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Revision Surgery for Developmental Dysplasia of the Hip
A Retrospective Study—

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Abstract : Good results after revision surgery following a failed open reduction for developmental dysplasia of the hip (DDH) are unlikely due to the complexity of the problem. We reviewed 14 patients who required a revision open reduction for DDH. The aim of this study is to identify the possible causes of redislocation after the primary open reduction and the clinical and radiographic outcome of the revision surgery. Our study is retrospective and cross-sectional. The study period is between January 1994 and December 2003. The mean age at presentation for DDH was 31.1 months (range 1-84) and the mean age at primary open reduction surgery was 38.4 months (range 15-84) and the mean age at revision surgery was 69.4 months (range 21-180). The mean follow up period after revision surgery was 20.3 months (range 3-84). All the revision surgery was performed via an anterior Smith Petersen approach. We found the most common cause for redislocation was inadequate exposure and failure to release tight structures around the hip. Other technical matters such as failure to pre-plan operation, excessive correction of an anteverted femoral head and not performing femoral shortening when reduction is difficult were also seen as possible causes for failure. Simultaneous pelvic osteotomy procedure without obtaining concentric reduction is a common pitfall which will certainly lead to failure.

We documented a 50% AVN rate. Seven patients had limb length discrepancy ranging from 1 cm to 4 cm. Only 2 patients were asymptomatic and the majority had a limp and limitation of motion. But all were pain free except one.

In view of the poor results after a revision open reduction and since the revision surgery is technically more demanding it is highly recommended that open reduction for DDH should be conducted by well trained surgeons.

Introduction

The incidence of developmental dysplasia of the hip (DDH) in Malaysia is reported to be 0.7 in 1000 live births[26]. Ang and Sivanantham[32] found that majority of the cases were not detected at birth but noted when they started to walk (only 5 out of the expected 37 cases from the total number of live births in 1987 and 1988 were referred to them). The natural history of

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Table 1. Patients profile

Case	Sex	Birth weight (KG)	Type of delivery*	Intrapartum Presentation*	First child	Age when started walking (Y+M)	Age when first diagnosed with DDH (Y+M)	First treatment at government (G) or private (P) hospital	Side of DDH
1	F	1.8	FTSVD	C	Y	1+0	2+0	G	L
2	F	2.5	FTSVD	C	Y	1+2	1+4	P	L
3	F	2.7	FTSVD	C	N	1+2	2+7	G	L
4	F	N/A	FTSVD	C	Y	1+0	3+0	G	L
5	M	3.0	FTSVD	C	N	1+2	0+1	G	R
6	F	2.65	FTSVD	C	N	1+2	1+4	P	L
7	M	3.3	FTSVD	C	Y	1+6	1+6	P	R
8	F	2.8	FTSVD	C	Y	1+0	1+3	G	L
9	F	3.2	FTSVD	C	Y	1+0	5+0	G	R
10	F	2.2	FTSVD	C	Y	1+2	1+4	G	R+L
11	F	3.1	LSCS	B	Y	1+0	6+6	G	R
12	F	2.5	FTSVD	C	Y	0+10	2+3	G	R
13	F	N/A	FTSVD	B	N	1+0	5+0	G	R

• FTSVD full term spontaneous vaginal delivery, LSCS lower segment Caesarean section, C=cephalic, B breech, N/A not available

DDH in newborn is quite variable. It is generally accepted that open reduction is indicated for DDH when a congruous, concentric and stable reduction is not achieved by closed means. Redislocation after an open reduction occurs at different rates depending on the surgical approach used during the primary surgery and it is reported to be 0-8% for the anterior approach[27)28)] and 0-55% after the anteromedial approach[28)]. Redislocation after an open reduction in DDH is emerging as a serious problem in the management of these patients in Malaysia as more orthopaedic surgeons attempt to perform the open reduction. The only data regarding the redislocation rate after an open reduction in this country was found in an article published by Ang and Sivanantham in 1990[32)]. In their series of 22 patients (25 hips), open reduction was done in 16 hips after failed closed reduction and three or 19% redislocated.

