SURGICAL TREATMENT OF THE LATE - PRESENTING DEVELOPMENTAL DISLOCATION OF THE HIP AFTER WALKING AGE

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ABSTRACT

Objective: Cases of developmental dislocation of the hip (DDH) still occur after walking age because of late or missed diagnosis and failed conservative treatment. The choice of treatment for DDH after walking age continues to be controversial, and one of the options is open reduction combined with innominate osteotomy. Methods: Twenty patients with 26 surgically treated hips with DDH, were evaluated from 2005 to 2008, using innominate osteotomy by Salter's technique after open reduction and capsulorraphy. The age of patients, fifteen females and five males, at time of surgery ranged from 12 to 18 months (mean age 14.7 months). Six patients had bilateral dislocation and in the remaining, nine had their left hip dislocated and five had their right hip dislocated. Results: The results were evaluated according to modified McKay criteria and to Severin radiological criteria, after a mean follow-up of 46.7 months. Eighty – nine percent of hips were rated as excellent or good by McKay criteria. There were no poor results. According to Severin criteria, 77% were type I and II while 23% showed type III and IV, no hips were rated as Severin's group V or VI. There was one case (3.8%) of re-dislocation, but revision surgery resulted in stable, concentric, and permanent reduction. No cases of infection, graft fracture and vascular or nervous injury were reported. Conclusion: Open reduction combined with Salter osteotomy does not hurt the hip with regard to acetabular remodeling for children between 12 and 18 months of age. ***Level of Evidence IV, Case Series.***

Keywords: Hip dislocation, congenital. Bone diseases, developmental. Osteotomy.

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INTRODUCTION

Developmental dysplasia of the hip (DDH) involves several abnormalities ranging from simple hip instabilities with capsule looseness to complete dislocation of the femoral head relating to an abnormal acetabulum cavity.[1] The inciting pathology is agreed to be abnormal laxity of the hip joint leading to subsequent displacement of the femoral head. The sustained subluxation or dislocation of the femoral head over time does not permit normal development of the acetabulum and results in a predictable pattern of acetabular growth disturbance that is termed hip dysplasia (strong evidence).[2] Although the rate of occurrence of DDH has been substantially reduced as a result of better clinical assessment, especially with the availability of sonographic hip screening,[3] there are still some cases that present in older patients as a result of late or missed diagnoses.[4] After walking age, the choice of treatment for DDH continues to be controversial. Authors advocating closed reduction do so in light of the risk of decreased postoperative range of motion and AVN after extensive surgery.[5] However, surgeons who are in favor of open reduction[6] note the high incidence of redislocation and the need for secondary surgery after closed reduction. Mardam–Bey and MacEwen[5] found that 66% of children of walking age with developmental dysplasia of the hip who had undergone closed reduction required additional surgery, compared with 33% of such patients treated with open reduction. In addition, forceful traction and prolonged immobilization in forced abduction leads to AVN because of high intraarticular pressure.[7] This is the reason many authors recommend primary open reduction. Open reduction can be performed with or without additional procedures, such as femoral and pelvic osteotomy. Some authors therefore recommend one–stage procedure consisting of open reduction, capsulorrhaphy, and innominate osteotomy. The choice of osteotomy is controversial. Innominate osteotomies can be divided into two types: complete and incomplete transiliac osteotomies. The osteotomy described by Salter in 1961, is an example of complete tran-

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siliac osteotomy. The most widely known incomplete transiliac osteotomy is that described by Pemberton[8] in 1965. In 1969, Dega[9] reported on what he called a transiliac osteotomy which was actually an incomplete transiliac osteotomy in which the cut penetrated the anterior and middle portions of the inner cortex of the ilium, leaving an intact hinge posteriorly consisting of the intact posteromedial iliac cortex and sciatic notch. Salter and other researchers reported good to excellent radiographic results in patients who were between 18 months and 4 years of age when the Salter innominate osteotomy was performed with open reduction.[10] There is still debate on the necessity of Salter osteotomy for DDH between 12 and 18 months of age. Some believed that it is unnecessary and aggressive, whereas others accepted it without notable disadvantages. The virtue of the traditional Salter procedure is that it redirects the acetabulum, thus immediately improving anterolateral coverage of the femoral head. The aim of this study was to assess the clinical and radiographic results of open reduction combined with Salter innominate osteotomy in children with DDH between 12 and 18 months of age at the time of surgery. We attempted to determine the influence of age, magnitude of dislocation, ability to walk, previous conservative treatment, and absence of ossific nucleus of the femoral head on the final result.

