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Postoperative clinical and radiological assessment of patients with developmental dysplasia of hip after open reduction and salter osteotomy

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Abstract

Background and objectives: Developmental dysplasia of the hip is one of the most important and challenging conditions in pediatric orthopedics. If not diagnosed and treated on time, it leads to remarkable morbidity. This study aimed to assess the clinical and radiological outcomes of open reduction and Salter osteotomy in patients with developmental d ysplasia of the hip **Methods:** In this trial, a total of 30 children aged 18 months - 6 years of both genders who were diagnosed with Developmental dysplasia of the hip underwent open reduction and Salter osteotomy and were followed up for one year for clinical and radiological improvements. **Results:** The median age of the patients was 3.0, ranging from 18 months - 6 years. The study showed that 26 (86.7%) and 27 (90.0%) of patients obtained normal hip locations following six months and one year, respectively. The overall final clinical results were excellent in 15 patients (50.0%), good in 9 (30.0%), fair in 3 (10.0%), and poor in 3 (10.0%) following six months of the surgery. One of the patients with grade II hip dislocation converted to grade III according to Tönnis classification following one year. No avascular necrosis of the ossific nucleus was seen in most of the cases. However, two of the patients with no sign of avascular necrosis converted to avascular necrosis grade III according to Kalamchi classification following one year. **Conclusions:** The study suggests that the operative treatment of developmental dysplasia of hip following the walking age is an effective procedure to obtain satisfactory results.

Key words: Developmental dysplasia of the hip, Open reduction, Salter osteotomy, Outcomes.

Introduction

Developmental Dysplasia of the Hip (DDH) is a congenital medical condition of the hip joint. Its incidence is one in every 1000 live births. It is the most common lower limb condition in children[1,2]. Developmental Dysplasia of the Hip is defined as "a spectrum of diseases ranging from minor dysplasia of the hip to irreducible dislocation". Hip joint dislocation is defined as the displacement of the articulating bones that result in complete separation of the joint surfaces. Subluxation of the hip joint is defined as an incomplete separation of the joint surfaces with some joint surface contact. Dysplasia of the hip joint is an abnormal development of the acetabulum that leads to a shallow and dysmorphic socket. Developmental Dysplasia of the Hip may resolve or determinate with growth in children[3,4].

Neonatal hip screening has been shown to associate with early diagnosis and conservative treatment, with successful results in the majority of the patients. The incidence of this medical issue has been substantially decreased by better clinical assessment[5], particularly by the availability of sonographic hip screening[6]. Despite these advantages, development of dislocation of the hip occur following walking age due to late or missed diagnosis and failed conservative or operative therapy.

Developmental Dysplasia of the Hip includes femoral head subluxation or dislocation and acetabular dysplasia. Treatment of neglected DDH among children following the walking age is a big challenge to the orthopedic surgeons. The DDH treatment following the walking age is usually performed by the surgical procedures. It is due to pathological changes of the children at this age. The pathological changes include severe contracture of the muscles, tendons, and capsule around the hip, increased shallowness of the acetabulum, excessive femoral anteversion, hypertrophied inverted labrum, hypertrophied ligamentum teres, excessive pulvinar, misdirected acetabulum that make closed reduction very difficult and forcible that may result in avascular necrosis of the femoral head or redislocation. Therefore, surgeons advise the parents to per-

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form open reduction for their children[7]. The selection of the treatment type of pelvic osteotomy is performed following careful pre-operative assessment of the severity of the acetabular dysplasia and the patient's age [8, 9]

The aim of this study was to assess the clinical and radiological outcomes of open reduction and Salter osteotomy in patients with developmental dysplasia of hip between 18 months to 6 years. Besides, the postoperative complications were evaluated using both modified McKay's criteria and Kalamchi classifications and compared postoperative complications to the degree of acetabular index correction.

Patients and methods

In the present clinical trial, a total of 30 patients aged 18 months to 6 years old (4 males and 26 females) were included. The patients who were diagnosed with different degrees of congenital mal-development of the acetabulum of both right and left femur were involved. The patients were recruited from the orthopedic department of Erbil Teaching Hospital in Iraqi Kurdistan. The patients were diagnosed by an orthopedic specialist according to radiological changes, and they underwent open reduction and Salter osteotomy and were followed up for six months and one year postoperatively.

