85.7%) had excellent (Severin I) and good (Severin II) results, one (2.9%) had fair results (Severin III), and four (11.4%) had poor results (Severin IV+V). In the second operated hips, 33 (94.3%) were regarded as excellent and good, none as fair and two (5.7%) as poor. For radiological evaluation, results of the second operated hips were similar to those of the first operated hips (Figure 1). Ten patients obtained an unequal radiographic outcome, one had dysplasia, three

Table 1. Preoperative and postoperative data.

Preoperative data	First operative side	Second operative side	P value
Age at surgery (months)	38.6 ± 17.9	44.5 ± 17.6	0.14
Follow-up (months)	40.3 ± 13.6	34.3 ± 13.6	0.07
AI (degrees)	36.6 ± 5.3	36.7 ± 5.1	0.93
Tönnis grade			0.54
II	7	11	
III	10	8	
IV	18	16	
Immediate postoperative data			
Femoral shortening length (cm)	1.2 ± 0.6	1.1 ± 0.7	0.79
AI	20.4 ± 3.2	20.2 ± 3.3	0.74
Late postoperative data			
AI	17.2 ± 4.2	16.9 ± 3.8	0.72
McKay class			0.03
I	11	8	
II	15	7	
III	6	17	
IV	3	3	
Severin class			0.41
I	14	11	
II	16	22	
III	1	0	
IV+V	4	2	
Kalamchi class			0.34
Osteonecrosis absent	22	21	
I	9	7	
II	0	4	
III	2	1	
IV	2	2	

Data are presented are mean ± standard deviation or frequency
Data were compared with the independent samples *t*-test, the chi-square test ($n > 40$, $T > 5$), or Fisher's exact test ($n < 40$, $T < 5$)
AI, acetabular index

had subluxation, one had redislocation in the first operated hip, and two had subluxation in the second operated hip.

Twenty-six (74.2%) first operated hips and 15 (42.8%) second operated hips had satisfactory outcomes (excellent or good) according to the McKay classification. Therefore, first operated hips had better clinical outcomes than did the second operated hips. Twenty-three patients had an unequal clinical outcome. Among them, 18 patients had better outcomes in the first operated hips than in the second operated hips. Six patients had a leg length discrepancy greater than 1 cm (maximum leg length discrepancy was 1.8 cm).

AVN occurred in 13 (37.1%) first operated hips. Among them, nine hips were grade I, two were grade III, and two were grade IV. In the second operated hips, AVN occurred in 14 (40%) hips. Among them, seven hips were grade I, four were