MATERIAL AND METHODS

The study was approved by the Ethics Research Committee and the patients' free informed consent form was obtained and published in Jubail and Qatif, Saudi Arabia, between 2005 e 2008. A prospective study involving 26 hips in 20 children with DDH between 12 and 18 months of age were investigated. There were 5 boys and 15 girls. The mean age was 14.7 months. The mean follow–up period was 46.7 months (range 36 - 70). Six cases were bilateral, left hips were involved in 9 cases of the remaining 14 cases, and the right hip in 5 children. Patients with a specific syndrome, a neuromuscular condition, infection or previous hip surgery were excluded. Patients who had a minimum follow–up of three years and for whom essential radiographs were available for review were included in the present study. Seventeen of the twenty six hips had no prior treatment, whereas nine underwent a previous attempted closed reduction. Documentation of the range of motion, presence or absence of a limp, limb–length discrepancy, hip pain, and limitation of activity was assessed both preoperatively and at the last follow-up visit. All cases were found to have adduction deformity, limb shortening and totally dislocated hip (s). In cases with bilateral DDH, open reduction and osteotomy was planned on separate occasions two months apart. We graded preoperative subluxation or dislocation according to the Tonnis[11] classification, in which the centre of the ossific nucleus of the femoral head is related to Perkins' line and to an horizontal line at the level of the lateral margin of the acetabulum. Fourteen of the hips (53.8%) were classified as grade III. (Table 1)

Table 1. DDH types According to Tonnis.

Grade	Criteria	Number	Percentage
I	Capital femoral epiphysis medial to Perkins line	0	0
II	Capital femoral epiphysis medial to Perkins line, but below the level of the superior acetabular rim	3	11.5%
III	Capital femoral epiphysis at the level of the superior acetabular rim	14	53.8
IV	Capital femoral epiphysis above the level of the superior acetabular rim	9	34.7

Surgical technique:

It was not performed previous traction in any case, due to nursery care technical difficulties. All patients placed supine, under general anesthesia and a sandbag was used to tilt the child up on the operation side, but this should be placed under the flank and not the buttock. We followed the recommendations of Salter and Dubos[10] on preoperative indications and surgical technique, and the capsulorrhaphy was similar to that described by Wenger.[12] Intraoperative instability was considered if the containment of femoral head could not be easily maintained in the hip, with the leg slightly flexed 30°, abducted 45°, and fully internally rotated. The instability was used as a determining factor for an additional Salter osteotomy before capsulorrhaphy. Before performing Salter's innominate osteotomy we preferred to take the wedged bone graft from the iliac crest first, as this method reduced the time needed after the pelvic osteotomy, then doing the osteotomy, correction , graft positioning and stabilization with 2 Kirschner wires as described by Salter in 1961. After surgery, the patients were placed in a 1 - ½ hip spica cast with the hip in 30 degrees abduction, 30 degrees flexion and 15 degrees of internal rotation for 6 weeks after surgery, followed by abduction brace at night for two additional months.

Follow up

Most of the cases did not require blood transfusion either intra-operative or postoperative except those with bilateral DDH after the second surgery. The evaluation was based on clinical and radiologic aspects. The clinical examination consisted mainly on examining the range of motion, function, and limb length discrepancy; at the latest follow-up, clinical data were recorded and results evaluated with modified McKay criteria. (Table 2) Radiographic assessment for all cases was made on day one post-operative and at 6 weeks, 3 months, and every 6 months after removal of cast, till the end of follow-up. After radiographic assessment for healing of the osteotomy site, progressive exercises begun. Walking was allowed 4 months after surgery. All pre- and postoperative radiographs were examined for assessment of acetabular index (AI), center-edge angle (CEA), neck - shaft angle (NSA), the true neck-shaft angles were calculated and femoral head Sphericity was evaluated according to Mose to assess the proximal end of the femur. The size of the femoral head on the involved side was related to the contralateral side for evaluation of coxa magna according to the criteria of Gamble et al.[13] The Shenton line was evaluated to assess the femoral head/acetabulum relationship. Preoperatively the presence or absence of avascular necrosis (AVN) of the femoral head was determined using the criteria of Salter[14] and later classified according to the Tonnis – Kohlman classification. (Table 3) At the latest follow – up radiological results were evaluated according to Severin's classification[15], (Table 4) and postoperatively the presence of AVN was determined using the criteria of Salter;[14] its magnitude was graded according to the classification of Bucholtz and Ogden. (Table 5) The correlation between the final result and the variables were evaluated with the Mann – Whitney test.

