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Outcome of the treatment of developmental dysplasia of the hip after walking age with open reduction, varus derotation osteotomy with femoral shortening and acetabular osteotomy

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ABSTRACT

Background: The principles of treatment of developmental dysplasia of hip after walking age are different than those of infants and neonates. The purpose of this study is to evaluate the radiographic and functional results of open reduction, varus derotation osteotomy with femoral and acetabular osteotomy of DDH in older children.
Methods: Between March 2021 and August 2023, 22 patients underwent one-stage triple procedure of open reduction, varus derotation osteotomy with femoral shortening and acetabular osteotomy for the treatment of DDH. Clinical outcomes were assessed using the modified McKay's criteria. Radiographic assessment was made using Severin's scoring system.
Results: The mean age at the time of operation was 5.068±1.8535 years (range 3–8 years) with male to female ratio 1:2.66. Mean preoperative acetabular index of the study population was 48.55±7.63 which significantly reduced to 23.68±2.93 postoperatively ($p<0.05$). The McKay's score was excellent in 14 (63.6%) hips, good in 02 (9.1%) hips, fair in 01(4.5%) and poor in 05(22.7%) hips. The modified Severin's class excellent was in 14 (63.6%) hips, good was in 02(9.1%) hips, fair is in 01 (4.5%) hip and poor was in 05 (22.7%) hips at the time of final evaluation as compared to none at the time of presentation.
Conclusions: Young children having DDH can be safely treated with an extensive one-stage procedure of open reduction, varus derotation osteotomy with femoral shortening and acetabular osteotomy, without increasing the risk of AVN. This one-stage surgical procedure for managing DDH patients after walking age also revealed acceptable clinical and radiological outcome.

Keywords: Developmental dysplasia of the hip, Open reduction, Osteotomy, Varus derotation

INTRODUCTION

Developmental Dysplasia of the Hip (DDH) encompasses a spectrum of conditions affecting the hip joint, including instability, subluxation and dislocation. It represents a continuum from mild acetabular dysplasia to complete dislocation of the femoral head from the acetabulum. The transition from the term "congenital dislocation of the hip" to DDH acknowledges postnatal abnormalities, emphasizing that some cases present with normal hips at birth but develop issues later.[1] The etiology of DDH is multifactorial, involving a failure of the femoral head to maintain its position within the acetabulum during growth. Contributing factors include fetal positioning, ligamentous laxity and abnormal mechanical forces.[2]

In newborns, clinical signs of hip instability, such as a positive barlow test (provocation of dislocation) or Ortolani test (relocation of a dislocated hip), are key diagnostic tools. In teratologic dislocations, these tests may be negative but are often accompanied by limited hip abduction or a limb length discrepancy (Galeazzi sign).[3]

Symptoms such as limping, hyperlordosis and restricted mobility typically emerge when the child begins walking.[4]

The global incidence of DDH shows significant variation, influenced by population-specific factors. The reported prevalence of hip instability ranges from 1 to 3.4 per 1,000 live births, while actual dislocations are documented in approximately 1 to 1.5 per 1,000 live births.[5] Low rates are observed in African Bantu and Chinese populations, whereas higher incidences are noted in Navajo Native Americans and certain Canadian communities.[6,7] Diagnostic modalities for DDH vary by age.

Ultrasonography is preferred in infants younger than six months, transitioning to radiographic evaluation once the femoral head begins ossifying. Radiographs are essential for assessing acetabular and femoral development in older children.[8] Treatment options for DDH are age-dependent and include Pavlik harness for infants, open or closed reduction in toddlers and combined surgical procedures such as acetabular osteotomy and femoral shortening in older children.[9]

Despite significant progress in DDH management, complications such as avascular necrosis (AVN) remain a concern, particularly in bilateral cases. Reported AVN rates vary widely, from 11% to over 50%, depending on treatment approaches and patient populations.[10] Effective management of DDH, including early diagnosis and timely intervention, is crucial for reducing the long-term risk of osteoarthritis and optimizing functional outcomes.

