

# Management of DDH in children between age of (1-2.5) years old by open reduction & derotation osteotomy without pelvic osteotomy

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## Abstract

**Background;** Developmental dysplasia of the hip (DDH) means femoral head subluxation or dislocation and/or acetabular dysplasia. Management of neglected (DDH) in children after the walking age is challenging to the orthopedic surgeons. It is usually surgically demanding procedures at this age group. There will be always children who reach walking age with DDH, either secondary to failed treatment or delayed diagnosis.

**Aims:** To evaluate the results of open reduction & derotation osteotomy in treatment of DDH in children without pelvic osteotomy.

**Methods:** At the Orthopedic Department in AL-Yarmook hospital from the period of December 2010 to November 2015. Twenty-three patients (3 patients had bilateral DDH) [26 hip joints] with DDH, the age of patients at time of the operation ranged from (12-30) months, treatment done in two stages open reduction (1<sup>st</sup> stage) and derotation osteotomy of femur (2<sup>nd</sup> stage), except Five cases, we did open reduction, shortening & derotation osteotomy in one session because of difficulty in reduction. Final functional & clinical evaluation of patients were done according to a combination of **modified MacKay criteria and modified Harris hip score**. Radiological evaluation at the end of follow-up was done according to the **modified Severin radiographic criteria**.

**Results:** - The overall final clinical results were excellent in 8 hips (30.8%), good in 16 hips (61.6%), fair in one hip (3.8%) and poor in one (3.8%), satisfactory (excellent and good) in 24 hips (92.3%) and unsatisfactory (fair and poor) in 2 hips (7.7%). The radiological end result was Class I (excellent) in 15 hips (57.7%), Class II (good) in 10 (38.5%), Class III (fair) in one (3.8%). The results were satisfactory in 25 (96%) hips and unsatisfactory in one (4%) hip.

**Conclusion:** We concluded that operative treatment of neglected DDH ( after the age of walking ) is a surgically demanding procedure but when it performed properly by an open reduction & derotation osteotomy with spending good time for cleaning of acetabulum & excise part of capsule with secure capsulorrhaphy without need for pelvic osteotomy for those children below age of 2.5 years old.

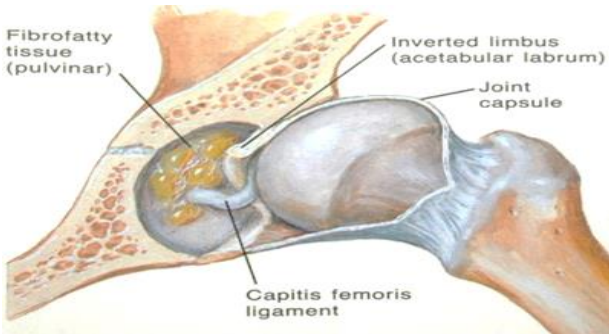
**Key words:** Developmental dysplasia of the hip, open reduction, derotation osteotomy.

## INTRODUCTION

Developmental hip dysplasia (DDH) is a generic term describing a Spectrum of anatomical abnormalities of the hip that may be congenital or after birth (during infancy or childhood).<sup>[1]</sup> The subject covers mild defects such as a shallow acetabulum to severe defects such as

teratologic dislocations.<sup>[2]</sup> Teratologic dislocations occur before birth and include severe deformity of both proximal femur and the acetabulum. <sup>[3]</sup> Although there is no single cause of DDH, a number of predisposing factors have been identified, these factors include ligamentous laxity, prenatal positioning, postnatal positioning, and racial predilection. The etiology of

DDH clearly is multifactorial and is influenced by hormonal and genetic elements. [4,5] The acetabulum is often shallow and maldeveloped. The proximal femur shows coxa valga & anteversion. Soft tissues interposition between the displaced femoral head and acetabulum are common (Fig. 1). [7] The acetabular labrum is inverted into the joint, enlargement of the ligamentum teres and the acetabulum may contain fatty tissue. [8] The iliopsoas tendon is interposed between the femoral head and acetabulum, causing a depression in the joint capsule [8]. This gives the capsule an hour glass appearance. [8]