Table 2. McKay's criteria modified by berkeley et al. for clinical evaluation of results[3].

Grade	Rating	Description
I	Excellent	Painless, stable hip; no limp; more than 15 degrees of internal rotation
II	Good	Painless, stable hip; slight limp or decreased motion; negative Trendelenburg's sign
III	Fair	Minimum pain; moderate stiffness; positive Trendelenburg's sign
IV	Poor	Significant pain

Table 3. Tonnis and Kuhlmann Classification of AVN of the proximal end of the femur.

Grade	Description
I	Capital ossific nucleus is slightly granular and irregular, self-limiting and without sequelae.
II	The margins of the ossific nucleus are more irregular, greater mottling and granularity than in grade 1 cases; cystic changes may be present within the ossific nucleus. regress with time, sometimes leaving a mild flattening of the head.
III	The ossific nucleus as a whole is fragmented or appears as a flat strip. This grade may develop even before the ossific nucleus has appeared. Deformity resolves if the physis is undamaged.
IV	There is involvement of the physis, leading to serious growth. Irregulaties may be seen along both edges of the physis, though in some cases metaphyseal involvement is not apparent until valgus or varus-type growth disturbances and shortening of the femoral neck have occurred.

Table 4. Severin criteria for evaluation of radiographic results.

Type I	Normal hips
Type II	Concentric reduction of the joint with deformity of the femoral neck, head or acetabulum
Type III	Dysplastic hips without subluxation
Type IV	Subluxation
Type V	The head articulating with a secondary acetabulum in the upper part of the original acetabulum.
Type VI	Redislocation.

Table 5. Bucholz - Ogden classification system of avn of the proximal femur.

Type	Description
I	Irregular ossification of the femoral head with no abnormalities of ossification of the metaphysis is the hallmark of type I AVN.
II	Lateral metaphysis shows evidence of injury; femoral head grows into valgus deformity following premature lateral epiphyseal closure; relative overgrowth of greater trochanter
III	Entire metaphysis affected; femoral neck extremely short, with marked trochanteric overgrowth
IV	Lucent defect along medial metaphysis indicates growth disturbance of medial growth plate, which causes femoral head to grow into varus deformity; relative overgrowth of greater trochanter

RESULTS

Preoperative radiologic assessment revealed grade III dislocation in 14 hips and grade IV in nine hips. The acetabular index ranged from 24 to 48 degrees (mean 35.4 degrees). The true neck – shaft angle ranged from 110 to 144 degrees (mean 125.2 degrees). In five hips the ossific nucleus was not visible on the preoperative radiographs. (Table 6) AVN was observed in nine hips (five hips grade I, one hip grade II, and three hips grade IV, according to the Tonnis – Kuhlman classification). All hips were operated on with the method described above. The postoperative course was uneventful, with no early or late infection being observed. One hip (3.8%) redislocated five months after surgery, but revision surgery resulted in stable, concentric, and permanent reduction.

Table 6. Incidence of avascular necrosis in the studied cases.

Bucholz–Ogden	Type I	Type II	Type III	Type IV
Pré-operatório (9 quadris = 34,6%)	5	1	-	3
Pós-operatório (6 quadris = 23,1%)	3	1	2	-

Clinical Evaluation

At the latest follow-up no patient reported significant hip pain; a positive Trendelenburg sign was recorded in one patient and significant limp in one patient. A minor decrease in the range of motion was noted in 11 hips; leg length discrepancy exceeding 1 cm was found in one patient. Ten children had equal length of lower extremities. Eighty - nine percent of the hips were rated as excellent or good by the McKay criteria. There were no poor results.