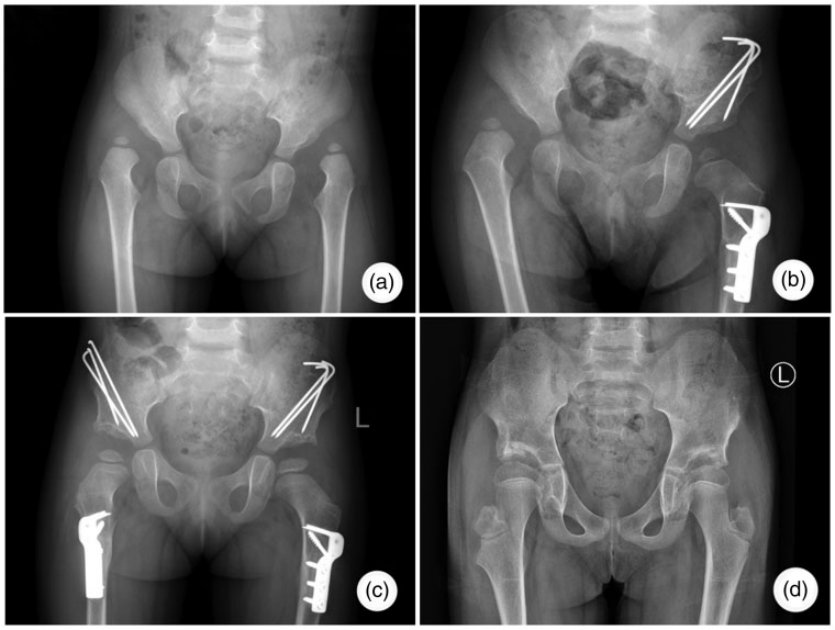

Figure 1. (a) Anteroposterior pelvic radiograph of a girl aged 2 years and 1 months shows equal Tönnis grade III dislocation with bilateral developmental dysplasia of the hip. (b) Open reduction and Salter osteotomy combined with shortening osteotomy were performed on the left side at 2 months of follow-up. (c) A similar surgical procedure was performed on the contralateral side 6 months later. (d) Radiograph 7 years after the operation shows type I according to the Severin classification on both sides.

grade II, one was grade III, and two were grade IV. There was no difference in AVN between the first and second operated hips.

Overall, 24/35 (68.6%) patients in our series had an asymmetric outcome postoperatively. A total of 10/35 patients obtained unequal radiographic outcomes. A difference in McKay classification was found in 23/24 (95.8%) patients. Satisfactory radiographic and clinical outcomes were found in 63/75 (90%) hips and 41/75 (58.6%) hips, respectively (Table 2).

Discussion

Treatment of late-presenting bilateral DDH is a perplexing and unsolved problem with many unpredictable prognoses. Most previous studies on this issue included unilateral or combined unilateral and bilateral cases together, and focused on hips rather than patients.[3,13,14] In contrast to unilateral DDH, children with bilateral involvement have poorer outcomes with a higher risk of failure and less possibility of symmetric correction of acetabular dysplasia.[15] In a child of walking age (>18 months), the one-stage combined procedure including open reduction with femoral or pelvic osteotomies is recommended as the gold standard.[16] However, the best treatment protocol in terms of strategies and techniques of surgery is still a highly controversial issue. The following issues need to be addressed: (1) what type of pelvic osteotomy should be chosen; (2) whether the choice of pelvic osteotomy should be consistent in both hips; (3) whether these children should be operated on simultaneously or sequentially, and (4) if choosing to operate sequentially, the interval

Table 2. Preoperative and postoperative symmetry/asymmetry

	Preoperatively			Postoperatively		
Patients' characteristics	Tönnis difference	AI 5° difference	Overall difference	Radiographic difference	Clinical difference	Overall difference
Symmetry	26	31	23	25	12	11
Asymmetry	9	4	12	10	23	24
Total	35	35	35	35	35	35

Tönnis difference, difference in the grade of Tönnis classification; preoperative overall difference, difference in the grade of Tönnis classification or difference of 5° in the AI; radiographic difference, difference in the Severin classification; clinical difference: difference in the McKay classification; postoperative overall difference: difference in the Severin or McKay classification

time between the two procedures needs to be determined.

Salter et al.[17] suggested that performing bilateral simultaneous osteotomy would result in instability of the pelvic ring and failure of internal fixation. These authors recommended osteotomy on the second hip 2 weeks later after the first hip. Moussa et al.[12] reported 15 patients with bilateral DDH who had a sequential one-stage combined operation between 2 and 8 years old. The second hip was surgically treated 7 to 21 days after the first hip. Neto et al.[18] analyzed 21 patients with bilateral DDH who were treated by open reduction and Salter innominate osteotomy, with or without femoral shorting sequentially. The mean interval time between the surgical procedure was 7.1 months. Wang et al.[19] reported 56 children with bilateral dysplasia who were diagnosed after walking age. All of these children underwent open reduction, capsulorrhaphy, and Pemberton osteotomy. Femoral shortening was routinely performed for children aged older than 3 years and the interval was 6 to 11 weeks. Morbi et al.[4] recommended 3 months apart for sequential open reduction.