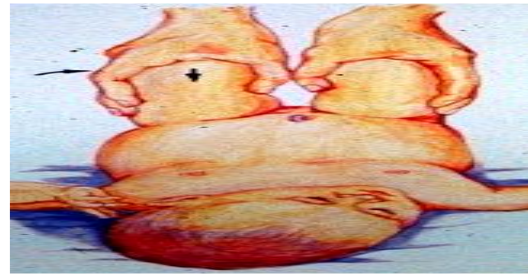


**Fig (1):** pathology of hip joint in DDH [8]

The early diagnosis of DDH is critical for successful outcome, so every newborn should be screened for signs of hip instability. The hip should be examined using both the Barlow and Ortoloni tests (Fig.2). The signs of DDH change with the infant's age (Fig3). For example, the incidence of hip instability declines rapidly about 50% within the first week. The classic findings of shortening and stiffness increase over the first few weeks of life. These signs become well established in the older infant (Fig.4). In early infancy, instability is the most reliable sign. Later, limitation of abduction and shortening (Fig.5) are common with asymmetry of skin folding on inner side of thigh (Fig.6). [9] Beware of the bilateral dislocations, as they are more difficult to identify (Fig.7). If hip abduction is less than about 60° on both sides, order an imaging study



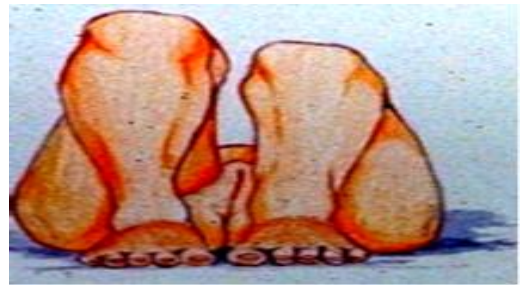
**Fig. 2** Ortoloni's sign [10]



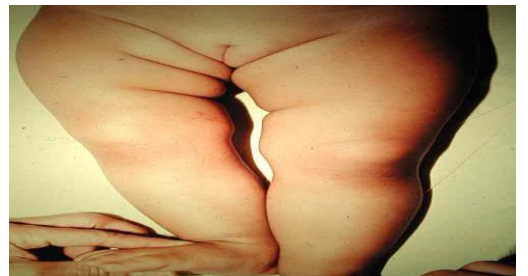
**Fig.3** Barlow's test [10]



**Fig. 4** DDH in older infant. Note the limited abduction [11,12]



**Fig.5** Gelliazi sign [11,12]



**Fig.6** asymmetry & shortening [13,14]

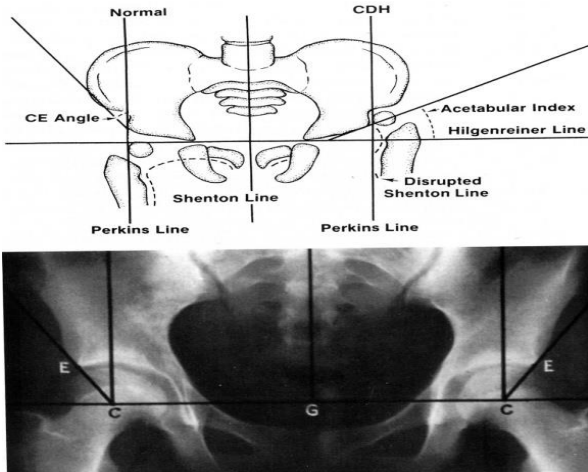


**Fig. 7** Bilateral DDH [13,14]

Ultrasound imaging is an effective screening method for early detection of DDH. It's appropriate method to evaluate a suspicious finding, when hip-at-risk factors

are present, and to monitor the effectiveness of treatment in early infancy (1<sup>st</sup> 6 months of life)<sup>[15,16,17,18]</sup>.

Above the age of 6 months of age, X-ray is reliable and is the suitable age for screening by this method.<sup>[16, 17,18]</sup> A single (AP) view is adequate by measure the acetabular index (AI). Normally, the (AI) in early infancy falls below 30°, is questionable in the 30°– 40° range, and abnormal if above 40°. Hip subluxation or dislocation may often be demonstrated by the metaphysis of the femur positioned lateral to the lateral acetabular marginal line (Fig. 8).



