How are outcomes affected by performing a one-stage combined procedure simultaneously in bilateral developmental hip dysplasia?

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Abstract

Purpose The aim of this study was to compare the outcomes of one-stage combined surgical treatment in children of unilateral and bilateral developmental hip dysplasia diagnosed after walking age.

Methods We reviewed 24 patients who underwent one-stage combined surgery for DDH diagnosed after walking age. Group I consisted of 12 patients with bilateral disease who underwent bilateral operation at one operative setting. Group II consisted of 12 patients with unilateral disease. Pre-operatively the hips were classified according to Tönnis classification. Acetabular dysplasia was evaluated by measuring acetabular index (AI) angles pre-operatively. The acetabular improvements with time regarding AI was noted immediately postoperatively, every six months, and at the final follow-up examination.

Results Mean follow up of the bilateral group I and group II were 54.8 months (range 20–84 months) and 52.6 months (24–80), respectively. There were no statistically significant differences between immediate postoperative and final follow up acetabular index improvement rates in both groups. Also there was no significant difference when both hips were compared in group I. The clinical final outcome of both groups and within group I was similar.

Conclusions Simultaneous combined surgery is a challenging but worthwhile procedure for late diagnosed patients with bilateral DDH. The short–mid term outcomes of the procedure are encouraging.

Keywords Developmental hip dysplasia · Salter osteotomy · Simultaneous operation

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Introduction

Despite neonatal screening and early treatment of congenital dislocation of the hip in newborns, it is not uncommon to see an older child who has untreated congenital dislocation of the hip in developing countries [1–5]. Treatment of children with late diagnosed (after 18 months) bilateral developmental dysplasia of the hip (DDH) remains a challenge [6]. The one-stage surgical treatment consisting of open reduction femoral shortening and derotation is a popular treatment modality for these children. The theoretical advantages of a one-stage operation for DDH include a short hospital stay with no need for long or repeated immobilization, and decreased joint stiffness [2, 7–9].

The reported incidence of bilaterality in DDH cases is approximately 20 % and generally this kind of demanding combined surgeries are performed one at a time respectively for each hip [10]. There are only very few studies reporting bilateral pelvic osteotomies in a single operative setting for the treatment of bilateral DDH [11].

The purpose of the present study was to analyse the short- to mid-term outcomes of bilateral simultaneous combined osteotomy versus unilateral combined osteotomy in the treatment of DDH diagnosed after walking age.

Patients and methods

Thirty-six hips of 24 consecutive DDH cases who were diagnosed after walking age and treated with combined surgical method by the senior authors (AH, KO) at our institution were prospectively recorded. All patients in this study were subjected to one-stage operative treatment in the form of: open reduction, pelvic Salter osteotomy and femoral derotation and shortening followed by a period of immobilization in a hip spica cast for about six weeks. Group I consisted of 12 patients

with bilateral late diagnosed DDH and group II consisted of 12 patients with unilateral late diagnosed DDH. Group I patients had combined surgery simultaneously on both hips in one operative setting.

The bilateral group consisted of two boys (16.6 %) and 12 girls (83.4 %), whereas the unilateral group consisted of 13 (75 %) girls and one boy (8.3 %). Mean age was 31 months (24–27 months) in group I whereas mean age of group II was 29.2 months (24–48 months). Patient characteristics are presented in Table 1.

The pre-operative radiographs were reviewed to determine the degree of displacement of the femoral head (the Tönnis grade) and the acetabular index [12] (Fig. 1a). The immediate postoperative and latest follow-up radiographs were used to measure the acetabular index to value the correction of the acetabular dysplasia and the subsequent maintenance thereof (Fig. 1b–d). Radiographic evidence of osteonecrosis (ON) in the femoral head was evaluated according to the system of Kalamachi and MacEwen [13].

Surgical technique

No pre-operative traction was used. Patients in group I were operated bilaterally in the same session with a one-stage combined surgical method. All the procedures were performed in supine position. An anterior iliofemoral surgical approach was used, and an iliopsoas tenotomy was routinely performed over the pelvic rim. We removed any fibro-fatty tissue in the acetabular fossa but preserved the limbus. A Salter-type iliac osteotomy was carried out in all cases and a femoral shortening osteotomy was carried out at the level of the subtrochanteric region and fixed with an infant blade plate. We usually shortened the femur by 1 to 2 cm to achieve a force-free reduction. Derotation and shortening of the femur was performed simultaneously and the amount of rotation and shortening was decided intra-operatively under direct visualization. We performed femoral derotation osteotomy in those children who had excessive femoral anteversion or in order to facilitate the femoral head reduction. In patients with bilateral involvement, the hips were treated sequentially. Patients were immobilized postoperatively in a bilateral hip spica cast for six weeks.

