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Surgical outcome of one-stage treatment of developmental dysplasia of the hip in children of walking age

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Abstract
Introduction: Developmental dysplasia of the hip (DDH) is a term that encompasses a wide spectrum of pathology ranging from mild acetabular dysplasia with or without instability to a complete dislocation at birth which may or may not be reducible. The purpose of this study is to assess the results of one-stage combined operative management of developmental dysplasia of the hip in children of walking age.
Methods: is a retrospective study involving 21 hips in 17 children with DDH, who underwent surgical operation at the department of orthopaedic surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, from January 2014 to December 2019.Tönnis and Severin grading systems were used to classify the radiographic status of the hip in pre- and postoperative period respectively. The operative procedure included open reduction, capsulorraphy, Salter's osteotomy and a femoral derotation osteotomy. Catteral's 'test of Stability' was used after open reduction as an indicator for need of pelvic and femoral osteotomy. The children were evaluated clinically on McKay's criteria and radiologically on Severin's criteria.
Result: Among the 17 cases, 11(64.7%) were female and 6(35.3%) were male; 4(23.52%) children had bilateral involvement; 9(52.94%) had left-sided and 4(23.52%) had right-sided involvement. The average age was 3.3 years (range 18 months—8 yrs.) at the time of operation. Follow-up range between 1 to 3.8 years. At the time of last follow-up, 8(38.09%) children had excellent outcomes, 10(47.61%) had good, 2(9.52%) had fair, and 1(4.76%) had poor outcomes on McKay's criteria. Avascular necrosis of femoral head was noted in 2(9.52%) and hip re-dislocation was observed in 1(4.76%) hip.
Conclusion: One-stage surgery which include open reduction, capsulorraphy, Salter's and femoral derotation osteotomy in walking age children with DDH is a safe and highly effective method. Complication rate and the need for repeat surgery is very low.

Keywords: Developmental dysplasia of the hip, one-stage procedure, walking age, femoral shortening, derotation, salter's osteotomy

Introduction

Developmental dysplasia of the hip (DDH) is a term that encompasses a wide spectrum of pathology ranging from mild acetabular dysplasia with or without instability to a complete dislocation at birth which may or may not be reducible The worldwide incidence of DDH ranges from 1 to 24 cases per 1000 births [1]. The wide range of incidences can be attributed to different methods of diagnosis, timing of evaluation, definition of DDH, clinical experience of reporting physicians and the true variation in incidence is attributed to genetics and environmental factors [2, 3]. In addition, lack of agreement in the screening regimes of neonates worldwide contributes to the wide variation in incidence [4]. DDH is relatively rare in the developed world due to a well- functioning neonatal screening procedure [5]. Dueto lack of screening programme children with DDH in Bangladesh are usually diagnosed late, particularly when they start walking. The goal of DDH treatment is to obtain and maintain a safe concentric reduction of the hip in order to provide an optimal environment for the development of the femoral head and acetabulum, avoid avascular necrosis (AVN) and reduce the risk of early osteoarthrosis [6, 7]. In the older child the reduction of the hip is difficult because of adaptive shortening of the extraarticular soft tissue, acetabular dysplasia, capsular

constriction, increased femoral ante-version, fibrofatty tissue in the acetabulum, hypertrophy ligamentum teres and fixed inversion of limbus. There are different treatment options for DDH depending on the age and grade of the disease. Bracing, traction, closed reduction, open reduction, and femoral or pelvic osteotomies are the frequently used treatment modalities for older children.[8] The incidence of osteonecrosis of the femoral head has been reduced by avoiding immobilization of the hip in extreme abduction and by using femoral shortening osteotomies when appropriate.[9] Traction has been used before reduction of a dislocated hip to decrease the risk of ischemia of the femoral head but data supporting use of this treatment are inconsistent [10].

Treatment with one-stage procedure (open reduction, capsulorrhaphy, pelvic osteotomy and femoral osteotomy with or without shortening) is preferred by many authors. The choice of osteotomy is controversial. Innominate osteotomy can be divided into two types: complete and incomplete transiliac osteotomies. The osteotomy described by Salter in 1961, is an example of complete transiliac osteotomy. The most widely known incomplete transiliac osteotomy is that described by Pemberton [11] in 1965. The purpose of this study is evaluation of the results of one-stage operation in DDH presented between 1.8 to 8 years of age.