Methodology

We retrospectively reviewed the records of patients treated for failed open reduction referred to our center at National University of Malaysia since 1994. Total of 14 patients underwent revision surgery for failed open reduction of DDH at HUKM from January 1994 till December 2003. There were 12 females and 2 males with 8 left hips and 6 right hips. 12 patients were referred to HUKM after failed open reduction from various hospitals in Malaysia and Brunei and 2 patients were revised after a failed open reduction in HUKM. Radiographic evaluations include the acetabular index and the center edge angle. Avascular necrosis of the femoral head was evaluated before the secondary surgery and at final follow-up using the Kalamchi classification[23)]. The final radiographic outcome was evaluated using the Severin Classification System[24)]. The final clinical outcome was assessed by using the Ponsetti Classification[25)]. During the revision surgery we assessed the causes of failure of the primary open reduction. The patients were assessed clinically and radiographically before the revision surgery, immediately after the surgery and at final follow up. All cases were assessed clinically and radiographically. The affected hips of these patients

Table 2. Details of primary treatment and later operations in 14 hips with congenital dislocation requiring repeat open reduction.

Case	Side	Previous closed reduction	Age at first open surgery	Procedure(s) performed*	Approach used*	Later operations* (including revision by primary surgeon)	Interval*
1	L	No	3+2	OR+DRO+KW	A	OR+SO+FS+KW	10 w
2	L	No	1+3	OR+KW	A	OR+KW	9 m
3	L	No	2+8	AT+OR+DRO	A		
4	L	No	7	OR+DRO+FS	A		
5	R	No	1+3	OR	A	AT+OR+DRO+FS	4 m
6	L	No	1+4	OR+KW	A		
7	R	No	1+9	OR+KW	A		
8	L	Yes	1+7	OR	A	CMR+KW	3 m
9	R	No	5	OR	A		
10	R+L	Yes	1+7	OR+KW(L)	A		
11	R	No	7	OR+SO+FS	A	AT+CMR	2 m
12	R	No	2+3	OR	A	AT+OR+DRO+FS	6 m
13	R	No	6	OR+FS+AT	A	AT+OR+SO+FS	10 m
14	L	Yes	3	OR+VDRO+KW	A	CMR	3 m

*OR open reduction, DRO derotational osteotomy, VDRO varus derotational osteotomy, KW k wiring, FS femoral shortening, AT adductor tenotomy, CMR closed manual reduction, w weeks, m months, A anterior.

were mobilized to prevent stiffness. The revision surgery was done after at least 6 months for soft tissues to heal and to reduce the risk of avascular necrosis of the femoral head. Preoperative traction was not used. Revision open reduction was done through the same anterior approach by the fourth author.

Results

All the patients were delivered by spontaneous vaginal delivery except for 1 delivered by Caesarean section for breech presentation. There were 2 breech presentations and the rest were cephalics. The majority were the first child in the family (Table 1). The mean age at presentation for DDH was 31.1 months (range 1-84) and the mean age at primary open reduction surgery was 38.4 months (range 15-84) and the mean age at the last revision surgery was 69.4 months (range 21-180). The mean follow-up period after the last revision surgery was 20.3 months (range 3-84). In 3 out of 14 patients closed reduction had been attempted by the primary surgeon before open reduction (Table 2).

All the patients underwent open reduction through an anterior approach[15)~17)]. None had undergone traction prior to open reduction and only 2 had a percutaneous adductor tenotomy during the primary open reduction. 4 had derotational osteotomies to attain concentric reduction and one had a Salter osteotomy and 3 had femoral shortening during the primary surgery. 6 had additional K-wire stabilization to maintain reduction. All patients were protected with a hip spica following the open reduction. Two of the hip spicas were removed early, one due to parental intervention and the other due to loosening after an episode of acute gastroenteritis. 8 patients had reoperation to address the redislocation. 5 patients had revision open surgery carried out by the primary surgeon once the redislocation was discovered. Closed reduction was attempted in two of the patients and one of which had an additional percutanoeus adductor tenotomy and the other K-wire stabilization. The exact time when the hip redislocated after the primary open reduc-

