The Factor Causing Poor Results in Late Developmental Dysplasia of the Hip (DDH)

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Background: *Treatment of DDH in walking-age children often resulting in persistent or recurrent hip dysplasia, AVN and/or loss of reduction. The incidence of secondary procedures in this age group after closed or open reduction of the hip in DDH varies from 38% to 80% in longterm studies. The goal of this study was to determine the factors that will predict poor results in walking-age children with DDH.*

Material and Method: *The study was a retrospectively study of 25 walking children with late DDH (22 female and 3 male) treated with closed or open reduction of the hips. The data were collected from medical records and radiographs. Tonnis and Severin classifications were used to evaluate the condition of the hips. Fisher exact test and student t-test were used to evaluate the factors related to the poor result.*

Results: *Age >28 months and >30 months at the reduction is a factor resulting in poor results evaluated by Tonnis and Severin classification (p = 0.007), and (p = 0.008). Acetabular index (AI) and Center-edge angle (CE) at the time of index surgery are not statistical significant causing the poor results. Bilateral or unilateral of DDH are not statistical significant to cause poor results.*

Conclusion: *From our study, age at presentation is the most important factor predicting poor results in walking DDH, age >28 months at presenting leading to secondary procedure and poor Tonnis and Severin Grades. National Health Policy for Hip Screening is the most important for early detectoing of children with DDH to improve the outcome and prevent the children from multiple operations.*

Keywords: *DDH, Acetabular dysplasia, Pelvic osteotomy, Femoral osteotomy*

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Late DDH is a common problem in pediatric orthopedics practice. The goals of operative treatment in older children are concentric-reduction, stable hips to promote acetabular remodeling and to avoid complications such as avascular necrosis, persistent or recurrent hip dysplasia and/or loss of reduction[1-3]. As the disease progresses, operative correction becomes more difficult, and the rates of poor results and complications increase[4,5]. Closed reduction is the treatment of choice for most patients younger than 18 months of age. The acetabular procedure can be performed in patients who are at least 18 months. For late DDH, one stage procedure, consisting of open reduction, femoral shortening and pelvic osteotomy, is recommended because the potential for acetabular development is markedly decreased. After treatment, the radiographic should be monitored to Confirm normal hip at maturity in order to prevent degenerative joint disease in the future. In late presenting DDH, the problems of residual acetabular dysplasia, non-concentric reduction, AVN are common problems leading to secondary procedures, which sometimes even make the condition of the hips worse. Some literature reported the factors causing poor results included age, poor Acetabular, index (AI) and bilateral hip dislocation[16,17]. Much literature reported limited surgery in late DDH after 6 years old due to poor results[11,12,16]. Our study not only tried to find the factors related to poor results, but also tried to find the age limit for surgical procedure.

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Material and Method

25 walking children with DDH treated with closed or open reduction of the hip were included. The data were collected from medical records and radiographics at initial and last follow-up. Exclusion criteria included: patients with teratologic,

neuromuscular, syndromic conditions, patients with traumatic hip dislocations, hips with post-infection sequelae, non-walking patients, and patients who had previous operative or non-operative treatment from another hospital. The patients with incomplete documentation or radiographic records were also excluded. Radiographics of the patients were evaluated and classified base on Severin classification and Tonnis grade[8,9]. Acetabular index (AI) at index at surgery, AI at last follow-up and Center edge angle (CE angle) at last follow-up were measured. Poor Severin classification as Severin 4,5,6 and Poor Tonnis grade classification as Tonnis grade 2,3.

Statistical methods

The relationship between the Severin classification, Tonnis grade, predictive variables such as age group at reduction, affected sides, AI at index at surgery, AI at last follow-up and CE angle at last follow-up, are assessed using Fisher's exact test. The independent student t-test was used to assess differences in the mean age at reduction.

Definitions for Severin classification, and Tonnis grade of osteoarthritis

Severin classifications (radiographics)

IA Center-edge angle >19, age 6-13 year; center-edge angle >25, age >14 year.

IB Center-edge angle 15-19, age 6-13 year; center-edge angle 20-25, age >14 year.