In this study, retrospective analysis was done to evaluate the radiographic and functional results of one-stage triple operative procedure of open reduction, femoral osteotomy, and innominate osteotomy in walking age children.

Materials and Methods

This study was carried out in 21hips of 17 children who underwent one-stage triple procedure of open reduction, femoral and innominate bone osteotomy for the treatment of DDH. Out of 17 patients, 11(64.7%) were female and 6(35.3%) were male; All the surgeries were done by the same surgeon between January 2014 to December 2019 at the Department of Orthopaedic Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka. The average age was 3.3 years (range 18 months to 7.9 yrs.) at the time of operation. Patients with known neuromuscular and chromosomal disorders and those with prior surgical procedures of a pelvic or a femoral osteotomy were excluded. Only the patients with idiopathic developmental dysplasia of the hip were included. Detailed clinical information about these patients was obtained (Table 1) before surgery.

Table 1: Patient details:

Case	Sex	Hip	Age (yrs+months)	Femoral short	Derotation	Pelvic osteotomy	AI
1	M	B/L	7 +5	2	30	Salter	42
2	F	L	1 + 8	0	20	Salter	26
3	F	L	2 + 2	1	25	Salter	30
4	M	L	1 + 11	1	20	Salter	25
5	F	L	3 + 4	1	25	Salter	32
6	F	L	1 + 10	0	20	Salter	24
7	F	B/L	7 +9	2	30	Salter	45
8	M	B/L	5 +6	1.5	25	Salter	39
9	M	R	2+7	1	25	Salter	34
10	F	L	1 + 9	0	20	Salter	25
11	F	R	2 +3	1	20	Salter	32
12	M	L	1 +10	1	20	Salter	28
13	F	B/L	3 + 8	1	25	Salter	30
14	F	L	2 + 4	1	20	Salter	25
15	F	R	3 +2	1	25	Salter	30
16	M	R	4 +5	1.5	25	Salter	35
17	F	L	1 +9	0	20	Salter	25

The study was approved by the institutional review board and informed consent was obtained from respective parents. The statistical Package for the Social Sciences (SPSS version 20.0) software was used for analysis. Clinical data regarding pain symptoms, gait pattern, range of hip joint motion and presence of Trendelenburg sign were recorded for each patient preoperatively and during postoperative follow-up using the modified McKay's criteria (Table 2) [12]. Tönnis classification system was used to assess the degree of dislocation of the femoral head [13]. Radiographic evaluations included examination of preoperative and follow-up plain radiographs to classify patients according to the Severin's grading system [14]. Avascular necrosis was assessed using Bucholz and Ogden's classification [15, 16].

Table 2: McKay's criteria for clinical evaluation

Grade	Rating	Description
1	Excellent	Sable painless hip, no limp, negative Trendelenburg sign, full range of movement. Stable painless hip,
2	Good	slight limp, negative Trendelenburg sign, slight decrease in range of movement. Stable painless hip,
3	Fair	positive Trendelenburg sign and limited range of
4	Poor	movement, or a combination of these. Unstable or painful hip or both, positive Trendelenburg sign.

Results

Among 17 patients, 11(64.7%) were female and 6(35.3%) were male; 4(23.52%) children had bilateral involvement; 9(52.94%) had left-sided and 4(23.52%) had right-sided involvement. The average age at the time of operation was 3.3 years (range 1.8-7.9 years). The average duration of follow-up was 3.8 years (range 1—4.5 years). Immediate postoperative shortening of lower limb was 0 .5 – 2 cm (average 0.8 cm) which improved to 0.2- 1 cm (average 0.3 cm) during the last follow-up examination. Femur derogated to an average of 24.5^0 (range 20- 30^0) to correct the anteversion that was noted during the operation.