All patients who were included in this investigation had undergone complete physical and clinical examinations at the preoperative stage then six months and one year follow-up postoperatively. At the follow-up visit, the patients were assessed for Trendelenburg test, limping, hip stability in the supine position, presence or absence of deformity and the range of motion. The clinical changes in hip condition were performed by modified McKay's criteria as shown in the measurement criteria. Anteroposterior radiographs were taken to measure the Acetabular Index (AI) at six months and one year of follow-up. The changes in the femoral head were checked for sphericity and the radiodensity. Values of the acetabular index were checked to include the abnormal dislocation into the study. All of the patients who were included in this study had an AI>25 at the preoperative stage.

Moreover, the patients underwent one-stage operative therapy treatment in all or in combination of the following forms: open reduction and capsulorrhaphy, Salter pelvic osteotomy, femoral derotation, and shortening. The patients underwent immobilization in a hip spica cast for about 6 weeks after the operation. The preoperative clinical and radiological results were used for the treatment plan guide.

The patients underwent general anesthesia. Preoperative traction was done for some of the cases. Adductor tenotomy was performed for most of the cases; a curved anterolateral incision was performed for open reduction operation. The incision was started 1 cm below the middle of the iliac crest and was extended anteriorly, inferiorly and medially. The extension was to a point where anterior superior iliac spine becomes centered midway in the incision. As required, the femoral head was reduced without opening the hip. This procedure was performed under image guidance. In a femoral osteotomy, the same incision or lateral femoral was incised separately and was fixed with a small fragment dynamic compression plate. Salter pelvic osteotomy was performed by anterior incision of open reduction. A Gigli saw was used to complete the Salter osteotomy. Its graft was taken from the iliac crest and fixed with one or two K wires.

The pediatric patients who were diagnosed with typical DDH of both genders with different severities were included in the present investigation.

The following exclusion criteria were applied to the patients: teratologic DDH, postoperative recurrent DDH, and DDH due to neuromuscular disease.

Clinical presentations of DDH depend on the age of the child. Newborns present with hip instability, infants have limited hip abduction on examination, and older children and adolescents present with limping, joint pain, and/or osteoarthritis. Repeated careful examination of all infants from birth and throughout the first year of life until the child begins walking is important to prevent late cases. Provocative testing includes the Barlow and Ortolani maneuvers. Other signs, such as shortening of the femur with hips and knees flexed (Galeazzi sign), asymmetry of the thigh or gluteal folds, and discrepancy of leg lengths are potential clues[10].

Hip dislocation was classified according to the Tönnis classification at both six months and one year post-oper-

ative dates by radiological methods. Tönnis classification is categorized by radiological changes based on the following criteria:

Grade 1: The ossification center of the femoral head is displaced laterally but still inferior to the superolateral corner of the right acetabulum. Grade 2: The ossification center of the femoral head is at the level of the superolateral corner of the right acetabulum, grade 3: The ossification center of the femoral head is superior to the superolateral corner of the right acetabulum.

Avascular necrosis (AVN)was detected radiologically and graded by Kalamchi's classification according to the following criteria: Grade I (KI): changes affecting the ossific nucleus, Grade II (KII): lateral physeal damage, grade III (KIII): central physeal damage; grade IV (KIV): total damage to the head and physis.

Hips with no evidence of any Kalamchi's classification criteria for avascular necrosis were classified as K0.

Acetabular index (AI) was considered to be normal when it was less than 25 and above 25 was considered as abnormal AI.

McKay's criteria assessed the clinical improvement in hip dysplasia. In this scale, the improvement in clinical changes was categorized as excellent, good, fair and poor according to the following Table 1[7]:

Table (1): McKay criteria for clinical evaluation of improvement in hip dysplasia.