II Moderate deformity of femoral head, femoral neck or acetabulum but otherwise same as grade I.

III Dysplastic hip, no subluxation; center-edge angle <20, age >14 year.

IV Subluxation.

V Femoral head in false acetabulum.

VI Redislocation.

Tonnis grade of osteoarthritis (radiographic)

Grade 0 No signs of osteoarthritis.

Grade 1 Increased sclerosis, slight joint space narrowing, no or slight loss of head sphericity.

Grade 2 Small cysts, moderate joint space narrowing, moderate loss of head sphericity.

Grade 3 Large cysts, severe joint space narrowing, severe deformity of the head.

Results

Twenty-five walking-age children with (DDH), (twenty-two female and three male). Twenty-five hips were included of which 21 patients with unilateral hip, and four patients with bilateral hips. The mean age at the index surgery was 47.7 months (range 13 to 144 months). Mean follow-up was 50.78 months (range 7 to 118 months).

Seven (28%) patients were received closed reduction treatment and 18 (72%) patients received open reduction. 12 (48%); patient's use of pre-operative traction (range 2 to 4 weeks). The mean age at reduction in the closed group was 17.4 months and the mean age at opened reduction group was 55.6 months. Only one patient after open reduction had performed femoral osteotomy only. The rest had performed open reduction, femoral osteotomy and acetabular osteotomy. Thirteen patients had performed Salter osteotomy. Three patients had performed Pemberton osteotomy. One patient was performed with Chiari osteotomy. Twelve (48%) patients were successful in their first operation. Seven patients, who did not have concurrent femoral or pelvic osteotomy at index surgery, 5 (73%), required a secondary procedure. AVN was found in closed reduction (2 in 7 patients) (29%) and in open reduction (10 in 18 patients) (55%).

Thirteen patients (52%) had at least one secondary surgery at a mean of 17.5 months (range 4 to 39 months). Patients with residual dysplasia (Severin III/IV) tended to be significantly older at age reduction (average 75.69 months versus 30.85 months, $p<0.007$) (Table 2). No significant relation between the poor Severin classifications with affected sides, acetabular index (AI) at index of surgery, acetabular index (AI) at last follow-up and center edge angle (CE) at last follow-up in our study.

The poor Tonnis grade was significantly associated with age at reduction (average 65.17 months versus 28.64 months, $p<0.008$) (Table 3). No significant relation between the poor Tonnis grade with affected sides, acetabular index (AI) at index of surgery, acetabular index (AI) at last follow-up and center edge angle (CE) at last follow-up occurred in our study.

Discussion

Even with optimal management, a subset of walking-age children with DDH treated by closed or open reduction required secondary procedures. The need for such procedures caused by advanced DDH pathology, inadequate acetabular or femoral remodeling, and the adverse effects of lateral loading of the hip in a walking child with an already dysplastic acetabulum[15]. A primary reduction with concurrent pelvic and femoral osteotomy has gained acceptance in the treatment of walking children with this disorder.

Table 1. Summary of index procedure and the number of secondary procedures required for each patient, AI at time of surgery, AI at time of last follow-up, CE at time of last follow-up, Tonnis grade of osteoarthritis at last follow-up, and clinical outcomes for all patients using the severin classification