Untreated DDH will cause early onset arthritis and joint destruction, ultimately the need for artificial joint replacement which will adversely affect patient's quality of life. In those cases, who will refractory to close reduction, early open reduction to reorient the acetabulum in order to maintain the physiologic growth of the hip joint must be surgically addressed.Favorable coverage of the femoral head will require to obtain a functional hip by shifting the center of the femoral head caudally and medially with femoral shaft in external rotation. The goals of the operative treatment in older children will not differ from those in young patients to obtain a well reduced and stable hip. There will be a tendency to recommend a one stage procedure consisting of open reduction, varus derotation osteotomy with femoral shortening and pelvic osteotomy to correct DDH.

Objectives

General objectives: To find out the one stage post-surgical outcome of the treatment of DDH after walking age by assessing clinical outcome, radiological outcome and post-surgical complications.

Specific objective

To assess the clinical outcome according to modified McKay criteria for DDH. To assess the radiological outcome of the DDH according to modified severin classification and acetabular index (AI). To observe the post-operative complications of the operative procedures.

METHODS

Study design

The study was a Prospective Interventional Study (Quasi-Experimental Study) aimed at evaluating single-stage surgical outcomes of DDH in children aged 18 to 96 months. Conducted over 24 months (01/09/2021 to 31/08/2023) at Dhaka Medical College and Hospital, it involved 22 patients selected via purposive sampling based on strict criteria. Surgical procedures included open reduction, varus derotation osteotomy with femoral shortening, acetabuloplasty and hip spica application. Pre- and post-operative clinical and radiological assessments, along with follow-ups, were performed to monitor outcomes and complications.

Sample calculation formula

The sample size was determined using the formula, where

n=desired sample size, Z = standard normal deviation (1.96 at 95% confidence level), p = prevalence rate (6%, based on Vasilcova et al) = 0.06, q =1−p1 -p1−p =0.94 and d=allowable error (10%) = 0.1

Considering a 10% dropout rate, the final sample size was adjusted to 23 and a total of 22 patients were included in the study.

Inclusion criteria

Children aged 18 to 96 months with clinical and radiological evidence of DDH were included in the study. Both male and female patients were considered, regardless of unilateral or bilateral involvement. Candidates were selected based on their ability to undergo the proposed surgical procedures and follow the treatment plan, ensuring compliance with post-operative care and follow-up.

Exclusion criteria

Children with acquired dislocations of the hip or those with DDH associated with other congenital abnormalities were excluded. Additionally, patients with a history of prior unsuccessful surgical intervention for DDH or those with medical conditions contraindicating surgery were not considered for the study.

Study procedure

The study involved a detailed pre-operative assessment, including clinical history, physical examination and radiological evaluation to measure the acetabular index (AI) and assess hip stability. Patients underwent a single-

stage surgical intervention comprising open reduction, varus derotation osteotomy with femoral shortening, acetabuloplasty and application of a hip spica. Open reduction involved clearing the acetabulum, dividing the iliopsoas tendon and performing capsulorrhaphy. Femoral shortening was conducted to minimize pressure on the reduced femoral head and prevent avascular necrosis.

Acetabuloplasty was performed to improve anterior acetabular coverage using bone grafts. Post-operatively, patients were immobilized in a hip spica cast for 6–12 weeks, followed by gradual rehabilitation. Follow-ups were scheduled at 2, 6 and 12 weeks, with subsequent visits every 6 months to monitor clinical and radiological outcomes and manage complications. Data were collected and analyzed to assess outcomes based on Modified McKay and Severin criteria and acetabular index improvement.

Statistical analysis

Statistical analysis of the collected data was performed using SPSS version 26.0. Quantitative data, such as age, limb length discrepancy and acetabular index, were expressed as mean±standard deviation. Qualitative data, such as the presence of complications, were presented as frequency distributions and percentages. The analysis of different variables was done using standard statistical tests, with significance set at a p value of<0.05.