Table 3. Causes of failed primary open reduction

Causes	Number of cases
Inadequate release of tight structures	14
Failure to address excessive anteversion of femoral head	7
Femoral shortening not done when needed	6
Inverted labrum not everted	8
Inadequate immobilization post op	2
Adequate capsulorhaphy not done	4
Acetabular dysplasia	9
Overcorrection of anteversion	1
Salter osteotomy done resulting in poste rior wall deficient.	3

tion, whether during cast immobilization or after removal was not well documented. Therefore the median time to the recognition of failure is not ascertained in this study. Pre operatively(revision surgery), 11 hips were dislocated and 3 were subluxed. 2 of the patients with subluxed hips did not undergo open reduction since they were much older. One was 13 years old and the other 15 years old. One underwent adductor tenotomy and percutaneous epiphyseodesisto correct the limb length discrepancy and the other a shelf procedure only. In one patient the dislocated hip was unable to be reduced due to presence of massive scarring and adhesion. In view of the high risk of injuring the sciatic nerve the procedure was abandoned and only an adductor tenotomy was performed. In the remaining patients apart from the revision open reduction, 11 had adductor tenotomy, 7 had varus derotational osteotomy to correct excessive anteversion and 7 had femoral shortening when the hip was difficult to be reduced, 1 had Salter osteotomy and 4 had additional K-wire stabilization to maintain the concentric reduction. The K-wires were passed through the greater trochanter into the illium above the capsule and maintained for at least 6 weeks. The derotational osteotomy and the femoral shortening were done through a separate lateral incision. One patient had a shelf procedure performed 6 weeks after the last open reduction. Post operative immobilization in a hip spica was done for all patients after the revision open reduction. The cast was changed to a fibre glass type after 2 weeks and converted to a pantaloon cast at 6 weeks. Total period of the immobilization was 12 weeks. No wound infection was seen during the period of the follow up. The main reason for failure of the primary open reduction was technical error (Table 3, 4). Inadequate release of tight structures was seen in all cases of revision surgery. The tight structures that were identified as a possible cause leading to failure of the primary surgery were tight adductor tendon, ligamentum teres, iliopsoas, and capsule. Tight and thickened transverse acetabular ligament was seen in 6 cases. Inadequate capsulorraphy or failed capsulorraphy was identified in 4 cases. Inverted labrum that was not address, appear to block a concentric reduction and this was seen in 6 cases. Failure to address excessive anteversion was noted in 7 cases. Failure to perform femoral shortening as warranted could also be a possible cause and this was seen in 6 cases. Inadequate immobilization post operatively or early removal of hip spica was seen in 2 cases. In 9 cases severe acetabular dysplasia was noted. In one patient the femoral head was retroverted due to over correction of anteversion. A Salter pelvic osteotomy had been combined with the primary open reduction in one patient and with a second open reduction in two patients. This combination of procedures can result in posterior displacement of the head[33], and in all 3 patients the revision open reduction revealed posterior dislocation.

Table 4. Intraoperative finding during final surgery

Findings/case	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tight adductor tendon	/	/		/	/	/	/	/			/		/	/
Tight ligamentum teres											/			
Shallow/Dysplastic acetabulum		/		/	/		/	/	/		/		/	/
Pulvinar	/	/	/		/					/	/	/	/	/
Excessive anteversion	/					/		/		/	/			/
Retroverted femoral head	/													
Tight posteromedial capsule												/		
Tight psoas		/	/		/	/	/			/		/		
Deficient posterior acetabular wall											/	/		
Inverted limbus	/		/			/				/		/		/
Tight transverse acetabular ligament			/			/	/			/				/
Tight inferior capsule	/						/							
Lax capsule			/		/	/							/	
Tight fibrotic capsule		/	/											/
Tight anteromedial capsule										/				
Medially flattened head						/	/			/		/		/
Dysplastic head	/	/			/						/		/	
Subluxed joint				/				/					/	
Dislocated joint	/	/	/		/	/	/			/	/	/		/