In our study, the average acetabular index (AI) values of the operated hips were 31 (25-45) degree in the preoperative period. However, AI values in the final radiography measure had an average of 19.35 (13-28) degree. The improvement in AI in the hips after the surgery was determined at 18.55 degree on average. The relationship between the follow-up period and the percentage of AI recovery was found to be significant (r= 0.36. $p<0.05$). The adequacy of acetabular remodelling was evaluated by comparing the immediate postoperative radiograph with the latest follow-up radiograph.

Superficial wound infection developed in three hips over the

course of our study. The infection was treated with oral antibiotics and antimicrobial dressings. Re-dislocation was seen in one patient in our study.

According to Tönnis classification of the degree of dislocation severity (preoperatively), 2 patients (9.52%) were in grade ll, 8(38.09%) in grade lll and 11(47.8%) in grade lV, as compared to only 1(4.35%) in grade ll postoperatively.

On the final clinical evaluation, the clinical results according to McKay's scoring system (Table-3) were also favourable. At preoperative evaluation, 16 hips (76.19%) were in fair condition and 5 hips (23.81%) were in poor condition. At the end of the study, there were 8 hips (38.09%) in excellent condition, 10 (47.61%) in good condition, 2 (9.52%) in fair condition, and 1(4.76%) in poor condition.

Table 3: Results according to McKay's criteria for clinical evaluation.

McKay's Score	Pre-op (n)	Pre-op (%)	Post-op (n)	Post-op (%)
Excellent			8	38.1%
Good			10	47.62%
Fair	16	76.19%	2	9.52%
Poor	5	23.81%	1	4.76%

Discussion

The primary goal of treatment of developmental dysplasia of hip is concentric reduction. Failure to treat at early age may lead to gait abnormalities, limitation of motion of the hip, joint pain and osteoarthritis at an earlier age. However, the age beyond which surgical treatment is contraindicated has been the subject of debate due to the risk of serious complication. Concentric reduction in older children may be a challenge more so when the femoral head is flattened or when the acetabulum is dysplastic. Reduction may be hindered by soft tissue contracture with undue pressure on the femoral head. Femoral shortening has been shown to facilitate reduction in children who are more than three years old. It was concluded that a one-stage operation consisting of open reduction, femoral shortening, and correction of an acetabular deficiency with the appropriate pelvic osteotomy is the best option (Figure-1) [13].

A B C

Fig 1: 4.5 years –old male child with right developmental dysplasia of hip corrected with open reduction combined with Salter's Osteotomy and femoral shortening, derotation osteotomy. A) Pre-Operative X-ray; B) 6 weeks postoperative showing good reduction; C) 6 Months postoperatively with excellent remodelling of the acetabulum.

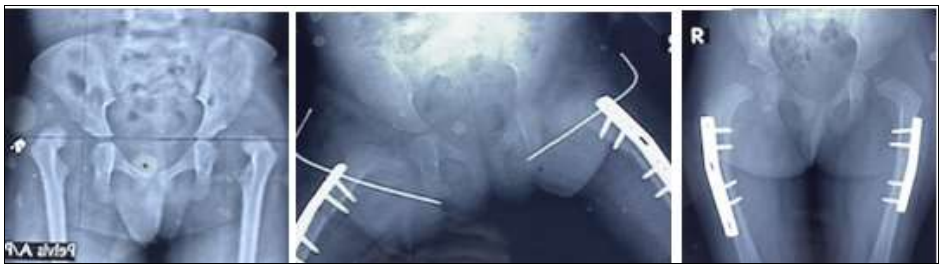
There have been numerous reports discussing the merits of a more aggressive surgical approach that includes a single procedure combining an open reduction with a femoral or pelvic osteotomy. Salter and Dubos showed 93.6% good to excellent results in children of younger age group [17]. Klisicand Jankovic (n=60) reported 63% excellent to good results in the age group of 5-15 years [18]. Karakas *et al*. Operated on 47 patients(55 hips), who were 4 years and more, with 67% good or excellent clinical results and 65% good or excellent radiological results.[19] Ryan *et al*. showed 92% excellent to good results clinically and 72% radiologically [20]. Vallamshetla *et al*. operated on 15 patients(18 hips), who were 4 years and more, with 100% good or excellent clinical results(McKay's criteria) and 100% Severin's classification class l (10) and ll (8) [21]. In this study showed 85.72 excellent to good results in the age group of 1.8 Months to 8 years.