Pre- and post-operative results were compared using appropriate statistical tests to evaluate the effectiveness of the surgical intervention. The data were meticulously checked for accuracy and consistency, with corrections made for any discrepancies.

Ethical consideration: Ethical considerations were strictly adhered to throughout the study. Informed written consent was obtained from the guardians of all patients after explaining the study details, procedures, potential risks and benefits.

The study was approved by the institutional ethical review board of Dhaka Medical College and Hospital to ensure the ethical treatment of all participants. Confidentiality and privacy were maintained at all stages and participants were allowed to withdraw from the study at any time without consequence. The study ensured that no patient was deprived of standard medical care or treatment.

RESULTS

Total 22 patients and 29 hips were enrolled on the basis of inclusion and exclusion criteria. All patients were evaluated preoperatively, operated and then followed up at 2nd, 6th, 12th weeks and 06 months postoperatively.

Quantitative data were expressed as mean and standard deviation and qualitative data were expressed as frequency and percentage. A probability value (p) of less than 0.05 was considered as statistically significant.

Age ranges of the patients were found between 3 to 8 years. Most of the patients 07 (31.80%) were 04 years of age followed by 05 (22.7%) of 03 years and 04 (18.2%) by of 7 years.

Mean age were found 5.068±1.8535 years. Most of the study patients were female with a male-female ratio was 1:2.6. Most of the patients were with negative family history 20 (90.10%) whereas only 02 (09.90%) were with positive family history.

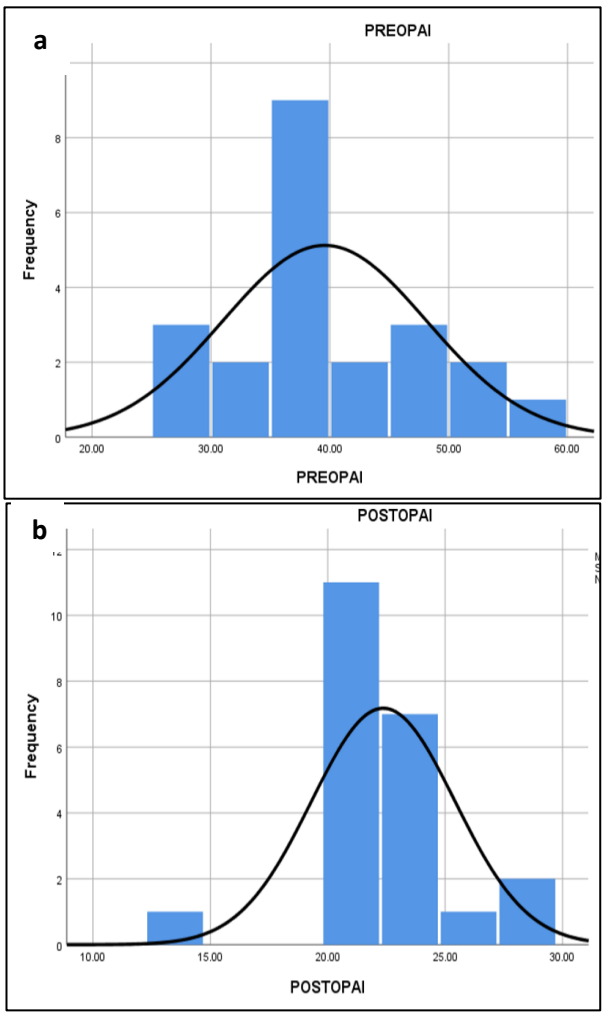

Figure 1: (a, b) Histogram with normal distribution (A) pre-operative acetabular index (AI) mean and (B) post-operative acetabular index (AI) mean.

Here, points estimation between two mean (P)= (48.55-23.68) = 24.68. Standard error mean (SEM)= $\sqrt{(SE12+SE22)}=\sqrt{}$ (2.62+0.38)=1.73. (Here, SE1=SD1/√n=7.63/√22=1.62, SE2= SD2/√n=2.93/√22=0.62). So, at 95% Confidence interval (CI) difference between two means=24.68± (1.96×SEM) =24.68 ± (1.96×1.73)=24.68±3.39=21.26 to 28.04. So, the null hypothesis H0) is rejected and the result is considered significant at 5% level of significance.