**Fig.8 Demonstration of Hip subluxation or dislocation [16,17]**

The objectives of management of DDH include early diagnosis, reduction of the dislocation, avoidance of avascular necrosis, and correction of residual dysplasia<sup>[19,20]</sup>. The management of neglected DDH in children who reach the ambulatory age is challenging to orthopedic surgeons & usually needs surgery at this age group as shown in table (1).<sup>[19,20,21,22]</sup>

**Table (1) Summary of management of DDH [19, 20]**

Guidelines for treatment of DDH in relation to age group
<b>Neonate:</b> Place in Pavlik harness splint for 6 weeks duration.
<b>1 to 6 months:</b> Place in Pavlik harness for 6 weeks after hip reduces by closed reduction.
<b>6 to 18 months:</b> skin traction; closed reduction. If closed reduction is successful, place in cast for 3 months. If closed reduction is unsuccessful, perform open reduction.
<b>18 to 24 months:</b> Trial of closed reduction, or open reduction. A Salter osteotomy may or may not be part of the procedure.
<b>24 months to 6 years:</b> primary open reduction and femoral shortening, with or without a Salter osteotomy.

## PATIENTS AND METHODS

At the Orthopedic Department in AL-Yarmouk hospital from the period of December 2010 to November 2015. Twenty –three patients (26 hips ) with DDH were treated surgically ,treatment done in two stages in (21 hips ) by open reduction (1<sup>st</sup> stage) and derotation osteotomy of femur ( 2<sup>nd</sup> stage) below age of 2.5 years, except Five cases, we did open reduction , shortening & derotation osteotomy in one session because of difficulty in reduction .The follow up ranged from sixteen to twenty four months with an average twenty months. There were 21 females and 2 males (both of them left side of hip joint are involved), the youngest age was 12 months and the oldest was 30 months with an average of 21 months. 3patients females had bilateral DDH & the other 20 patients had unilateral DDH (12 had involving left hip joints & the other 8 patients , the right hip joints had involved ,5 patients treated by conservative treatment before the age of one years while the others 18 patients discovered after the baby starting walking after the age of one year. All of these patients had been given history of delivery by caesarian section, 8 patients had family history of DDH while the others (15 patients) had idiopathic causes, and these data are shown in Table (2).

**Table (2) Statistics of the study**

<b>No. of patients</b>	23 patients (26 hips)
<b>Male: Female</b>	2:21
<b>Rt: Lf</b>	8:12(3 bilateral)
<b>Average age</b>	21months
<b>OR +DO</b>	21 hips
<b>OR+DO+shortening</b>	5 hips
<b>Average follow up</b>	20 months

**OR=Open Reduction, DO=Derotation Osteotomy**

Pre-operatively, all patients in this study were subjected to clinical examination at serial of follow-up."Limping, Trendelenburg's test, hip stability in supine position, deformity (presence or absence) and the range of motion were measured at the last patient visit."Objective clinical evaluation of patients was done according to a combination of *modified MacKay criteria and modified Harris hip score*" (Table3)<sup>[23, 24]</sup>. Subjective radiological evaluation using (AP) radiographs to measure the acetabular index (AI), changes in the femoral head related to sphericity and the density were also researched. Values of the (AI) more than 30° were considered abnormal and indicative of impending subluxation or dislocation. All patients in this study had an acetabular index above 30 degrees which were considered abnormal. The average acetabular index pre-operatively was  $43 \pm 2.5^\circ$  (range, 36°–50°)." Objective

radiological evaluation at the final results of follow-up was done according to the *modified Severin radiographic criteria* "(Table 4) [23].

**Table (3) Modified MacKay criteria and modified Harris hip score.** [23,24]

<b>Pain</b>	
No pain	40
Mild pain, no effect on ordinary activities	30
Moderate pain, moderate limitation of ordinary activities	20
Severe pain, severe limitation of ordinary activities	10
Pain at rest	0
<b>Limp</b>	
No	10
Limp	0
<b>Trendelenburg sign</b>	
Absent	10
Present	0
<b>Stability of the hip in supine position</b>	
Stable	10
Unstable	0
<b>Deformity</b>	
Absence of deformity	10
Presence of deformity where any of the following is present	0
More than 30° fixed flexion deformity	
More than 10° fixed adduction contracture	
More than 10° fixed internal rotation in extension	
Limb length discrepancy more than 2 cm	
<b>The range of motion</b>	
Full range	20
Mild limitation	15
Moderate limitation	10
Severe limitation	0

The overall clinical result is considered satisfactory when the final score is excellent (91–100) or good (81–90) and unsatisfactory when the score is either fair (71–80) or poor (less than 70).