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 degree to 27 degree and improve the CEA averaging 15 degree [17]. The best time to perform an osteotomy of the acetabulum for DDH patients is still a concern [22]. Saleh *et al*. [28] 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 [23]. Salter osteotomy virtually eliminated acetabular dysplasia in all cases and allowed further undisturbed acetabular development. Principle of preserving the shape and capacity of the acetabulum by Salter's innominate osteotomy is important for the future function and development of the joint as compared to Pemberton osteotomy which alters the shape of acetabulum and decreases its capacity. Our results were 85.72% excellent and good clinical outcomes, and 14.28% fair to poor clinical results. The reoperation rate for re-dislocation in our series (4.3%) also compares favourably with other reports. Similarly, favourable results were also observed when clinical parameters were compared before and after surgery. At final follow-up, excellent to good results were noted in 18 hips (85.72%) compared to none before surgery. Only 3(14.28%) hips joint demonstrated fair to poor condition at follow-up compared to 23(100%) prior to surgery.

AVN of femoral head is one of the most serious complications in the treatment of DDH and inevitably results in deformity and late degenerative arthritis.[24] The major

causes of AVN of femoral head are excessive pressure on the cartilaginous femoral head due to tight reduction of high displacement of the hip and contracted soft tissues in older children [25]. The vascular compromise of femoral head may also be caused due to excessive abduction and internal rotation during the maintenance of reduction in Spica cast or injury to circumflex artery while cutting the transverse acetabular ligament. The reported incidence of AVN following open reduction with femoral or pelvic osteotomy varies from 7% to 22% [5, 26]. However, we were fortunate to have AVN in only 2(9.52%) hips which may be due to our extra conscious attitude of reduction at ease and maintaining hip in Spica cast at 25^0 abduction, neutral rotation and extension. Our overall AVN rate is comparable with that reported in other studies [16, 20, 21, 24] although it was slightly higher. AVN is a common complication in the treatment of DDH, particularly after open reduction rather than pelvic osteotomy [17].

We always operate bilateral DDH under single anaesthesia to minimize hospitalization, psychological impact on patient/ parents, expenditure and use of medicine (Figure-2). A trans fixation K-wire 1.5mm was used to stabilize femoral head in the true acetabulum in almost every hip and a small DCP to osteosynthesis proximal femoral osteotomy site. Till re-subluxation and AVN development, premature epiphyseal fusion, which leads to short femoral neck and partially uncovered femoral head due to less effective development of acetabulum, as seen in our two cases, have been reported previously [26, 27]. One hip in this study that went to re-dislocation, had no pelvic osteotomy at primary procedure. They required secondary procedure of Salter's osteotomy. This further supports the claim of addition of pelvic osteotomy, especially in those hip that have stable hip on Catteral's test of stability [27], in position of flexion, abduction and internal rotation. Only one subluxation and one re-dislocation were encountered in our study, which was comparable to results in other series [2, 9, 20, 21].



A B C

Fig 2: 3.8 years-old female child with bilateral developmental dysplasia of hip corrected with open reduction combined with Salter's osteotomy and femoral shortening derotation osteotomy. A) Pre-operative x-ray; B) 8 weeks postoperative x-ray; C) 9 months postoperatively with good remodelling of the acetabulum.

There were few limitations of this study that include small sample size, short period of follow-up, lack of good record-keeping, and lack of compliance on the part of parents who failed to ensure proper rehabilitation in post-cast period.

Conclusion

One-stage surgery for DDH, which include open reduction, capsulorraphy, Salter's and femoral derotation osteotomy in walking age children is a safe and highly effective method. This procedure doesn't need preliminary traction to re-locate and the complications rate is low. In addition, it is a cost effective procedure and minimizes socio-economic burden and psychological trauma incurred by lengthy hospitalization by treatment with traction followed by closed reduction.

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