Discussion

Ponseti[1)2)] best described growth and development of the acetabulum in the normal child and in the child with developmental dislocation of the hip. He notes that the hip joint, acetabulum and femoral head develop from the same primitive mesenchymal cells, with the cleft developing at seven weeks gestation. The hip joint is fully formed at 11 weeks gestation. Avisse et al[4)] described the fetal acetabulum as always being deformable. Dysplasia appears to be the result rather than cause of dislocation[5)]. The long term results and the factors leading to failed open reduction in DDH are rarely reported in the literature. There are many factors attributing to and compounding the risk of failure in maintaining concentric reduction after an open reduction surgery in DDH. The delay in diagnosis and the delay of the initial treatment certainly appear to decrease the chance of successful closed or open reduction. This may be due to the underdeveloped acetabulum. The mean acetabular index prior to the final revision surgery was 36 degrees in this series[10)~14)]. Lindstrom et al reported that hips with AI of more than 24 degrees have a higher likelihood of poor clinical results[31)]. Development of significant soft tissue impediments due to the delayed diagnosis will make an attempt at closed reduction unsuccessful and be a great obstacle during open reduction. Poor understanding and failure to address these problems during the primary open reduction will lead to redislocation. Errors in surgical technique appeared to be the main predisposing factor for failure of the primary open reduction. The apparent redislocation was probably a failure to attain concentric reduction and not a true redislocation in most instances. The errors in surgical technique that were noted were failure to enlarge the acetabular socket by performing a capsulotomy down to the transverse acetabular ligament and dividing this structure and also releasing the tight inferior capsule. Enlarging the acetabular socket is crucial especially if the first open reduction was performed after the age of 18 months. In this study 6 patients were noted to have a tight and thickened transverse acetabular ligament[6)] and

Table 5. Details of revision surgery after failed open reduction.

Case	Age at final OR* y+m	Duration after last operation*	Radiological evidence of AVN pre op*	Preoperative state*	Procedure(s) performed*
1	5+0	10 m	Y	D	AT+OR+VDRO+FS+KW
2	2+6	8 m	Y	D	AT, failed OR
3	2+8	3 d	N	D	OR
4	13+0	6 y	N	S	AT+PE
5	2+3	1 y	N	D	AT+OR
6	1+10	6 m	N	D	AT+OR+VDRO+FS
7	6+6	4 y	N	D	AT+OR+VDRO+FS
8	1+9	11 m	Y	S	AT+OR+VDRO
9	15+0	10 y	N	S	Shelf procedure(Staheli)
10	5+0	1 y	N	D	OR+SO+VDRO+FS
11	8+0	5 m	Y	S	AT+OR+VDRO+FS+KW
12	3+8	9 m	N	D	AT+OR+FS+KW
13	8+0	14 m	Y	S	AT+OR+KW+Shelf procedure(Wilson)
14	5+10	2+10	Y	D	AT+OR+VDRO+FS

*AVN avascular necrosis, d days, m months, y years, D dislocated, S subluxated, AT adductor tenotomy, OR open reduction, VDRO varus derotational osteotomy, FS femoral shortening, KW k wiring, PE percutaneous epiphyseodesis

5 of these patients were above 18 months old and one was 16 months old. Therefore the operating surgeon must keep in mind that when performing an open reduction for DDH in a child above 18 months, apart from releasing tight muscles the surgeon must also enlarge the underdeveloped acetabular socket[6]. In this respect our findings are similar with the study done by Boss and Slooff[29] where 11 out of 14 patients(mean age>18 months)did not have their acetabular socket enlarged during the primary open reduction and redislocation occurred soon after. Failure to perform adequate capsulorrhaphy may lead to early failure in the cast. In this study various forms of capsular scarring and attenuation was noted. Tight inferior, anteromedial, posteromedial and generalized fibrotic scarring of the capsule were seen. A balanced anterior and posterior capsular repair should be obtained. Failure to tighten the posterior capsule or over tightening of the anterior capsule may lead to posterior subluxation of the hip. Our findings were similar with those by Bos and Slooff[29] and McCluskey et al[28]. Ligamentum teres should be excised because invariably it will be hypertrophied and will impede reduction. The adductor tendon is another notable structure that was consistently tight during the revision surgery. Though in some cases it was divided during the initial open reduction it appeared to have reconstituted and had to be divided again. Inverted and occasionally hypertrophied limbus was noted in 6 patients in this series as described by Ortolani[3]. Limbusectomy was only performed if it truly impedes concentric reduction especially in older children otherwise it was everted by radial incisions. This cartilaginous labrum was maintained where possible since it is an integral part of the acetabulum and by everting it, additional support can be achieved.