21 patients (hips) in this study were subjected to two-stage operative treatment in the form of: open reduction with proper cleaning of acetabulum & proper secure capsuloraphy without pelvic osteotomy and 6 weeks later derotation osteotomy followed by a period of immobilization in a hip spica cast for 6 weeks, 5 hips we did open reduction, femoral osteotomy & shortening in one stage because of difficulty in reduction by 2 separate incision. All of these 23 patients below age of 2.5 years without need pelvic osteotomy.. The plane of treatment

depend on pre-operative clinical examination and imaging findings (acetabular index), in addition to spend good time (intra-operative) cleaning of the acetabulum as shown in (table5)

**Table (4) Modified Severin radiographic criteria.**[23]

<b>Class I (excellent)</b>	<b>Normal hip with acetabular index &lt;25°</b>
<b>Class II (good)</b>	Concentric reduction, abnormal shape of head, neck or acetabulum acetabular index <25°
<b>Class III (fair)</b>	Dysplastic hip with mal developed acetabulum roof., no subluxation
<b>Class IV (poor)</b>	Subluxation (femoral head displaced cranially and laterally)
<b>Class V (poor)</b>	Femoral head articulates with a false acetabulum
<b>Class VI (poor)</b>	Complete redislocation

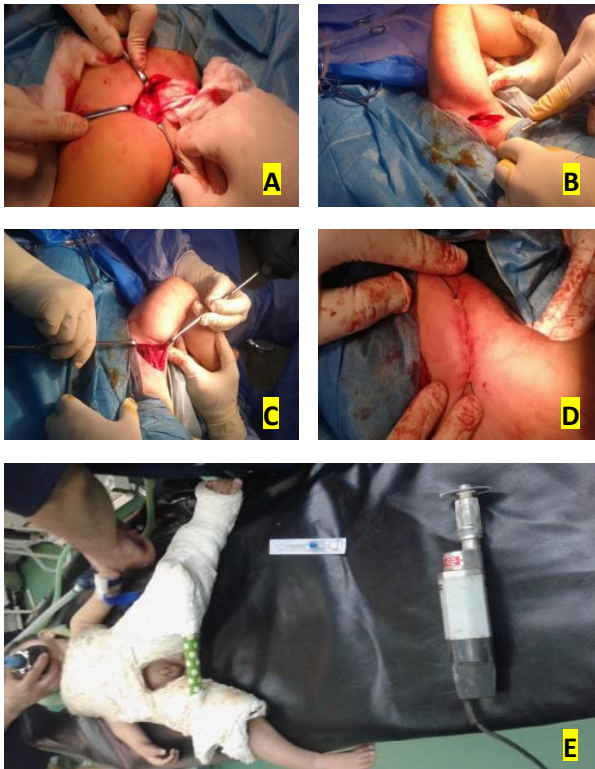
**Table (5) Methods of treatment.**

<b>Method</b>	<b>Frequency</b>
OR,femoral osteotomy	21hips
OR,femoral osteotomy ,shortening	5hips
<b>Total</b>	<b>26 hips</b>

**Operative Technique**

Under GA, the patient is placed supine in position with a roll under the hip (to make iliac crest more prominent). Adductor tenotomy done in all patients (fig.9-A) as a first step. The skin incision is an oblique “bikini” (fig.9-B) incision. . The incision is then extended over the iliac crest and the dissection is carried down to the apophysis of the crest. The lateral femoral cutaneous nerve is protected. The sartorius muscle is detached & reflected. The straight head of rectus femoris is identified as it origin from the anterior inferior iliac spine & it is cut & detached. The iliac apophysis is cut by cautery down to the bone of the crest. The hip capsule is exposed laterally and iliopsoas tendon which is cut by cautery, medial exposure of capsule by flexion of the hip which relaxes the iliopsoas, the capsule is opened with a knife (fig9.C). The incision extends between the transverse acetabular ligaments medially and to point above the greater trochanter laterally. A longitudinal capsular incision is made down ward to the femoral neck, forming a “T shape.” The ligamentum teres is sectioned & followed to the depths of the acetabulum. After proper cleaning of the acetabulum with thorough release medially, the head reduced beneath the labrum, by flexion, abduction & medial rotation of the hip with gentle traction on area of the greater trochanter with elevation of the labrum out of the acetabulum. This