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

The descriptive purposes of the study were determined in frequency and percentage. The improvement number of the acetabular index, radiological changes, hip dislocation, and avascular necrosis preoperatively and postoperatively were presented in frequency and percentage. The age of the patients was presented in median and interquartile ranges. Level of Acetabular index in patients with different clinical changes at six months and one year of follow-up was examined in ANOVA One-Way test. The null hypothesis was rejected in a p-value $\leq$ 0.05. The statistical calculations were performed in the Statistical Package for Social Science (SPSS 24:00) version 24.0.

The ethical approval of the present clonal trial was obtained from the Kurdistan Board for Medical Specialties (KBMS). The permission for the surgery was obtained from the children's parents. Also, their personal information was protected throughout the study stages.

Results

The median age of the patients included in this study was 3.0 (Interquartile range: 2.04 years). Most of the patients were females (86.7%) and had dysplasia in the left side of their femur (76.7%), Table 2.

Table (2): General information of the patients with dysplasia

Patients' characteristics (n=30)	No.	%
Age; Range: 18 months to 6 years		
Median: 3.0		
Interquartile range: 2.04		
Gender		
Male	4	13.3
Female	26	86.7
Dysplasia Side		
Right	7	23.3
Left	23	76.7

Of the total 30 patients with abnormal acetabular index who underwent surgery, 26 (86.7%) and 27 (90.0%) of them obtained the normal hip locations (based on the AI) following six months and one year postoperatively, Table 3.

Table (3): Comparison of improvement number of an acetabular index between baseline and after six months and one year

AI Categories (n=30)	Preoperative No. (%)	After 6 Months No. (%)	After One Year No. (%)
Normal (<25 AI)	0 (0.0)	26 (86.7)	27 (90.0)
Abnormal (>=25 AI)	30 (100)	4 (13.3)	3 (10.0)

The data are in No (%).

The overall final clinical results were excellent in 15 patients (50.0%), good in 9 (30.0%), fair in 3 (10.0%), and poor in 3 (10.0%) following six months of the surgery. Following one year of follow-up, the overall final clinical improvement was excellent in 18 (60.0%), good in 8 (26.7%), fair in 1 patient (3.3%), and poor in 3 (10.0%). Of the total 30 patients who underwent surgery, 27 of them were observed to have no dislocation, and one of them had grade I following six months and one year. But one of the patients with grade II converted to grade III following one year of surgery, Table 4.

Table (4): Clinical and radiological change of DDH patients after six months and one year

Clinical and radiological changes (n=30)	After 6 Months	After 1 year
	No. (%)	No. (%)
McKay grade	15 (50.0)	18 (60.0)
Excellent	9 (30.0)	8 (26.7)
Good	3 (10.0)	1 (3.3)
Fair	3 (10.0)	3 (10.0)
Poor		
Dislocation		
No dislocation	27 (90.0)	27 (90.0)
Tönnis type 1	1 (3.3)	1 (3.3)
Tönnis type 2	1 (3.3)	0 (0.0)
Tönnis type 3	1 (3.3)	2 (6.7)

The necrosis degree determined by radiology was shown in Table 5. No AVN was seen of the ossific nucleus of the patients following six months and no AVN in 28 (93.3%) of the patients following one year. However, two of the patients with no sign of AVN converted to AVN grade III following one year, Table 5.

Table (5): Necrosis changes of the hip following six months and one year of surgery

Avascular necrosis (n=30)	After 6 Months	After 1 year
	No. (%)	No. (%)
No AVN	30 (100)	28 (93.3)
Grade I	0 (0.0)	0 (0.0)
Grade II	0 (0.0)	0 (0.0)
Grade III	0 (0.0)	2 (6.7)
Grade IV	0 (0.0)	0 (0.0)

The levels of the acetabular index in patients with different clinical changes showed no significant difference following six months (p-value=0.283) and one year (p-value=0.904), Table 6.

Table (6): Level of Acetabular index in patients with different clinical changes at six months and one year of follow-up

	Acetabular index				
Clinical changes (McKay)	Mean	SD	95% Confidence Interval for mean		p-value (two-sided)
			Lower bound	Upper bound	
At six month follow-up					0.283
Excellent	21.87	2.39	20.55	23.19	
Good	21.67	1.87	20.23	23.10	
Fair	23.67	1.53	19.87	27.46	
Poor	24.33	4.73	12.59	36.07	
At one year follow-up					0.904
Excellent	21.56	1.98	20.57	22.54	
Good	21.13	.99	20.30	21.95	
Fair	21.00	.	.	.	
Poor	22.00	3.61	13.04	30.96	

ANOVA-One way was performed for statistical analyses.