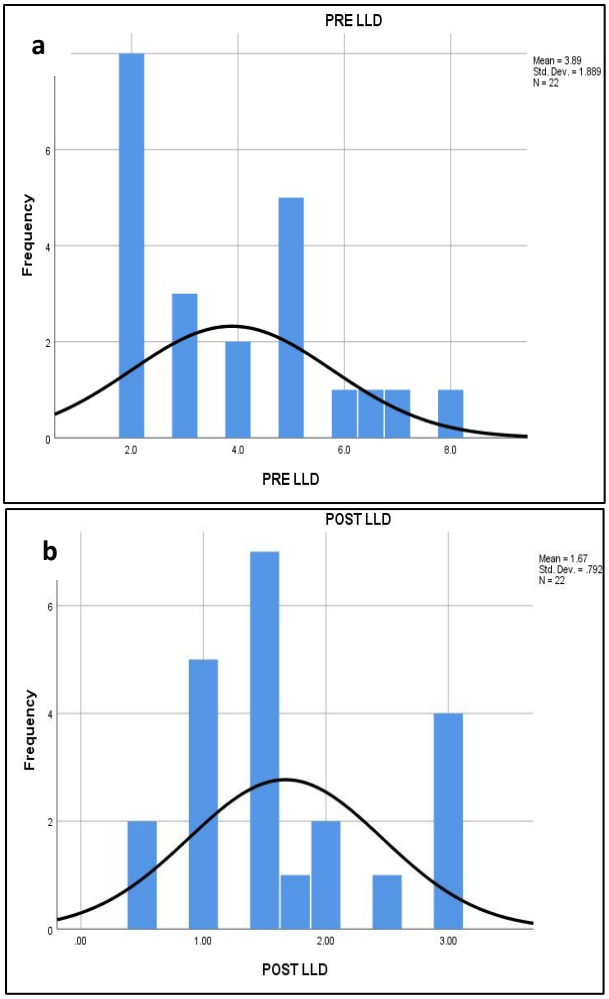

Figure 2: (a, b) Histogram with normal distribution (A) pre-operative LLD mean and (B) post-operative LLD mean.

Here, points estimation between two mean (P)= 3.88-1.67=2.21. Standard error mean (SEM)= $\sqrt{(SE12+SE22)}$ =√ (0.16+0.03) =0.435. (Here, SE1=SD1/√n=1.88/√22=0.4, SE2= SD2/√n= 0.79/√22=0.17). So, at 95% Confidence interval (CI) difference between two means= 2.21± (1.96×SEM) = 2.21±(1.96×0.435) =2.21±0.85= 1.36 to 3.06. so, the null hypothesis H0) is rejected and the result is considered significant at 5% level of significance.

In terms of the side involved, left side was the commonest 10 (45.50%), followed by bilateral 07 (31.800%) patients and right side 05 (22.70%).

As for the distribution of the patients by breech presentation 08 (36.40%) and combined breech and oligohydramnios patients are 08 (36.10%) followed by cephalic presentation patient are 05 (22.70%).

Preoperatively mean of AI of the study population was 48.55±7.63 which significantly reduced to 23.68±2.93 postoperatively (P<0.05) and preoperatively range of AI of the study population was 32.00-60.00 which significantly reduced to 20.00-30.00 postoperatively (p<0.05).

Preoperatively mean LLD of the study population was which was 3.886±1.8894 significantly reduced to 1.6750±0.79202 postoperatively (P<0.05).

Radiographically Severin's class I was found in 14(63.60%) patients, Severin's class II was found in 02 (09.10%) patients and Severin's class III was found in 01 (04.50%) and Severin's class IV was found in 05 (22.70%) of patients.

After clinical evaluation by McKay's criteria excellent was found in 14(63.60%) patients, good was found in 02 (09.10%) patients, fair was found in 01 (4.50%) patients and poor was found in 05 (22.70%) patients.