Age at index (mo)	Index procedure	AI at time of surgery	AI at time of last follow-up	CE at time of last follow-up	# of secondary procedures	Tonnis grade of osteoarthritis	Severin classification	Follow-up time (mo)
13	CR	34	8	35	1	2	IA	67
14	CR	30	17	8	3	2	IV	71
15	CR	25	15	-	0	0	-	7
16	CR	-	7	36	1	0	IA	118
20	CR	22	15	32	2	1	IA	39
22	CR	23	22	13	0	1	II	58
22	CR	-	0	34	2	1	IA	90
24	OR + FO + S	35	20	28	1	1	IA	61
24	OR + FO + S	23	12	23	0	1	IA	7
24	OR + FO + S	48	11	28	0	1	IA	95
24	OR + FO + S	15	11	-	0	-	-	15
26	OR + FO + S	25	6	34	0	1	IA	66
28	OR + FO + S	17	15	17	1	0	IB	44
33	OR + FO	34	20	21	1	2	IA	49
35	OR + FO + S	23	12	28	0	1	IA	15
45	OR + FO + S	14 (Rt), 23 (Lt)	0 (Rt), 24 (Lt)	74 (Rt), 0 (Lt)	2	3 (Rt), 3 (Lt)	V (Rt), V (Lt)	61
48	OR + FO + P	25	7	44	2	3	III	41
55	OR + FO + S	14	10	25	2	2	IA	23
60	OR + FO + S	13 (Rt), 15 (Lt)	6 (Rt), 4 (Lt)	29 (Rt), 44 (Lt)	2	1 (Rt), 1 (Lt)	IA (Rt), IA (Lt)	47
66	OR + FO + P	20	25	-11	0	2	IV	15
84	OR + FO + S	28	16	34	0	3	V	28
86	OR + FO + P	8 (Rt), 39 (Lt)	14 (Rt), 22 (Lt)	15 (Rt), 13 (Lt)	0	0 (Rt), 3 (Lt)	IB (Rt), III (Lt)	14
89	OR + FO + S	17 (Rt), 23 (Lt)	10 (Rt), 3 (Lt)	34 (Rt), 42 (Lt)	5	0 (Rt), 3 (Lt)	IA (Rt), IV (Lt)	90
105	OR + FO + S	60	44	0	0	2	V	18
144	OR + FO + C	26	13	0	0	3	III	27

AI indicates acetabular index; C = chiari osteotomy; CE = center-edge angle; CR = closed reduction; FO = femoral osteotomy; OR = open reduction; P = pemberton osteotomy; S = salter osteotomy

Table 2. Age at reduction, Affected sides, Radiographic variables by Severin classfication

Variable	Good severin grade	Poor severin grade	*p*-value
Mean age at reduction (mo)	30.85±13.48	75.69±37.89	0.007
Age group at reduction			3.010
Age ≤24 mo	6	1	
Age >24 mo	7	8	
Affected sides			2.350
Unilateral	12	6	
Bilateral	1	3	
AI at index of surgery			0.002
Good AI	3	2	
Poor AI	10	7	
AI at last follow-up			4.090
Good AI	12	5	
Poor AI	1	4	
CE at last follows-up			6.044
CE angle >25	11	3	
CE angle ≤25	2	6	

Table 3. Age at reduction, affected sides, Radiographic variables by Tonnis grade

Variable	Good tonnis grade	Poor tonnis grade	*p*-value
Mean age at reduction (mo)	28.64±12.13	65.17±38.5	0.008
Age group at reduction			3.630
Age ≤24 mo	6	2	
Age >24 mo	5	10	
Affected sides			1.011
Unilateral	10	9	
Bilateral	1	3	
AI at index of surgery			0.157
Good AI	2	3	
Good AI	9	9	
AI at last follow-up			1.982
Good AI	10	8	
Poor AI	1	4	
CE at last follows-up			2.121
CE angle >25	8	6	
CE angle ≤25	2	6	

Even with this approach, only a part of acetabular dysplasia and femoral pathology is corrected initially, the residual correction expected to occur from remodeling and normalization of hip mechanics. Variables such as age at treatment, unilateral or bilateral, pre-operative traction, presence of an ossific nucleus, Tonnis grade of dislocation, surgical approach (anterior vs. medial), and concurrent pelvic osteotomy or femoral osteotomy have been studied previously to understand their effects on the need for secondary procedures, acetabular or femoral remodeling, and their outcomes[6,7,10,13,14]. Our result showed that age at presentation more than 28 months is the main factor for poor results. This may be explained by older children's being more likely to be treated with a combined procedure when compared with children less than 18 months old. Albinana found maximum acetabular remodeling in the first 4 years after reduction in Severin