Discussion

The present investigation showed that 26 and 27 of 30 DDH patients obtained the normal AI following six months and one year of surgical therapy, respectively. Moreover, 27 of the patients had not dislocation following six months and one-year follow-up. However, one of the patients with type 2 dislocation at six months converted to type 3 at one year. In patients with DDH, excessive femoral neck anteversion is usually present without clear clinical features. In these patients, the hip is in a subluxated or dislocated position; it could be stable following internally rotating the hip. These two patients may need a femoral derotational osteotomy following reduction treatment of the femoral head in the acetabulum under vision.

Interestingly, all patients had no clinical signs of avascular necrosis at six months, while two of these patients converted to grade III of avascular necrosis at one-year follow-up. Baghdadi[11] reviewed the medical records of the patients who had undergone innominate Salter osteotomy and were diagnosed with non-pathological DDH. They followed-up the patients for 70.28 months. They found that 13 patients were converted to Avascular Necrosis of the femoral head (15%), while it was 6.7% in our study. Based on the Kalamchi's classification, four patients were categorized in class I, 2 in class II, 1 in class III, and 6 in class IV of femoral head avascular necrosis. Avascular necrosis (AVN) of the femoral head is considered to be the most feared complication in DDH children. It is iatrogenic and not part of the natural history of the DDH. It is considered to be devastating and often untreatable[12]. The possible reason behind this complication is that the cartilaginous femoral head without an ossific nucleus is more vulnerable to ischemia than a more developed femoral head where an ossific nucleus is previously present[13, 14]. Obesity may play a significant role in Avascular necrosis. Fakoor[15] found that 4 (40%) of the cases were converted to Avascular necrosis (grade II).

Roposch[16] reviewed 118 hips treated for DDH by closed or open reduction with or without femoral osteotomy retrospective. The study was conducted to determine the effect of osteonecrosis related to acetabular remodeling. They found that AI has been improved over time in all hips, but the hips without osteonecrosis had a higher magnitude of improvement.

Also, 15 and 18 of the patients were excellent for clinical changes following six months and one-year follow-up, respectively. Abdullah[7] treated 35 patients with DDH by different combinations of open reduction, femoral (shortening, derotation, and varus) and pelvic (Salter or Dega) osteotomy. They followed-up their patients by a mean of 33.5 months. At the end of the follow-up, the authors found that the overall final clinical results were excellent in 13 (31%) patients, good in 24 (57%), fair in 4 (9.5%) patients and poor in one 1 (2.5%) patient.

The present study did not find different AI levels in patients with different clinical changes; the level of AI was in a normal value in all stages of clinical changes. The important point is that the mean of AI in patients with different clinical changes was at the normal AI range. But four and three patients at six months and one-year follow-up had AI greater than the normal range. Wang[17] reviewed the published investigations that compared the role open and closed reduction for DDH in children aged <3 years. They included nine retrospective investigations in the analysis.

They found that the pooled odds ratio for comparing open reduction with closed reduction for all grades of AVN was 2.26 (95%CI=1.21–4.22). They found a significant association for further surgery between open and closed reduction, with a pooled odds ratio of 0.30 (95%CI=0.15–0.60). The findings from their meta-analysis suggest that open reduction is a risk factor for the AVN development in comparison with closed treatment. The findings reported in the study must be interpreted in the light of study design and setting, as the patients were selected from one setting that makes difficulties to generalize the findings to other settings in the rest of the country.

Conclusions

The present study showed that most of the patients diagnosed with DDH and underwent surgical treatment obtained an excellent or good result in clonal improvement and radiological changes at six months and one year of the follow-up. However, two of the patients were converted to Avascular necrosis at one-year follow-up (grade III). Also, two patients remain dislocated at Tönnis type 3.

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