Amount of blood transfusions and length of hospital stays were determined and compared for each group. Reduction of hips were evaluated in postoperative pelvic X-rays and the difference between pre-operative and postoperative acetabular index angles was accepted as surgically achieved acetabular correction rate. Spica casts were removed at six weeks and thereafter non weight bearing hip range of motion exercises were started. Full weight bearing was restricted for eight weeks until radiological signs of healing were seen. The internal fixation was removed after bony union had been achieved (Fig. 1).

All follow-up radiographs were evaluated for the presence of osteonecrosis with the use of the Kalamachi and MacEwen classification. At the final follow up radiological evaluation was evaluated via measuring AI angles. The comparison between two groups and between two hips within group I were carried out respectively. Patients were clinically classified according to McKay's criteria [14] (Table 2). A survey among the patients' parents in the bilateral group was conducted to present treatment satisfaction.

Written informed consent was obtained from all parents, and approval to use their medical records and reevaluate each patient was given by the local research Ethics Committee.

Results

The mean follow-up was similar in bilateral and unilateral groups (54.8 and 50.6 months, respectively). According to pre-operative Tönnis classification, six hips were stage III (25 %) and 18 hips (75 %) were stage IV dislocations in the bilateral group, and four hips were graded as stage III and eight hips as stage IV in the unilateral group. Mean pre-operative acetabular index angles were 40.6° and 40.2° for right and left hips, respectively, in group I. Mean acetabular index angle and acetabular correction rate of group II patients were 38.8° and 10.2°, respectively. There were no statistically significant differences between pre-operative acetabular index angles and acetabular correction rates between two hips in the bilateral group. The results also did not show significant differences when the bilateral group was compared with the hips in the unilateral group regarding pre-operative AI. Acetabular correction rates and final follow-up AI measurements (Table 3). The mean acetabular index in the unilateral group was improved from 38.8° pre-operatively to 28.6° postoperatively and to 15.1° at the time of the latest follow-up. Outcomes of the bilateral group were revealed in detail in Table 4.

The average amount of erythrocyte suspension transfusion was 170 cc (142.5–200) and 100 cc (100–150) for groups I and II, respectively. The comparison of required blood transfusion revealed a significant difference between groups. The amount of blood transfusion was significantly higher in the bilateral group (group I). On the other hand mean length of hospital stay was five days (three to seven days) for group I patients and 4.2 days (three to six days) for group II patients. There was no significant difference between the two groups regarding the duration of hospitalization.

Complications

We encountered no cases of nerve or vessel damage or deep wound infections. None of the patients had any intra-operative or immediate postoperative complications such as infection or

Table 1 Demographic characteristics of the patients

Patient characteristics	Bilateral, N=12	Unilateral, N=12	P value
Age at surgery (month), Mean	31.0 (24–48)	29.2 (24–48)	NS
Female, <i>n</i> (%)	10 (%83.1)	9 (%75)	NS
Follow up (months)	54.8 (20–80)	52.6 (24–70)	NS
Tönnis grade	Type III 6: (%25) Type IV 18: (%75)	Type III: 4 (%30) Type IV: 8 (%70)	NS
Duration of hospitalization	5.0 (4–7)	4.2 (3–6)	NS
Transfusion requirements	170 (142.5–200)	100 (100–150)	0.039

The values are given as the mean

NS non-significant

graft displacement. Lateralization of left hip occurred at the sixth week follow up in one of the bilateral cases. The patient was immobilized in hip spina cast for an additional six weeks after the conformation of centralization by arthrogram. The hip remained stable after the removal of the cast and the radiological improvement was comparable with the right hip at follow ups. Another patient had a varus malignment (femoral neck-shaft angle 90°) due to implant failure at the femoral osteotomy site in his right hip. We continue to follow the patient. She continuous to function well despite the developmental of coxa vara and 2.3-cm limb-length discrepancy.

At the final follow up four patients in group I and two patients in group II had a limb-length discrepancy over 1.5 cm (1.8 mean). Of those four patients in the bilateral group, one had a coxa vara deformity due to internal fixation failure in the femoral osteotomy site and another one had grade III AVN.

Two of those four patients had significant limping but did not have a Trendelenburg limp. Five hips developed AVN in group I. Among these, two hips were grade I (8.3 %), two hips were grade II (8.3 %) and one hip was grade III (4.2 %) severity as classified by Kalamchi and MacEwen. In group II two hips were grade II and one hip was grade III.