After evaluation of final outcome, excellent was found in 14 (63.60%) patients, good was found in 02 (09.10%) patients, fair was found in 01 (4.50%) patients and poor was found in 05 (22.70%) patients. Satisfactory outcome of the study is the summation of excellent, good and fair outcome together is 17 (77.20%) and poor outcome is considered as unsatisfactory in 5 (22.50%).

Therefore, at 95% confidence interval (CI), satisfactory outcome is ranged between 60.14 to 94.4. Since these ranges have no null values (zero), so H0 (Null hypothesis) is rejected. So, the result of Outcome of the treatment of developmental dysplasia of the hip after walking age with open reduction, varus derotation osteotomy with femoral shortening and acetabular osteotomy is statistically significant.

Regarding post-operative complications of study patients; in this study, 04 patients (18.20%) developed AVN of hip joint, 01 (4.50%) patients of superficial wound infection who responded to conservative treatment, another 02 (09.52%) patients of superficial cutaneous femoral nerve injury and stiffness of hip joint were improved within 06-12 weeks by conservative treatment.

Table 1: Distribution of demographic data of the study patients (n=22).

Characteristics	Number of patients	%
Age (in years)		
3	5	22.7
4	7	31.8
4.5	1	4.5
6	2	9.1
7	4	18.2

Continued.

Characteristics	Number of patients	%
8	3	13.6
Mean±SD	5.068±1.8535	
Range (min-max)	3-8	
Gender		
Female	16	
Male	06	27.30
Family history		
Positive	02	09.10
Negative	20	90.90
Side involved		
Left	10	45.50
Right	05	22.70
Bilateral	07	31.80

Table 2: Distribution of the study patients by prenatal history (n=22).

Presentation and history	Number of patients	%
Breech	08	36.40
Cephalic	05	22.70
Oligohydramnios	00	00
Twin pregnancy	00	00
Combined breech and oligohydramnios	08	36.40
Combined cephalic and oligohydramnios	01	04.50
Total	22	100.00

Table 3: Pre-operative & post-operative status of acetabular index (AI) (angle in degrees) of the study patients (n=22).

Acetabular Index	Mean±SD	Median	Range
Preoperative	48.55±7.63	50.00	32.00-60.00
Postoperative	23.68±2.93	23.00	20.00-30.00
P value	<0.05		

Table 4: Pre-operative & post-operative limb length shortening (LLD) of the study patients (n=22).

LLD	Mean ±SD (cm)	Median	Range
Preoperative	3.886±1.8894	3.50	2.0-8.0
Postoperative	1.6750±0.79202	1.50	0.5-3.0
P value	<0.05		

Table 5: Distribution of the study patients by radiographic Severin's classification (n=22).

Severin's class	Number	%
I (Excellent)	14	63.60
II (Good)	02	09.10
III (Fair)	01	04.50
IV (Poor)	05	22.70
Total	22	100

Table 6: Functional outcome according to McKay's criteria for clinical evaluation (n=22).

McKay's criteria	Number of patients	%
Excellent	14	63.60
Good	02	09.10
Fair	01	04.50
Poor	05	22.70
Total	22	100

Table 7: Final outcome according to modified Severin's classification and McKay's criteria for clinical evaluation (n=22).

Final outcome	Number of patients	%
Excellent	14	63.60
Good	02	09.10
Fair	01	04.50
Poor	05	22.70
Total	22	100

Table 8: Distribution of the study patients by postoperative complications (n=22).