Radiographic evaluation

The AI in hips had a pre-surgical mean of 35.4° (range: 24 – 48°), and after surgery the mean was 19° (range: 6–30°), which yielded an average descent of 15.4° (±4°) over AI (maximum descent 34°). The angle of Wiberg in the hips presented a post-surgery mean of 26° (±7°); this showed statistically significant ($P < 0.05$). In addition, the Shenton line was discontinuous before osteotomy in 82 % hips and after osteotomy continuity was observed in 90% [statistically significant difference ($P<0.05$) in the postoperative correction of the Shenton line]. The true neck – shaft angle ranged from 115 to 156 degrees (mean 130 degrees); compared with preoperative assessment, it remained practically unchanged. Nine hips (34.6%) in children with monolateral involvement had developed coxa magna, but in no case did this interfere with hip concentricity. Six hips showed AVN on the latest radiographs: Three hips were type I, one hip was type II, and two hips were type III in Bucholtz – Ogden system of AVN grading. Five of those hips had displayed signs of AVN prior to surgery. One hip (3.8%) developed AVN after surgery. Sphericity of the femoral head evaluated according to Mose showed that 11 hips were grade 1, 12 were grade II, and 3 were grade III. According to McKay's criteria modified by Berkeley et al., for Clinical Evaluation of results 80.8% of the hips were rated as excellent or good while 19.2% as fair and no poor. According to Severin criteria for evaluation of radiographic results 77% were type I and II while 23% showed type III and IV, no hips were rated as Severin's group V or VI. Both clinical and radiographic average results were compared across the five subgroups (age at surgery, grade of dislocation, failed conservative treatment, presence of ossific nucleus). Statistical analysis (Mann – Whi-

tney test) of the differences in distribution of excellent, good, fair, and poor results within these categories did not show any significance. Detailed clinical and radiographic results are presented in Table 7. (Figures 1 and 2)

DISCUSSION

The Salter osteotomy provides anterolateral coverage of the femoral head that allows the acetabulum to develop and the hip joint to stabilize. It had been thought that innominate osteotomy should be performed in children older than 18 months of age and it usually provides correction of acetabular direction in term of the AI. The osteotomy will correct the AI averaging 10° to 27° and improve the CEA averaging 15°.[10] The best time to perform an osteotomy of the acetabulum for DDH patients is still a concern.[16] Saleh *et al*.[17] demonstrated that the acetabulum remodels quickly after the Salter innominate osteotomy in a range of age groups. The lower limit of surgical timing is under debate, e.g., at a younger age. Many studies found that it could be done safely for children between 12 and 18 months of age without major disadvantages.[6] The advantages of immediate acetabular alignment include the probability that stability will be enhanced if a careful capsulorrhaphy is carried out after the open reduction, and that later surgery will be avoided (although the fixation pins may still require removal under a general anesthetic). To decide whether Salter osteotomy is necessary in addition to open reduction, we use intraoperative stability as a reference. Macnicol and Bertol,[18] concluded that Salter osteotomy should produce an alteration in the acetabular inclination of at least 15° when carried out concurrently with open reduction, or at least 12° following the staged procedure. Our results were 89% excellent and good clinical outcomes, and no poor clinical results were comparable with other investigations,[6,19] but our radiographic results were not as good as those noted by other authors.[6,20] Salter osteotomy virtually eliminated acetabular dysplasia in all cases and allowed further undisturbed acetabular development. The femoral head coverage was excellent, with the CE angle of Wiberg alone qualifying 77% of all hips as Severin class I and II. Since all hips included in this study proved unstable at the intraoperative test, transiliac osteotomy was performed in all cases. The deformity of the proximal end of the femur, which we attribute to AVN existing already prior to surgery in 9 hips, was responsible for lower radiographic rating (Severin class II and III). Femoral osteotomy could be avoided in all cases due to the result of intraoperative stability test but

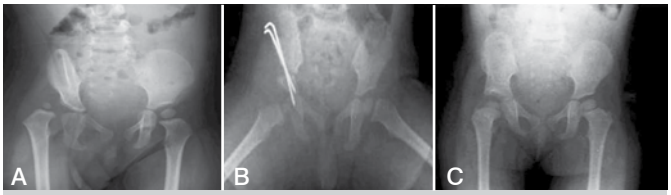

Figure 1. Fourteen months old child with right developmental hip dislocation corrected with open reduction combined with innominate salter's osteotomy: A) Preoperative x-rays; B) 6 weeks postoperative showing good reduction and containment of the head of femur; C) 118 months postoperatively with excellent remodeling of the acetabulum.