Of the 24 hips 14 hips were regarded as excellent (58.8 %), six (25 %) as good and two (16.6 %) as fair according to the modified McKay criteria in group I. Results of group II were similar regarding functional evaluation in group I. The pre-operative and post-operative AI angles are given in Table 3. There was a significant improvement in the values and the scores in both groups ($p<0.01$).

A survey was conducted to assess treatment satisfaction of the parents in group I. Parent satisfaction after bilateral procedures was high. All parents stated that they would prefer a

Fig. 1 **a** Anteroposterior (AP) radiograph obtained at presentation at two years and four months of age shows bilateral Tönnis grade IV dislocation. **b** AP radiograph obtained after simultaneous bilateral open reduction was combined with shortening osteotomy, derotation of the femur, and Salter osteotomy. **c** AP radiograph obtained at 26 months after reduction. **d** At the latest follow-up examination. AP radiograph obtained at 62 months after reduction. The patient had no limb-length discrepancy

Table 2 Modified McKay criteria

Excellent: Stable, painless hip, no limp, negative Trendelenburg sign, and a full range of movement
Good: Stable, painless hip, slight limp, negative Trendelenburg sign, and a slight decrease in range of movement
Fair: Stable, painless hip, limp, positive Trendelenburg sign, and limitation of movement
Poor: Unstable or painful hip, or both; positive Trendelenburg sign

single session/one-stage combined method over a two-session procedure despite the increased risk factors due to extensive surgery.

Statistics

All statistical analyses were conducted using the SPSS program. The Mann–Whitney *U* test was used to determine differences in the parametric values (pre-operative AI and last follow-up AI) between the groups. The chi-square (χ^2) test was used to evaluate the nonparametric values, such as the pre-operative Tönnis grade, and the follow-up McKay criteria. The level of significance was set at $p < 0.05$.

Discussion

It has been well documented that a one-stage combined surgical method is an effective treatment modality for bilateral DDH diagnosed after walking age [1, 9]. The most important advantage of this method is the simultaneous correction of acetabular dysplasia while helping a concentric reduction of femoral head by releasing periacetabular muscles and soft tissues after femoral shortening and derotation osteotomy [2, 9]. An increased rate of complications from simultaneous procedures has been a potential concern. However, potential economic and logistical benefits from simultaneous rather than staged procedures have been described and there is a trend towards performing major surgeries simultaneously in recent years [15].

Table 3 Comparison of radiological improvements in unilateral and bilateral groups

Group	Postoperative acetabular index correction rates				
	N	Mean	Standard deviation	Maximum	Minimum
Bilateral right (A)	12	11.42	3.14	18	8
Bilateral left (B)	12	11.58	3.23	18	8
Unilateral (C)	12	10.25	2.006	14	8

P values: P(A–B)=0.932, P(A–C)=0.443, P(B–C)=0.378

In the present study, the outcomes of 12 children (24 hips) who had simultaneous bilateral pelvic and femoral osteotomies were evaluated and compared with the outcomes of 12 patients who underwent unilateral surgery. There was no significant difference among the outcomes of groups in our study. Additionally, there was no difference in peri-operative mortality among the groups or in the rates of mortality during the follow-up period.

Salter considered bilateral simultaneous osteotomy to be contraindicated and recommended that the osteotomy on the second hip be performed approximately two weeks after the first [16]. He noted bilateral osteotomy as a technical fault and stated that bilateral one-stage pelvic osteotomy may result with pelvic instability and loss of fixation. On the other hand, Ochoa et al. stated that the improvement in the acetabular index after a single-stage bilateral Salter osteotomy may be even better when compared with a unilateral osteotomy [11]. To the best of the author's knowledge there is not a comparative study that shows poor results due to simultaneous Salter osteotomy.

Simultaneous bilateral osteotomy is a more invasive and extended surgical procedure compared with unilateral or one at a time operations. Due to extensive nature of the procedure there was a significantly higher rate of transfusion requirements in bilateral group compared with the unilateral group. However this did not correspond to an increase in mortality or prolongation of hospital stay in the present study. We think that this should be weighed against the decreased cost, morbidity associated with the additional administration of general anaesthesia and the additional immobilization in a spica cast. Besides we obtained high average patient satisfaction scores confirmed by a survey. Therefore we can speculate that one-stage surgery may have positive psychological effects on parents. However we are aware that this result is variable depending on the success of the surgery.