Postoperative complications	Number of patients	%
AVN of hip joint	04	18.20
Superficial infection	01	04.50
Superficial cutaneous femoral nerve injury	01	04.50
Stiffness of hip joint	01	04.50
Total	07	31.70

DISCUSSION

The aim of treating developmental dysplasia of the hip (DDH) after the walking age is to achieve favorable clinical and radiological outcomes with minimal persistent dysplasia, ultimately preventing secondary degenerative arthritis. This study evaluates the outcomes of single-stage surgical management comprising open reduction, femoral shortening with derotational osteotomy and acetabular osteotomy. The mean age at surgery reported in this study was 5.1 years, comparable to the findings, who reported a mean age of 5.2 years.[11] Other studies have documented a mean age of 11.9 years, 4.1 years and 3.2 years.[12-14]

A higher prevalence of DDH in females (72.72%) was observed, which may be attributed to increased ligamentous laxity caused by circulating maternal relaxing. Left-sided DDH was present in 45.50% of cases, possibly due to the left occiput anterior positioning in breech newborns, which limits hip abduction. Bilateral hip involvement was noted in 31.80% of cases, consistent with previously reported rates of 26%–36%.[15]

Clinical and radiological outcomes were consistent with previous studies that used similar surgical approaches. Significant improvements after open reduction, femoral and pelvic osteotomies, supporting the notion that a similar degree of correction can be achieved despite minor variations in techniques.[12,14,15] One-stage surgery has been advocated by several authors for children older than three years.[12,15,16]

This study treated untreated DDH in children aged 2–8 years with a one-stage procedure. Suvorov et al. reported excellent radiographic outcomes in 50% of cases and good outcomes in 36.4% of cases after one-stage surgery in patients aged 2–6 years.[13] Li et al, reported satisfactory clinical outcomes in 58.6% of cases and radiographic outcomes in 95.8% of cases in a series of 70 hips aged 18–89 months.[14] Jamil et al observed satisfactory clinical outcomes in 72.7% and radiographic outcomes in 71.2% of cases, while Zein et al reported clinical satisfaction in 87.3% and radiographic improvement in 8.7% of cases.[12,17] In the present study, satisfactory clinical and radiographic outcomes were observed in 72.6% of cases, aligning with these findings.

Avascular necrosis (AVN) of the femoral head remains a significant iatrogenic complication, especially in cases of higher-grade dislocation, inverted limbus, hypertrophic soft tissue or older treatment onset. Femoral shortening has been shown to facilitate reduction and mitigate the risk of AVN.[12-14,16] Reported AVN rates include 34.8% by Jamil et al, 8.0% by Badrinath et al and 50% Suvorov et al, Hussain et al reported a 23.4% incidence in 45 of 192 hips.[11,13,18] This study found an AVN rate of 18.20%, consistent with previous reports.

Early detection and appropriate treatment are critical for achieving favorable outcomes and minimizing complications. However, walking-age DDH remains common in developing countries, presenting a challenge for orthopedic care. A single-stage operation offers the advantage of reducing AVN risk while correcting deformities, providing a stable, concentric and functional hip joint. This study supports the efficacy of a one-stage procedure in achieving satisfactory clinical and radiological outcomes in walking-age DDH patients.

This study was conducted at a single hospital setup, so the study population may not represent the whole community which is needed for study. There is a chance of selection bias due to purposive sampling. Long term outcome couldn't be assessed due to short follow up duration. Our study is limited by its retrospective design and relatively small number of subjects. Measurements on radiograph were performed by single researcher, but we did not perform reliability study prior to data collection. We had

difficulty in comparing our results with other studies due to the different age group, duration of follow up, surgical procedures and techniques.

CONCLUSION

Treatment of developmental dysplasia of the hip after walking age with open reduction, varus derotation osteotomy with femoral shortening and acetabular osteotomy as onestage surgical treatment for DDH gives excellent clinical & radiological outcome. We believe that the surgical principle in DDH, which is "concentric reduction without tension" should be strictly adherent to, even with additional bony procedures may need to be performed to achieve it.

Correction of acetabular dysplasia by Pemberton, Salter. Shelf or other innominate osteotomies is very important to achieve a stable reduction of the hip. Femoral shortening should be performed in cases where tight reduction is achieved to avoid pressure on the femoral head and development of AVN. Femoral derotational osteotomy is usually required with femoral shortening for excessive femoral neck anteversion. In addition, meticulous surgical technique by highly skilled surgeon is paramount in difficult cases.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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