Figure 2. Fifteen months old child with bilateral developmental hip dislocation: A) Preoperative x-rays; B) 4 weeks postoperative from the second open reduction and salter's osteotomy of the left hip; C) 24 months post operative showing well remodeled acetabular covering of both hips.

Table 7. Clinical and radiographic results.

Case	Conservative treatment (months)	Age at surgery (months)	Dislocation type (Tonnis)	Presence of ossific nucleus	AVN prior to surgery (Tonnis-Kohlman)	Follow-up (months)	AVN at latest follow-up (Bucholtz-Ogden)	Clinical result (McKay score)	Radiographic result (severin class)
1	?	13	III	-	0	70	0	G	II
2	3,5	14	IV	+	0	65	0	F	III
3	?	12	II	-	0	60	0	E	I
4	?	14	III	+	0	65	0	G	I
5	4	15	III	+	0	72	0	G	II
6	3	14,5	III	+	I	56	0	E	II
7	?	12,5	III	-	0	68	0	G	I
8	?	17	IV	+	IV	58	III	F	IV
9	?	16	II	+	0	52	0	G	II
10	?	15,5	IV	+	I	54	I	G	III
11	3	14	III	+	0	60	0	F	III
12	4	13,5	II	+	0	58	0	E	II
13	?	13	III	-	0	68	0	G	II
14	?	16	III	+	I	48	0	G	I
15	?	18	III	+	IV	46	II	E	I
16	2	17,5	IV	+	0	44	0	G	I
17	?	18	IV	+	I	50	0	G	II
18	5	14,5	III	+	0	42	0	G	II
19	?	16,5	IV	+	0	40	III	F	III
20	?	18	IV	+	IV	62	I	F	IV
21	?	15,5	III	+	0	54	0	G	I
22	4	16	III	+	I	42	0	G	II
23	?	18	IV	+	II	50	I	E	I
24	3,5	17	III	+	0	38	0	E	II
25	??	14	III	-	0	36	0	G	I
26	?	16	IV	+	0	36	0	G	I

E, excellent; G, Good F, Fair;? undocumented conservative treatment.

also due to the fact that all our patients were under 18 months of age, so the risk of developing AVN was relatively low. In some hips excessive anteversion of the femoral neck in combination with high value of the neck–shaft angle resulted in breaking of the Shenton line on AP radiographs and a worse radiographic rating (Severin class IV) despite a satisfactory value of the Wiberg angle. Coxa magna, although it developed in 48% of hips, did not interfere with the sphericity and did not worsen the final result. It was also not directly related to AVN. Similar observations have been presented by others.[21] AVN, that we attribute to surgery, appeared in one hip (3.8%); this rate compares favorably to other reports. However, the total number of hips with AVN regardless of its origin remains a concern. We are aware that our assessment may overestimate the proportion of good radiologic results, since we agree with other authors[22] that radiographic assessment of the hip with AVN before termination of growth is preliminary. That was true for the majority of hips in our study. The reoperation rate for redislocation in our series (3.8%) also compares favorably with other reports.[23] Since no subgroup had significantly better results than the others, we conclude that the grade of dislocation, walking prior to surgery, age, and earlier conservative treatment did not matter in this study. Also, the absence of the ossific nucleus of the femoral head prior to surgery did not seem to pose any additional risk for the operated hip joint, and we do not advise postponing surgery because of that. This finding confirms the results of others.[24] Our overall results appear to be comparable with other series, but we did not attempt any direct comparison since there are too many differences in patient selection, operative techniques, length of follow - up, criteria for secondary surgery, and classification systems used among the reported series.

CONCLUSION

From the results of our series we concluded that open reduction combined with Salter osteotomy does not hurt the hip with regard to acetabular remodeling for children between 12 and 18 months of age

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