Acetabular index is the most commonly used measurement for evaluation, treatment planning and follow up of acetabular dysplasia [17]. Subasi et al. reported a mean of 20.2° AI in his bilateral DDH series treated with a combined procedure in sequential procedures for each hip [1]. The author reported a 12-week interval between two procedures. Our findings are consistent with the authors results. Our series demonstrates a significant improvement regarding AI angles in both groups. Overall this series includes the review of 36 DDH cases diagnosed after walking age and treated with combined osteotomy. The present study shows that the outcomes of simultaneous and sequential pelvic osteotomy are comparable and favourable. There was no significant difference with regard to correction of acetabular dysplasia in both groups. Besides, there was no significant difference when both sides were compared within the simultaneous bilateral group. In other words bilateral procedures did not have any detrimental effect on the stability of pelvis and maintenance of the

Table 4 Outcomes of patients with bilateral DDH

Case	Gender	Age (months)	Follow-up (months)	Transfusion amount (cc)	Acetabular index (degrees)				Modified McKay system	AVN	
					Preoperative		Postoperative correction rates	Final follow up			
					Right/Left	Right/Left		Right/Left			Right/Left
I	F	48	55	200	34/36	10/11	10/10	Excellent/Good	Type II at left hip		
II	F	30	20	140	34/33	10/9	12/16	Excellent/Excellent			
III	M	36	42	160	44/40	16/16	17/20	Excellent/Good			
IV	F	30	60	180	40/47	12/11	24/28	Good/Fair	Type I bilateral		
V	M	24	60	100	46/40	14/15	22/18	Good/Good			
VI	F	36	59	200	46/46	18/18	20/16	Good//Excellent			
VII	F	24	62	180	33/32	10/12	5/5	Excellent/Excellent	Type III at right hip		
VIII	F	24	37	150	46/44	8/10	8/10	Fair/Excellent			
IX	F	24	59	200	46/42	10/12	22/12	Excellent/Excellent			
X	F	24	36	100	44/45	12/9	22/17	Excellent/Excellent	Type II at left hip		
XI	F	24	84	200	38/40	8/8	14/14	Excellent/Good			
XII	F	48	84	160	38/36	9/8	14/12	Excellent/Excellent			

AVN avascular necrosis, F female, M male

correction at the site of initial pelvic osteotomy in the present study. Our findings suggest that symmetrical and favourable outcomes can be obtained in both hips after bilateral combined osteotomies that were performed in a single operative setting.

Among the 24 patients enrolled into this study only one patient in the simultaneous operation group had non-concentric reduction. The patient who had a lateralization of the left femoral head was immobilized in a hip spica cast for an additional six weeks. The concentrically reduced position of the hip was confirmed by arthrography. Recurrent dislocations, avascular necrosis and limb-length discrepancy are among possible complications of single-session combined surgical treatment of DDH, diagnosed after walking age. Kamath et al. reported that recurrent dislocations may be the result of inadequate surgical technique. The author also stated that biological factors may also be concomitant factors in bilateral DDH [18]. None of our patients in both groups had recurrent dislocation after surgery. However our series is relatively small to draw any conclusions about the re-dislocation rate.

Avascular necrosis is a major cause of disability after the treatment of DDH. In bilateral DDH, development of AVN is mostly associated with Tönnis stage and older age rather than bilaterality [19–21]. According to Subasi et al., rates of AVN increase after a mean age of 5.5 years, whereas another study by Ryan et al. reported an increase in AVN after age seven [1, 2]. Osteonecrosis is identified in five (20.8 %) of our patients in the simultaneous operation group. The majority of the cases of osteonecrosis in our series were Kalamchi types I and II. These findings are similar with current literature. Although some of our patients were younger than 36 months during the procedures, all were Tönnis stage 3 or 4.

The author acknowledges some limitations of the present study. First, the number of the patients contributing is relatively small and follow-up period is relatively short. Studies with a larger patient sample and a longer duration of follow up would be better placed to ensure our results. Second, in this study, the control group consisted of patients who underwent unilateral surgery. Comparison of the results of the simultaneous versus staged combined osteotomy group rather than unilateral surgery group would be more meaningful and distinctive.

The results of the present study demonstrate that simultaneous one-stage surgery on both hips is a reasonable alternative surgical option. Undoubtedly it is not logical to propose the simultaneous combined surgery in the treatment of every bilateral DDH diagnosed after walking age. However we think that it is a feasible option in the hands of experienced surgeons. Several important points must be taken into account to achieve symmetrical and satisfactory outcomes for both sides. These include cautious protection of the first hip during the surgery on the second hip and symmetrical surgical procedures on both hips.

Conflict of interest The authors of this study certify that there is no conflict of interest.

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