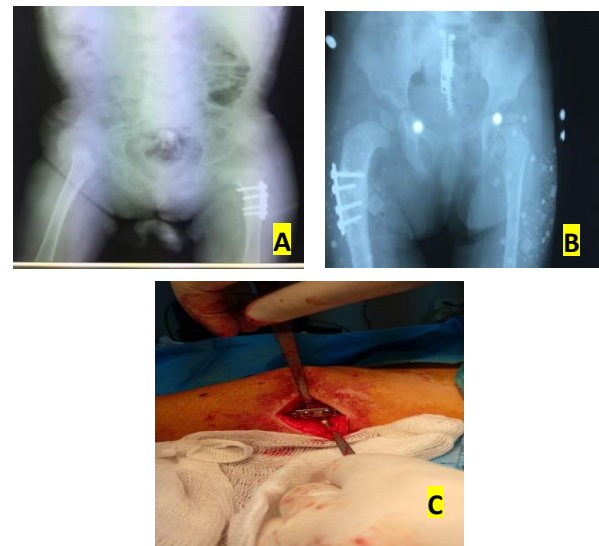
maneuver is reversed to redislocate the hip, sterile nylon No.1 is put in the margins of the capsule for capsulorrhaphy, and the hip is reduced. A careful secure capsulorrhaphy is performed next., the hip joint is held in abduction 30 degree, flexion 30 to 45 degrees, and medial rotation 20 to 30 degree (depend on the degree of anteversion ) throughout the remainder of the operation by a second assistant. The sutures are passed through the capsule in this position and tied. The two halves of the iliac apophysis are resutured together over the iliac crest. The sartorius muscle & straight head of rectus femoris are resutured to their origins. The wound is closed in subcuticular manner (fig.9D). A one-and-one-half-hip spica cast is applied. , a spica cast is applied with the hip in a flexed, abducted, and internally rotated position. We apply the cast to below the knee (including the foot) on the affected side and above the knee on the contralateral side, and incorporate a bar between the legs. The knee is flexed at 30 to 60 degrees to relax the hamstrings and control rotation in the cast. (Fig.9E)



**Fig.9 (A) adductor tenotomy, (B) bikini incision for open, (C) open reduction, (D) closure of skin, (E) hip spica**

Femoral shortening and derotation osteotomy combined with open reduction of the hip done in five cases (5 hips) because of tightness in performing reduction. The procedure is performed through a separate lateral longitudinal incision of the upper thigh (a separate incision), "femoral shortening facilitates reduction when reduction is difficult because of increasing pressure on the femoral head & decompresses the hip (in 5 hip

joints) ". ". A longitudinal mark is made with the saw on the femoral shaft, the femur is transected below the lesser trochanter, and reduction of hip is done then alignment of the distal femoral shaft with the proximal shaft." The amount of overlap is noted, in order to determine the amount of shortening necessary .”This overlap is marked on the distal fragment, and the femoral shaft is transected again at that level. A four-hole plate is applied. The screws are placed, fixing the plate to the proximal & distal fragment (Fig 10). The lateral thigh wound is closed in the usual manner. Postoperative care is similar to that after open reduction of the hip. Derotation osteotomy (DO) is done in all other 21 hips in which the internal rotation position is needed & done after 6 weeks from the first operation. (Fig. 11, 12). The average duration of surgery was 2h (range 1.5–2.5) hours for 1<sup>st</sup> stage & 45 minutes (range 1/4-1) hour for 2<sup>nd</sup> stage.



**Fig.10 A. OR+shortening+DO (one stage), B. OR+DO (2 stages), C. OR+DO (2 stages).**

## RESULT

Overall results were based on objective radiographic & subjective assessments with *Modified MacKay criteria* and *modified Harris hip score*. The patients were followed both objective & subjective evaluations for an average mean duration of 16 months (range, 12–20 months). Final clinical and radiological results were evaluated at the end of follow-up., The overall final clinical results were excellent in 8 hips (30.8%), good in 16 (61.6%), fair in 1 hip (3.8%) and poor in 1 hip (3.8%), satisfactory (excellent and good) in 24 hips (92.3%) and unsatisfactory (fair and poor) in 2 hips (7.7%) as shown in (Table 6). The final radiological end result was Class I (excellent) in 15 hips (57.7%), Class II (good) in 10 (38.5%), Class III (fair) in one (3.8%). The radiological

results were satisfactory in 25 (96%) patients and unsatisfactory in one (4%) patients. No hip had Severin Class IV, V or VI as shown in (Table 7).