It must be clear in the surgeon mind that the primary objective of the revision surgery is to obtain a stable and concentrically reduced femoral head. But adding complexity to an already difficult surgery may prove to be counterproductive. Therefore pelvic reconstructive osteotomies such as the Salter procedure, if required should be done at a later stage. In this respect we agree with McCluskey et al[28]. Pre

Table 6. Clinical and radiological results after repeat open reduction for DDH

Case	Age at last review	Duration of follow-up (months)	Ponseti grade	Kalamchi grade	Severin grade	LLD*	CE angle*	AI_a*	AI_b*	Trende lenburg test
1	7+0	24	4	4	3	2	18	26	22	+
2	2+10	4	4	1	6	2	D*	38	38	+
3	4+0	16	1	—	3	0	16	40	36	−
4	15+0	24	4	3	2	1	14	F*	F*	+
5	3+6	15	4	1	3	2	24	38	32	−
6	3+6	20	1	—	3	0	18	40	32	−
7	8+4	22	4	—	2	0	26	30	20	+
8	3+0	5	4	—	4	0	14	34	26	−
9	17+0	24	2	—	3	0	18	F*	F*	−
10	6+6	18	3	—	3	0	20	40	32	+
11	9+6	18	4	3	3	4	19	F*	F*	−
12	4+0	8	3	—	3	0	24	40	34	−
13	15+0	84	6	4	3	4	26	F*	F*	+
14	6+1	3	4	2	3	1.5	18	34	34	−

LLD limb length discrepancy, CE center edge angle, AI_a acetabular index prior to last surgery, AI_b acetabular index at last follow up, D dislocated hip, F* fused triradiate cartilage

operative radiographs should be analyzed to look for excessive anteversion of the femoral head. Failure to address this problem during the open reduction will lead to loss of concentric reduction later. This was noted in 7(50%) of the cases in our series. Over correction will lead to failure which was noted in one patient. If concentric reduction requires rotation of the femur it should be performed simultaneously with the open reduction as recommended by Bos and Slooff[29]. A femoral shortening should be performed if the reduction is in tension. This will also help reduce the pressure on the femoral head after reduction. 7 out of 14 hips(50%) in our series had avascular necrosis of the femoral head(AVN). Bos and Slooff reported AVN of the femoral head in 10 of 15(60%) redislocated hips[29], McCluskey et al reported AVN in 11 of 25(44%) hips[28] and Kershaw et al reported it in 19 of 33(58%) hips[27]. Most authors believe that AVN develops as a result of repeated surgeries leading to vascular damage of the femoral head and also the increased pressure after reduction[9)18)~22)]. Whether the avascular necrosis was a consequence of the original treatment or following revision surgery was impossible to determine. Limb length discrepancy was seen in 7 out of 14(50%) hips after an average of 20.3 months of follow-up. In the series by McCluskey et al[28], 13 out of 23 patients(56%) had limb length discrepancy after a mean follow up period of 7 years. Limitation of motion of the affected hip was seen in 9 out of 14 patients in this series but none were severely affected functionally. Pain was noted in only one patient who was followed up for 84 months. The long term results of these revision open reductions are not known. The eventual outcome is adversely affected by the number of previous closed and open attempts at reduction. It is very likely these patients will eventually develop premature osteoarthritis of the affected hip joint[8].

Conclusion

The aim of treatment in DDH is to attain stable and concentric reduction of the femoral head. If the surgeon embarks on surgery to reduce the hip joint, it is critical that he possess a sound knowledge of the problems as well as

the surgical approach. Pre-operative planning is mandatory. Post operative protection is a must. Similar principals should be observed when conducting a revision surgery though it is much more difficult due to scarring and loss of normal tissue planes. In view of the poor results after a revision open reduction and since the revision surgery is technically more demanding it is highly recommended that open reduction for DDH should be conducted by well trained surgeons.

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