However, Ochoa et al.[20] analyzed 15 children who underwent bilateral simultaneous innominate osteotomy and compared them with 30 children who were treated with bilateral successive innominate osteotomy. They found that one-step bilateral innominate osteotomy could obtain a better AI. Ezirmic et al.[21] reported a single-stage procedure by using Salter innominate osteotomy for one hip and Pemberton pericapsular osteotomy for the contralateral hip to treat patients with bilateral DDH compared with consecutive operations. These authors found that a simultaneous operation resulted in a similar biomechanical outcome to a sequential operation. However, the age of children was limited to younger than 3 years and a higher request for surgical skill was demanded for the surgeons. Agus et al.[22] compared 12 patients with bilateral DDH who had a bilateral one-stage combined procedure, which consisted of open reduction, Salter pelvic osteotomy, and corrective osteotomy within the proximal femur simultaneously, with 12 patients with unilateral disease. The bilateral group had a higher requirement of blood transfusion than did the unilateral group.

Our study included 35 patients who had already started to walk, with bilateral DDH who were treated with the one-stage combined procedure sequentially. The mean interval time between the two surgical procedures was 5.9 months. Undergoing bilateral successive innominate osteotomy was

less risky and invasive. The overall outcomes were satisfactory, with 58.6% of Makay classes I and II hips and 90% of Severin classes I and II hips, respectively.

Occurrence of AVN is still an inevitable complication in bilateral DDH. The incidence of AVN in bilateral DDH widely varies. Morbi et al.[4] reported that 33.3% of patients had AVN in 36 bilateral cases compared with 11.2% in a combined unilateral and bilateral series. Neto et al.[18] described 15 (35.7%) hips with AVN among 21 patients (42 hips) with bilateral DDH. Wang et al.[19] found that 55% of their cases in the bilateral group presented with AVN, and this rate was higher than 38% in the unilateral group. Subasi et al.,[23] who used the same method of reduction as that in Wang et al.'s study[19], found that 54.5% of patients had AVN. In contrast, Greene et al.[24] showed the opposite conclusion in that the unilateral group had a higher incidence of AVN than did the bilateral group. In our series, AVN occurred in 13/35 (37.1%) hips in the first operated hip and in 14/35 (40%) hips in the second operated hip. There was no significant difference in the rate of AVN between the two sides, which suggested that the increased dislocation time for the second hip (age at surgery was older for the second operated side than for the first side) in sequential reduction had no effect on the outcome of AVN.

An asymmetric outcome is thought to be a special complication that might cause worse overall clinical outcomes than the preoperative status. Anatomical variants, sequential surgical procedures, and a different degree of dislocation on the two hips lead to a complex or protracted course of treating bilateral dysplasia. Twenty-four (68.8%) patients in our study developed an asymmetric outcome. Moussa et al.[12] reported a 27% occurrence rate of asymmetric outcome. Wang et al.[19] found that 34% of the patients in their series had such an asymmetric outcome. In our series, we found a higher incidence of asymmetric outcome than that in Moussa et al.'s[12] and Wang et al.'s[19] studies. A difference in McKay classification affected 23 patients. The first surgery tended to include patients with a younger age and a longer follow-up, which might explain some of the asymmetric results in our series. However, there was no significant difference in these variables between surgeries in our study. This suggested that the increased dislocation time for the second hip affected functional outcome. Moreover, with a prolonged follow-up duration, satisfactory McKay classification would be anticipated with a decrease in stiffness of the hip. To achieve symmetric and satisfactory outcomes for both sides, several precautions must be taken into consideration. These include performing similar surgical procedures on both hips, resecting equal segments of bone on both sides when femoral shortening is required, and recovering hip joint function early.

There are some limitations to this study. First, this was a retrospective study with a relatively small number of patients and all cases were not followed up to skeletal maturity. A long-term outcome of the procedure has not been performed. Therefore, further studies with a long follow-up and a larger sample size are required to confirm our results. Second, this series of patients focused on bilateral DDH to investigate sequential bilateral open reduction for late-presenting cases. Our study only represents the experience of a single institution without a comparative study.

Conclusions

For late diagnosis of bilateral DDH, our study shows that the sequential one-stage combined procedure is a good treatment alternative. The first operated hip achieves better results than the second operated hip.

An asymmetric outcome is a special complication of treatment for bilateral dysplasia.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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