**Table (6): The final clinical result**

Final clinical result	No. of hips	percent
Excellent	8	30.8%
Good	16	61.6%
Fair	1	3.8%
poor	1	3.8%
Total	26	100%

**Table (7): The final radiological results**

Criteria of Severn	No. of hips	percent
Class I	15	57.7%
Class II	10	38.5%
Class III	1	3.8%
Total	26	100%

**The clinical parameters in relation to final outcome data:**

The overall final results were not significantly affected by the duration of surgery ( $p=0.431$ ). The mean age had no statistically significant effect on the final outcome regarding all patients below age of 2 years old ( $p=0.068$ ). The final outcome also was not affected by sex ( $p=0.91$ ), side affected ( $p=0.97$ ) and whether the patient had been treated previously by conservative treatment or not ( $p=0.69$ ). The overall final result was not significantly affected by the amount of shortening (amount between 1-2 cm) in those 5 patients done due to tightness of soft tissue around the hip joints ( $p=0.12$ ). The overall final result was not significantly affected by the degree of derotation ( $p=0.94$ ).

**The radiographic parameters in relation to final outcome data:**

Acetabular index (AI) improved in all hips at final evaluation. The mean pre-operative AI was  $43 \pm 2.5^0$  (range 36-50). At the final end of follow-up it was reduced to an average of  $24 \pm 3^0$  (range  $20^0-30^0$ ) and there was statistically significant difference between the pre-operative AI and that at the final radiological evaluation ( $p=0.0001$ ).

**Complications:**

One patient developed superficial wound infection after 6 weeks of the 1<sup>st</sup> stage of operative treatment which responds to 3 day of injectable antibiotic (ceftriaxone 250mg twice daily), no redislocation or

avascular necrosis in all our patients at time of follow up. The final clinical outcome in one patients was fair (score: 80) although radiographic Severin class I due to limping & moderate limitation of hip movement, the final radiological outcome was graded as Severin (Class II) due to abnormalities in the shape of the head and neck of the femur. The other one patients with poor final clinical outcome (score 60) with Severin (class III) that probably was due to immobilization in the cast for longer period. (8weeks).

**DISCUSSION**

Meticulous history & clinical examination is still the main stay in the diagnosis of DDH. Children who reach walking age group with DDH, either secondary to delayed diagnosis or failed other options of treatment. Once discovered, management of developmental dysplasia of the hip in this age group is surgically demanding procedures & is based largely on the experience of the surgeon. The aims of treatment are largely to obtain a concentric reduction without stiffness or avascular necrosis & without recurrence of subluxation or dislocation. Options of treatment vary from closed reduction to open reduction with combined pelvic or femoral osteotomies. "Open reduction in this age group (1-2.5) year's old gives an excellent visual confirmation about adequacy of reduction with fewer traumas exposing the femoral head generally. In addition, open reduction gives the surgeon the opportunity to assess the amount of acetabular dysplasia [12]" In this age group, Zionts and MacEwen<sup>[25]</sup> found that "closed reduction was associated with a high rate of avascular necrosis (23.7%) and a high incidence of secondary procedures for recurrent subluxation or persistent acetabular dysplasia." While in our study by open reduction with good cleaning of acetabulum & secured capsulorrhaphy enhancing the growth of the roof of acetabulum (improve acetabular index) for coverage of the head of femur (concentric reduction) without tightness of the reduction, all of these decrease incidence of stiffness or avascular necrosis. "Zionts& MacEwen<sup>[25]</sup> also found that nearly 66% of their patients treated with traction, adductor tenotomy, and closed reduction under general anesthesia required secondary surgical procedures". Similarly," Mardem-BeyandMacEwen<sup>[26]</sup> found that 66% of children of walking age with DDH who had treated by closed reduction required additional surgery, compared with 33% of such patients treated with open reduction". Usually excessive femoral neck anteversion is present in cases of DDH but it's not obvious clinically in these children when the hip is in a subluxated or dislocated position, but it becomes so obvious when the hip is reduced at open reduction where the head is