grade III/IV hips and for 6 years in Severin grade I/II hips[16]. Acetabular growth and remodeling has been an important topic of debate. The lower limit for acetabular remodeling has been shown to be 18 months, whereas the upper limit is considered to be 11 years of age. So the more delay in treatment, the more limited acetabular remodeling resulting in poor results, as the walking age of the patient will increase load at the lateral aspect of acetabulum and make it more sclerotic and increase cystic formation. The incidence of AVN is reported to be between 3% and 60% after open or closed reduction of DDH. From our data AVN was found in closed reduction (2 in 7 patients) (29%) and in open reduction (10 in 18 patients) (55%). Radiologics changes from AVN were classified as very poor results in Tonnis grade and from our data which show 55% in open reduction group, which means most of this group age was more than 24 months. From our study, age at presentation is the most important factor predicting poor results in walking DDH, >28 months at the presentation leading to secondary procedure and poor Tonnis and Severin Grades. National Health Policy for Hip Screening is the most important for early detection in children with DDH to improve the outcome and prevent the children from multiple operations.

Potential conflicts of interest

None.

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เหตุปัจจัยสำคัญที่ทำให้ผลการรักษาไม่ดีในภาวะสะโพกหลุดหลังอายุหนึ่งปี

พีระจิตร เอี่ยมโสภณา, ค้ำวงษ์ สายสมร, ธนาทิป ศรีสุชินธารา, ธัญชนก จิตติวิไล, กมลพร แก้วพรสวรรค์

ภูมิหลัง: *ภาวะสะโพกหลุดที่พบภายหลังอายุหนึ่งปีเป็นปัญหาที่พบได้บ่อย ปัญหาสำคัญของการรักษาล่าช้าคือ จะมีการพัฒนาของเบ้าสะโพกที่ไม่ดี การหลุดของข้อสะโพกซ้ำ ภาวะหัวสะโพกตายจากการขาดเลือด ผู้ป่วยกลุ่มนี้มีอัตราการถูกผ่าตัดซ้ำอยู่ที่ 38-80% การศึกษานี้ทำขึ้นเพื่อหาปัจจัยสำคัญเหตุของผลการรักษาที่ไม่ดีในภาวะสะโพกหลุดที่พบภายหลังอายุหนึ่งปี*

วัสดุและวิธีการ: *ทำการศึกษาย้อนหลังผู้ป่วยจำนวน 25 คน หญิง 22 คน ชาย 3 คน ที่ทำการรักษาข้อสะโพกหลุด โดยวิธีการดึงให้เข้าที่หรือเปิดจัดข้อสะโพกให้เข้าที่ เก็บข้อมูลจากแฟ้มผู้ป่วยและเอกซเรย์โดยใช้เกณฑ์ Tonnis and Severin classification และทำการคำนวณทางสถิติโดยใช้ Fisher exact test and student t-test เพื่อหานัยสำคัญทางสถิติเพื่อหาปัจจัยที่มีผลต่อการรักษาที่ไม่ดี*

ผลการศึกษา: *วัดผลการรักษาโดยใช้เกณฑ์ Tonnis grade พบว่าอายุ >28 เดือนมีผลต่อการรักษาที่ไม่ดี (p = 0.007) และ Severin classification พบว่าอายุ >30 เดือน มีผลต่อการรักษาที่ไม่ดี (p = 0.008) Acetabular index (AI) และ Center-edge angle (CE) ไม่พบว่ามีนัยสำคัญทางสถิติที่ทำให้ผลการรักษาไม่ดี การมีภาวะสะโพกหลุดข้างเดียวหรือสองข้างไม่พบว่ามีนัยสำคัญทางสถิติที่ทำให้ผลการรักษาไม่ดี*

สรุป: *ผลการศึกษาพบว่าอายุที่เริ่มมารักษามีผลต่อการรักษาที่แย่ลงในผู้ป่วยมาพบแพทย์และเริ่มทำการรักษาหลังอายุ 28 เดือน โดยผู้ป่วยกลุ่มนี้มักต้องมีการผ่าตัดหลายครั้งและผลการรักษาประเมินโดย Tonnis และ Severin Grade อยู่ในเกณฑ์ไม่ดี การวินิจฉัยให้ได้เร็วและเริ่มการรักษาได้เร็ว โดยจัดระบบโปรแกรมตรวจสะโพกทารกแรกเกิดจะช่วยทำให้การรักษาเร็วได้ผลดีและป้องกันการผ่าตัดหลายครั้ง*