reduced and becomes stable after internal rotation of the hip. This was found to be true in this study, as 26 hips included were found to need a femoral derotational osteotomy after reducing the femoral head in the acetabulum. The average derotation angle was found to be 20° (range 10-30)<sup>0</sup>. "Schoenecker and Strecker<sup>[16]</sup> found that femoral shaft shortening to be superior to traction as an aid in operative reduction of DDH with a decreased rate of avascular necrosis and a decreased rate of subluxation or redislocation". Craig WA, Risser JC<sup>[19]</sup> "concluded that sufficient shortening and dissection of the rectus femoris and iliopsoas tendons are of very importance in preventing any difficulty in the reduction and avascular necrosis". In our study, we found that femoral shortening was needed in 5 hips (19.2%) due to tightness in reduction in order to decrease incidence of avascular necrosis. There is controversy about the relationship between the upper age limit for open reduction and the potential growth for acetabular remodeling. "Ok et al.<sup>[27]</sup> found that, in order to achieve good hip joint functionally with remodeling & biological growth, an open reduction is suitable method for treatment neglected DDH in patients". Although many authors suggest an upper age limit of 8 years for treatment, they found that joint remodeling continued even after this age after open reduction of the DDH. In this study we found no relationship between the age at the time of treatment and the final outcome.

Most of studies that using one stage operation for treatment of neglected DDH after the ambulatory age used varies combinations of surgical treatment without standardized or fixed surgical method or protocol in order to evaluate the final functional & radiological outcome, in addition to the difference in patients selection, type of classification system used for evaluation & duration of follow up of patients. This made statistical study for comparism of their results with ours result very difficult. "Ryan et al.<sup>[29]</sup> reported their results of surgical treatment of patients with DDH below age of 3 years old as follows: seven hips had excellent results; 11 good results, four fair results and three poor results. "Galpin et al. in a study of 33 hips in 25 patients, 2 years of age or older treated by one-stage surgical method, they reported satisfactory results clinically in 85% of their patients and radiographically in 75%.<sup>[28]</sup> They suggested that a one-stage operative procedure consisting of open reduction, femoral shortening and derotation osteotomy with or without pelvic osteotomy for treatment DDH in children who are three to eight years old can result in biological remodeling of the acetabulum and a functional hip. Nakamura et al.<sup>[30]</sup> reported: excellent results in five joints, good in three and fair in three. In our study, 26 hips (92.3%) had good

or excellent in final clinical results and 96% had good or excellent in final radiological results at the final follow-up. Regarding complications, there is a wide range of variation in the incidence of AVN between different studies, this may be due to variation in the classification systems used, difference of the periods of follow-up or different methods of treatment including both conservative and surgical treatments. In our study no patients had redislocation of the hip." Rudolf et al.<sup>[31]</sup> reported 3 of 54 hips with redislocation", Grill<sup>[32]</sup> "reported 12 of 50 hips with redislocation and resubluxation". Ruzzkowski and Pucher<sup>[33]</sup> "reported one of 33 hips in 26 children with redislocation". Regarding infection rate, Ryan et al.<sup>[29]</sup> reported their results of treatment of cases of DDH below age of 3 years old surgically ,no patient developed serious or superficial infection & this corresponding to our result, only one patients developed superficial infection responding to 3 days of injectable antibiotics. No patient in this study developed avascular necrosis of the femoral head at the time of final examination. "Zionts and MacEwen<sup>[25]</sup> identified major AVN in approximately 5% of their patients".

#### **Conclusion:**

Treatment of neglected DDH after the age of walking is usually surgically demanding procedure due to the pathological changes occur at this age related to structures around the hip joint involving capsule, tendons & muscles , in addition to excessive anteversion of the femoral neck & shallowness of the acetabulum. But the surgical procedures when performed properly by an open reduction with spend good time for cleaning of acetabulum & excise part of capsule with secure capsulorrhaphy (1<sup>st</sup> stage) & derotation osteotomy (2<sup>nd</sup> stage) , it gives satisfactory results without need for pelvic osteotomy for those children below age of 2.5 years old.

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